Order Number 9321205

A framework for incorporating indigenous knowledge systems into agricultural research and extension organizations for sustainable agricultural development in India

Rajasekaran, Bhakthavatsalam, Ph.D.

Iowa State University, 1993

U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

A framework for incorporating indigenous knowledge systems into agricultural research and extension organizations for sustainable agricultural development in India

by

Bhakthavatsalam Rajasekaran

A Dissertation Submitted to the
Graduate Faculty in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY

Department: Agricultural Education and Studies
Major: Agricultural Education
(Agricultural Extension Education)

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

For the Major Department

Signature was redacted for privacy.

For the Graduate College

Iowa State University
Ames, Iowa
1993

DEDICATION

To
Mary Warren
for her constant support and encouragement

TABLE OF CONTENTS

CHAPTER I. INTRODUCTION

Large-scale Indian farmers with holdings of at least six acres have relatively easy access to agricultural inputs and improved agricultural technologies. Increases in productivity per unit of land have been dramatic in India where farmers have relatively uniform environments and well-developed infrastructures (Chambers and Jiggins, 1987). The majority of rural-based resource-poor people, including small-scale farmers, and landless men and women laborers are the focus of many development efforts. Increasing population pressure has forced the resource-poor farmers to produce their food, energy, and income from declining supplies of arable land (Kotschi, 1989).

Problem

The resource-poor farmer behind the plow is the most neglected farmer in the rural societies of India (Sainju, 1989). Simple and high-input packages do not fit well with the small-scale complexity and diversity of resource-poor farming systems, nor with their poor access to agricultural services and risk-prone environments (Chambers, Pacey and Thrupp, 1989). In contrast, increases in agricultural productivity per unit of land have been dramatic in areas of India where farmers have relatively uniform conditions and well-developed infrastructural facilities (Chambers and Jiggins, 1987).

Moreover, technological efforts to increase food production through modern technologies have rarely considered the natural environments (e.g., local water sheds), indigenous knowledge systems (e.g., indigenous soil classification), and resource endowments (e.g., labor availability) around which resource-poor farmers normally operate (Chambers 1989; Fujisaka 1992; Gupta 1991; Jodha 1990; Raman 1989; Warren et al., 1989). Continuing these food production strategies while neglecting the above-mentioned grass-roots factors may worsen the physical, natural, and human environments of resource-poor farmers.

Chambers and Jiggins (1987, p.2) illustrated the farming conditions of resource-poor farmers:

> The conditions of resource-poor farmers' farming differ from those of resource-rich farmers and those of research stations. Environmentally, resource-poor farmers have less control over physical conditions (e.g., less flat land, less irrigation), less access to inputs, different priorities (e.g., family food first, crops for sale second, and risk reduction), often farming with more complex interactions (e.g., agroforestry, intercropping) and multiple household enterprises. In contrast with the relatively uniform conditions of core areas, the hinterlands in which many resource-poor farmers are found are highly diverse geomorphologically, ecologically, and culturally, demanding highly differentiated and locale-specific research.

The higher productivity of rice and wheat has led many farmers to substitute these cereals for other staples and for more traditional mixed patterns of cropping (Conway and Barbier, 1990). This has resulted in the displacement of traditional crop varieties. For example, local varieties of gourd vegetable crops such as bottle gourds (*surai kai*), bitter gourds (*pagal kai*), snake gourds (*pudalang kai)*, and ribbed gourds (*peerkan kai*) are rapidly disappearing in Shollinganallur, a village in the coastal tract of Tamil Nadu State, India (Rajasekaran, 1987). The farmers use complex indigenous knowledge systems in growing, watering, storing, and preserving the seeds of these gourd varieties. Farmers who possess even less than half an acre can generate some income by selling the gourds in nearby towns.

The plant residues of the gourd crops contribute to natural resource management by conserving soil fertility. Farmers do not use pesticides on the gourd varieties, protecting the environment from chemical pollution and groundwater contamination. Also, gourd vegetables contribute to the food basket of farm families in these areas. Monocultured high-yielding varieties of rice and wheat have resulted in the loss of soil fertility, ecological vulnerability (pests and disease infestation), erosion of genetic resources, and destabilization of soil-water-plant relationships (Rajasekaran, Warren and Babu, 1991).

Frequently, agricultural researchers ignore the indigenous knowledge systems of local farmers regarding soils, crops, livestock, and other natural resources. A case study conducted by the International Crops Research Institute for Semi-Arid Tropics (ICRISAT) in Shirapur, a South Indian village, showed that the indigenous soil classification systems of farmers were more accurate than the formal system in stratifying the soils into groups for analysis, and provided improved bases for indexing variations in land quality (Dvorak, 1988). In addition, indigenous soil types are considered better for long term sustainability of the soil structure and soil fertility (Warren, 1992e). Because soil analysts in soil testing laboratories (STLs) are not familiar with the indigenous classification, their fertilizer recommendations may not fit in with the local soil categories.

The agricultural extension system in Tamilnadu, India has also overlooked indigenous agricultural knowledge. A case study conducted by Rajasekaran indicates that the indigenous classification of rice varieties in Chengalpattu District, Tamil Nadu State, is based on criteria such as water source, cropping season, crop duration, and grain quality (Rajasekaran and Warren, 1992). The village extension workers disseminate information on the seed varieties recommended by the researchers to the farmers. These extension decisions are reflected in the types of seeds made available through the seed multiplication units. Although several varieties suitable to semi-arid zones of Tamil Nadu are adapted to severe drought conditions, most of the varieties being encouraged through the agricultural extension system are suitable only in resource-rich environments such as those with an assured supply of irrigation. The indigenous, locally adapted varieties of *Vadan samba, Kulla kar, and Arcot kichilli* are no longer as easily available (Rajasekaran, Warren and Babu, 1991).

Attitudes generated by the top-down transfer of technology (TOT) paradigm have precluded learning indigenous knowledge of farmers. Reasons for non-adoption of innovations resulting from the conventional TOT paradigm have been attributed to outsider's stereotypes of small-scale farmers (e.g., ignorance, laziness, conservatism) or an inadequate delivery system (e.g., poor extension service, lack of credit facilities) but seldom to the characteristics of the innovations themselves (Waters-Bayer, 1987). Chambers (1990, p. 3) stated that:

> As we enter the 1990s, the dominant paradigm of development expressed by normal professionals and implemented through normal bureaucracy is still top-down and center-outwards. Power is concentrated in hands of the old men in high offices and central places. Knowledge is generated in universities, laboratories, and research stations, and then transferred packaged for adoption. The approach is centralized, standardized, and simple. Reductionist research, high input packages, and top-down extension had their successes: in the uniform and controlled conditions of industrial agriculture. But the sustainability of that increase is open to question, and TOT does not work well with the more complex, diverse and risk-prone rain-fed agriculture of much of the poorer South.

Programs based on the conventional transfer of technology paradigm in India underestimated the risk-aversion and decision-making strategies of landless agricultural laborers during off-farm seasons according to Krishnamoorthy (1986, p.12):

> The landless poor laborers in Karupatti village, Madurai district, Tamilnadu state, work as watchmen in medium and large-scale coconut gardens in dry land areas and hence earn some money for their livelihood. The women make "brooms" from coconut sticks. These brooms cater to the needs of front and back yard cleaning in urban and rural households. By selling the brooms,

the women generate some cash income during the off-farm seasons. On the other hand, the resource-poor farmers generate cash income during the off-farm season by maintaining milk cows and goats.

These indigenous risk-aversion and decision-making strategies may appear simple to outsiders but they represent mechanisms to ensure minimal livelihoods for the rural people in India.

During the process of technology development, farmers' informal experimentation has long been under-perceived (Rhoades and Bebbington, 1988). In spite of increased coordination between research and extension through periodical extension-scientific workers' conferences, it is found that farmers' priorities are not considered while conducting on-farm research trials (Rajasekaran and Martin, 1990). On-farm trials conducted by researchers and extensionists mostly concentrate on crop varietal comparison, fertilizer response, and test different packages of practices for cereals and millets. In contrast, farmers experiment with: (a) alternative coping mechanisms to avoid extreme conditions such as droughts and floods, (b) diversified food production techniques such as intercropping, (c) border cropping in order to broaden food and fodder requirements, and (d) adjustment of sowing and harvesting periods to meet the local market demand.

After technology dissemination, feedback from farmers regarding the characteristics of the introduced technologies were rarely recorded. Development of technologies in research stations has become a continuous process without considering what is happening in the field. Following are the factors contributing to this problem:

1. Agricultural researchers do not investigate the impact of the technologies they develop. They feel their responsibility ends once the technologies are released to the extension system;
2. Agricultural extension personnel feel that dissemination of technologies to farmers is their only responsibility. Once the

technologies are disseminated to the farmers, they are completely satisfied with their jobs; and

3. Even some enthusiastic extension workers who have tried to bring feedback from the farmers were not encouraged by extension administrators and researchers.

In summary, farmers' needs, priorities, and indigenous knowledge systems are not considered while developing and disseminating technologies through the research-extension pipeline.

Perceived limitations in indigenous knowledge systems strengthened the attitudes of outsiders that these knowledge systems are 'primitive', 'unproductive' and 'irrelevant' contributing to the above problems. Among these perceived limitations are: (1) indigenous knowledge systems are oral in nature; (2) indigenous knowledge systems are not documented; (3) each individual possesses only a part of a community's indigenous knowledge systems; (4) indigenous knowledge systems may be implicit within local people's practices, actions, and reactions, rather than a conscious resource; and (5) farmers' rarely recall information on quantitative data pertaining to their indigenous knowledge systems (Reijntjes et al., 1992).

Need for the Study

The aforementioned problems represent the basis for a major rethinking of the attitudes and approaches of extensionists, researchers, policy makers, and in the mode of operation of extension organizations. The major strength of indigenous knowledge systems lies in their functional integration of different resources and farming techniques (Reijntjes et al., 1992). Giving due regard to indigenous knowledge is the first step in this process. Sensitizing the agricultural research-extension community to learning from resource-poor people and their understanding of the natural environments must be one of the essential principles of agricultural and extension education efforts in the 1990s.

Devaluing indigenous knowledge systems as "low productive," "primitive," and "old" is no longer a useful attitude.

Technological developments are essential to increase food production, but they should be carefully built on the foundation of indigenous knowledge systems in order to successfully accomplish the mission of food security and the preservation of natural resources for future generations. Farmers' knowledge regarding food production, natural resource conservation, micro-environments, and risk-adjustments have proved to be accurate and often complex. As conditions change, farmers also recognize weaknesses which they actively seek to address. This is where it is essential that scientific endeavors reflect an understanding of locally-derived knowledge.

Identifying and documenting indigenous knowledge systems are, therefore, the first steps towards understanding and learning from local people. The indigenous knowledge systems exist in numerous forms--indigenous decision-making systems, indigenous agricultural practices, and indigenous beliefs. As a next step, it is important to determine the extent to which indigenous knowledge systems are being used by farmers. This step also enables one to determine the contribution of indigenous knowledge systems to agricultural productivity and sustainability. As a final step, indigenous knowledge systems need to be incorporated into agricultural research and extension organizations. These systematic people-oriented approaches would certainly provide a major rethinking in the attitudes and approaches of extensionists, researchers, policy makers, and in the mode of operation of research and extension organizations.

Purpose of the Study

The purpose of the study was to formulate a methodological framework to incorporate indigenous knowledge systems into agricultural research and extension organizations for sustainable agricultural development in India.

The philosophy of the International Federation of Agricultural Producers, "building on traditions," supports the purpose to which the study was intended (IFAP, 1990, p.24):

> Rather than attempting to impose new intensive methods in socio-economic environments which are ill-adapted to such techniques, what is now needed is the reappraisal of traditional farming practices such as multiple cropping and traditional soil management methods---building on those principles which previously formed a solid foundation for sustainable agriculture, and tailoring agricultural adaptation to the existing ecological framework.

Objectives

The specific objectives of the study were:

1. To determine the extent to which farmers agreed with selected indigenous decision-making systems;
2. To determine the extent to which statements regarding indigenous knowledge systems are believed to be true by farmers;
3. To determine the extent to which selected indigenous technical practices are being used by farmers;
4. To determine the relationship between selected demographic and indigenous technical practices;
5. To determine the influence of selected indigenous technical practices on productivity;
6. To determine the influence of selected indigenous technical practices on sustainability; and

7. To develop a methodological framework for incorporating indigenous knowledge systems into agricultural research and extension organizations.

Operational Definitions

Indigenous: Occurring or living naturally in a specific area, such as native plants or animals (opposite to exotic); to be differentiated from 'endogenous', which means having its origin within a specific area (opposite of exogenous) (Reijntjes et al., 1992).

Indigenous knowledge system: The accumulation of concepts, beliefs, familiarity, and facts through experiences, ancestral sources, informal experiments, and intimate understanding of the environment of a given culture at a specific geographical location.

Indigenous technical practices: Agricultural practices developed by farmers, often by modifying and incorporating modern agricultural technologies, that fit the local agro-ecological and socio-economic conditions.

Indigenous decision-making system: It is the process by which farmers frame farming objectives and choose methods to reach those objectives using their cognitive strategies and resources available at hand.

Resource-poor farmers: Farmers who have less control over physical conditions (e.g., less irrigation), less access to inputs (e.g., quality seeds, chemical fertilizers), different priorities (e.g., family food first, crops for sale second), and often farming with more complex interactions (e.g., agroforestry, intercropping) (Chambers and Jiggins, 1987). Although most of the farmers may be resource-poor in physical conditions, they are resource-rich in knowledge.

External inputs: Inputs that originate from outside the system (farm, village, region, country). Artificial external inputs are based on fossil fuel, such as chemical fertilizers (Reijntjes et al., 1992).

Productivity: Productivity is the output per unit of land, labor, capital, time or other input. Outsiders tend to measure farm productivity according to total biomass yield, economic yield of profitability, often with a view to maximization of output per unit of land. Farmers have their own ways of defining and assessing productivity, measured by per unit of labor expended at planting or weeding time or per unit of irrigation water used (Reijntjes et al., 1992).

Sustainability: Sustainability is the capacity to remain productive while maintaining the natural resource base (Reijntjes et al., 1992).

Sustainable agriculture: It is the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources (Technical Advisory Committee, 1990).

'Emic' perspectives: 'Emic' perspective involves putting outsiders as much as possible into the insiders' shoes to understand how they view their practices in both ecological and socio-cultural terms.

Transecting: It is a process of drawing maps by walking through the study villages to demarcate various agro-ecological zones.

Implications for Educational Practice

This study had implications for educational practice and agricultural extension educators. Though the need to incorporate indigenous knowledge systems into agricultural extension programs is increasingly recognized, it is difficult to proceed further in this direction without understanding the level at which local people are currently using indigenous knowledge systems and also the impact of indigenous knowledge systems on productivity and sustainability of the agricultural system. The results of this study provide greater insight for agricultural and extension educators involved in developing training resource materials on indigenous knowledge systems. The results also provide insights for conducting training programs for extension workers on the methodologies for recording indigenous knowledge systems related to food production and resource conservation.

Incorporating indigenous knowledge systems into agricultural and extension education programs will result in: (1) understanding the 'emic' perspectives of local people; (2) bridging the communication gap between outsiders and insiders; (3) recognizing the accomplishments of local farmers; (4) helping outsiders familiarize themselves with local conditions and abstract terms; and (5) increasing the participation of farmers and their organizations in integrating, utilizing, and disseminating what already exists (Rajasekaran, 1991).

CHAPTER II. REVIEW OF LITERATURE

> Let us rediscover the truth that the unlettered villager is often the wisest of teachers and that, without our (outsiders) guidance and direction, the villager survives and even thrives in conditions we could not face (Kurien, 1989, p. 15).

The purpose of the study was to formulate a methodological framework to incorporate indigenous knowledge systems into agricultural research and extension organizations for sustainable agricultural development in India. The specific objectives of the study were: (1) To determine the extent to which farmers agreed with selected indigenous decision-making systems; (2) To determine the extent to which statements regarding indigenous knowledge systems are believed to be true by farmers; (3) To determine the extent to which selected indigenous technical practices are being used by farmers; (4) To determine the relationship between selected demographic factors and indigenous technical practices; (5) To determine the influence of selected indigenous technical practices on productivity; (6) To determine the influence of selected indigenous technical practices on sustainability; and (7) To develop a methodological framework for incorporating indigenous knowledge systems into agricultural research and extension organizations.

Literature searches were conducted with an objective to lay a theoretical foundation for this study. Most of the searches were conducted using the facilities available at the Documentation Unit and Library of the Center for Indigenous Knowledge for Agriculture and Rural Development (CIKARD), Iowa State University. Several AGRICOLA and CAB searches were also conducted at the main library of the Iowa State University. A visit to the library of the Tamil Nadu Agricultural University, Coimbatore, India also provided relevant literature. Most of the literature related to this study was of a very recent nature.

Most literature related to indigenous knowledge systems indicates that these systems are sophisticated and complex, reflecting generations of careful observations of the natural and physical environments of the local people (Warren et al. 1989). Much of this research emphasized the need for a shift from high-intensive, production-oriented agricultural systems to farmer-oriented, ecologically-based, low-input agriculture. Other reports suggest a need for a careful blend of indigenous knowledge systems (IKSs) of local people and scientific technologies developed from International Agricultural Research and Development Centers (IARDCs) and also regional research stations in India.

Indigenous Knowledge Systems: Definitional Concepts

The term 'indigenous' is often interchangeably used with terms such as 'traditional' or 'local' (Wang, 1988). Fisher (1989) defined the term 'indigenous' as "systems that are generated by internal initiative within a local community itself." He further stated that the term indigenous should be used in preference to traditional because the term 'traditional' implies continuity where as indigenous refers to a new development. Indigenous knowledge (IK) is the systematic body of knowledge acquired by local people through the accumulation of experiences, informal experiments, and intimate understanding of the environment in a given culture. IK is local knowledge that is unique to a given culture or society (Warren, 1987). McClure (1989) defined IKSs as the sum of experience and knowledge of a given ethnic group that forms the basis for decision-making in the face of familiar and unfamiliar problems and challenges. According to McClure (1989, p. 1):

> Indigenous knowledge systems permeate all that we do and think and believe. Some indigenous knowledge is fact as Western scientists know and define fact. Some of it is belief as philosophers and theologians define belief. And a lot of it is folk wisdom. Indigenous knowledge systems are learned ways of

> looking at the world. They have evolved from years of experience and trial-and-error problem solving by groups of people working to meet the challenges they face in their local environments, drawing upon the resources they have at hand. Indigenous knowledge system is a broad topic which cuts across many disciplines and professions. Indigenous knowledge system is an integrative concept which keeps the focus on the individual or group as it functions in the local setting and it facilitates bringing together the social scientist and the biological scientist on collaborative work within a task environment.

IK is the information base for a society which facilitates communication and decision-making (Warren, 1990). IK is the actual knowledge of a farming population which reflects their experiences based on traditions as well as recent experiences with modern technologies (Haverkort, 1991). This knowledge is far more than technical methods and cultivation practices of farmers. It entails many kinds of insights, wisdom, perceptions, and practices related to people's resources and environments. It is not static. Experimentation, screening, and integration of knowledge represent activities of farming, as much as tilling of the soil.

Principles of Adult Learning

It is essential to look at the principles of adult learning since they have implications for the acquisition of indigenous knowledge systems. Acquiring indigenous knowledge is a life-long learning process. Creswell (1990) stated that life-long learning is necessary for anyone, young or old, who has to live with the escalating pace of change. The process of knowledge acquisition by farmers can be related to the principles of adult learning as expressed by Smith (1982): (1) learning occurs throughout life; (2) learning is personal; (3) learning is partially a function of human development; (4) learning pertains to experience; and (5) learning is partially intuitive. According to Creswell (1990), adult learners also exhibit four essential characteristics: (1) adults have multiple roles and responsibilities; (2) adults have accumulated many life experiences; (3) adults pass through a number of developmental phases in the physical, psychological, and social spheres; and (4) adults experience anxiety and ambivalence in their orientation to learning. Cross (1981) stated that adults are goal-oriented pragmatic learners.

Box (1989) illustrated with specific cases how farmers learn from diversified learning sources. (1) Learning by observation: Farmers in Central America observed that deposits of compost along the edge of contour ditches check soil erosion. (2) Learning by experimenting: Non-toxic pest control was used in Guatemala when wild rabbits were wiping out program-introduced soybeans. One day a local farmer smelled a strong odor as he was walking by a drug store. It was iodine. He bought a pound, mixed it with water, and spread the solution around the borders of his soybean field. The rabbit problem was eliminated. (3) Learning by discovery: A farmer in the World Neighbors Highlands Programme area of Peru, who was managing a eucalyptus nursery at 3800 m above sea level, was having to cover the seedbeds with plastic every night in order to protect them from heavy frosts. He discovered that when he located the beds in a small forest of eucalyptus, the plastic cover was unnecessary. In addition, farmers also learn by adapting modern technologies to suit their own conditions (Rajasekaran et al. 1991).

The knowledge acquired throughout these learning processes spontaneously spread from farmer to farmer, from one village to another. Outsiders must understand these informal teaching-learning processes in order to effectively facilitate learning from formal learning sources (research-extension). The following six principles are essential for facilitating learning according to Brookfield (1987):

1. Farmer participation in learning should be voluntary;
2. Effective facilitation should be characterized by a respect among participants for other's self-worth;

3. Facilitation should be collaborative;
4. Praxis (practice rather than theory) should be placed at the heart of effective facilitation; and
5. The aim of facilitation is the nurturing of self-directed, empowered adults (farmers).

Value of Indigenous Knowledge

IK is dynamic, changing through indigenous mechanisms of creativity and innovativeness as well as through contact with other local and international knowledge systems (Warren, 1990). Today, because of its oral tradition as well as the introduction of new technologies, the preservation of IK is at risk. IKSs are tuned to the needs of local people and the quality and quantity of available resources (Pretty and Sandbrook, 1991). Their efficiency lies in the capacity to adapt to changing circumstances.

IKSs often are elaborate, and they are adapted to local cultural and environmental conditions (Warren, 1987). IKSs reflecting agriculture are often broad, detailed, and comprehensive, although this is not always the perception among agricultural scientists and development workers (Thurston, 1992). In fact, it has often been overlooked by western scientific research and development (Warren, 1990). Any development program should respect and reinforce indigenous knowledge by emphasizing and restoring local knowledge (Salas and Tillman, 1989). According to Norgaard (1984, p. 7):

> Traditional knowledge has been viewed as part of a romantic past, as the major obstacle to development, as a necessary starting point, and as a critical component of a cultural alternative to modernization. Only very rarely, however, is traditional knowledge treated as knowledge *per se* in the mainstream of the agricultural and development and environmental management literature, as knowledge that contributes to our understanding of

agricultural production and the maintenance and use of environmental systems.

Peasant societies have developed their own logic in the use of nature partly based on a wealth of local experimentation (Salas and Tillman, 1989). By recording these systems, the agricultural extensionists can understand better the basis for decision-making within a given society. IK may not always be as abstract as scientific knowledge; it is often concrete and relies strongly on intuition, historical experiences, and directly perceivable evidence (Farrington and Martin, 1987). Hence, IK is key to successful participation of resource-poor farmers.

The salient features of IKSs according to Thrupp (1989, p. 139-140) are as follows:

> IKSs are adaptive skills of local farmers usually derived from many years of experience and often have been communicated through "oral traditions" and learned through family members over generations. IKSs pertain to various cultural norms, social roles, or physical conditions. Such knowledge is not a static body of wisdom, but instead, usually consists of dynamic insights and techniques which are changed over time through experimentation and adaptations to environmental and socio-economic changes. IKSs are not possessed by only one sector of the society. For example, in many cultures, women and elders have impressive insights into certain aspects of a culture. Sometimes, researchers have been unaware of such perceptiveness among rural people due partly to their biased focus on land-owning male farmers, neglecting other members of society.

By comparing and contrasting IKSs with the scientific technologies of International Agricultural Research and Development Centers (IARDCs) and regional research stations, it is possible to see where technologies can be utilized to improve upon local systems (Warren, 1987). They have evolved from years of experience and trial-and-error problem-solving by groups of people working to meet the challenges they face in their local environments, drawing upon the resources they have at hand (Roling and Engel, 1988).

IKSs are as ancient as human civilization. IKSs are time-tested management practices of land and thus pave the way for a sustainable agriculture (Venkataratnam, 1990). Farmers are the best sources of local knowledge, in that they are well informed about their own situations, their resources, what works and doesn't work, and how one change impacts other parts of their system (Butler and Waud, 1990). Policy actions, especially in the 1990s, should give attention to actively preserving this diversity of knowledge. This can be done by recording, classifying, and disseminating this knowledge, and by creating awareness and supporting projects among local populations so they themselves are able to treasure and to preserve such knowledge for their own advancement.

Consequences of Disregarding Indigenous Knowledge Systems

Undermining farmers' confidence in their traditional knowledge can lead them to become increasingly dependent on outside expertise (Richards, 1985; Warren, 1990). Atteh (1989, p. 12) stated that indigenous knowledge systems of local people are considered as 'unproductive' and 'primitive.' Small-scale farmers are often portrayed as backward, obstinately conservative, resistant to change, lacking innovative ability, and even lazy (IFAP, 1990, p. 24). The International Federation of Agricultural Producers (IFAP) enumerated certain reasons for such a perception:

1. Lack of understanding of traditional agriculture which further leads to a communication gap between promoters and practitioners giving rise to myths;

2. The accomplishments of farmers often are not recognized, because they are not recorded in writing or made known; and

3. Poor involvement of farmers and their organizations in integrating, consolidating, and disseminating what is already known.

One of the greatest consequences of the under-utilization of IKSs, according to Atteh (1989, p. 30), is the:

> Loss and non-utilization of IK [which] results in the inefficient allocation of resources and manpower to inappropriate planning strategies which have done little to alleviate rural poverty. With little contact with rural people, planning experts and state functionaries have attempted to implement programs which do not meet the goals of rural people, or affect the structures and processes that perpetuate rural poverty. Human and natural resources in rural areas have remained inefficiently used or not used at all. There is little congruence between planning objectives and realities facing the rural people. Planners think they know what is good for these 'poor', 'backward', 'ignorant', and 'primitive' people.

Indigenous Knowledge on Food Production

Small-scale farmers have access to a systematic and historic body of knowledge which may influence their food production practices (Fernandez and Salvatierra, 1989). Balasubramanian (1987, p.9) depicted how Tamil Nadu farmers with their vast experience handed down from generation to generation utilize the microclimate in a skillful manner:

1. In Cauvery delta of Tamil Nadu, black gram *(Phaseolus mungo)* and green gram *(Phaseolus aureus)* are sown as relay crops in rice fields after the long duration rice crop. Farmers sow the gram seeds in a standing rice crop just one week before the harvest of the long duration rice crop. The moisture level and soil condition of the standing rice crop is optimum for the germination and establishment of the gram seedlings. After the harvest of the paddy crop, the seeds get the required sunshine and yield is good. The entire crop is grown under zero cultivation.

2. In certain pockets of the Tanjore Delta of Tamil Nadu, peanuts are sown in late December, immediately after the harvest of the rice crops. The peanuts are grown without irrigation. The water requirements are met from the soil moisture stored from the previous rice crop. The farmers weed the peanuts by hand at the 20th and 40th days after sowing. During hand weeding at the 20th day, the soil clods are broken and fine tilth is produced to act as a soil mulch. This soil mulch maintains the soil temperature and prevents soil moisture evaporation.

3. The available micro-climatic conditions in the bunds of the paddy fields are utilized for growing crops such as pulses, and vegetables.

Indigenous Soil Classification System

Highly technical methods for describing and classifying soils have little practical value and are therefore rarely used for research and extension aimed at improving the small-scale peasant farmers (Kerven et al., 1991, p.12). Kerven et al. further provided reasons for the above statement:

> First, the criteria used by technical scientists for classifying the soil may not match the criteria considered by farmers---the latter being concerned with the soil's usefulness for cropping. Secondly, sampling and analysis required to classify a soil using conventional technical methods are often too laborious, time-consuming, and costly for applied ('on-farm') researchers and extensionists to carry out. Thirdly, researchers and extensionists may lack the skills and training required to identify and analyze a soil in the field. Fourthly, interpretation of conventional soil classification manuals may be beyond the technical ability of some researchers and extensionists.

In Malabar (Kerala state, India), farmers classify soils into three categories based on the productivity: (1) *Pasheemah Koor* - rich clay soil, (2) *Rashee Pasheemah Kor* - moderately clay, and (3) *Rashee Koor* -

loose lime soil (Dharampal, 1983). Soils of the arid zone in India are mainly sandy in nature. Hence, farmers collect clayey clods from the nearby ponds during summer, transport it to their fields by bullock cart and incorporate it at the time of land preparation (Gupta, 1991). Tamil Nadu farmers believe that sandy soil is more suitable for groundnuts because during the flowering stage, the pegs could easily penetrate into the loosely structured sandy soil and the pod formation is easier when compared to the clayey soils (Gnanadeepa, 1991).

Warren (1992e, p.23) conducted an analysis of indigenous soil classification systems in four ecozones of Nigeria and came out with the following findings:

1. The indigenous soil classification systems for the Yoruba, Kulere, Nupe, and Hausa are very similar, being based on identifiable properties of texture, color, and water retentiveness;
2. All four systems include comparable knowledge of the nature of soil fertility and ways to retain and improve fertility. The traditional types are considered excellent for long term sustainability of the soil structure and fertility;
3. The Hausa dry-season farmers carried out a remarkable rehabilitation of soils regarded by most agriculturalists as useless for agriculture; and
4. Recorded indigenous soil taxonomies have clearly provided the basis for communication with the farmers and understanding how their knowledge system influences their decision-making for farming.

Indigenous Soil and Water Conservation Methods

Expensive mechanized conservation methods, high labor requirements to carry out maintenance for which farmers do not have enough time, and top-down approaches resulted in the poor adoption of soil and water conservation technologies (Reij, 1991). On the other hand, indigenous methods for conserving soil and moisture are cost-effective (Sanghi and Kerr, 1991). Farmers in Kerala and Karnataka states of

India have used *vetiver* grass for more than a century for protecting bunds from erosion (Warren, 1991c). Trees planted above and below crop fields decrease the intensity of soil erosion in Claveria, Philippines (Fujisaka, 1986). Farmers in the Indo-Gangetic plain break the soil crust by hoeing or plowing to renew gaseous exchange and thereby preventing wilting of crops (Randhawa, 1983). In Auroville, Pondicherry, India, new crops are planted before harvesting the existing crop (Jhunjunwala and Deshingkar, 1984). Aurovilleans mulch trees with leguminous crops and use certain legumes which can survive for six months in the dryland so that some biological activity always takes place in the soil instead of leaving it dry.

Farmers in eastern Uttar Pradesh state of India reclaim alkaline soils by applying large quantities of farmyard manure and water (Balasubramanian, 1987). Summer or fallow plowing is a common practice followed by farmers in north as well as south India. Dharampal (1983, p.247) provided the rationale behind this practice:

> The farmers however know from experience that the soil at the surface, and which has been well heated by exposure to the sun, is that which yields the best returns. It is not uncommon to see them before the hot season plough their more valuable lands, so as to expose as much of the soil to the reviving influence of the sun. It is a fact too, that in most soils in northern Gujarat, the lands are more productive, when kept continually from year to year under cultivation, then when allowed to lie fallow. Soils however improve by a year or two's respite, which they always receive. This is not uncommon in Surat, and even in Broach district, and in some parts of the Deccan.

Moreover, summer plowing improves the soil microbial activity, controls weeds effectively, and incorporates rains for the ensuing season (Gupta, Capoor and Shah, 1990). The common belief regarding summer plowing among the farmers of Hissar village of Gujarat state is that it opens the soils into ridges and furrows and therefore prevents soil erosion (Gupta, 1985).

Farmers recycle nutrients and protect the soil against erosion: (1) by producing and applying organic matter; (2) by using nitrogen fixing and deep-rooted plants; and (3) by enhancing soil cover or by fallowing and rotation (Alders et al., 1991). The problems of soil erosion in cultivated fields is minimized by certain indigenous soil conservation practices in dry regions of Andhra Pradesh (Sanghi and Kerr, 1991):

1. Field bunds without waste weirs (mainly in areas with low rainfall and deep soils);

2. Field drains and conservation drains with waste weirs (mainly in higher rainfall areas in black as well as red soils). Usually the height of the waste-weirs is gradually increased so that siltation is increased and the fields are converted into terraces over the years;

3. Perennial grasses on field boundary bunds;

4. Construction of small stone checks across rills within the field (in shallow red soils with low rainfall); and

5. Sub-division of land holdings into smaller fields.

Some farmers utilize moisture conservation practices:

1. Deep ploughing during the summer (in black soils with low rainfall and in red soils with high rainfall);

2. Sowing seeds across the major slope; and

3. Furrowing as a part of seeding and intercultural operation (for maize in red soil areas).

The occurrence of *manjanathi* trees (Morinda tinctoria) indicates high moisture content in the soil according to Tamil Nadu farmers (Selevanayagam, 1986). Intercropping, relay cropping and sequential cropping protect the soil from the heat of the tropical sun and from the physical damage of rainfall, wind, and soil erosion.

Indigenous Cropping Systems

A study of indigenous cropping systems and their architecture is necessary to design and incorporate what is available in research stations (Thurston, 1992). Crop rotation is a traditional agricultural practice that, in addition to its agronomic value, is important in managing soil borne plant pathogens (Thurston, 1992). According to Palti (1981), farmers have followed crop rotations for hundreds of years because of the following advantages: (1) more efficient use of nutrients, (2) improved soil texture, (3) water conservation, (4) weed control, and (5) management of soil borne pathogens. Crop rotational practices that involve a rotational pattern of cereals, legumes, oilseeds, and vegetables result in the availability of a wide variety of food for marginal farmers (Rajasekaran, Warren and Babu, 1991). They also reduce the farmers' dependency on credit and external input supply. Moreover, it improves soil texture and enhances the uptake of nutrients and water (Thurston, 1992). In Chile, the peasant farmers developed a diversified combination of vegetables, staple crops (corn, beans, potatoes, fava beans), cereals, forage crops, fruit trees, forest trees, and domestic animals by using a seven-year rotational system designed to produce a maximum variety of basic crops in six plots, taking advantage of the soil-restoring properties of the legumes (Altieri and Merrick, 1988).

The farmers of both today and yesterday are aware of intercropping, a technique that resembles crop rotation (Radcliff et al. 1992). While crop rotation is traditionally followed in irrigated areas, intercropping is widely practiced in rainfed areas (Jodha, 1979). Intercrops makes use of land and available rainfall when the plants complement one another. Intercropping reduces the risks and uncertainties due to fluctuations in market prices. Growing black gram, green gram, and cow pea as intercrops in groundnut fields helps Tamil Nadu farmers to meet subsistence as well as market needs in

India (Rajasekaran, Warren and Babu 1991). Intercropping with a native species of wild lupin (*Lupinus mutabilis*) helps farmers to meet the nitrogenous requirements of potatoes and cereals in the highlands of Bolivia (Wilson and Peter, 1988). Intercropping has been practiced not only for its nutritional value but also for the ability to control weeds and insect pests. Moreover, intercropping generally reduces the yield variability because the different species are not equally affected by adverse environmental conditions.

In various regions of India, swidden cultivation, one of the indigenous cropping systems is referred to by different terms (Mahapatra, 1983). In Assam, Meghalaya, Nagaland, Mizoram, Manipur, and in Arunachal Pradesh, swidden cultivation is widely known as *Jhum* and the swiddener as *Jhumia.* In Orissa, the Kondh, the Koya and other Dravidian-speaking tribes refer to it as *Podu*, *Gudia* or *Dongarchas*. In Madhya Pradesh, among the *Baiga*, swidden cultivation is known as *Bewar*. In Tamil Nadu and south Kanara of Karnataka, it is called *Kumari*. According to Mahapatra (1983, p.38), M.S. Shivraman, adviser to the Programme Administration of the Planning Commission, observed in 1957 that:

> It is a mistake to assume that shifting cultivation in itself is unscientific land use. Actually, it is a practical approach to certain inherent difficulties in preparing a proper seed-bed in steep slopes where any disturbance of the surface by hoeing or ploughing will result in washing away the fertile top soil. The tribal people, therefore take care not to plough or disturb the soil before sowing. The destruction of weeds and improvement of tilth necessary for a proper seed-bed are achieved with the help of fire. In most of the interior areas, where communication is not developed and not sufficient land suitable for terracing is available, *Jhumming* alone can be done for the present and as such every efforts should be made to improve the fertility of the *Jhummed* land.

Rab is a traditional system of seed bed cultivation practiced in the past in Thana district of Maharashtra state with the use of wood twigs, leaves, grass, and cow dung with earth on top (Mahapatra, 1983). This system was appropriate in the past, given the existing ecology and the level of development of technology. Even now a well-regulated utilization of forest resources for *rab* may be sound from the viewpoint of preservation of soil fertility and a pollution-free environment.

Indigenous cropping systems such as crop rotation, mixed cropping, intercropping, and swidden cultivation exhibit a high degree of stability. These systems provide farmers with opportunities for harvesting diverse crops from the same land; increasing total land productivity; maintaining and improving soil fertility through the use of legumes; and above all, reducing or avoiding risks of crop failures due to weather (Hoque, 1984).

Indigenous Practices on Seeds and Sowing

Clean seed or healthy propagating material often has positive and dramatic effects on plant health and crop yield (Thurston, 1992). Traditional farmers have used several practices that help to manage seed-borne pathogens. The extensive use of seed beds and the subsequent transplanting of carefully selected healthy seedlings are examples. If seeds are continually used season after season, they lose their yield potential and may contain admixtures like weed seeds and other crop seeds. Hence, Tamil Nadu farmers normally change their seeds at least once in three years (Gnanadeepa, 1991).

Early formed earheads of rice possess higher germination capacity, hence farmers in Tamil Nadu prefer to collect seeds from them (Gnanadeepa, 1991). Closer spacing for the short duration rice crop and wider spacing for the medium duration rice crop is practiced by farmers to ensure optimum plant population and higher yield (Gnanadeepa, 1991). However, the farmers adopt an excess seed rate and almost similar spacing during both the seasons.

Indigenous Crop Nutrient Management Practices

Mixing castor seed cake with urea is a traditional crop nutrient management practice followed in the arid zones of India. This practice releases nitrogen slowly and regulates a uniform supply of nutrients during various stages of the cereal crops (Mane, 1989). Some farmers in Faizabad district have observed that application of potassium fertilizers increases the sweetness in watermelon (Gupta and Saha, 1989). Ploughing the moong plants *in situ* after harvesting the pods improves the soil fertility significantly (Gupta and Saha, 1989).

Farmers apply neem cake to correct soil alkalinity in Tamil Nadu (Kandaswamy, 1978). Farmers of eastern Tamil Nadu strongly believe that the *gingelly* (sesamum) crop depletes soil fertility (Gnanadeepa, 1991). The rationale behind this belief is that *gingelly* is a soil exhaustive crop, and its duration is only 80-85 days. Within this short period, the crop has to convert the nutrients into fats and oils. This belief is also highlighted by a well known *Tamil* proverb, "*Ellu potta vayalil kollu kooda vilayathu*" meaning "Even horsegram does not perform well in the field where *gingelly* was grown as a previous crop." Though Tamil Nadu farmers are aware of the value of green manure in increasing the soil fertility, they are unable to adopt this practice since they seldom find any gap to include green manure crops in their cropping pattern (Gnanadeepa, 1991). Dryland farmers of Tamil Nadu state believe that the growth of the weed *aduthinnapalai* indicates low fertility of soil (Selvanayagam, 1986). According to Selvanayagam, farmers also found that weeds shoot up in fertile soils immediately after rains.

Indigenous Water Management Systems

Farmers who depend on wells, tubewells, and canals for irrigation adopt a wide variety of indigenous water management practices. These practices aim at conserving the energy to be used for irrigation, assuring an economical usage of irrigation water, and irrigating at correct stages of the crops.

Indigenous water management systems offer special opportunities for conserving critical eco-systems, while meeting urgent social and economic needs of local communities (Groenfeldt, 1990). Enhanced productivity of these systems can relieve pressure on surrounding areas, and the sustainability of indigenous water management systems is thereby directly linked to the environmental sustainability of the watersheds. The institutional arrangements embedded in traditional irrigation systems are important both to the political stability of the immediate region, and for the cultural integrity of the people whose land is to be irrigated. The farmers who build, operate, and monitor indigenous irrigation systems are also involved in other economic activities such as rainfed agriculture, fishing, wage labor, and crafts (Groenfeldt, 1990).

Tamil Nadu farmers avoid irrigating the rice nursery on the fourth day after sowing (Gnanadeepa, 1991). The rationale behind this practice is that after three days of sowing, the plumules of the rice seeds start emerging. At that time, if the water stands on the field, the plumule is affected. Gnanadeepa (1991) also found that farmers in Tamil Nadu adopt alternate wetting and drying of rice main fields to improve soil aeration. This process enhances microbial activity though many farmers are not aware of the scientific rationality behind this practice.

Based on the rainfall and soil type, the farmers in Andhra Pradesh state evolved the following major types of water harvesting systems (Kerr and Sanghi, 1992):

1. Individual farm ponds for supplemental irrigation or percolation:
   These are observed in areas where rainfall is high (more than 750 mm per annum) and where the existing crops are highly sensitive to moisture stress at critical stages.

2. Community tanks for regular irrigation or percolation:
   These are mainly found in red soil areas under a wide range of rainfall conditions (500-1200 mm per annum). Tanks for percolation purposes are used primarily in areas with red soil with low to medium rainfall.

3. *Khadins* (earthern embankments across the gullies) for harvesting moisture in the root zone: The *khadins* are observed in areas with very low rainfall (less than 500 mm per annum) but deep soil. This system has evolved essentially to recharge the root zone during the *khariff* season for raising a post rainy season crop under residual moisture as observed in Jaisalmer and Barmer districts of Rajasthan state.

Indigenous Plant Protection Strategies

Indigenous plant protection strategies comprise a wide variety of non-chemical methods adopted by local farmers to minimize the pest and disease incidence in cereal and legume plants (Edwards et al., 1990; Thurston, 1992). These methods include effective utilization of resources, performing religious rituals and practicing mechanical methods of pest control (Upawansa, 1989). Moreover, these measures do not aim at complete eradication of pests but rather minimizing the pest population. In addition, these measures prevent soil and air pollution, and they are friendly to earth worms and other living creatures of the environment.

Reddy (1988), a practicing farmer of Karnataka state, enumerated indigenous plant protection strategies that were adopted by him:

1. Immerse the banana suckers in boiling water for a few minutes to check root knot nematodes;
2. Companion planting of onion, carrot, rose, garlics, banana and coconut keeps pests under control;
3. If marigold flower plants are grown 15 feet apart, both the aroma of the plant and the flowers check about 40 percent of insect multiplication in the cabbage family crops;
4. The root excretion of the marigold plants attracts and kills the root knot nematodes in Solanaceous crops;
5. Spraying neem leaf or oil cake solution checks pests to a certain extent because of its bitter taste and strong repellent odor;
6. Finely pulverized chili powder mixed with neem oil is found to be effective against the pests of cabbage and cauliflower;
7. *Maida* and fine salt powder mixed well and dusted over cabbage results in the death of larvae due to thirst; and
8. Natural predators like birds, frogs, snakes, and snails should be protected as they check the pest population considerably.

In short, Reddy abstained from the application of chemical pesticides and thus, successfully moved towards low input sustainable agriculture.

Some farmers in Mangrol village of Gujarat state follow the practice of growing sorghum and pearl millet as a border crop in groundnut fields (Mane, 1989). This practice is believed to protect the groundnut crop from salty air in the coastal area. Mane (1989) also provided certain plant protection strategies that have been adopted by farmers in the semi-arid region of Gujarat state:

1. Application of fresh cowdung should be avoided to keep the potato tubers free from pest attack;
2. Keep the sweet potato field wet to prevent the attack of *mangra,* an insect pest; and
3. Irrigate the sugarcane crop to check the termite population.

Application of common salt to *bengal gram* (chick pea) proves to be effective against wilting (Mane, 1989). The attack of army worms in the rice crop can be prevented if the field is flooded. Farmers in sub-humid regions of Gujarat state apply a mixture of castor oil and legumes such as green gram as a prophylactic measure against stored pests (Mane, 1989).

In Thanjavur delta of Tamil Nadu state, the early paddy crop sown in June-July will be ready for harvest in September-October. If cloudy weather is prevalent during this period, the micro-climatic conditions at the root zone will be conducive for the multiplication of brown plant hoppers, so the farmers will deliberately disturb the microclimatic conditions at the root zone by draining the water and drying the fields (Balasubramanian, 1987). In rice nurseries, the whole nursery is irrigated in order to submerge the plants for some time before the water is drained to wash away the insects. This practice helps the young seedlings to recover from the attack of thrips, an epidemic pest of rice nurseries (Upawansa, 1989).

Pulichai (Hibiscus cannabinus) seeds are sown inter-mixed with rice in upland rice fields to control termite attacks (Balasubramanian, 1989). Intercropping onion and turmeric also prevents termite attacks on turmeric rhizomes. Planting castor as a border crop around chillies not only prevents dropping of flowers but also acts as a trap crop for Prodenia sp. The symptoms of the disease *khaira* are not found if moong plant is plowed *in situ* after the harvest of pods (Gupta and Saha, 1989). Farmers in Gujarat state grow 2-3 lines of okra (Abelmoschus esculentus) plants surrounding the cotton fields (Gupta, 1991). Farmers believe that cotton pests prefer okra when compared to the cotton plant and attack the okra first. Farmers uproot and eradicate the okra plants after the pest attack is completed. A mixture of groundnut cake seeds and flour of the *kidamari* (Aristolochia bracteata) when put near the field burrows kills rats to a certain extent (Gupta, 1991). Drums operated with flowing water scare rats (Upawansa, 1989). They also disturb the communication between male and female insects and reduce the mating of insects.

Upawansa (1989, p.17) recorded several indigenous mechanical methods of pest control:

1. A rough large broom made of bamboo tops or strong twigs without leaves is used to brush the standing rice crop;
2. A gummed rope is drawn across the rice fields. Sometimes, the back of the winnowing fan, called *kulla*, is gummed and the crop is winnowed. The insects get struck to the ropes or fans;
3. A recent practice for brown plant hopper is lighting powerful fire crackers near infested spots. According to farmers, this practice gives very good results; and
4. Discarded robes of Buddhist monks are ignited in pest infested areas.

Groundnut farmers in Tamil Nadu trap and kill the moths of the red hairy caterpillar by hanging a broad-mouthed vessel filled with water and a little kerosene near electric lights (Sashi and D'Silva, 1989).

Selected herbal treatments are also adopted by Sri Lankan farmers (Upawansa, 1989, p.18):

1. *Daluk* (Euphorbia antiquorum) chips with milk are placed at the point of impounding irrigation water to control thrips;
2. Creepers called *kaluwel'* (Derris scanders) are placed in a similar way to control hoppers;
3. The plant called *Mahapatta* is crushed and spread in affected areas to control hoppers;
4. Areca nut flowers and young coconut leaves are hung in several places to demarcate affected areas;
5. Fresh Gliricidia (Gliricidia purpurea) leaves are applied as a mulch to control the vector of virus mosaic disease; and
6. A solution prepared from Mimosa pudica, and an extract of cattle urine, margosa leaves, and asafoetida is used as a general purpose insecticide.

Ashes were recommended for disease control in many parts of ancient India (Raychaudhuri, 1964). A slash and burn practice referred to as *Jhumming* practiced by tribal people in the eastern hills of India reduces the incidence of bacterial wilt (Pseudomonas solanacearum) in potato (Shekhawat et al., 1988). When the investigators experimentally burned straw to simulate slash and burn planting in potato fields at three different locations, they found a 100% reduction of bacterial blight (Thurston, 1992). Summer plowing helps to conserve the soil moisture and manages the pest attack and weeds by exposing the soil to the sunlight (Gnanadeepa, 1991). This indigenous practice was highlighted by the Tamil proverb, *"Chithirai matha puzhuthi, pattharai matthu thangam,"* meaning the fine soil tilth received due to summer plowing can be compared to pure gold (Kandaswami, 1978). In addition, Vijayalakshmi (1991) also recorded a number of Tamil proverbs highlighting indigenous plant protection practices. In summary, proverbs represent the wisdom of our ages. Thurston (1992) provided a long list of indigenous practices for managing plant diseases. These included altering of plant and crop architecture, biological control, burning, adjusting crop density, planting diverse crops, fallowing, flooding, mulching, planting without tillage, using organic amendments, planting in raised beds, rotation, sanitation, and manipulating shade (Thurston, 1992)

Indigenous Agroforestry Systems

The critical need to incorporate an understanding of indigenous agroforestry systems into the agricultural planning process is clearly summarized by Olofson (1983, p.150):

> Quite a literature [exists on how] so-called Western scientific agriculture has been applied in the tropics without full understanding of the ecological context, leading to disastrous consequences. To divorce the concept of agroforestry from its indigenous roots is to unfairly underplay: (1) its historical significance as the precursor to modern agroforestry, (2) the goodness of fit which often obtains between indigenous agroforestries and their environments, and (3) the potential contribution of indigenous agroforestry to modern agroforestry in terms of part or even whole models of agroforestry systems.

Rusten (1992, p.11) identified a very effective indigenous technique for propagating *Ficus nemoralis*, an important tree fodder species in the middle hills of Nepal:

> *Ficus nemoralis* is a major source of tree fodder for many hill communities in Nepal, but because of its palatability, grazing animals make it very difficult to propagate, especially on public lands. This difficulty has been overcome by farmers in one community who use *Neolitsea umbrosa*, a small bushy tree that grazing animals ignore, as a nurse plant for *F. nemoralis*. From field observations and according to farmers who use this technique, companion planted *F. nemoralis* grows more quickly than trees grown without *N. umbrosa*. This technique has obvious application to forestation projects in Nepal and possibly elsewhere.

Farmers of the Ilocos region of the Philippines favor Gliricidia (*Gliricidia sepium)* for planting because of its easy propagation and management and its excellent fuel wood characteristics (Wiersum and Veer, 1983). They like the fuelwood of Gliricidia better than that of native *ipil-ipil (Leucaena)*, considering the less dense wood of the giant varieties of *ipil-ipil* even more inferior. Many farmers refused to change to the *ipil-ipil* because of their inferior fuel wood characteristics. Moreover, farmers' replacement of Gliricidia with *ipil-ipil* would involve uprooting the existing *kakawati* rootstock, as newly interplanted *ipil-ipil* cannot withstand its competition. These forms of indigenous resource management strategies must be considered while planning social forestry projects.

Indigenous Dryland Management Practices

In Rayalaseema region of Andhra Pradesh state, mixed cropping of *ragi* (finger millet) with groundnuts, chillies, and cotton is practiced by farmers on thousands of hectares. If all these *khariff* sowings fail, safflower is sown as a *rabi* crop. On the other hand, in Telangana region of the same state, Jowar with red gram or green gram with cucumber is sown as mixed crops. If all these fail to germinate due to erratic monsoons, castor is raised in August as a late sequence crop (Venkataratnam, 1990). Hence, sequential as well as mixed cropping helps the resource-poor dryland farmers in managing risk situations and also in meeting subsistent food needs.

Red gram and groundnuts are grown as intercrops in dryland regions of Tamil Nadu, Gujarat, and Andhra Pradesh states. This practice is well established due to their value as legumes, oilseeds, and fodder for livestock (Venkataratnam, 1990). Farmers in arid regions of northern India sow *bajra* (pearl millet) utilizing the pre-monsoonal showers (Gupta, 1987). *Grasia* tribes of Gujarat state practice mixed cropping and strip cropping to enable the different sizes of root length to reach the varied levels of ground water (Shankaran, 1988).

Dharampal (1983, p.236) provided the rationale behind the practice of mixed cropping by dryland farmers:

> It has been found by experience that mixed crops not only thrive in the same field; but improve each other. Rye and oats for instance, serve to support the weak creeping tares, and add besides to the bulk of the crop by growing through the intersites. Clover and rye grass are sheltered by the corn. *Sota jowar* is broadcasted with sugar cane. The *jowar* serves as a shelter to the sugar cane, from the violent heat of the sun, during the most scorching season of the year.

Dryland farmers in Tamil Nadu state watch the weather pattern using a farming calendar which is usually referred to as *panchangam.* This calendar divides the season into '*karthis*,' definite periods enjoining the farmer to manage his/ her resources of land (Venkatratnam, 1990). Suitable timings for various dryland management practices such as timely preparation of land, sowing, weeding, and harvesting are also provided in the calendar.

Indigenous Natural Resource Management Systems

It is now apparent that many indigenous agricultural and natural resource management systems evolved in ways that did not override the carrying capacity of the environment (Warren, 1991a). An understanding of how farmers perceive their environments is fundamental in any type of development project which strives to change farmers' viewpoints or their behavior (Rhoades and Bidegaray, 1987).

Unfortunately, many researchers involved with natural-resource management seem unwilling to learn from small-scale farmers of the developing world. Due to their closeness to the land and its ecology, local people are more likely to learn from their ecological errors than are urban-based people (Lovejoy, 1989). The research community's relative ignorance about indigenous plants used by rural people adds a special need for research on indigenous knowledge of genetic resources to identify promising species for agroforestry systems and to understand what is already known about their interaction with soil, animals, and other crops, along with their uses and management (Rocheleau, 1987).

A recent figure on the underutilization of diversified plant species provided by Vietmeyer (1989, p.2) is quite revealing: "Of the 20,000 species of grasses we are using only seven species intensively as basic food crops, and only six of the 18,000 legumes have been the focus of most of our pulse program." The skills of local women in ecologically oriented land use and their knowledge of indigenous plants are increasingly being recognized. Indigenous plants are important genetic resources for sustainable land-use systems. They are often resistant to drought and diseases, do not need special fertilizers, and some have high nutritional and medicinal value (Hoffmann-Kuehnel, 1989). Use of indigenous genetic resources in the third world is gaining popularity, both in NGO circles as well as among policy makers, as a more farmer-oriented and sustainable approach to conservation and seed production (Vellve, 1989; Prain, 1992).

The key to successful natural resource management for sustainable agriculture lies in partnerships between researchers, extensionists, and farmers (Pretty and Sandbrook, 1991, p.11). They further explained the need for such partnerships:

1. Integrated approaches such as agroforestry, IPM, and integrated nutrient conservation require a greater range of scientific knowledge and understanding if all the apparently conflicting goals are to be met;

2. Each of these integrated approaches requires detailed local ecological and socio-economic knowledge on livelihood

systems---who better to provide this than the rural people themselves; and

3. These partnerships help researchers, extension workers, and policy makers to understand some of the complexities and achievements of rural people's livelihoods.

Ecologically stable and economically viable indigenous natural-resource management systems provide the basis for a major part of small-scale agriculture.

Farmer Experimentation

Farmers are not passive consumers, but active problem solvers who develop for themselves most of the technology they use. For many hundreds of years before today's national agricultural research systems were set up, farmers did their own research (Pretty, 1991; Prain, 1992). And, by integrating technology from different sources and continuing to adapt it on their farms, they still do so today (Roling, 1989; Warren, 1991b). Indigenous knowledge systems form the basis for local innovations and informal experimentation of farmers. The factors which influence farmer innovations according to Gupta (1990) are: (1) ecological: innovations that result due to interaction among crops, soil, and climate; (2) historical: a major happening such as crop failure or year of glut or scarcity; (3) serendipity: a practice discovered by farmers accidentally; (4) economical: farmers innovate new practices taking advantage of government subsidies for flood and drought relief activities.

Gupta and Saha (1989, p.15) provided an interesting case from Gujarat state, India, to illustrate how farmers conduct informal experiments by deviating from a conventional transfer of technology approach:

> While it is a usual practice to irrigate *urd* crop (black gram) during 15-25 days after sowing, farmer Ajoy Kumar (21 years old)

> did something very exceptional. He applied water when the crop was two months old and almost dried up in the field. He did not think that it would survive. But to his surprise, he observed that after receiving water it regained its life. The green leaves appeared and the pod formation started. Farmers could not normally keep the *urd* crop deprived of water for two months. He explained that when the whole plant has much of the vegetative growth, the pod setting was poor. Checking the vegetative growth later on fosters the reproductive growth (fruit formation). He reaped the best harvest in the village.

Hence, farmer experimentations should be formally recognized, verified, and disseminated (Worman, Heinrich and Norman, 1991).

Incorporating Indigenous Knowledge Systems into Agricultural Research and Extension Organizations

The capacity of farmers using their indigenous knowledge systems to classify and evaluate the technological innovations in the local environment can complement station-based development of agricultural technologies (Raman and Balaguru, 1990). The endeavor to build market-oriented agriculture on the energy intensive model must accept ecological and economic strengths of indigenous practices which could be secured with a desired blend of tradition and modernity (Sankaram, 1991).

Understanding farmers' knowledge allows a framework of reference for posing technical, scientific questions in research. It also provides the basis for evolving technological options that are not imposed as alien 'packages' which contradict its existing practices (Scoones, 1989). For instance, technological interventions with respect to agroforestry must be based on the principles of ethnobotany, agroecology, and farmers' experiments on home gardens (Rocheleau, 1987). Integrating biotechnology with the insights of traditional farming practices can contribute to increasing crop yields and reduce the risk of crop failures in marginal areas (Wolf, 1987; Warren, 1989).

Adja farmers of Benin have found that improved maize varieties are not drought-resistant, require fertilizer or fertile soil, do not store well, and are not suitable for consumption (Dangbegnon and Brouwers, 1990). Hence, they modify some innovations through informal research to generate an intermediary technology based on both external knowledge (research stations) and their own knowledge.

According to Schafer (1989), historically, various constraints limit the utilization of indigenous knowledge systems in the development of technologies in the developing countries. These constraints are lack of mutual respect between agricultural and ethnoscientists, the way each scientific area gathers research data, difference in research publication demands, lack of time, and lack of appropriate methodologies to identify indigenous knowledge systems. He further called for a successful cooperative effort that includes the following steps: (1) the research goal must be more narrowly defined than most ethnoscientific studies; (2) the ethnoscientists, working closely with agricultural scientists, must identify the indigenous knowledge; (3) suitable documentation and information retrieval systems need to be developed; (4) local ethnoscientists and agricultural scientists must play important leadership roles in the identification and utilization process; and (5) proper information channels must be opened to continually update the original findings.

Learning from, building on, and working through the indigenous knowledge of local people will be one of the essential goals of agricultural extension education programs in the 1990s (Warren and Rajasekaran, 1991). Awareness of the importance of indigenous knowledge is on an increasing trend in India. However, no sign of integrating these systems into agricultural extension settings has been observed so far (Rajasekaran and Martin, 1990). The top-down extension approach significantly contributes to the dismissal of the value of indigenous knowledge. Cape (1990, p.17) stated that: "(1) extension agents do not stop to find out what is causing a problem in a locality; (2) extension agents do not try out all available technical solutions; and (3) they make unrealistic demands on the local labor of resource-poor farmers."

Agricultural research for the most part has been and still is highly reductionist, parochial, and discipline-oriented. Normal science generates packages, whereas resource-poor families engage in farming as a continuous performance (Richards, 1989). Research station technologies have focused primarily on attaining high yield of target crops. The introduction of high energy technologies through the application of chemical fertilizers, agrochemicals, machinery, and modern methods of irrigation in developing countries was a complete departure from traditional agriculture and has led to pollution and land degradation (Ezaza, 1989).

Lack of relevance to small farm conditions was found to be one of several constraints in the station research technologies. Sanghi and Kerr (1991) provided a specific example to support the above statement. The conventional graded bunding system is not an appropriate soil and moisture conservation technology under small-scale dryland farming conditions due to the following reasons:

1. Continuous bunds leave corners in some fields thus creating the risk of losing the piece of land to the neighboring farmer;

2. Contour farming causes inconvenience in field operations (particularly where multi-row implements are used) and reduces the efficiency of operations (where the *desi* plough is used) due to repeated cultivation in the same direction;

3. Systems based on a central water course provide benefit to some farmers at the cost of others with regard to disposal of excess runoff; and

4. The overall system emphasizes only long-term gains, hence creating an impression that short-term gains are not possible through such measures (Sanghi and Kerr, 1991, p.2).

Technologies recommended by extension personnel are often based on research conducted at regional research stations (Rajasekaran and Martin, 1990). Farmers are mainly seen as the recipients of expert recommendations but not the originators of either technical knowledge or improved practice (Moris, 1991). The technical messages concentrate mainly on seed-to-seed packages of practices for different crops grown in the region. Resource conservation strategies such as watershed management, agroforestry, and soil conservation rarely form part of the technical messages. Technological recommendations based on the findings of research stations, though initially followed by contact farmers were not well received by other groups of farmers (non-contact farmers). Farmers who were active during the initial stages of implementation of the T&V extension system became bored of the stale technical messages of the system. In general, the nature of the technical messages can be grouped into three categories (Rajasekaran and Martin, 1990):

(1) Repeated nature of the technical messages: Most of the technical messages were developed entirely based on research conducted at regional research stations in India. These messages concentrate mainly on seed-to-seed package of practices. Dissemination of these crop production technical recommendations was a matter of gaining new knowledge and skills in the beginning of the T&V implementation. Once the message has been repeated season after season, farmers not only became bored but also tended to play an inactive role in the entire system.

(2) Technical messages that do not reflect local crop production conditions: Some technical messages do not reflect local crop production conditions. For instance, line planting has been recommended as one of the technical messages for rice production under wet land conditions in Tamil Nadu state, India. Though planting of rice seedlings in lines certainly increases per unit production of rice when compared to

random planting, the cost of labor incurred towards line planting is significantly higher than that of the latter method.

(3) Blanket technical messages: Some technical messages tend to be blanket recommendations which are evolved from the research and cannot be adapted to heterogeneous farming conditions. For instance, the regional research stations recommend only blanket recommendations for fertilizers such as urea, di-ammonium phosphate and muriate of potash whereas nitrogen, phosphorous, and potassium content of soil varies widely from village to village, in many cases from plot to plot.

Chambers and Jiggins (1987, p.5) stated that:

1. The transfer of technology model fits badly with the needs and priorities of resource-poor farmers;
2. Agricultural extension programs are still biased towards techniques and strategies which are capital-intensive, large-scale, high-input, and market-oriented;
3. Resource-poor farmers are scattered and are not able to make their needs and priorities readily known and felt; and
4. The TOT model cannot easily handle the complex interactions of resource-poor farming; links between crops, especially with intercropping and multiple tiers; agroforestry and livestock-crop-tree complementaries; creation and exploitation of microclimates; and the progressive adjustments required in the field in the face of seasonal and inter-annual fluctuations.

What is needed now is an interactive approach which provides a 'basket' of technologies instead of complete packages along with a range of alternatives from which farmers can select (Maurya, 1989). The old idea of a 'transfer-of-technology' from the research experts is thus being displaced by something more like a technology exchange, with benefits on both sides (IDS Workshop, 1989). Improving the internal management of extension, stimulating farmer participation, and understanding the emerging farmer-first paradigm are the keys to a successful extension system in developing countries (Moris, 1991).

Ultimately, the use of ethnobotanical knowledge systems depends on an attitude change by extension workers, development specialists, and rural people (Alcorn, 1988; Compton, 1989). Extension agents must change their attitudes that the only good knowledge originates in universities and experiment stations. The onus for making that change lies with those institutions (Alcorn, 1992).

Social norms and behavior embodied in Village Extension Workers (VEWs) of the extension system is rarely exploited (Hayward, 1987). Village extension workers represent an interface between farmers' knowledge and formal agricultural knowledge (Waters-Bayer and Farrington, 1990). Understanding local terms for soils, crop varieties, seasons, and plant diseases helps extension workers to facilitate an effective communication between farmers and researchers. Extension workers are often able to 'translate' farmers' practices and concepts from folk to scientific language. Confidence of both farmers and extension workers in locally-developed techniques can be reinforced if their efforts are supported by research scientists (Waters-Bayer and Farrington, 1990).

The need for conducting training programs for extension workers on the role of indigenous knowledge in agricultural development has been expressed by Waters-Bayer and Farrington (1990, p.12):

1. If the extension personnel including VEWs and Agricultural Extension Officers are provided training on scientific technological innovations, but have not learned to regard farmers as their colleagues, their potential to support farmers' local research efforts will be comparatively lower;
2. Training programs on the role of indigenous knowledge in agricultural development help to remove the impression among the extension workers that research scientists are the

only generators of technological innovations and their (extension workers) job is to merely transmit those innovations;

3. Information provided in these training programs regarding local farmer organizations and their functions can stimulate ideas among extension workers for a number of viable action-programs; and
4. Extension workers can help local farmers' organizations establish and strengthen links with agencies such as government services, private organizations, commercial firms, and other farmer organizations for information and other inputs.

The contents and methods of training programs should be established on the basis of the peasant forms of communication which are related to rural, everyday life, which has its own seasonal and life rhythms (Salas and Tillman, 1989). The need for a training manual to present the methodologies to record indigenous knowledge systems is emphasized by Warren and Rajasekaran (1991, p.1):

> Though the value of IKSs in facilitating development and extension is gradually being recognized by national and international development agencies, the concepts, principles, and methodologies for recording and utilizing these systems are not yet familiar to many professionals working in agricultural and rural development. Many extension and training programs are still focused exclusively on scientific and technological developments generated through formal on-station research. This manual is designed to help agricultural extension and training programs to experience ways in which IKSs can facilitate understanding and communications between farmers and extension workers leading to participatory approaches to agricultural development.

For effective technology dissemination, on-farm research has to develop strong links with technology transfer agencies, such as extension services, non-governmental organizations, development projects, and commodity organizations (Cernea et al., 1985; Merrill-Sands and Kaimowitz, 1990; Norman, 1989). Strong and flexible links with extension must be developed to reach resource-poor farmers operating complex production systems in diverse and marginal areas (Merrill-Sands et al., 1991). An integrated research-extension effort, based on on-farm client oriented research, has met with considerable success in serving this client group in recent years (Oritz et al., 1991).

Maintaining vigor and innovativeness, strong scientific leadership, methodological experimentation, creative thinking, strong team work, broad knowledge spawning, attitudes to learn from farmers and integrating farmers' knowledge into the research process are the essential criteria for a successful on-farm research program (Merrill-Sands et al., 1991).

On-Farm Research

Successful adaptive research trials create working relationships between experimenting cultivators, agricultural researchers, social scientists, and generate interfaces between the different networks (Box, 1987). Ashby (1987) conducted on-farm varietal trials by involving farmers successfully. The stages of on-farm trials include: types of trials and stages of on-farm research, establishing varietal trials with farmer participation, evaluating varietal trials with farmer participation, participatory research with groups, and group evaluation of trial results. The experience of the on-farm research trials shows that this activity can provide breeding programs with important information to streamline the selection of new varietal materials for specific farming systems (Ashby, 1986; Ashby, 1987).

Certain changes are needed in individual approaches and attitudes to encourage farmer participation that includes listening to farmers, flexibility, collaboration and *a la carte* menus (Worman, Heinrich, and Norman, 1990). Researchers need to listen to farmers. Box (1989, p.61) reported an incident that demonstrates the need to listen, which he calls "Virgilio's theorem":

> When we had just met, Virgilio stood up and said, 'Lucus: I understand you want to know. You are a scientist and you want to know. But there is only one way to know what I know about cassava. Speak with me; don't speak to me like others did. Ask me about my life and I will tell you about cassava (Box, 1989, p.61).

Researchers need to develop their listening skills and to seek opportunities to use these skills in communicating with farmers (Worman, Heinrich and Norman, 1991). In order to respond to farmers' expressed interests, we as researchers need to develop flexibility. Being flexible is a challenge that may require researchers to leave familiar territory and search for solutions to farmer-identified problems. In addition, farmers need to be given necessary information about the performance of the technology under different conditions so that they can make modifications based on their resource constraints and management abilities (Byerlee, 1987).

Because farmers have varying resource bases and may be hesitant to make widespread basic changes due to the risk involved, it is rare that a single all-inclusive package will be wholly adopted (Worman, Heinrich, and Norman, 1991). Farmers tend to be more receptive to an *a la carte* menu containing a range of options and technologies that they can combine with the traditional system to make their own customized package (Chambers, 1989). The components of this customized package includes farmers' indigenous knowledge systems, results of informal farmer testing (both locally and from a wider area), on-station and on-farm research results, and recommendations of extension and/or non-governmental organizations.

On-farm participatory research is a means by which two bodies of knowledge can be brought together and can interact so that the solution of small-scale farming problems can take place over a shorter period of time than in conventional research and with greater confidence that the results will be adopted (Fernandez and Salvatierra, 1989). In farmer participatory research, questions to be investigated are determined by farmers rather than scientists (Waters-Bayer, 1987). Biggs (1988) distinguished four modes of relationships between scientists and farmers in on-farm research: (1) Contract, (2) Consultative, (3) Collaborative, and (4) Collegiate. The first three types fall under a transfer-of-technology paradigm whereas the collegiate mode possesses the essence of the farmer-first approach. In the collegiate mode, the formal research system strengthens informal research at the farmer and community level, and enhances farmers' capacity to make demands on the formal system. In more than half the 25 case studies analyzed, participation was consultative, with the farmers playing a relatively passive role (Merrill-Sands et al., 1991). In only a third of the cases had researchers set up mechanisms for more direct, intensive, and continuous farmer participation (Merrill-Sands et al., 1991).

Lack of active farmer participation partly reflects lack of methods and training in skills required for a productive interaction with clients (Chambers and Jiggins, 1987; Chambers et al., 1989; and Norman, 1989). It also reflects logistical constraints and, in some cases, managers' impressions that intensive farmer participation may be too costly for national research programs (Merrill-Sands and Kaimowitz, 1990). Using an indigenous knowledge could enhance participatory approaches to both research and extension. This is important in most countries where the number of research and extension staff will never be sufficient to adequately service the immense number of farmers. In Chengai district of Tamil Nadu state, for example, the one research station has 32 scientists representing the disciplines of agronomy, entomology, plant pathology, genetics and plant breeding, soil science, and seed technology. This one station is expected to service 170, 000 farming communities, making farmer-researcher interaction very difficult (Rajasekaran and Martin, 1990).

Eliciting indigenous knowledge increases farmer participation in the research process. Furthermore, the respect given to farmer knowledge puts the relationship between farmer and scientist on a correct footing (Lightfoot, 1991). Based on farmers' local wisdom, technology for improved landshaping, irrigation and drainage has been developed and refined through a participatory programme in which Ramakrishna Mission in West Bengal State worked closely with farmers (Reijntjes et al., 1992). Increasing farmer participation in the agricultural research system will empower farmers (Worman, Heinrich and Norman, 1991). Participatory methods can lead to improved design, implementation, and analysis of on-farm experiments. By encouraging farmer suggestions concerning station-based technologies to be studied, by having them select the technologies they wish to test, and by actively soliciting their observations on the technologies and how to improve them (Baker, 1990; Worman, Heinrich and Norman, 1991).

Indigenous Organizations

In addition to ignoring local knowledge and skills, many development efforts have ignored existing formal and informal local institutions (Pretty and Sandbrook, 1990). Indigenous organizations are crucial for sustainable resource use and development because they can act as institutions for resource management and control. They enforce rules, provide incentives, and apply penalties for eliciting behavior conducive to rational and effective use of local resources. Local associations are embedded in local social structures and characterized by voluntary, personalistic, face-to-face transactions; hence, they tend to be highly participatory and reflect well with their members' interests (Cook and Grut, 1989). Leaders of local organizations have a comprehensive understanding of existing strengths and weaknesses in their own organizations and are exceptionally open to trying new management and planning mechanisms for development (Warren, 1992d).

Janseva Mandal, a local non-governmental organization in Nadurbar, Dhule district, Maharashtra state, has been working with tribal farmers in more than forty villages for the last twenty years (Sashi and D'Silva, 1989). The organization is actively involved in a number of agricultural development projects that aims at developing viable alternatives that are sustainable, ecologically sound, and involve community management of resources. The organization has involved local farmers from the stage of experimental design to that of implementation. The project has demonstrated the possibility of sustainable agriculture using minimal quantities of external inputs like chemical pesticides and fertilizers by emphasizing the importance of compost, water harvesting techniques, and even earthworms (Sashi and D'Silva, 1989).

The working methods of farmer organizations and non-governmental grassroots support organizations are highly participatory, greatly reduce the research/ extension linkage problem and are built upon local knowledge (Bebbington, 1989). These organizations often have the capacity to distribute technology and train indigenous agricultural promoters. Warren (1992d) developed a systematic approach for the identification of indigenous organizations, analyses of their structures and functions, and existing capacity for development.

Need for Public Policy

An understanding of traditional small-farm systems is a prerequisite to developing a national agricultural and food policy. An international meeting on agro-ecological approaches to development held at Penang, Malaysia, recommended policy options for developing countries in the Asian region (Anon. 1990, p. 6). These policy recommendations are relevant to the proposed project:

1. Reviving the holistic practices that ensure durability and success of traditional agriculture instead of resource-intensive, capital-intensive and chemical-intensive agriculture;

2. Systems that empower local communities and foster greater local self-determination in place of political and economic structures that place decision-making in the hands of central governments and international agencies;

3. Trading patterns that encourage local self-reliance through strengthening of local markets instead of patterns that favor the developing countries at the expense of the poor and which are dominated by international corporations and northern hemisphere governments;

4. Policies that put the satisfaction of local needs first rather than export oriented development policies; and

5. Policies that give priority to fostering social and ecological security instead of economic policies that promote growth through increased output and consumption, regardless of environmental and social costs.

Related Research

Recently a number of alternative approaches have evolved to reverse the typical top-down approach to information sharing (Transfer-of-Technology paradigm) to a more bottom-up approach (Farmer-oriented). Relevant research literature related to the research study are discussed below:

* Farmer-back-to-Farmer Model (Rhoades and Booth, 1982): The basic philosophy of this model is that successful agricultural research and development must begin and end with the farmers. The salient features of this model include building interaction and communication between researchers and farmers, eliciting and exchanging information from farmer-to-farmer, from-farmer-to-researcher and researcher-to-farmer.

* Farmer-First-and-Last Model (Chambers and Ghildyal, 1985):
  Reversals of behavior and attitudes, to respect farmers as people and desire to learn from them, are essential components of a self-reliant extension program. The salient features of this model include empowering farmers to learn from their experiments, and encouraging and facilitating farmers' own analysis.

* Indigenous agricultural revolution (Richards, 1985): Inventive self-reliance is one of Africa's most precious resources. Rapid rates of agricultural change will occur when state resources are used to back changes that small-scale farmers are already keen to make. The populist approach is the most effective way to foster the resource management and biological skills upon which an agricultural revolution might rest.

* Farmer participatory approach (Farrington and Martin, 1987):

Indigenous knowledge systems are complementary to formal scientific knowledge, adding location-specific classification aspects of the biophysical environment as well as explanatory and predictive elements of causal relationships observed by local persons.

* Farming Systems Research (Collinson, 1987):
  The Farming Systems Research has four stages: (1) diagnosis, (2) planning, (3) experimentation and assessment, and (4) use of results. FSR is a multi-disciplinary process that actively involves farmers, FSR scientists, commodity and specialist (CST) scientists, extension staff, and regional or national policy makers and planners. Study of the background information of the target group area using informal and verification surveys forms the diagnosis stage. The planning process identifies on-farm research program components.

Summary

As we enter the 21st century, there is an opportunity to move forward in productivity and sustainability by bringing the desired blend of modernity and tradition in India. A resource-poor farmer-oriented approach to sustainable agricultural development is the need of the 1990s. Broad-based regional approaches and standardized packages will rarely provide adequate answers to complex situations at the micro-environmental level. Recognizing the needs of the target audience at the grass-roots level is essential for sustainable agricultural development. Traditional production methods that restore community stability should be employed, a maximum of organic matter and nutrients must be recycled, the best possible multiple use of the landscape should be made, and efficient energy flow should be ensured (Altieri, Letourneau, and

Davis, 1983). Rural development strategies based on indigenous knowledge systems that are biologically and economically stable are proving to be viable survival alternatives for a great portion of the impoverished rural population in the developing countries (Altieri and Anderson, 1986).

This study was holistic in its perspective. It is a multi-disciplinary approach to address the broad problems of achieving sustained food production for the 21st century. The study deviated from the normal procedure of specializing in one particular area of the agricultural sciences, for example, agronomy, soil science, plant pathology, or entomology and was based on a multi-disciplinary approach. This study aimed at bringing various agricultural disciplines together under a common goal of learning from farmers. The failure of individual agricultural disciplines to address the problems of farming systems as a whole has led some scientists to look for such a multi-disciplinary approach (Farquhar, 1990).

In short, the process of acquiring and using IKSs can be grouped into the following consecutive phases: (1) identifying IKSs, (2) recording IKSs, (3) communicating IKSs, (4) Evaluating IKSs, and (5) Using IKSs. The preceding pages review case studies of indigenous knowledge systems and how they contribute to the first and second phases. The role of indigenous knowledge systems in agricultural extension is also emphasized by some authors. However, very few attempts have been made to (1) determine the extent of utilizing IKSs, (2) determine the impact of IKSs on agricultural productivity and sustainability, and (3) utilize indigenous knowledge systems during the process of developing technologies. At this stage, it is highly important to mention the contributions of Rhoades and Booth (1982), and den Biggelar (1991) in developing a model for integrating indigenous knowledge systems and research station technologies. Hence, the need for the proposed study.

CHAPTER III: METHODS AND PROCEDURES

The purpose of the study was to formulate a methodological framework to incorporate indigenous knowledge systems into agricultural research and extension organizations for sustainable agricultural development in India. The specific objectives of the study were: (1) To determine the extent to which farmers agreed with selected indigenous decision-making systems; (2) To determine the extent to which statements regarding indigenous knowledge systems are believed to be true by farmers; (3) To determine the extent to which selected indigenous technical practices are being used by farmers; (4) To determine the relationship between selected demographic factors and indigenous technical practices; (5) To determine the influence of selected indigenous technical practices on productivity; (6) To determine the influence of selected indigenous technical practices on sustainability; and (7) To develop a methodological framework for incorporating indigenous knowledge systems into agricultural research and extension organizations.

This chapter is divided into eleven sections as follows: research questions, research design, population and sample, transecting, participant observation, unstructured interaction, instrumentation, quantitative data collection, data analysis, limitations of the study, assumptions for the study, and summary.

Research Questions

The following research questions were addressed by this study:

1. What factors influencing indigenous decision making systems are agreeable to farmers?
2. What perceptions do farmers have of indigenous knowledge systems?

3. What indigenous technical practices are used by farmers?
4. Is there a significant difference between selected demographic factors and indigenous technical practices?
5. What demographic factors are the best predictors of selected indigenous decision making systems and technical practices?
6. What indigenous technical practices are the best predictors of productivity and sustainability?
7. How can indigenous knowledge systems be integrated into agricultural research and extension organizations?

Research Design

Elements of the keynote address delivered by Dr. Mohan Man Sainju, Nepalese Ambassador to the United States, at the eighth Farming Systems Research/ Extension Symposium provide a solid rationale for the research design used in this study:

> Perhaps the best lesson to learn is to listen to farmers, learn their problems, needs, goals and then work with farmers on their fields to improve technologies, to achieve their perceived objectives, (and) not what scientists and extensionists think they need (Sainju, 1989).

Therefore, this study has been conducted using a variety of farmer participatory approaches (Rhoades and Bidegaray 1987; Chambers 1991). Though these approaches are time-consuming, using these methods seemed appropriate given local conditions. Living in the farming community, maintaining constant interaction with farmers by listening, observing, recording, and working with farmers formed the basic ingredients for the success of these methods. These methods have helped the researcher to understand the psycho-cultural and socio-economic environments of local farmers. Moreover, it formed the basis for various tools and techniques used in different stages of the research process.

The value of participatory rural appraisal (PRA) as a qualitative research technique is succinctly provided by Grandstaff et al. (1987, p.11):

> Participatory rural appraisal (PRA) technique is carried out as close to the source as possible. Farmers' perceptions and understanding of resource situations and problems are important to learn and comprehend because solutions must be viable and acceptable in the local context and because local inhabitants possess extensive knowledge about their settings. In many instances, PRA researchers have also discovered that farmers are capable not only of devising viable solutions to local problems based on their own understanding, but also conducting relatively sophisticated field experiments in response to local constraints and opportunities. For the above reasons, an understanding of indigenous knowledge and practices is extremely valuable for viable and appropriate rural development, and many of the methods, tools and techniques of PRA have been selected for their abilities to elicit, evaluate, understand, and avoid misunderstanding indigenous knowledge.

Transecting, participant observation, and unstructured interactions are the PRA methods adopted in order to obtain qualitative data pertaining to this study. These methods were adopted in different but consecutive stages. The qualitative data collected from these three stages formed the baseline for conducting a descriptive survey.

Population and Sample

The study was regional in scope. The study was conducted in the Union Territory of Pondicherry, India. The target population for the study was 15,753 farm households of the Union Territory of Pondicherry. A cluster sampling procedure was adopted in order to select the sample.

The principle of cluster sampling procedure was highlighted by Hinkle, Wiersma, and Jurs (1989, p.167):

> Cluster sampling involves the selection of clusters rather than individual population members. When a cluster is selected for the sample, all members of that cluster are involved in the sample.

Three villages---Sivaranthakam, Kizhur, and Pillayarkuppam---belonging to the Union Territory of Pondicherry were selected as cluster samples. All the farm households in these villages (clusters) were involved in the study in its various stages. Table 1 shows the number of farm households that participated in different stages such as transecting, participant observation, unstructured interactions, and instrumentation. Proper care was taken not to select the same farm holdings for the different stages.

Research linkages were established between Iowa State University and the M.S. Swaminathan Research Foundation, Madras, India. The M.S. Swaminathan Research Foundation is currently implementing a micro-level project, the biovillage project, in the above-mentioned villages. These villages were selected as cluster samples since the purpose of this study was similar to the goal of the biovillage project:

> The term 'biovillage' is used to denote the integration of recent advances in biological technology with the best in traditional techniques, in a manner that the livelihood security of rural people can be upgraded ecologically and economically. The aims of the biovillage project are to promote the efficient and sustainable use of natural resources, and to achieve a continuous and steady growth of agricultural production while protecting and improving the environmental capital stocks of the villages. Unless the ecological security of the farm and the economic well-being of the farm family are linked in a symbiotic manner, sustained advances in agricultural productivity and family welfare cannot be achieved (M.S. Swaminathan Research Foundation, 1991).

Table 1. Number and percentage of farm households participating in various stages of the research study

Research techniques	Sivaranthakam		Kizhur		Pillayarkuppam	
	N	%	N	%	N	%
Transecting	27	18.3	33	18.4	40	17.9
Participant observations	36	24.5	32	17.9	41	18.0
Unstructured interactions	39	26.5	28	16.6	49	21.5
Surveys	51	34.6	83	46.4	93	40.9
Total	147	100	176	100	223	100

In addition, the following reasons have also contributed to the selection of these villages as cluster samples for the study:

1. Certain baseline information such as area maps and demographic information for these villages were already available with the Foundation.
2. Human resources of the Foundation could be used for collecting data for the study.
3. The scientists of the Foundation have agreed to review the content validity of the instrument.
4. Above all, Professor M.S. Swaminathan, Chairman of the Foundation, agreed to provide guidance and institutional support for the field study.

The rationale for selecting these villages for the biovillage project has been already provided by the M.S. Swaminathan Research Foundation (1991, p.16):

> Sivaranthakam, Kizhur, and Pillayarkuppam are representatives of different types of social structure, land ownership patterns, and other socio-economic characteristics in the Union Territory of Pondicherry. Inferences drawn on the detailed survey should therefore lend themselves to extrapolation for the entire Pondicherry state. Urbanization rate is slow and agriculture will continue to be the mainstay of the economies of these three villages during this decade.
>
> * Sivaranthakam is a relatively prosperous village with progressive farmers. Large, medium, and small holdings are found here. The population of landless labor is the highest in this village.
> * Kizhur has a dominant *yadava pillai* community. Dairy farming is an important traditional occupation in this village.
> * Pillayarkuppam is a very poor village consisting of only small and marginal farmers and landless labor families.

Transecting Stage

Analysis of the agro-ecosystem of the study villages was the first stage of the study. This analysis provided an understanding of the village environment and its physical conditions (Chambers, 1990). The agro-ecosystem analytical techniques developed by Conway (1987) were used to identify various agro-ecological environments of the study villages. Maps and transects were constructed by walking through the study villages to demarcate the agro-ecological zones. *Adangal*, the base-line village record maintained by village accountants, was consulted to cross-check while constructing the transects. Transects provided an opportunity to characterize the study villages in terms of crops and livestock husbanded, land use pattern and utilization, and different problems encountered.

Local-level seasonal-cropping calendars were drawn for all the villages. Local people were interviewed during the transecting stage to obtain information regarding crops and trees grown, soil classifications, crop rotational patterns, and pest and disease cycles. This stage provided a basis for the participant observation stage.

Participant Observation Stage

Participant observation formed the second stage of the research process. Participant observations were conducted by the researcher using the transects developed in order to identify and document various indigenous technical practices adopted by farmers. Jorgensen (1989, p. 82) provided the salient features of participant observation as a method to document the insiders' world:

> Participant observations begin the moment the participant observer makes contact with a potential field setting. Aside from collecting information, the basic goal of these largely unfocused initial observations is to become increasingly familiar with the insiders' world so as to refine and focus subsequent observation and data collection. It is extremely important that you record these observations as immediately as possible and with the greatest possible detail because never again will you experience the setting as so utterly unfamiliar.

The following step-wise procedures were adopted while conducting participant observations to document indigenous technical practices of farmers. The procedures recommended by Jorgensen (1989) and Colfer et al. (1988) were modified to fit the objectives of this study while conducting the participant observations:

1. The researcher walked through farm holdings of the study villages and selected those holdings where farmers were adopting indigenous technical practice/s;

2. After entering the field (i.e., farm holdings), the researcher looked for the agro-ecological features of the farm holdings. Certain specific questions were kept in mind during observation. A few examples are: What are the crops grown in various agro-ecological environments of the study villages? Is it a monocropped or intercropped area? What are the sources of irrigation? What is the size of the farm holding? What are the primary soil types of the farm holding? The researcher was familiar with the agro-ecological conditions of the farm holdings upon completing this step;
3. As a second step of the participant observation stage, the researcher looked at the role of the farmers. How are the farmers classified? What kind of division of labor exists? What are the roles of men and women laborers? What are the tools and implements used by them? This step helped the researcher to get acquainted with the participant farmers;
4. After becoming familiar with the agro-ecological and human settings of the selected farm holdings, the researcher began observing the matters of specific interest, i.e., ITPs. This process of observing the matters of specific interest has been referred by Jorgensen (1989) as 'more focused observations';
5. The following procedures were adopted while observing and documenting ITPs: (1) Observing ITPs: ITPs adopted by farmers and farm laborers in their respective farms were observed; (2) Documenting ITPs: The observed ITPs were documented using a camera; (3) Analyzing ITPs: The salient features of ITPs were recorded in a pocket notebook by carefully observing, and listening to the conversations between laborers and farmers.; and (4) Titling ITPs: Later on, an appropriate title for each of the ITPs recorded was identified through informal discussion either with the

participant farmers or with the laborers who were encountered in the farm holdings;

6. The researcher stopped the procedure when approximately twenty percent of the farm holdings in the study area were observed; and
7. By adopting the above procedure systematically and patiently, ITPs related to the following areas of food production and resource conservation were documented: (1) cropping systems, (2) seeds and sowing, (3) seed processing, (4) soil health care management, (5) planting techniques, (6) crop nutrient management systems, (7) weed management techniques, (8) plant protection strategies, and (9) post-harvesting procedures. ITPs pertaining to rice, groundnuts, chillies, cassava, casuarina, cotton, finger millet, and sugarcane were observed and documented.

Participant observations were conducted during the first two and half months of the study period with an objective to cover a wide variety of ITPs.

Unstructured Interaction Stage

Indigenous technical practices documented during the participant observation stage formed the basis for conducting unstructured interactions. The purpose of unstructured interactions was to elucidate relevant information pertaining to ITPs documented during the previous stage: (1) farmers' beliefs, values, and customs related to the ITPs, and (2) the process of decision-making while selecting the ITPs. This interaction provided an in-depth understanding of the 'emic' perspectives of local farmers. The 'emic' perspective involves putting oneself as much as possible into the farmers' shoes to understand how they view their practices in both technical and socio-cultural terms (Rhoades and Booth, 1982).

Unstructured interactions were conducted by informal discussions with key informants of the study villages. Key informants are those local people who are willing to talk or be interviewed intensively regarding the matter of specific interest (Jorgensen, 1989). Selection of key informants was done by a few preliminary discussions with the following people: (1) the local extension agent, (2) local school headmasters, (3) credit cooperative society officials, (4) village milk cooperative society members, (5) farmers, and (6) men and women laborers. The following criteria were used to select the key informants: (1) good knowledge about the historical background of food production and resource conservation of study villages; (2) a minimum of ten years of farming experience; and (3) not being involved in other stages of the study.

Instrumentation Stage

The information collected during the participant observation and unstructured interaction stages formed the base-line for developing an instrument for the rest of the study. The instrument used in this study was designed to identify the extent to which selected indigenous technical practices regarding food production and resource conservation are currently utilized by farmers and also to determine the extent to which selected indigenous technical practices contribute to productivity and sustainability.

The following steps were adopted in order to develop the instrument for collecting data pertaining to the above mentioned objectives:

1. The entire instrument was developed in *Tamil,* the native language;

2. A list of 15 statements regarding indigenous decision-making systems were compiled to determine the extent to which these statements were agreeable to farmers. These statements formed the first section of the instrument;
3. Twenty eight statements to determine perceptions held by the farmers regarding the extent to which they believe selected indigenous knowledge statements regarding food production and resource conservation to be true were framed. These statements formed the second section of the questionnaire;
4. A list of 63 indigenous technical practices was compiled based on the information collected from the participant observation and unstructured interaction stages. These practices were divided into ten sub-sections based on the crops and characteristics of the practices involved: (1) indigenous cropping systems, (2) indigenous soil health care practices, (3) indigenous rice seed processing techniques, (4) indigenous rice planting techniques, (5) indigenous rice nutrient management strategies, (6) indigenous weed control techniques in rice, (7) indigenous water management practices in rice, (8) indigenous pest management practices in rice, (9) indigenous agronomic practices in groundnuts, and (10) indigenous agronomic practices in tapioca;
5. A Likert-type scale with points ranging from 1 to 5 was used to collect information regarding perceptions of farmers in the following areas:
    a. Extent to which farmers agree with factors influencing indigenous decision-making systems;
    b. Extent to which indigenous knowledge systems are believed to be true by farmers; and
    c. Extent to which indigenous technical practices are used by farmers;

6. Questions pertaining to the respondents' demographic information were asked in section four of the questionnaire;
7. Crop yield data on rice, groundnuts, cassava, and chillies were collected in section four of the questionnaire in order to analyze the impact of selected ITPs on productivity;
8. Data on external inputs usage, local resource management, and soil fertility status were also collected in section four of the questionnaire to analyze the impact of selected ITPs on sustainability;
9. The first draft of the proposed questionnaire was reviewed by an interdisciplinary team of scientists of the M.S. Swaminathan Research Foundation, Madras, India. The areas which were not directly related to the objectives of this study were deleted according to the suggestions of the team;
10. The first draft was revised and a second draft was formed by incorporating the revisions;
11. The second draft of the questionnaire was pilot-tested with a group of farmers from the study villages who were not members of the sample strata; and
12. Following the pilot test, minor modifications were made based on the responses of the pilot-testing. A final draft was then constructed and copies to be used were printed. The questionnaire was approved by the Iowa State University Human Subjects Committee. An original and a translated version of the questionnaire used in the study can be found in Appendix.

Collection of Quantitative Data

The researcher, assisted by one research assistant of the M.S. Swaminathan Research Foundation, contacted the sample farmers at their homes and farms to collect the data. Fifty percent of the farmers who did not participate in the previous stages were contacted. Thus, all the farmers belonging to the cluster samples (study villages) were involved in this study. In the beginning of the data collection process, each respondent was briefed about the objectives of the study. Then their input for the study was solicited. They were also informed that they were free to withdraw from the study whenever they wanted. It took nearly 45-60 minutes to complete each questionnaire. A code number was assigned to each respondent and it was marked at one corner of the last page of the questionnaire for identification purposes. If the selected farmers were not available on the first visit, repeated visits were made to contact them. A participation or response rate of ninety-seven percent was achieved while collecting the data.

Statistical Analysis

The data collected from the respondents were checked, coded, key punched, verified, and analyzed using the Iowa State University Computation Center facilities. The statistical procedures used to summarize and analyze the stored data were the following:

1. The Statistical Package for the Social Sciences (SPSS) program was used to compute frequency counts of the stored data. This procedure was used to locate incorrect data that were missed during the verification procedure;
2. A Cronbach alpha procedure was computed in order to evaluate the reliability of the instrument;
3. The mean scores and standard deviations were computed for all the factors influencing indigenous decision-making systems to determine the extent to which farmers agreed with these factors;
4. A one-factor analysis of variance (ANOVA) was computed in order to analyze the differences between demographic factors

and the extent to which farmers agreed with selected factors influencing indigenous decision-making systems;

5. The mean scores and standard deviations were computed for all the listed indigenous knowledge statements to determine the extent to which they are believed to be true as perceived by farmers;
6. A one-factor analysis of variance (ANOVA) was computed in order to analyze the differences between demographic factors and the extent to which selected indigenous knowledge systems are believed to be true as perceived by farmers;
7. The mean scores and standard deviations were computed for all the listed indigenous technical practices to determine the extent to which these practices were used by farmers;
8. A one-factor analysis of variance (ANOVA) was computed in order to analyze the differences between certain demographic factors and the extent to which selected indigenous technical practices were used by farmers;
9. To establish relationships between demographic factors and level of utilization of indigenous technical practices, Pearson-product-moment correlation coefficient was calculated at the 0.05 level of significance;
10. A multiple regression analysis was computed to predict which one of the demographic factors was the best predictor of the utilization of indigenous technical practices;
11. A multiple regression analysis was computed to predict which one of the indigenous technical practices was the best predictor of productivity; and
12. A multiple regression analysis was computed to predict which one of the indigenous technical practices was the best predictor of sustainability.

Assumptions of the Study

1. Respondents evaluated the statements regarding indigenous decision-making systems, indigenous knowledge systems, and indigenous technical practices in terms of a "realistic" perception of their role as farmers.
2. The cluster sample of the farm households proportionately represented the Union Territory of Pondicherry, India.
3. Accurate, unbiased, and objective information was provided by farmers in each of the areas of the questionnaire.

Limitations of the Study

1. The study was limited to indigenous knowledge systems related to crop plants and did not consider any other indigenous knowledge systems possessed by the respondents.
2. The indigenous technical practices recorded were related to crop plants that were grown during the study period. Hence, the practices were not intended to be a complete list of indigenous technical practices pertaining to the crop grown in the study villages.
3. This study was limited to irrigated areas of the Pondicherry region and results could not be extrapolated to dryland areas of the same region.

Summary

The purpose of the study was to formulate a methodological framework to incorporate indigenous knowledge systems into agricultural research and extension organizations for sustainable agricultural development in India. Participatory rural appraisal methods such as transecting, participant observation, and unstructured interactions, followed by instrumentation were used to collect data for this study. The target population for this study was 15,793 farm households of the Union Territory of Pondicherry, India. Three villages---Sivaranthakam, Kizhur, and Pillayarkuppam--- belonging to the Union Territory of Pondicherry were selected as cluster samples. All the farm households in these villages (clusters) were involved in the study, however, in various stages. Maps and transects were constructed by walking through the study villages to demarcate the agro-ecological zones. Indigenous technical practices pertaining to food and fuel crops such as rice, finger millet, groundnuts, cassava, chillies, and casuarina were documented using a camera during the participant observation stage. Farmers' beliefs, values, and customs regarding the documented indigenous technical practices were identified through unstructured interactions with farmers.

An instrument was designed based on the information collected from the first three stages, namely transecting, participant observation and unstructured interactions. The instrument was completed by collecting data directly from the farmers. Mean scores and standard deviations were computed for all the statements regarding indigenous decision-making systems, indigenous knowledge systems, and indigenous technical practices to determine the extent of agreement, belief, and utilization respectively. A multiple regression analysis was computed to determine the best indigenous technical practice to predict agricultural productivity and sustainability.

CHAPTER IV. ANALYSIS AND PRESENTATION OF DATA

The purpose of the study was to formulate a methodological framework to incorporate indigenous knowledge systems into agricultural research and extension organizations for sustainable agricultural development in India. The specific objectives of the study were: (1) To determine the extent to which farmers agreed with selected indigenous decision-making systems; (2) To determine the extent to which statements regarding indigenous knowledge systems are believed to be true by farmers; (3) To determine the extent to which selected indigenous technical practices are being used by farmers; (4) To determine the relationship between selected demographic factors and indigenous technical practices; (5) To determine the influence of selected indigenous technical practices on productivity; (6) To determine the influence of selected indigenous technical practices on sustainability; and (7) To develop a methodological framework for incorporating indigenous knowledge systems into agricultural research and extension organizations.

The findings of this study were presented under the following sub-headings:

1. Description of the study region
2. Demographic characteristics
3. Analysis of instrument reliability
4. Analysis of indigenous decision-making systems
6. Analysis of indigenous knowledge statements
7. Analysis of indigenous technical practices
8. Impact of demographic factors on using indigenous technical practices
9. Influence of indigenous technical practices on productivity
10. Influence of indigenous technical practices on sustainability
11. Summary of findings.

Description of the Study Region

The Union Territory of Pondicherry, India was chosen as the study region (Figure 1). India is politically divided into 22 states and 9 union territories. In 1950, the last of the 562 princely states were integrated, and the country became fully republican in form. Followed by this, the French coastal enclaves of Pondicherry, Karaikal, Mahe, and Yanam, collectively called Pondicherry, were assigned to India in 1954, and became a Union Territory (Ministry of Information and Broadcasting, 1982). Pondicherry, Karaikal, and Mahe are located on the sea coast of the Bay of Bengal. Yanam is located on the East Godavari delta. The states of India are administered by the Chief Minister, appointed by the Governor who also appoints other ministers on the advice of the Chief Minister. On the other hand, the union territories are administered by the President of India through an administrator appointed by him (Ministry of Information and Broadcasting, 1982).

Approximately 45 percent of the population in the Union Territory of Pondicherry is engaged in production agriculture and allied activities. In the region, nearly 89 percent of the cultivated area is irrigated in the region. Rice is the major food crop of this region. *Ragi* (finger millet) and *bajra* (pearl millet) are grown to a lesser extent. Sugarcane, groundnuts, and cotton are the principal cash crops. Rainfed tanks form the principal sources of irrigation in Pondicherry. Nearly twenty percent of the normal area in rice has been converted into casuarina (*Casuarina equisetifolia*), a multipurpose tree crop, in the Union Territory of Pondicherry, India during the past few years. At present, there is no electrical power source in Pondicherry. The entire power requirement is being purchased from the neighboring states of Tamil Nadu, Kerala, and Andhra Pradesh.

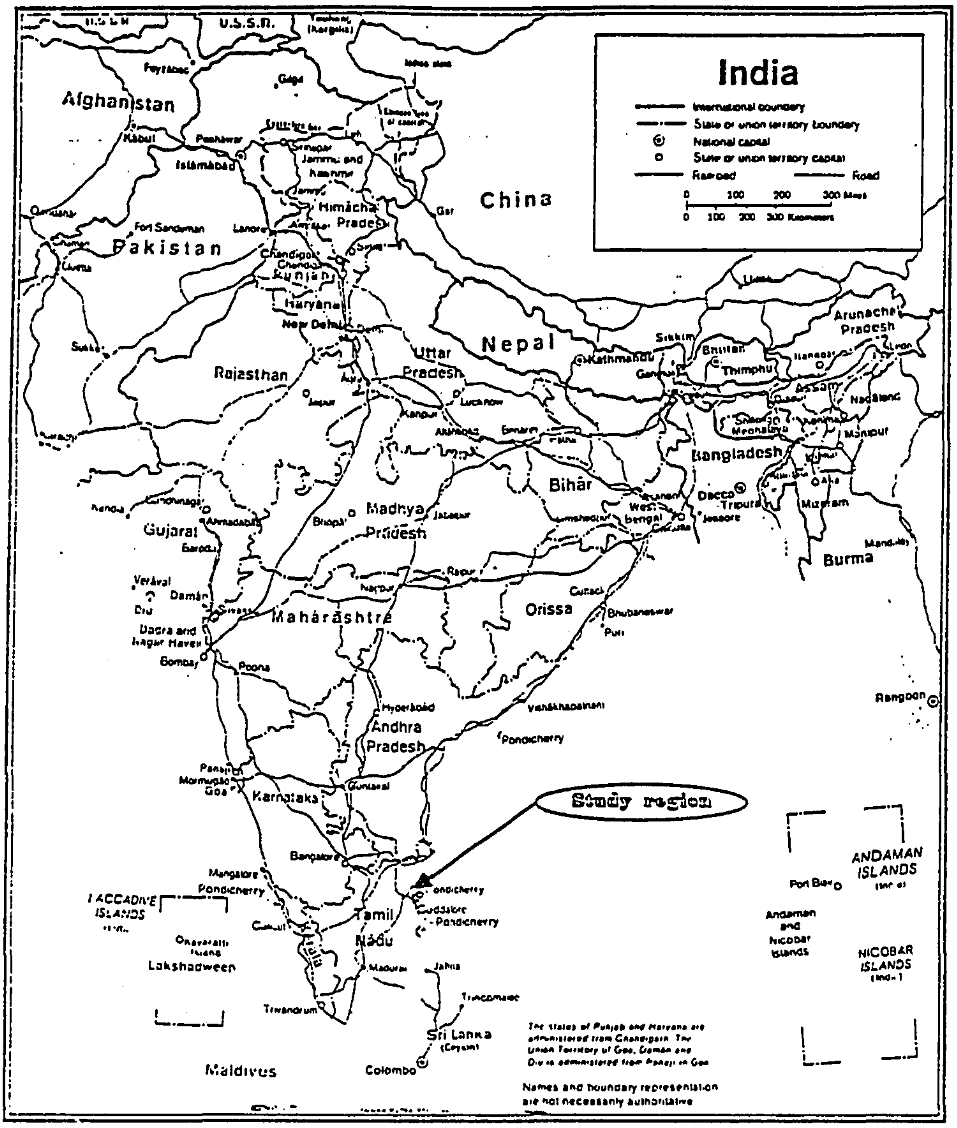

Figure 1. Study Region

Study Villages

The study villages, Sivaranthakam, Kizhur, and Pillayarkuppam, are located in the Villianur Commune of the Union Territory of Pondicherry. The rationale behind the selection of the study villages was discussed in the previous chapter. The villages consist mainly of irrigated wetlands. Agriculture is favored by a year-around growing season, by a north-east monsoon season from October to December, and by irrigated systems based on waters from irrigation tanks and tubewells.

With reference to cultivation of major crops, the agricultural cycle in the study villages can be divided into three seasons: (1) *Sornawari* season: June to September, (2) *Samba* season: September to January, and (3) *Navarai* season: February to June. These seasons overlap each other rather than being sharply separated. Factors such as availability of irrigation water, procurement of labor forces especially for planting and harvesting, and availability of credit facilities usually create an overlap of around two to three weeks between seasons.

Table 2 shows basic statistics for the villages of Sivaranthakam, Kizhur, and Pillayarkuppam. There is at least one tank for irrigation in each of the study villages. But these irrigation tanks can not satisfy the water requirements of the villages due to the following reasons:

1. Agricultural lands located closer to the tanks are the only ones to benefit from these tanks;
2. Poor maintenance of these irrigation tanks have a negative impact on their storage capacity;
3. Irratic monsoons reduce the quantity of water in the irrigation tanks; and
4. Due to population pressure, boundary areas of irrigation have been encroached upon by some politically influential farmers.

Table 2. Basic statistics for the study villages*

	Sivaranthakam	Kizhur	Pillayarkuppam
Land area	311 ha**		238 ha
Land/ capita	0.15 ha	0.15 ha	0.13 ha
Total population	1204	857	1787
No. of households	233	163	357
Avg. family size	5.16	5.25	5.00
Males	612	451	937
Females	592	406	892

* Note: From M.S. Swaminathan Research Foundation, Annual Report, (p. 59)
** includes land area for Kizhur

Sivaranthakam

Sivaranthakam is located on the banks of the Kodavayar river in the Western part of the Villianur Commune of the Union Territory of Pondicherry. The net cropped area in Sivaranthakam is 311 hectares. Tubewells form the major source of irrigation. The main crops grown in the village are rice, casuarina, sugarcane, and groundnuts. The minor crops grown are cotton, sesamum, millets and a few vegetables. Some coconut trees are planted on the field bunds. Only a few mango, banana, and papaya trees have been planted for home consumption. Fear of theft was given as the main reason why the people did not cultivate fruit tree crops.

The size of farm holdings in Sivaranthakam showed wide variation, from landless to 102 acres. The contrast among the three caste groups is very striking. *Reddiyars* (five households), regarded socio-economically as the leading caste group, own 81 percent of the total cultivated area in Sivaranthakam. *Gounders* (14 households), who hold moderate socio-economic status in the community, own 12 percent of the total cultivated area. Twenty-six scheduled caste households own 7 percent of the total cultivated area. A scheduled caste is a class of people economically and educationally depressed (Gupta, 1985). More than 40 percent of scheduled caste households hold virtually no land at all. They depend mostly on *reddiyars* and partially on *gounders* for their livelihood by working as farm laborers. These landless laborers also engaged

Kizhur

Though Kizhur is a separate village for spatial and social reasons, it is found as a hamlet of the Sivaranthakam village in official records. Tubewells form the major source of irrigation in Kizhur. There is only one irrigation tank in this village, and it serves practically no purpose. Encroachment of the boundaries of the tank for agricultural activities was found to be one of the major problems for the low storage capacity of the tank. *Mudaliyars* and *yadava pillais* are the predominant caste groups of this village. The land ownership pattern in Kizhur is similar to that in Sivaranthakam. Cattle rearing is one of the traditional off-farm occupations of this village.

Pillayarkuppam

Pillayarkuppam, the third study village, is located on the eastern banks of the Gingee River. Sankarabarani *eri*, an irrigation tank which runs along the eastern borders of this village, was the major source of irrigation a few years ago. Due to erratic monsoons, water flow in this tank was considerably reduced. Hence, most of the large-scale and small-scale farmers have installed tubewells in their farm holdings. However, the depth of water available through the tubewells is greatly determined by the water flow in the Sankarabarani *eri*. In other words, flow of water for longer periods in the *eri* recharges the groundwater and this, in turn, increases the level of water in the tubewells.

A diversified cropping pattern was observed in the village. Though rice was the major crop of this village, other food crops such as chillies, *brinjal* (egg plant), *ragi* (finger millet), and *cumbu* (pearl millet) are also grown. Sugarcane, groundnuts, and cotton are the major cash crops. Pillayarkuppam has the highest cattle population. Most of the women belonging to farm as well as labor families raise cattle as their off-farm occupation.

Demographic Characteristics

Farmer type

Farmers in Pondicherry Union Territory are classified into three types based on their land ownership pattern. Farmers who possess less than 2.5 acres of cultivated lands are classified as marginal farmers (*kuru vivasase*) (Figure 2). Farmers who own 2.6 acres to 5.0 acres are grouped as small-scale farmers (*siru vivasase*). Most of the small-scale farmers belong to *pillai* and *mudaliyar* caste. Large-scale farmers (*periya vivasase*) are those farmers whose size of farm holdings is more than 5.0 acres. Most of the large-scale farmers belong to *reddiyar* caste. Marginal farmers formed the largest group of the participants with 49 percent. Thirty-two percent of the participants belonged to the small-scale farmer category. Nineteen percent of the participant farmers in the study villages are large-scale farmers.

Farmer type is one of the principal factors in determining the social status of local people in the south Indian villages. Large-scale farmers enjoy a high status and social rank in the farming community where as small-scale farmers whose average land holding ranges from occupy a more moderate position in the community.

Age

Participants were asked to state their age. For the purpose of data analysis and presentation, this information was grouped into the following age categories: (1) 21 to 30, (2) 31 to 40, (3) 41 to 50, (4) more than 51. Twenty-three percent of the total participants belonged to age group 21 to 30 (Figure 3). Farmers between ages 31 to 40 comprised 27 percent of the total participants. Farmers between ages 41 to 50 made up 35 percent of the total participants. If these two groups are summed up, farmers from 31 to 50 formed the largest group (62 percent).

Farming experience

Participants were asked to state their experience in farming. They were grouped into the following categories for the purpose of data analysis: (1) years 1 to 10, (2) years 11 to 20, (3) years 21 to 30, (4) more than 31 years (Figure 4). Participants with 1 to 10 years of farming experience comprised 22 percent of the sample. Participants with farming experience of 21 to 30 years formed the largest group with 33 percent, followed by farmers with more than 31 years of farming experience (22 percent).

Soil type

Participants were asked to state the soil types on their farm holdings. Farmers belonging to all the study villages follow a similar pattern of soil classification, though there existed some minor variations. Farmers' soil classification is one of the influencing factors while making decisions on crop and varietal selection during all the three seasons. Farmers consider the following factors while classifying the soils: (1) hardness/ softness of soil, (2) size of soil particles, and (3) water-holding capacity of soil. The various types of soils include: (1) loamy soil (*vandal mann*), (2) sandy loam soil (*manameri mann*), (3) clayey loam soil (*karuvadai mann*), and (4) clayey soil (*kalippu*

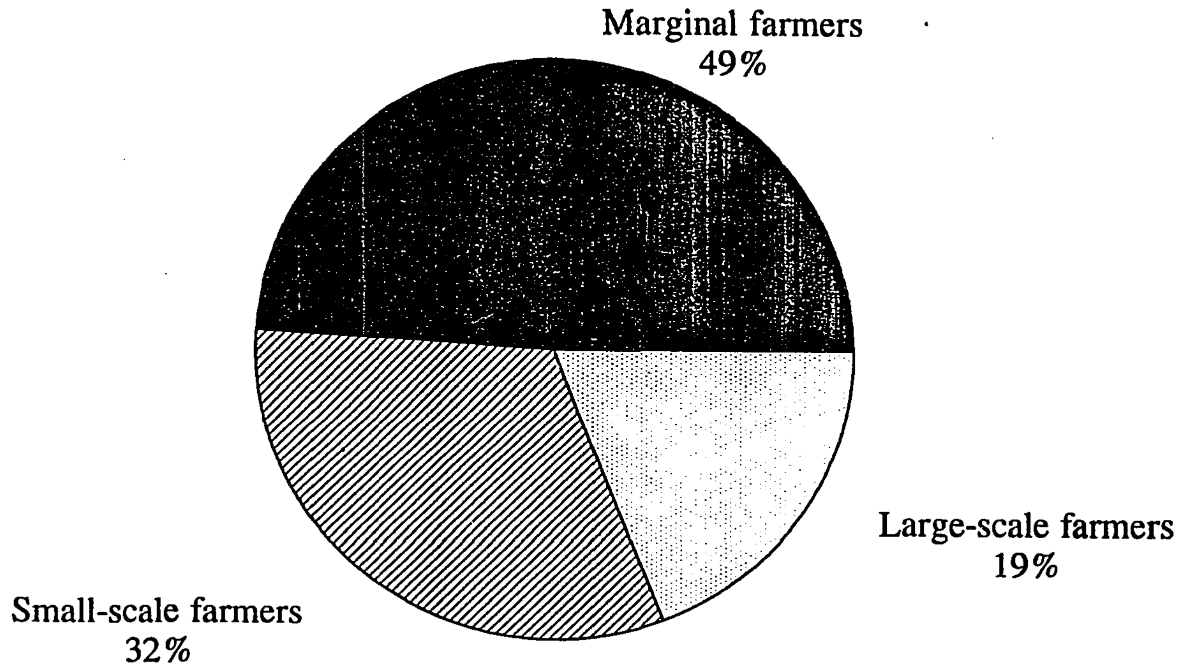

Figure 2. Distribution of farmers according to farm type

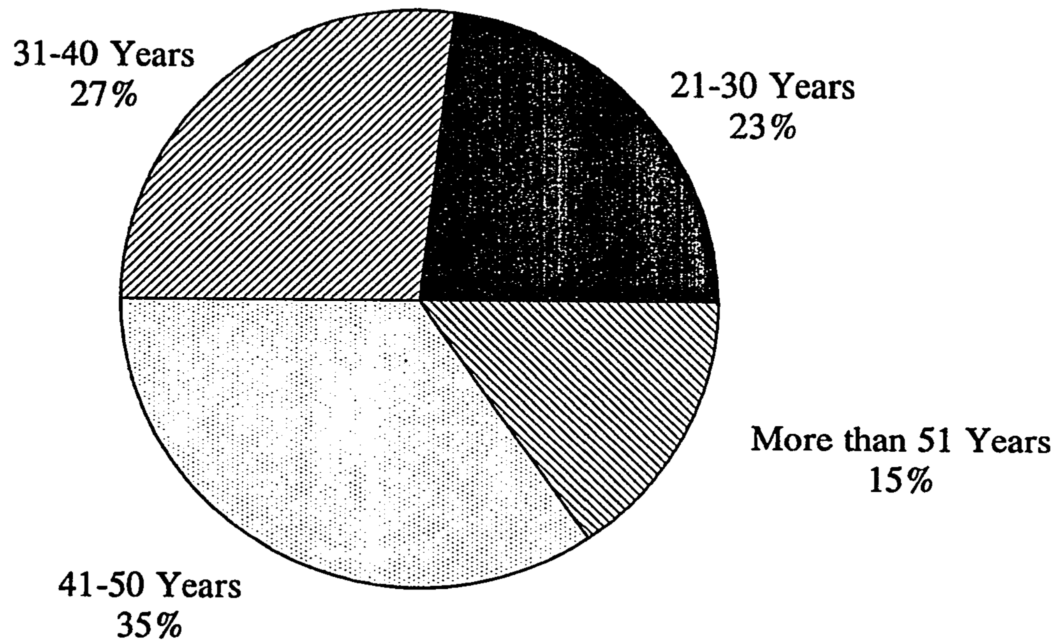

Figure 3. Distribution of farmers according to age

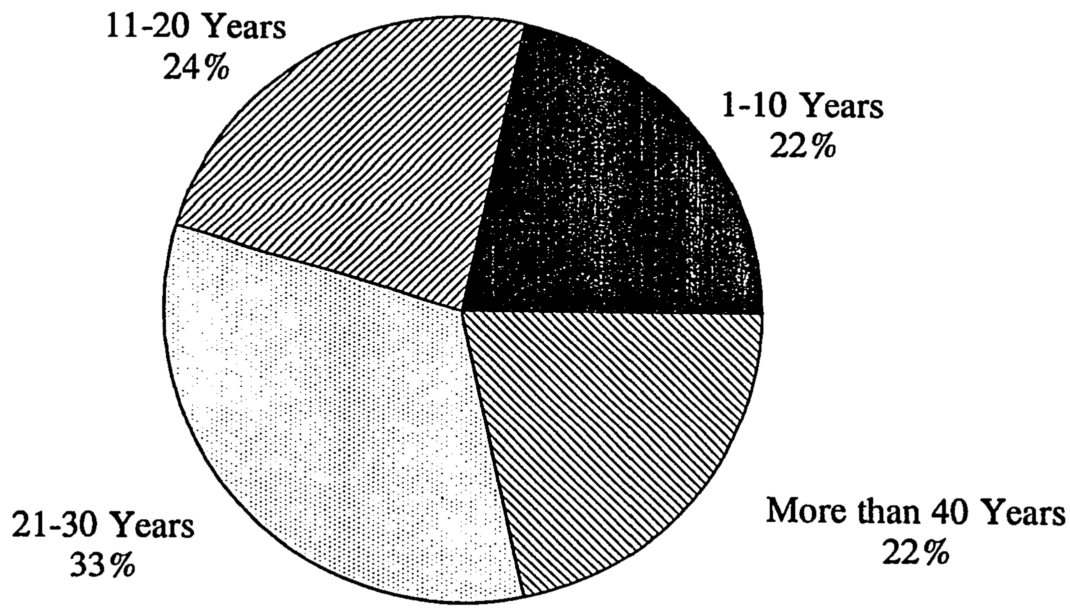

Figure 4. Distribution of farmers according to experience

mann) (Figure 5). Loamy soils (with poor water-holding capacity and softness) and clayey soils (with good water-holding capacity and hardness) formed the two ends of the continuum. The other two types of soils fall in between. Forty-six percent of the participants possess clayey soils whereas only 4 percent of the participants have loamy soils. Farmers who own both clayey soils and sandy loam soils form the largest proportion of the total participants.

Farming purpose

Participant farmers were asked to state the purpose for which they were farming. Farmers undertake farming as an occupation in order to meet the following needs: (1) subsistence, (2) subsistence and fodder, (3) subsistence, fodder, and fuel, (4) subsistence and marketing. Only 8 percent of the farmers took up farming to meet their subsistence needs alone (Figure 6). Thirty-six percent of the participants cultivate their lands to meet their food and fodder requirements. These groups of farmers meet their fuelwood requirements by collecting casuarina roots, sugarcane trash, and tapioca stems from the farm holdings of large-scale and small-scale farmers. Most of the marginal farmers fall under the above category. Twenty-three percent of the participants cultivate their lands to meet their food, fodder, and fuel requirements. Thirty-three percent of the participants depend on farming for food, fodder, and marketing. Most of the large-scale farmers fall under this category.

Family size

The extended family system is a common social phenomenon observed in Indian villages. The study villages are no exception to this factor. Fifty-four percent of the participant households had more than 6 family members. Twenty-one percent of the participant households had 5 family members (Figure 7). Only 6 percent of the participant households possessed less than 3 family members. Most of the labor households had more than 4 family members. Most of the decisions about farming operations are made by the male heads of the families. However, female members have profound influence on the household level decision-making systems. Female members play important roles while making decisions on food choices.

Irrigation type

Private tubewells form the major source of irrigation in the study villages. The mushrooming of tubewells in recent years has had an adverse effect on the watertable. Hence, the Government of Pondicherry passed an ordinance stating that farm holdings with an area of more than 2.5 acres are eligible to only install tubewells. Though the overall goal of this ordinance is to sustain the groundwater resources, the marginal farmers are severely affected by this ruling. This ordinance has made most of the marginal farmers depend either on small-scale or large-scale farmers for irrigation. Based on the irrigation ownership and rental pattern, the participants are grouped into farmers who own tubewells and farmers who use rental irrigation (Figure 8). Most of the marginal farmers depend on their neighboring large-scale as well as small-scale farmers who own tubewells for irrigation. These farmers have to pay one-third of the harvested produce to the tubewell owners as rent for irrigation. Forty percent of the participants depend on rental irrigation. Marginal farmers also obtain irrigation from nearby streams during the late *samba* season and *early* navarai season. They use oil engines to draw water from the streams.

Agricultural labor

Different types of agricultural labor arrangements were observed in the study villages. The agricultural laborers are classified into three groups: (1) family labor, (2) non-family labor, (3) both family and non-family labor. In Sivaranthakam village, the *reddiyars* depend exclusively on scheduled caste laborers for undertaking all farm operations. The *gounders* depend on scheduled caste laborers for

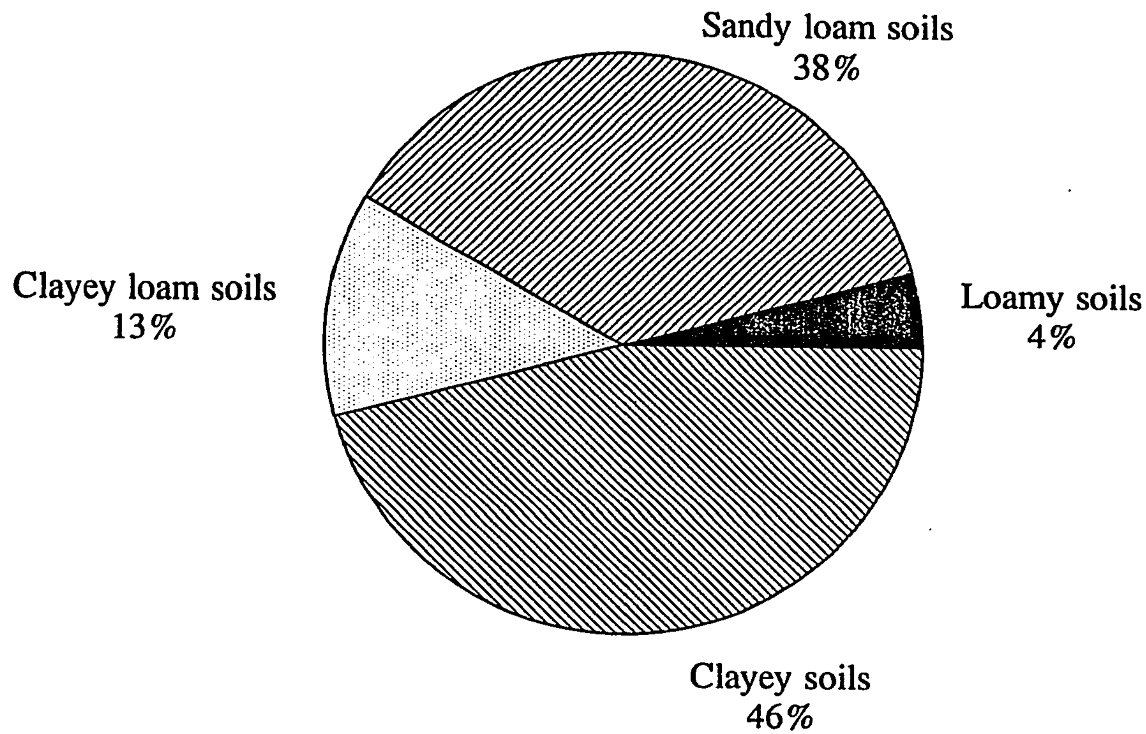

Figure 5. Distribution of farmers according to soil type

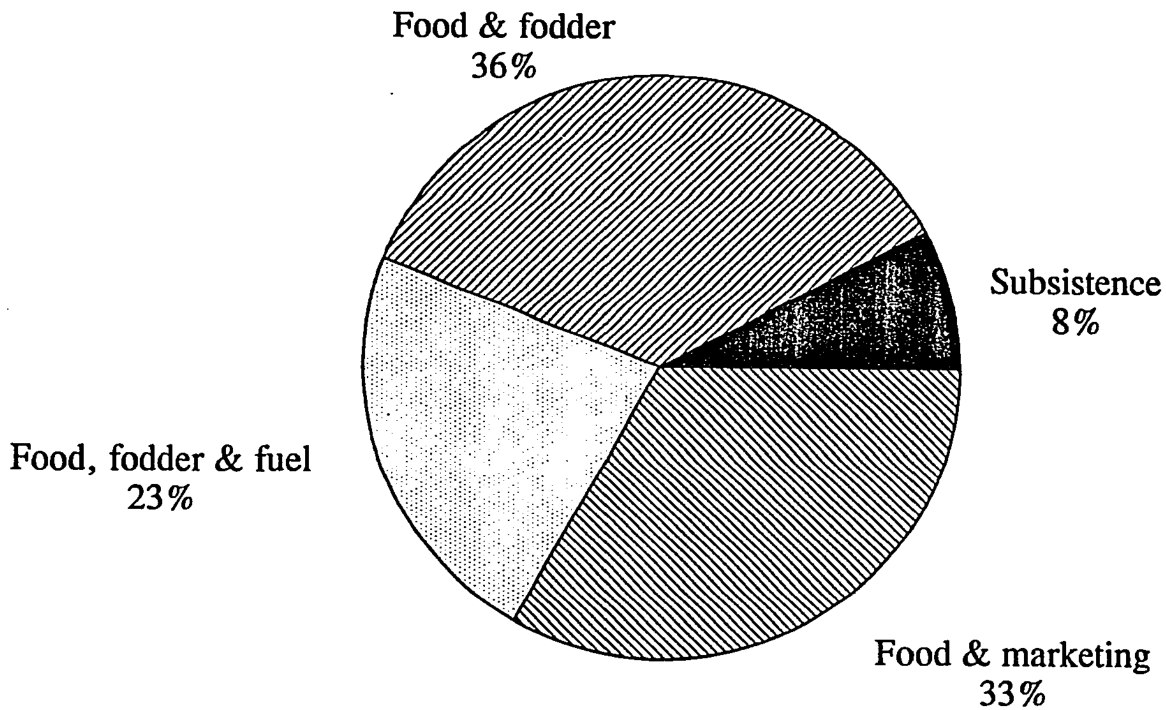

Figure 6. Distribution of farmers according to purpose

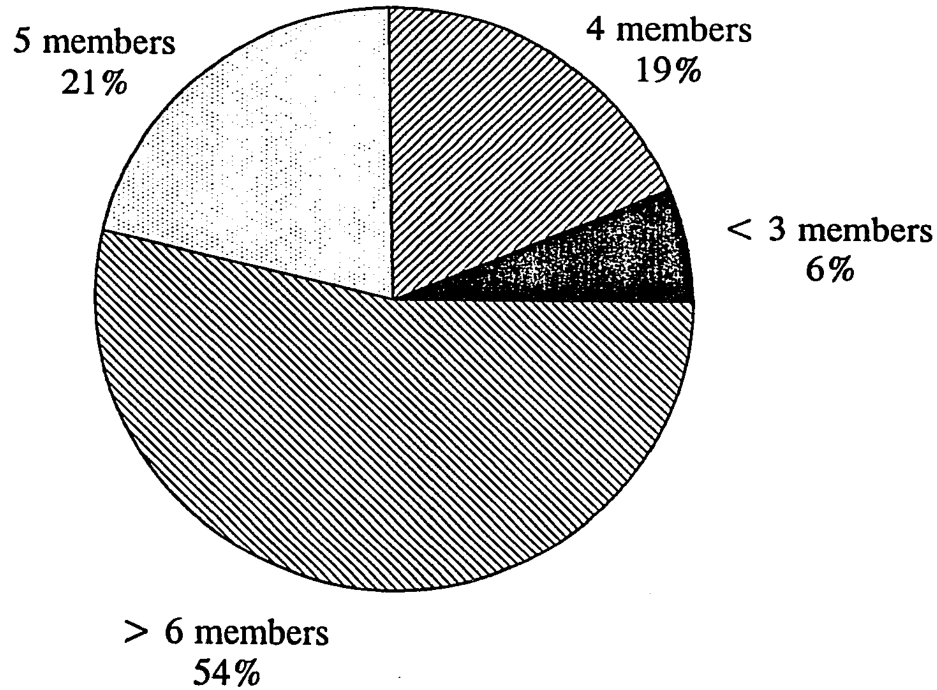

Figure 7. Distribution of farmers according to family size

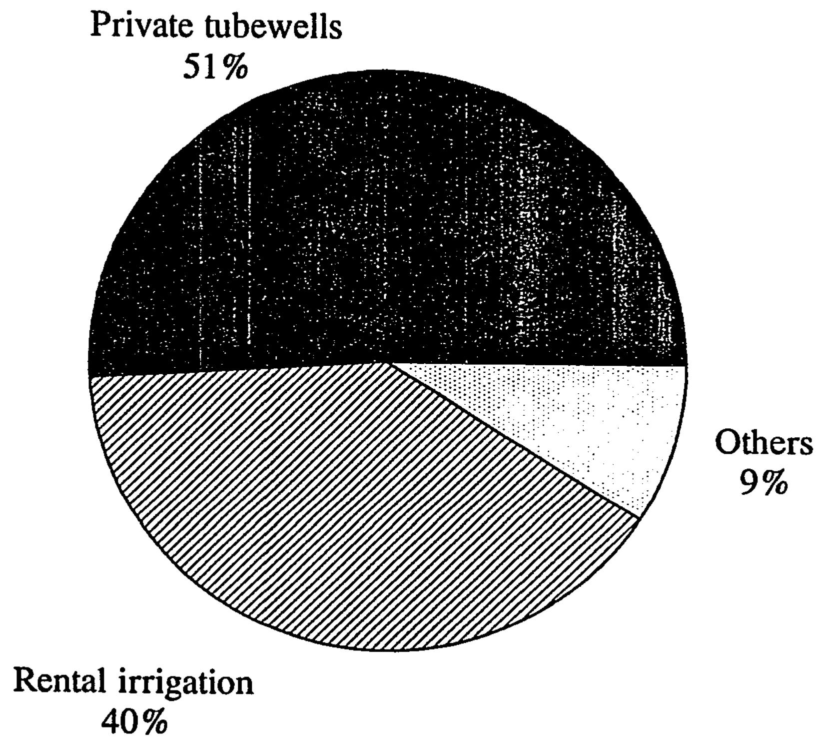

Figure 8. Distribution of farmers according to irrigation

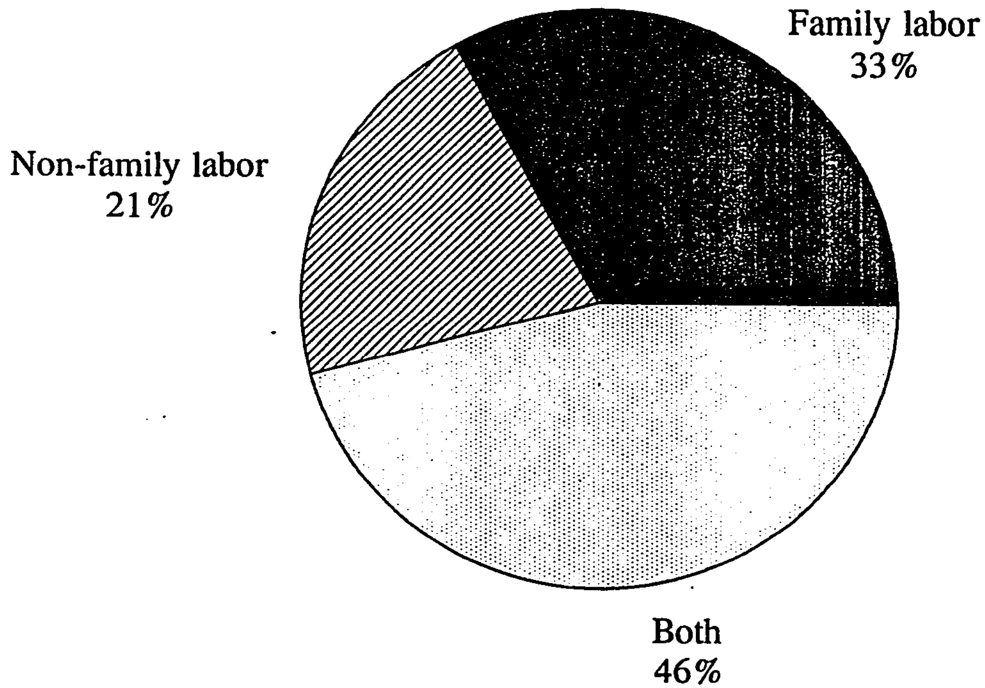

Figure 9. Distribution of farmers according to labor type

undertaking operations such as transplanting, weeding, and harvesting of rice. They undertake other farm operations using their family labor. In Kizhur and Pillayarkuppam villages, the laborers are drawn from the neighboring villages. Thirty-three percent of the total agricultural activities are carried out by family laborers in the study villages. Non-family labor cover 21 percent of the total agricultural activities. Forty-six percent of the total agricultural activities are shared by both family and non-family laborers. There exists an interesting division of labor in the study villages. Male laborers undertake farm operations such as plowing, levelling, application of pesticides, and fertilizers. Female laborers are involved in farm operations such as planting, weeding, harvesting, and processing of rice.

Increased demand for agricultural labor has created a shift from a labor-intensive cropping pattern to one of extensive cropping in in the study villages. This has led to a substantial reduction of the area in major food crops such as rice, sorghum, and finger millets.

Seed supply

Farmer to farmer exchange of seeds catered to the rice seed requirements of 55 percent of the participants (Figure 10). Producing seeds from their own farms served the rice seed requirements for 26 percent of the participants. The Pondicherry Agricultural Service Industries Corporation (PASIC) met 16 percent of the rice seed requirements in the study villages. Large-scale farmers in Sivaranthakam used to obtain newly released rice seed varieties from Tamil Nadu Agricultural University, Coimbatore (3 percent).

With respect to groundnut seeds, farmers belonging to neighboring villages formed the potential source of seed supply (42 percent), followed by private seed agencies (15 percent). Farmers in the study villages never preserve groundnuts for seed purposes.

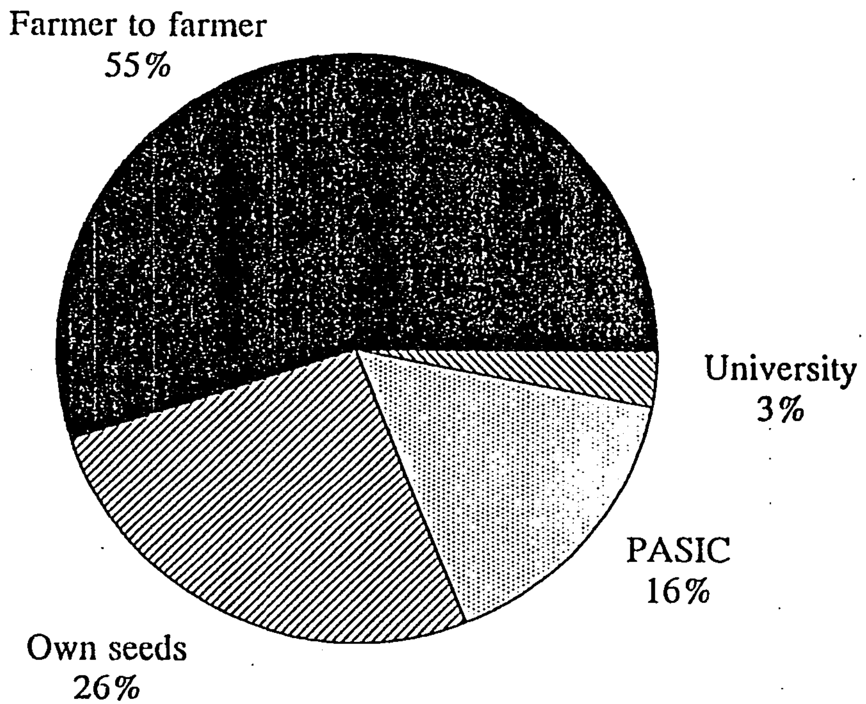

Figure 10. Distribution of farmers according to seed source

Analysis of Instrument Reliability

The instrument as described in Chapter 3 was divided into eleven sections: (1) indigenous decision-making factors, (2) indigenous knowledge statements, (3) indigenous cropping systems, (4) indigenous soil health care practices, (5) indigenous rice seed processing techniques, (6) indigenous rice transplanting techniques, (7) indigenous rice nutrient management strategies, (8) indigenous weed control techniques in rice, (9) indigenous pest management practices in rice, (10) indigenous technical practices for groundnuts, and (11) indigenous technical practices for tapioca. A composite reliability coefficient for the instrument was computed using Cronbach's alpha. The composite reliability coefficients were found to be .80 or above (Table 3). Based on the magnitude of the composite reliability coefficients, the items were considered adequate to measure the perceptions of farmers towards indigenous knowledge systems.

Analysis of Indigenous Decision-Making Systems

Table 4 shows the mean scores of the perception ratings of farmers in Pondicherry Region, India, regarding the extent to which selected factors influence indigenous decision-making systems. The factor, "farmers consult their neighbors before choosing a particular crop for planting" was perceived to influence local decision-making with a mean of 4.34. The factor, "farmers plant casuarina because they can fix the market price for it" was also perceived to be important by the respondents with a mean of 4.01. Seven out of ten factors received neutral ratings. The factor, "traditional food habits influence planting of *ragi* (finger millet) received a neutral rating with a mean of 3.16. The factor, "rising cost of fertilizers is one of the most influential factors for planting casuarina," and "availability of labor during the night is the

Table 3. Perceptions of participant farmers' composite reliability coefficients

Indigenous knowledge areas	Number of items	Reliability coefficient [a]
Decision-making factors	10	.8143
Knowledge statements	23	.8645
Indigenous cropping systems	9	.9635
Indigenous soil health care practices	10	.8431
Indigenous seed selection and processing techniques	10	.9669
Indigenous rice transplanting techniques	9	.9710
Indigenous rice crop nutrient management strategies	9	.9700
Indigenous rice weed control techniques	9	.8429
Indigenous rice pest management practices	10	.9763
Indigenous techical practices for groundnuts	9	.8754
Indigenous technical practices for tapioca	9	.9233

[a] Cronbach's alpha

determining factor for planting groundnuts" were rated low by the respondents with a mean rating of 2.85 and 2.59 respectively.

Table 4. Means and standard deviations regarding the extent to which selected factors influence decision-making as perceived by farmers in Pondicherry Region, India (n=137)

Factors	Mean	S.D.
Farmers consult their neighbors before choosing a particular crop for planting	4.34	1.47
Farmers plant casuarina because they can fix the market price for it	4.01	1.31
Need for fuel influences the planting of tapioca	3.88	1.26
Access to irrigation influences monocropping of rice	3.73	1.76
Rice variety Nehru fetches good price in the market next to *Ponni*	3.85	1.54
Rice variety *Ponni* is preferred for home consumption	3.46	1.79
Traditional food habits influence planting of *ragi* (finger millet)	3.16	1.66
Poor access to irrigation influences planting casuarina	3.13	1.58
Rising cost of fertilizers is one of the most influencing factors for planting casuarina	2.85	1.36
Availability of labor during night is the determining factor for planting groundnuts	2.59	1.74
Grand mean	3.44	

1=Strongly disagree
5=Strongly agree

Analysis of Indigenous Knowledge Statements

Table 5 shows the means and standard deviations regarding the extent to which selected indigenous knowledge (IK) statements are believed to be true by farmers in Pondicherry Region, India. Fifteen out of twenty-three statements pertaining to IK systems were strongly supported by the respondents. The IK statement, "lodging in rice variety *ponni* leads to chaffy grains" received the highest mean rating with a mean of 4.93. The IK statements, "coarse grain rice varieties generally do not lodge," (4.85) and "cost of cultivation for rice variety *Ponni* is low" (4.80) were also strongly supported by the respondents. Three IK statements received a neutral score. The statement, "repeated planting of rice variety *Mangala* results in delayed maturity" was not strongly supported by the respondents with a mean of 2.89.

Analysis of Indigenous Technical Practices

One of the objectives of this study was to identify the extent to which selected indigenous technical practices are being used as perceived by farmers of Pondicherry Region, India. Data pertaining to these objectives are organized and presented in Tables 6 to 14. The terms, 'practices', 'techniques' and 'strategies' were used interchangeably in this section.

The mean scores and standard deviations for the following areas of indigenous technical practices are presented in rank order in these tables: (1) indigenous cropping systems, (2) indigenous soil health care practices, (3) indigenous rice seed selection and processing techniques, (4) indigenous rice transplanting techniques, (5) indigenous rice nutrient management strategies, (6) indigenous weed control techniques in rice, (7) indigenous pest management practices in rice, (8) indigenous technical practices for groundnuts,and (9) indigenous

Table 5. Means and standard deviations regarding the extent to which selected indigenous knowledge statements were believed to be true by farmers in Pondicherry Region, India (n=137)

Indigenous knowledge statements	Mean	S.D.
Lodging in rice variety *Ponni* leads to chaffy grains	4.93	0.48
Coarse grain rice varieties generally do not lodge	4.85	0.70
Cost of cultivation for rice variety *Ponni* is low	4.80	0.76
Low relative humidity influences pest infestation in rice variety IR.50	4.63	0.84
Weed growth is faster in upland areas	4.58	0.71
Yield of rice variety *Ponni* is comparatively low	4.51	1.15
Rice variety *Mangala* is preferable because of its short duration	4.48	0.89
Greenish tillering during the active tillering is an indication of poor yield in rice	4.48	1.18
Rice variety *Mangala* produces good yield	4.47	0.92
Rice variety *Mangala* is a moderately pest resistant rice variety	4.39	0.91
Clayey soil is suitable for rice variety CO.43	4.35	1.05
Severe pest infestation limits the use of rice variety *Jawahar*	4.27	1.32
Rice variety CO.43 is suitable for alkaline soils	4.16	1.07

Table 5. Continued

Indigenous knowledge statements	Mean	S.D.
Earhead bug is first found in weeds	4.12	1.64
Casuarina crop acts as an alternative host for earhead bug	4.05	1.24
Continuous application of chemical fertilizers reduces the yield in rice	3.87	1.65
Rice Variety Jawahar is a high yielding variety	3.72	1.51
Rice variety *Ponmani* is susceptible to rice tugro virus	3.70	1.52
All IR rice varieties are susceptible to cold	3.63	1.71
Rice variety *vaigai* is resistant to pests if planted during *Navarai* season	3.62	1.49
Incidence of brown plant hopper is severe during *samba* season	3.56	1.43
Grain shedding is a major problem with rice variety *Ponmani*	3.69	1.69
Repeated planting of rice variety Mangala results in delayed maturity	2.89	1.58
Grand mean	4.26	

1=Strongly disagree
5=Strongly agree

technical practices for tapioca. A one-way analysis of variance was computed in order to compare the perceptions of respondents by (1) villages and (2) farmer types.

Indigenous cropping systems

Out of the nine indigenous cropping systems that were identified during the participant observation stage, three systems received mean scores of 4 or higher as expressed on a 1-5 Likert type scale. The indigenous cropping system, "monocropping of rice is practiced during all three seasons" was highly used by the respondents with a mean of 4.30. The cropping system, "groundnuts are sown after the harvest of rice" (4.07) was also highly used by the respondents (Table 6). It was found that the cropping system, "border cropping of legumes is practiced in the field bunds of rice" (2.67) was disagreed to by the respondents. To summarize, the grand mean for the indigenous cropping systems area was found to be 3.81. It was found that the farmers in all the three study villages differed significantly in their perceptions with respect to the indigenous cropping systems (Table 16). Significant differences were also found regarding the perceptions of different types of farmers with respect to the indigenous cropping systems (Table 15).

Indigenous soil health care practices

The area of indigenous soil health care practices consisted of ten items. The farmers rated "application of farm yard manure" with a mean of 4.75 as the highly used practice (Table 7). The second and third practices were "aerating the soil to maintain soil fertility" (4.66) and "crop rotation is practiced to maintain soil fertility" (4.33) respectively. According to the respondents, the statement, "sheep panning is practiced" was also perceived to to be highly used by

Table 6. Means and standard deviations regarding the extent to which selected indigenous cropping systems were being used as perceived by farmers of Pondicherry Region, India (n=137)

Indigenous cropping systems	Mean	S.D.
Monocropping of rice is practiced in all the three seasons	4.30	1.44
Groundnuts are sown after the harvest of rice	4.06	1.29
Sequential cropping of black gram, green gram and sesamum is practiced in casuarina fields	4.03	1.10
Intercropping casuarina and black gram is practiced	3.82	1.26
Cotton is grown as a solution to irrigation scarcity	3.73	1.65
Intercropping cotton and groundnuts is practiced	3.68	1.44
Mixed cropping of black gram, green gram, and cow pea is practiced	3.52	1.61
Fallowing is practiced before cultivating groundnuts	2.85	1.73
Border cropping of legumes is practiced in the bunds of rice	2.67	1.82
Grand mean	3.81	

1=Very low
5=Very high

Table 7. Means and standard deviations regarding the extent to which selected indigenous soil health care practices were being used as perceived by farmers of Pondicherry Region, India (n=137)

Indigenous soil health care practices	Mean	S.D.
Application of farm yard manure loosens the soil	4.75	0.53
Aerating the soil will maintain soil fertility	4.66	0.99
Crop rotation is practiced to maintain soil fertility	4.33	1.37
Sheep panning is practiced	4.17	1.29
Application of casuarina leaves will correct soil alkalinity	3.85	1.44
Application of sand will neutralize soil alkalinity	3.51	1.63
Plowing Daincha *in situ* is practiced	3.50	1.63
Fallowing for at least one season will maintain soil fertile	3.49	1.79
Mulching of sandy loam soils will prevent soil erosion	2.87	1.72
Application of *neem* leaves will correct soil alkalinity	2.46	1.57
Grand mean	3.52	

1=Very low

5=Very high

farmers of the study villages. The practices, "application of *neem* leaves will correct soil alkalinity" (2.46) was rated low. The one-way analysis of variance showed that no significant differences existed among the respondents belonging to different villages as well as various farmer types regarding their perceptions on the use of indigenous soil health care practices (Table 15). In summary, the grand mean for the area of indigenous soil health care practices that are being used by farmers was 3.52.

Indigenous rice seed selection and processing techniques

Out of ten items in the area of indigenous rice seed selection and processing techniques, it was found that three items were highly used. The top two items were: "exchange of rice seeds from farmer to farmer to increase germination potential" (4.63) and "sieve rice seeds to separate the weed seeds" (4.44) (Table 8). The practices that are carried out before harvesting of rice such as "selecting healthy plots to harvest high quality rice seeds" (3.82) and "remove the rogues at least 25 days before harvesting" (3.63) received neutral ratings. The practice, "dry the rice seeds for one month before storing" received the lowest rating. The mean scores for soil health practices did not significantly differ with respect to the villages. On the other hand, the mean scores of large-scale farmers were significantly higher than that of the marginal farmers (Table 15). In summary, the grand mean for the area of indigenous rice seed selection and processing techniques that are being used by farmers was found to be 3.75.

Indigenous rice transplanting techniques

Nine items contributed to the area of indigenous rice transplanting techniques. Data in Table 9 show that 3 items were rated a mean of 4.00 or higher. The highest rated items were:

Table 8. Means and standard deviations regarding the extent to which selected indigenous rice seed selection and processing techniques were being used as perceived by farmers of Pondicherry Region, India (n=137)

Indigenous rice seed processing techniques	Mean	S.D.
Exchange of rice seeds from farmer to farmer increase its germination potential	4.63	0.52
Sieve rice seeds to separate the seeds of weeds	4.44	1.33
Thresh rice seeds manually to maintain the seed quality	3.91	1.74
Rice seeds should be dried at least four times before storing	3.91	1.74
Rice seeds once processed and stored will be used during next sowing	3.86	1.80
Select healthy plots to harvest high quality seeds	3.82	1.73
Remove the rogues at least 25 days before harvesting	3.63	1.76
Rice seeds should not be stored warm temperatures	3.58	1.81
Spread *notchi* leaves over the rice seeds will prevent storage pests	3.30	1.92
Dry rice seeds for one month before storing	2.38	1.90
Grand mean	3.75	

1=Very low
5=Very high

Table 9. Means and standard deviations regarding the extent to which selected indigenous rice transplanting techniques were being used as perceived by farmers of Pondicherry Region, India (n=137)

Indigenous rice transplanting techniques	Mean	S.D.
Row planting results in increased tillers in rice variety *ponni*	4.67	1.57
Random spacing is followed while transplanting to save labor	4.53	1.48
Rice variety *mangala* produces good yield if 21 day old seedlings are transplanted	3.66	1.53
Row planting results in increased yield in rice variety *ponni*	3.92	1.51
Plant aged seedlings of rice variety *ponni* to prevent lodging	3.87	1.23
Pinch planting is adopted for medium duration rice varieties	3.76	1.32
Pinch planting is adopted during *navarai* season	3.66	1.32
Clump planting is adopted for short duration rice varieties	3.72	1.33
Gap filling is done 2-3rd day after transplanting	3.69	1.51
Grand mean	4.04	

1=Very low
5=Very high

"row planting results in increased tillers in rice variety *ponni*" (4.67), "random spacing is followed while transplanting" (4.53) and "rice variety *mangala* produces good yield if 21 day old seedlings are planted" (4.21). The rice transplanting techniques "clump planting is adopted for short duration varieties" (3.72) and "gap filling is done 2-3rd day after transplanting" (3.69) received the neutral ratings. All the practices were used by the respondents. The mean scores for rice planting techniques did not differ significantly either with the villages or with the farmer types. In summary, the grand mean for the area of indigenous rice transplanting techniques that are being used by farmers was found to be 4.04.

Indigenous rice nutrient management practices

Nine items constituted the area of indigenous rice nutrient management practices. Data in Table 10 show that seven items rated a mean of 4.00 or higher. The respondents strongly agreed that they use the following practices: "application of farm yard manure to increase strength to the rice tillers" (4.95), "farm yard manure application to increase the weight of grains" (4.92), and "sheep manure is applied as a basal dressing" (4.91). Farmers observed significant increases in the yield of rice where farm yard manure or sheep manure was applied. The indigenous rice nutrient management practice, "application of neem cake to improve the intake of nitrogen" (3.51) received the neutral rating. The practice, "apply *Teprosia populnea* leaves as a green leaf manure" was not used with a mean of 2.70. The participant farmers indicated that reduction in the area under trees did not allow them to apply the tree leaves as a green manure. The mean scores for rice nutrient management practices did not differ significantly either with the villages or with the farmer types. In summary, the grand mean for the area of indigenous rice nutrient applications that are being used by farmers was found to be 4.35.

Table 10. Means and standard deviations regarding the extent to which selected indigenous rice crop nutrient management strategies were being used as perceived by farmers of Pondicherry Region, India (n=137)

Indigenous rice crop nutrient management strategies	Mean	S.D.
Application of farm yard manure to increase strength to the rice tillers	4.95	0.26
Farm yard manure application to increase the weight of rice grains	4.92	0.35
Sheep manure is applied as a basal dressing	4.91	0.53
Reduce the amount of fertilizers when applied as top dressing	4.75	0.73
Avoid top dressing of nitrogen during rainy days	4.54	0.95
Thorough mixing of cow dung, urine, and rice straw to increase the effectiveness of farm yard manure	4.50	1.23
Farm yard manure is applied once in every year	4.37	1.39
Application of neem cake to improve the intake of nitrogen	3.51	1.63
Apply *Teprosia populnea* leaves as a green leaf manure	2.70	1.72
Grand mean	4.35	

1=Very low
5=Very high

Indigenous rice weed control techniques

The area of indigenous rice weed control techniques consisted of nine items (Table 11). All the items were highly used by the respondents except one item rated lower, "raising the bunds of main fields controls weeds" (3.41). The highest rated items were: "levelling of rice nurseries without undulations minimizes weeds" (4.94), "storing water for 15 days from transplanting controls weeds" (4.64), and "water level should be maintained at least at one inch" (4.57). The mean scores for rice weed control techniques did not differ significantly either with the villages or with the farmer types (Tables 15 and 16). In summary, the grand mean for the area of rice weed control techniques being used by farmers was found to be 4.38.

Indigenous rice pest management strategies

Ten items constituted the area of indigenous rice pest management strategies (Table 12). The respondents agreed that they use the following three practices at a higher rate: "rice variety *mangala* is grown to avoid the attack of pests" (4.40), "crop rotation minimizes pest incidence" (4.32), and "use rat traps to control rat damage" (4.27). The practices, "apply pesticides immediately when the first ear head is seen" (3.97) and "delaying the top dressing reduces the pest incidence (3.09) received moderate ratings. The three items which received the lowest overall mean ratings in this area were: "application of farm yard manure reduces the incidence of pests" (2.97), "community spraying to control pests" (2.88), and "community planting to minimize pest incidence (2.64). The mean scores for indigenous rice pest management strategies did not differ significantly either with the villages or with the farmer types (Tables 15 and 16). In summary, the grand mean for the area of indigenous rice pest management strategies that are being used by farmers was found to be 3.66.

Table 11. Means and standard deviations regarding the extent to which selected indigenous rice weed control strategies were being used as perceived by farmers of Pondicherry Region, India (n=137)

Indigenous rice weed control strategies	Mean	S.D.
Levelling of rice nurseries without undulations minimizes weeds	4.94	0.48
Storing water for 15 days from transplanting controls weeds	4.64	1.06
Water level should be maintained at least at one inch	4.57	1.00
Closer planting controls weeds in rice field	4.56	1.06
Puddling of rice nurseries followed by drying controls weeds	4.29	1.45
Raising the bunds of main fields controls weeds	4.25	1.43
Plowing the main field during alternate days reduces the weed growth	3.88	1.62
Grass weeds germinate in raised areas of the main field	3.64	1.73
Rice nurseries should be puddled once in two days	3.41	1.89
Grand mean	4.38	

1=Very low
5=Very high

Table 12. Means and standard deviations regarding the extent to which selected indigenous rice pest management strategies were being used as perceived by farmers of Pondicherry Region, India (n=137)

Indigenous rice pest management strategies	Mean	S.D.
Rice variety *mangala* is grown to avoid the attack of pests	4.40	0.97
Crop rotation minimizes pest incidence	4.32	1.32
Use rat traps to control rat damage	4.29	1.31
Providing proper aeration manages the attack of brown plant hopper	4.27	1.37
Apply pesticides immediately when the first ear head is seen	4.05	1.24
Alternate wetting and drying reduces brown plant hopper incidence	3.97	1.60
Delaying the top dressing reduces the pest incidence	3.09	1.86
Application of farm yard manure reduces the incidence of pests	2.97	1.87
Farmers apply pesticides during the same time to control pests	2.88	1.89
Community planting to minimize pest incidence	2.64	1.92
Grand mean	3.66	

1=Very low

5=Very high

Indigenous technical practices for groundnuts

Nine items constituted the area of indigenous technical practices for groundnuts (Table 13). All the items were highly used by the farmers. The highest rated practices were: "hoeing groundnut crop increases yield" (4.84), "groundnuts are sown on 15th of Tamil month Karthigai" (4.76), and "groundnuts are sown in rice fallows in clayey soils" (4.24). The mean scores for indigenous technical practices for groundnuts did not differ significantly either with the villages or with the farmer types (Tables 15 and 16). In summary, the grand mean for the area of indigenous technical practices for groundnuts that are being used by farmers was found to be 4.34.

Indigenous technical practices for tapioca

Nine practices constituted the area of indigenous technical practices for tapioca (Table 14). Eight practices were perceived to be used by the respondents except one item rated considerably lower than the other items: "apply green manures to increase the tapioca tubers" (2.92). The highest rated items were: "drain the tapioca fields frequently to prevent rotting of tubers" (4.58), "reduce the frequency of irrigation for tapioca in clayey soils" (4.45), "irrigate the tapioca while harvesting" (4.39), and "cultivating tapioca in sandy soils to increase the yield" (4.21). The items, "lowlying areas are good for growing tapioca and "sugarcane farmers grow tapica before planting sugarcane for increased yield" received a moderate score of 3.64 and 3.57 respectively. The results of the analysis of variance (ANOVA) showed that the mean scores for indigenous technical practices for tapioca did not differ significantly either with the villages or with the farmer types. In summary, the grand mean for the area of indigenous technical practices for tapioca that are being used by farmers was found to be 4.12.

Table 13. Means and standard deviations regarding the extent to which selected indigenous technical practices for groundnuts were being used as perceived by farmers of Pondicherry Region, India (n=137)

Indigenous technical practices for groundnuts	Mean	S.D.
Hoeing groundnuts increases yield	4.84	0.54
Groundnuts are sown on 15th of Tamil month Karthigai	4.76	0.80
Harvesting groundnuts in clayey soils results in reduced yield	4.61	0.83
Groundnuts are sown in rice fallows in clayey soils	4.24	1.46
Stagnating water near field boundaries controls fox attack	4.21	1.43
Groundnuts are sown to solve the problem of water scarcity	4.18	1.46
Fire crackers scare birds and foxes	4.08	1.49
Fox attack is severe during germination stage of groundnuts	4.03	1.62
Application of gypsum while sowing to increase the size of groundnut pods	4.01	1.51
Grand mean	4.34	

1=Very low
5=Very high

Table 14. Means and standard deviations regarding the extent to which selected indigenous technical practices for tapioca were being used as perceived by farmers of Pondicherry Region, India (n=137)

Indigenous technical practices for tapioca	Mean	S.D.
Drain the tapioca fields frequently to prevent rotting of tubers	4.58	0.80
Reduce the frequency of irrigation for tapioca in clayey soils	4.45	0.98
Irrigate the tapioca while harvesting	4.39	1.11
Sandy soil is good for growing tapioca	4.13	1.22
Cultivate tapioca in sandy soils to increase the yield	4.21	1.30
Dip the tapioca tubers in clayey solution to the tubers from rotting	4.20	1.17
Lowlying areas are good for growing tapioca	3.64	1.22
Sugarcane farmers grow tapica before planting sugarcane for increased yield	3.57	1.28
Apply green manures to increase the tapioca tubers	2.92	1.66
Grand mean	4.12	

1=Very low
5=Very high

Table 15. Means and F-values regarding the extent to which indigenous technical practices were being used as perceived by different types of farmers of Pondicherry Region, India

Indigenous technical practices	Farmer Types 1 n=21	2 n=43	3 n=73	F-value	Prob.
Decision-making factors	4.84	4.21	3.07	6.31	.00
Cropping systems	4.55	3.92	2.96	4.31	.04
Soil health care practices	4.28	3.60	2.68	1.89	.16
Rice seed processing techniques	3.19	3.43	4.63	3.24	.05
Rice transplanting techniques	4.73	4.28	4.42	.68	.52
Rice weed management strategies	3.82	2.43	3.07	.86	.34
Pest management strategies	4.33	4.49	4.61	.87	.47
Technical practices for groundnuts	4.63	4.39	3.29	1.61	.24
Technical practices for tapioca	3.82	2.54	4.03	1.02	.18

1=Marginal farmer
2=Small-scale farmer
3=Large-scale farmer

Table 16. Means and F-values regarding the extent to which indigenous technical practices were being used as perceived by farmers in selected villages of Pondicherry Region, India

Indigenous technical practices	Villages 1 n=21	2 n=43	3 n=73	F-value	Prob.
Decision-making factors	4.50	3.75	3.84	.58	.56
Cropping systems	3.85	4.71	3.42	6.31	.00
Soil health care practices	4.28	3.60	2.68	1.89	.16
Rice seed processing techniques	2.63	3.43	3.89	1.24	.29
Rice transplanting techniques	4.85	4.39	4.53	.79	.41
Rice weed management strategies	3.71	2.43	3.01	.92	.37
Pest management strategies	4.33	4.49	4.61	.87	.47
Technical practices for groundnuts	3.63	3.49	3.19	.61	.58
Technical practices for tapioca	3.82	2.54	4.03	1.02	.18

1=Sivaranthakam
2=Kizhur
3=Pillayarkuppam

Relationship between Demographic Factors and Indigenous Technical Practices

Correlational analysis

One of the objectives was to determine the impact of selected demographic factors on using indigenous technical practices. Tables 17 to 26 provide Pearson correlation among different indigenous technical practices and selected demographic factors. Table 18 provides a correlation matrix among selected indigenous cropping systems and demographic factors. The respondents' use of indigenous cropping systems were greatly influenced by the type of farmer group to which they belong. As explained previously, size of farm holding determines the type of farmer. On the one hand, as the size of farm holding increased, rate of adopting the monocropping practice also increased. As the size of farm holding decreased, farmers' use of sequential cropping of black gram, green gram, and cowpea in casuarina fields also increased. However, there was no significant correlation between farmers' practice of intercropping and their size of farm holding.

There existed a significant relationship between type of soil and the indigenous cropping system, mixed cropping of legumes. Small-scale and marginal farmers who possess sandy loam soils practiced mixed cropping of black gram, green gram, and cowpea or sesamum, especially during the *navarai* season. It is not surprising to find that as farmers' access to irrigation increased, the rate of adoption of monocropping of rice also increased. A statistically significant relationship was also observed between sequential cropping systems and size of family. Purpose of farming, as one of the demographic factors, did not have any impact on indigenous cropping systems.

There was a significant positive correlation between type of farmer and indigenous soil health care practices such as fallowing, sand application, and sheep panning. As the size of farm holding increased, fallowing, sand application, and sheep panning also increased. Experience in farming had a profound impact on the use of indigenous soil health care practices such as crop rotation and application of farm yard manure. More experienced farmers perceived that they rotate their crops more frequently. Type of soil had a significant impact on application of sand from river beds. Farmers with clayey soils and with alkaline problems were found to apply sand from river beds in order to correct alkalinity.

Type of farmer and rate of adopting the sheep panning practice were significantly related. As the size of farm holding increased, the rate of adoption of sheep panning also increased. No significant relationship existed between irrigation type of participant farmers and any of the indigenous soil health care practices.

A significant negative correlation was observed between farmer type and indigenous rice seed processing techniques, "sieving rice seeds to separate weed seeds" and "threshing rice seeds manually to maintain the seed quality" (Table 20). Increases in the size of farm holding of the participant farmers was found to have a negative impact on the use of these seed processing techniques. As the size of farm holding increased, the rate of adoption of the practice, "removing the rogue plants at least 25 days before harvesting" also increased. Farm experience and the seed processing technique, "spreading *notchi* leaves over the rice seeds" were positively correlated. None of the other demographic factors were found to have a relationship with the indigenous seed processing techniques.

Table 21 shows the correlation between indigenous rice transplanting techniques and demographic factors. The technique, "transplanting 21 day old seedlings of rice variety *mangala*" is influenced by demographic factors such as farmer type and labor type. As the size of farm holding of the participant farmers increased, the rate of adoption of this agronomic practice also increased. Moreover,

Table 17. Correlation among selected indigenous decision-making systems and demographic factors (n=137)

Indigenous decision-making systems	Demographic factors				
	Farmer type	Farming purpose	Soil type	Relationship	Labor type
Rice variety *ponni* is preferred for home consumption	0.2862*	0.0018	0.2510*	0.4645*	.1174
Rice variety *nehru* fetches good price in the market next to rice variety *ponni*	-0.3073*	-0.2581*	0.1670	-0.0751	0.2948*
Need for fuel wood influences the planting of tapioca	-0.451	-0.2215*	-0.0902	0.3738*	-0.0083
Rice cultivation is influenced by the availability of irrigation	-0.2079	-0.1267	0.0862	0.4347*	-0.0714
Traditional food habits influence the planting of *ragi* (finger millet)	-0.3408*	0.0285	-0.1845	0.0181	0.0832

* Significant at 0.05

Table 18. Correlation among selected indigenous cropping systems and demographic factors (n=137)

Indigenous cropping systems	Demographic factors				
	Farmer type	Farming purpose	Soil type	Irrigation type	Family size
Sequential cropping	-0.3502*	-0.1222	0.0211	-0.0621	0.2173*
Mixed cropping	-0.0780	0.1276	-0.2865*	-0.0422	0.1762
Monocropping	0.3175*	0.0711	0.1224	0.3762*	0.0356
Intercropping	0.0654	0.0456	-0.2856*	0.0897	-0.0342

* Significant at 0.05

Table 19. Correlation among selected indigenous soil health care practices and demographic factors (n=137)

Indigenous soil health care practices	Demographic factors				
	Farmer type	Farm experience	Farming purpose	Soil type	Irrigation type
Crop rotation	-0.0459	0.1987*	-0.1590*	-0.1156	0.0518
Fallowing	0.2234*	0.0032	-0.0621	0.0432	-0.1344
Application of farm yard manure	-0.0655	0.2456*	0.0789	0.1287	0.0988
Application of casuarina leaves	-0.0243	0.0654	0.1153	0.2564*	-0.1211
Application of sand	0.3441*	0.0021	-0.5630	0.2788*	-0.077
Plowing Daincha *in situ*	0.1890	-0.0121	0.9342	0.1476	0.0546
Mulching	0.1172	-0.0321	0.1212	0.0873	0.0423
Sheep panning	0.2749*	0.0027	-0.0736	0.1812	0.0972

* Significant at 0.05

Table 20. Correlation among selected indigenous rice seed selection and processing techniques and demographic factors (n=137)

Indigenous rice seed selection and processing techniques	Demographic factors				
	Farmer type	Farm experience	Farming purpose	Soil type	Labor type
Removing the rogue plants	0.3202*	-0.1430	-0.1058	0.0729	0.0202
Spreading *notchi* leaves over the rice seeds	-0.1969	0.2987*	-0.1349	-0.0047	-0.0011
Sieving rice seeds	-0.2509*	0.1802	0.1143	-0.1034	0.0149
Thresh rice seeds manually	-0.4289*	0.0598	-0.0849	0.0517	0.0296
Selecting healthy plots	-0.0026	0.1678	-0.1287	-0.0923	0.1812
Farmer to farmer seed exchange	-0.1989	0.1998	-0.0762	0.1167	-0.0643

* Significant at 0.05

Table 21. Correlation among selected indigenous rice transplanting techniques and demographic factors (n=137)

Indigenous rice transplanting techniques	Demographic factors				
	Farmer type	Farm experience	Irrigation type	Soil type	Labor type
Row planting	-0.1464	-0.0166	-0.0256	0.1272	-0.3239*
Planting aged seedlings	0.0335	0.3562*	-0.0838	0.1524	0.0293
Transplanting 21 day old seedlings	-0.2441	0.0344	0.0882	-0.0991	-0.3287
Random spacing	0.1287	-0.0543	0.1845	0.0234	0.0079
Pinch planting	0.0237	-0.1765	0.0076	-0.0091	-0.2178*

* Significant at 0.05

increases in the availability of non-family labor also increases the usage of the practice. As experience in farming increased, rate of use of the practice, "transplant aged seedlings of rice variety *ponni*" also increased irrespective of the type of farmers. The demographic factors, irrigation type and soil type did not have any significant impact on the use of indigenous rice planting techniques.

Table 22 provides a Pearson correlation matrix among indigenous crop nutrient management practices and demographic factors. The crop nutrient management practices, "application of farm yard manure" and "application of sheep manure" were significantly correlated with "farmer type." As the size of farm holding increased, the rate of application of farm yard manure and sheep manure decreased. The application of sheep manure was highly practiced by marginal farmers. None of the other demographic factors were significantly correlated with the use of indigenous crop nutrient management practices.

Table 23 shows the correlation between indigenous weed management strategies in rice and demographic factors. A negative correlation was observed between the strategy, "puddling rice nurseries followed by drying" and "farmer type." A positive correlation was found between the strategy, "closer spacing" and "farmer type." The demographic factor, "irrigation type" was found to have a positive correlation with two of the weed management strategies. As access to irrigation increased, the rate of adoption of the strategies, "maintaining one inch of water in the field" and "storing water for 15 days from transplanting" also increased. The demographic factor, "labor type" had a profound negative impact on the adoption of the strategy, "closer spacing while transplanting." None of the other demographic factors were significantly correlated with the use of indigenous crop nutrient management practices. The other demographic factors, farm experience and soil type did not have a significant impact on any of the indigenous weed management strategies.

A statistically significant relationship was found among a number of indigenous pest management strategies and all demographic factors except labor type (Table 24). Experience of farmers was found to have a profound influence on the use of indigenous pest management practices such as pest monitoring, crop rotation, and use of rat traps. Size of farm holding was negatively correlated with the use of pest management practices such as crop rotation and community spraying. The demographic factor, irrigation type was positively correlated with the use of pest management strategy, "alternate wetting and drying of the soil" on the one hand, and negatively correlated with the strategy, "crop rotation" on the other hand. As access to irrigation increased, farmers use of the practice "alternate wetting and drying of the soil" also increased.

Table 25 shows the correlation among indigenous technical practices for groundnuts and demographic factors. Farming experience was found to have a significant impact on the use of indigenous technical practices for groundnuts. The technical practices, "sowing groundnuts in rice fallow," "intercultural operation," "using fire crackers," and "application of gypsum while sowing groundnuts" were positively correlated with farming experience. As farming experience increased, use of these practices also increased. Type of soil had a significant impact on the use of the practice, sowing groundnuts in rice fallow. Farmers who own clayey soils used this practice at increased rates.

Table 26 provides the correlation among indigenous technical practices for tapioca and demographic factors. Size of farm holding was found to have a negative correlation with the technical practice, "drain the tapioca fields frequently." At the same time, farming experience had a significant positive relationship with the same practice.

Table 22. Correlation among selected indigenous rice nutrient management strategies and demographic factors (n=137)

Indigenous rice nutrient management strategies	Demographic factors				
	Farmer type	Experience	Irrigation type	Relationship	Labor type
Application of neem cake	-0.1545	0.1733	0.1209	-0.0332	-0.0947
Avoiding top dressing of nitrogen during rainy days	-0.1746	0.0796	-0.1921	-0.1534	0.0655
Application of farm yard manure	-0.2277*	-0.1312	-0.1606	-0.1354	0.1583
Application of sheep manure	-0.2702*	0.1785	-0.0321	-0.1312	-0.1762
Application of <u>Teprosia populnea</u> leaves	-0.1629	0.1447	-0.1288	0.0771	-0.2026
		1.7manure			

* Significant at 0.05

Table 23. Correlation among selected indigenous weed management strategies and demographic factors (n=137)

Indigenous weed management strategies	Demographic factors				
	Farmer type	Farm experience	Irrigation type	Soil type	Labor type
Puddling rice nurseries followed by drying	-0.2462*	-0.0354	0.0162	0.1018	0.0969
Maintaining one inch of water	0.0955	0.1228	0.2226*	-0.0343	0.2085
Storing water for 15 days	0.2039	-0.0162	0.2341*	0.0675	0.2091
Closer spacing	0.2887*	0.0987	0.0988	-0.1881	-0.2776*
Raising the heights of field bunds	0.0098	0.1238	-0.0675	-0.1921	-0.1765

* Significant at 0.05

Table 24. Correlation among selected indigenous rice pest management strategies and demographic factors (n=137)

Indigenous rice pest management strategies	Demographic factors				
	Farmer type	Farm experience	Irrigation type	Soil type	Labor type
Pest monitoring	0.1441	0.4421*	0.0182	0.1023	0.0439
Crop rotation	-0.2667*	0.3843*	-0.2412*	0.0998	0.0532
Providing proper aeration	0.0821	-0.9321	0.0547	-0.2209*	0.0211
Nitrogen management	0.2012	0.1983	0.0829	-0.0376	0.0998
Alternate wetting and drying of the soil	0.0453	0.1234	0.2342*	-0.0621	-0.0886
Using rat traps	0.0054	0.2235*	0.0347	0.1765	0.0784
Community spraying	-0.2354*	0.0327	0.1325	-0.0654	0.0764

* Significant at 0.05

Table 25. Correlation among selected indigenous technical practices for groundnuts and demographic factors (n=137)

Indigenous technical practices for groundnuts	Demographic factors				
	Farmer type	Farm experience	Irrigation type	Soil type	Labor type
Sowing on 15th of Tamil month *Karthigai*	-0.1230	-.0006 0.80	-0.0148	0.1867	-0.2425*
Sowing in rice fallows	-0.2504	0.2984*	-0.0659	0.3259*	-0.0547
Intercultural operation	-0.2773*	0.3421*	0.0112	0.0987	0.1221
Using fire crackers	-.02334*	0.2561*	0.0321	-0.1937	-0.2443*
Application of gypsum while sowing	0.1985	0.3985**	0.1782	-.0008	-0.1032

* Significant at 0.05

Table 26. Correlation among selected indigenous technical practices in tapioca and demographic factors (n=137)

Indigenous technical practices in tapioca	Demographic factors				
	Farmer type	Farm experience	Irrigation type	Soil type	Labor type
Drain the tapioca fields frequently to prevent rotting of tubers	-0.2334*	0.2250*	0.0118	0.1215	-0.2469
Reduce the frequency of irrigation for tapioca in clayey soils	-0.0020	-0.0684	0.2145	0.2422*	-0.2073
Dip the tapioca tubers in clayey solution to prevent the tubers from rotting	-0.0076	0.0987	-0.0543	0.1132	0.2671*

* Significant at 0.05

Multiple regression analysis

One of the major applications of multiple regression in this study is the prediction of one or more characteristics of variables on the basis of knowledge about related characteristics. Stepwise Multiple Regression procedure, available in SPSS, was used. One of the objectives of this study was to determine the impact of selected demographic factors on the use of indigenous technical practices. To determine which of the demographic variables specifically influence farmers' use of indigenous technical practices, a stepwise multiple regression was performed. Multiple regression was used to predict which of the independent variables, the demographic factors, (farmer type, family size, soil type, irrigation type, farming experience, and labor type) contributed to the explanation of the variance of the dependent variables, the indigenous technical practices, (cropping systems, soil health care practices, rice seed processing techniques, rice nutrient management strategies, rice planting techniques, rice weed management strategies, rice pest management strategies, indigenous technical practices for groundnuts, and indigenous technical practices for tapioca).

The beta or standardized regression coefficient measures the number of standard deviations by which the dependent variables (indigenous technical practices) change for one standard deviation change in the independent variable (demographic factors). The larger the absolute value of beta, the greater is the effect on the dependent variable that is produced by a standard deviation change in the independent variable controlling for the other variables.

The Adjusted R^2 or coefficient of determination measures the proportion of the total variation in the dependent variable that is explained by the predictive power of the independent variables. The Adjusted R^2 is corrected for the number of cases and, in this respect, is a better estimate of the population value. The probability indicates whether the test is statistically significant.

Tables 27-31 show regression analysis of indigenous cropping systems influenced by demographic variables. The demographic variable, "farmer type" explains 11 percent of the variation in the cropping system, "sequential cropping" while "family size" accounts for an additional 3 percent of the variation (Table 27). None of the remaining independent variables made a significant contribution. Data from Table 28 show that the demographic variable, "soil type" with negative beta values, explain 6 percent of the variation in the cropping system, "mixed cropping." "Farmer type" had a positive effect on the use of the cropping system, "monocropping of rice." This variable accounts for 8 percent of the variation in "monocropping of rice." The demographic variable, "irrigation type" accounts for an additional 13 percent of the variation (Table 29). None of the remaining independent variables made a significant contribution.The demographic variable, "soil type" explains 11 percent of the variation in the cropping system, "intercropping" which accounts for 6 percent of the variation (Table 30. None of the remaining independent variables made a significant contribution.

Table 27. Regression analysis of "sequential cropping" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farmer type	-.35	.35	.11	.00
Family size	.21	.21	.03	.05

Table 28. Regression analysis of "mixed cropping" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Soil type	-.28	.28	.06	.04

Table 29. Regression analysis of "monocropping of rice" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farmer type	.31	.31	.08	.00
Irrigation type	.37	.37	.13	.00

Table 30. Regression analysis of "intercropping" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Soil type	-.28	.28	.06	.04

Table 31. Regression analysis of "crop rotation" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Soil type	-.24	.24	.05	.04

Tables 31-37 show regression analysis of indigenous soil health care practices influenced by demographic factors. The demographic variable, "soil type" was the best predictor of the dependent variable, "crop rotation" accounting for 5 percent of the variance (Table 31). None of the remaining variables made a significant contribution to explain the variability. The demographic variable, "farmer type" was the best predictor of the indigenous soil health care practice, "fallowing" accounting for 4 percent of the variance (Table 33). None of the remaining demographic variables made a significant contribution to explain the variability. The demographic variable, 'farm experience" was the best predictor of the indigenous soil health care practice, "farm yard manure application" accounting for 5 percent of the variance (Table 34). None of the remaining demographic variables made a significant contribution to explain the variability.

The demographic variable, "soil type" was the best predictor of the indigenous soil health care practice, "casuarina leaves application" accounting for 6 percent of the variance (Table 35). None of the remaining demographic variables made a significant contribution to explain the variability. The demographic variable, "farmer type" was the best predictor of the indigenous soil care practices, "sand application" and "plowing Daincha *in situ*" accounting for 11 percent and 3 percent of the variance respectively (Tables 36-37). None of the remaining demographic variables made a significant contribution to explain the variability in the above practices.

Table 32. Regression analysis of "fallowing" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farmer type	.22	.22	.04	.03

Table 33. Regression analysis of "farm yard manure application" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farm experience	.24	.24	.05	.04

Table 34. Regression analysis of "casuarina leaves application" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Soil type	.25	.25	.06	.05

Table 35. Regression analysis of "sand application" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farmer type	.34	.34	.11	.00

Table 36. Regression analysis of "plowing Daincha *in situ*" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farmer type	.18	.18	.03	.07

Table 37. Regression analysis of "healthy seed plot selection" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Labor type	-.44	.44	.19	.00

Tables 38-43 explain the regression analysis of indigenous seed selection and processing techniques influenced by demographic factors. "Labor type" had a predictive relationship explaining 19 percent of the variance in the indigenous seed selection and processing technique, "healthy seed plot selection" (Table 38). After "labor type" had been considered, none of the other demographic factors made a significant contribution. After "farmer type" is accounted for, none of the other demographic factors had a significant predictive relationship to the indigenous seed selection and processing technique, "removing the rogue plants" (Table 39). The demographic variable, "farm experience" had a predictive relationship explaining 8 percent of the variance in the practice,

Table 38. Regression analysis of "removing rogue plants" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farmer type	-.32	.32	.10	.00

Table 39. Regression analysis of "spreading *notchi* leaves on seeds" by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farm experience	.29	.29	.08	.05

Table 40. Regression analysis of "sieving rice seeds" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farmer type	-.25	.25	.06	.04

Table 41. Regression analysis of "manual threshing of rice seeds" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farmer class	-.42	.42	.17	.00

Table 42. Regression analysis of "farmer to farmer seed exchange" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farmer type	-.19	.19	.03	.07

Table 43. Regression analysis of "row planting of rice" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Labor type	-.32	.32	.10	.00

"spreading *notchi* leaves over the rice seeds." The analysis revealed that "farmer type" with negative beta values accounted for 10 percent of the variance. The demographic variable, "farmer type" was the best predictor of the indigenous seed selection and processing techniques, "sieving rice seeds," "manual threshing of rice seeds," and "farmer to farmer seed exchange" accounting for 6 percent, 17 percent, and 3 percent respectively. None of the remaining demographic variables made a significant contribution to explain the variability in the indigenous seed selection and processing techniques.

Tables 44-46 explain the regression analysis of indigenous rice transplanting techniques influenced by demographic variables. From the regression analysis in Table 44, labor type explained 10 percent of the variation in the indigenous rice transplanting technique, "row planting of rice." From Table 45, it is observed that the demographic variable, "farm experience" accounted for 12 percent of the variation in the technique, "planting aged seedlings." "Labor type" as a demographic variable contributed to the prediction, accounting for 4 percent of the variation in the practice, "pinch planting" (Table 46). The demographic variable, "irrigation type" had a predictive relationship explaining 14 percent of the variance in the practice, "planting 21 day old seedlings." None of the remaining demographic variables made a significant

Table 44. Regression analysis of "planting aged seedlings" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farm experience	.35	.35	.12	.00

Table 45. Regression analysis of "pinch planting" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Labor type	-.21	.21	.04	.06

Table 46. Regression analysis of "planting 21 day old seedlings" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Irrigation type	.38	.38	.14	.00

contribution to explain the variability in the indigenous rice transplanting techniques.

Data from Tables 47 show that the demographic variable, "farmer type" had a significant impact on the indigenous crop nutrient management practice, "sheep manure application" accounting for 7 percent of the variation. The data in Table 48 show that the demographic variable, "farmer type" had a significant impact on the indigenous crop nutrient management practice, "farm yard manure application" accounting for 4 percent of the variation. None of the remaining demographic variables made a significant contribution to explain the variability in the above indigenous crop nutrient management practices.

Tables 49-51 provide the regression analysis of indigenous weed management strategies influenced by demographic variables. The demographic variable, "farmer type" was the best predictor of the indigenous weed management strategies, "puddling rice nurseries" and "storing water" accounting for 7 percent and 5 percent of the variance respectively. The demographic variable, "irrigation type" was the best predictor of the strategy, "maintaining one inch water." None of the remaining demographic variables made a significant contribution to explain the variability in the above practices.

Table 47. Regression analysis of "sheep manure application" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farmer type	-.27	.27	.07	.05

Table 48. Regression analysis of "farm yard manure application" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farmer type	-.22	.22	.04	.05

Table 49. Regression analysis of "puddling rice nurseries" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farmer type	-.24	.24	.07	.05

Table 50. Regression analysis of "maintaining one inch water" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Irrigation type	.22	.22	.04	.05

Table 51. Regression analysis of "storing water" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farmer class	.23	.23	.05	.05

Tables 52-56 show the regression analysis of indigenous pest management strategies influenced by demographic variables. The demographic variable, "farm experience" was the predictor of the pest management strategy, "pest monitoring" accounting for 19 percent of the variation. The demographic variable, "farm experience" with negative beta values was the predictor of "crop rotation" accounting for 14 percent of the variance. "Farmer type" and "irrigation type" accounted for an additional 6 percent and 5 percent of the variations respectively. The demographic variable, "farm experience" had a significant impact on explaining the variabilities in the indigenous pest management practice, "using rat traps" accounting for 22 percent of the variations. None of the remaining demographic variables made a significant contribution to explain the variability in the above practices.

Table 52. Regression analysis of "pest monitoring" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farm experience	.44	.44	.19	.00

Table 53. Regression analysis of "crop rotation" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farmer type	-.26	.26	.06	.05
Farm experience	.38	.38	.14	.00
Irrigation type	-.24	.24	.05	.05

Table 54. Regression analysis of "nitrogen management" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farm experience	.19	.19	.03	.07

Table 55. Regression analysis of "using rat traps" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farmer type	.23	.23	.05	.05

Table 56. Regression analysis of "sowing on 15th of Tamil month *Karthigai* " influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Labor type	-.24	.24	.05	.05

Tables 57-58 explain the regression analysis of indigenous technical practices for groundnuts influenced by demographic variables. The variables soil type and farm experience were found to have a signficant relationship with that of the indigenous technical practices for groundnuts. "Soil type" had a predictive relationship explaining 10 percent of the variance in the indigenous technical practice, "sowing groundnuts in rice fallow." After "soil type" had been considered, none of the other demographic factors made a significant contribution. The demographic variable, "farm experience" had a predictive relationship explaining 11 percent of the variance in the practice, "intercultural operations in groundnuts."

Table 57. Regression analysis of "sowing groundnuts in rice fallows" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Soil type	.32	.32	.10	.00

Table 58. Regression analysis of "intercultural operations in groundnuts" influenced by demographic factors

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farm experience	.34	.34	.11	.00

Influence of Indigenous Technical Practices on Productivity

Correlational analysis

One of the objectives of this study was to determine the impact of indigenous technical practices on productivity. Table 59 shows the statistical relationship among selected indigenous technical practices and productivity with respect to rice and groundnuts. Seven indigenous technical practices in rice were found to have a positive relationship with productivity of rice. As the usage of these seven indigenous technical practices increased, the productivity also increased. Among these practices, sheep panning was found to have a statistically significant relationship with rice productivity accounting for an r value of .44. Followed by this practice, the indigenous technical practices such as row planting, using rat traps, and farm yard manure application were found to have a positive relationship with yield accounting for r values .28, .25 and .24 respectively (Table 59).

With respect to groundnuts, the indigenous technical practices, "intercultural operations" and "sowing of groundnuts on the 15th of Tamil month *Karthigai*" were found to have a positive relationship with the yield of groundnuts, accounting for r values of .29 and .28, respectively. In summary, certain indigenous technical practices

Table 59. Correlation between selected indigenous technical practices and productivity

Indigenous technical practices	Yield
Rice:	
Farm yard manure application	.2482*
Row planting	.2897*
Planting aged seedlings	.1876
Pinch planting	.1903
Sheep panning	.4453**
Nitrogen management	.1975
Using rat traps	.2516*
Groundnuts:	
Sowing on 15th of Tamil month *Karthigai*	.2830*
Sowing in rice fallows	.1928
Intercultural operations	.2964*
Application gypsum while sowing	.1812

**Significant at 0.01
* Significant at 0.05

Table 60. Regression analysis of productivity influenced by indigenous technical practices in rice

Variable	Beta	Multiple R	Adjusted R^2	Probability
Row planting	.28	.28	.06	.04
Planting aged seedlings	.18	.18	.03	.07
Pinch planting	.19	.19	.03	.07
Sheep panning	.44	.44	.19	.00
Nitrogen management	.19	.19	.03	.07
Using rat traps	.25	.25	.06	.04

adopted by farmers without outside initiatives proved to contribute significantly to crop yields.

Multiple regression analysis

A multiple regression analysis was performed to determine the best indigenous technical practice to predict the productivities of rice and groundnuts. The indigenous technical practice, "sheep panning" contributed to 19 percent of the variation in the yield of rice (Table 60). The other practices, "row planting", "planting aged seedlings", "pinch planting", "nitrogen management", "using rat traps" and "farm yard manure application" all together accounted for additional variations of 25 percent in the yield of rice.

With respect to groundnuts, "intercultural operations" had a predictive relationship explaining 6 percent of the variance in the yield of groundnuts (Table 60). The practices, "sowing of groundnuts on 15th of Tamil month *Karthigai*," "sowing of groundnuts in rice fallows," and "application of gypsum while sowing" all together accounted for additional variations of 12 percent in the yield of groundnuts. None of the remaining demographic variables made a significant contribution to explain the variability in the yield of groundnuts.

Influence of Indigenous Technical Practices on Sustainability

Correlational analysis

One of the objectives of this study was to determine the impact of indigenous technical practices on sustainability of the agricultural system. Table 61 shows the statistical relationship among selected indigenous technical practices and sustainability of the agricultural system. Five indigenous technical practices were found to have a positive relationship with sustainability of the agricultural system. Use of indigenous technical practices were taken as independent variables. Three factors that contribute to sustainability of the agricultural system in the region of Pondicherry were taken as dependent variables: "level of external input usage," "maintenance of soil fertility," and "sustaining ground water resources." First, the statistical relationship among the use of indigenous technical practices and sustainability factors were analyzed using a Pearson correlation procedure. A multiple regression procedure was conducted to determine the best indigenous technical practice to predict sustainability of agricultural system. Table 62 shows correlation between indigenous technical practices and sustainability of the agricultural system. The indigenous technical practice, "sheep panning" was found to have a significant positive correlation with the sustainability factor "maintenance of soil fertility" on the one hand and negatively correlated with the sustainability factor, "external input usage" on the other. Use of "sheep panning" significantly decreased the

Table 61. Correlation between selected indigenous technical practices and sustainability of the agricultural system

Indigenous technical practices	Sustainability factors		
	External inputs usage	Maintaining soil fertility	Sustaining ground water resources
Using rat traps	-.4564**	-.1120	.0934
Sheep manure application	-.8660**	.2364*	-.1741
Crop rotation	-.1127	.4348**	.2382
Farm yard manure application	-.3333**	.2124	-.0112
Using stream water for irrigation	.0986	-.1546	.7845**

**Significant at 0.01
* Significant at 0.05

"use of external inputs." As the use of "sheep panning" increased, "soil fertility" also increased.

The indigenous technical practice, "crop rotation" was found to have a positive correlation with the sustainability factor, "maintenance of soil fertility." The practice, "farm yard manure application" was negatively correlated with external input usage. Not surprisingly, the indigenous practice, "supplementing stream water for irrigation" positively correlated with the sustainability factor "sustaining ground water resources." In other words, the rate of depletion of groundwater is slow in farm holdings where farmers supplemented the irrigation with stream water.

Multiple regression analysis

Tables 62-64 show the regression analysis of sustainability of agricultural system influenced by indigenous technical practices. The indigenous technical practice, "farm yard manure application" was the best predictor of the sustainability factor, "external input usage" accounting for 18 percent of the variation (Table 62). The indigenous technical practice, "sheep panning" was the best predictor of the sustainability factor, "maintenance of soil fertility" accounting for 18 percent of the variance (Table 63). The indigenous technical practice, "crop rotation" explains an additional 10 percent of the variation in the sustainability factor, "maintenance of soil fertility." None of the remaining demographic variables made a significant contribution to explain the variability.

The indigenous technical practice, "using stream water for irrigation" had a predictive relationship explaining 19 percent of the variance in the sustainability factor, "sustaining groundwater resources" (Table 64). After "using stream water for irrigation" had been considered, none of the other indigenous technical practices made a significant contribution to explain the variability.

Table 62. Regression analysis of "external input usage" influenced by "farm yard manure"

Variable	Beta	Multiple R	Adjusted R^2	Probability
Farm yard manure	-.45	.45	.18	.00

Table 63. Regression analysis of "maintaining soil fertility" influenced by "sheep panning" and "crop rotation"

Variable	Beta	Multiple R	Adjusted R^2	Probability
Sheep panning	.38	.38	.14	.00
Crop rotation	.33	.33	.10	.00

Table 64. Regression analysis of "sustaining groundwater resources" influenced by "using stream water for irrigation"

Variable	Beta	Multiple R	Adjusted R^2	Probability
Using stream water for irrigation	-.44	.44	.19	.00

Summary of Findings

The following statements summarize the major findings of this investigation:

1. The study villages, Sivaranthakam, Kizhur, and Pillayarkuppam, consist mainly of irrigated wet lands. Agriculture in these villages is supported by water storage tanks and private tubewells;

2. Rice is the major food crop in the study villages. *Ragi* (finger millet) and *bajra* (pearl millet) are grown in smaller extents. Casuarina, sugarcane, groundnuts, tapioca, and cotton are the major cash crops. Vegetables, such as chillies and *brinjal* (egg plant), are also grown in small areas;
3. Based on land ownership pattern, farmers were classified into three types: marginal farmers, small-scale farmers, and large-scale farmers. The average age of participant farmers was found to be 43.4 years. The average experience of the participant farmers was observed to be 28.3 years;
4. Clayey soils and sandy loam soils form the major soil types in the study villages;
5. Tubewells form the major source of irrigation in the study villages. Fifty-two percent of the farmers own private tubewells and thirty nine percent of the farmers depend on tubewell owners for irrigation on a rental basis. Family labor, non-family labor, and scheduled caste labor were the three types of labor arrangements existed in the study villages;
6. Participant farmers agreed most on the factor influencing indigenous decision-making that "farmers consult their neighbors before choosing a particular crop for planting." Seven out of ten factors influencing indigenous decision-making systems received neutral ratings. Participant farmers strongly agreed with fifteen out of nineteen statements pertaining to indigenous knowledge. Farmers strongly agreed that "lodging in rice variety *ponni* leads to chaffy grains";
7. With respect to indigenous technical practices, participant farmers agreed with most of the statements in the areas of "indigenous crop nutrient management strategies" and "indigenous rice weed control techniques." Most of the

indigenous technical practices pertaining to "indigenous rice seed selection and processing technique" received neutral ratings. Participant farmers disagreed with three out of ten statements regarding "indigenous rice pest management strategies";

8. A one-way analysis of variance revealed significant statistical differences for only one out of ten areas of indigenous technical practices;
9. Type of participant farmers was found to have a significant relationship with the perceptions of participant farmers regarding the use of indigenous technical practices;
10. Type of participant farmers significantly contributed to the explanation of the variations in the use of indigenous technical practices. Irrigation type, labor arrangements, and farming experience of the participant farmers also contributed to the explanation of the variations in the use of indigenous technical practices;
11. It was found that as the use of sheep panning increased, the productivity of rice also increased. With respect to groundnuts, as the use of indigenous intercultural operations increased, the productivity of groundnuts also increased; and
12. Sheep panning was the best predictor to explain the variabilities in soil fertility. Using rat traps significantly contributed to the explanation of the variations in the sustainability factor, external input usage. Using stream water for irrigation was the best predictor to explain the variabilities in the sustainability factor, sustaining groundwater resources.

CHAPTER V. DISCUSSION

The purpose of the study was to formulate a methodological framework to incorporate indigenous knowledge systems into agricultural research and extension organizations for sustainable agricultural development in India. The specific objectives of the study were: (1) To determine the extent to which farmers agreed with selected indigenous decision-making systems; (2) To determine the extent to which statements regarding indigenous knowledge systems are believed to be true by farmers; (3) To determine the extent to which selected indigenous technical practices are being used by farmers; (4) To determine the relationship between selected demographic factors and indigenous technical practices; (5) To determine the influence of selected indigenous technical practices on productivity; (6) To determine the influence of selected indigenous technical practices on sustainability; and (7) To develop a methodological framework for incorporating indigenous knowledge systems into agricultural research and extension organizations..

This chapter is divided into two major sub-chapters:

1. Discussion of findings
2. Development of a framework for incorporating indigenous knowledge systems into agricultural research and extension organizations.

Discussion of Findings

Indigenous decision-making systems

Most of the selected factors influencing decision-making systems were not highly supported by participant farmers. This information indicates that there exists numerous factors other than the selected ones that influence decision-making. However, farmers belonging to a particular group almost responded uniformly. For instance, most of the marginal farmers who depend on rental water for irrigation supported the factor, "poor access to irrigation influences the planting of casuarina."

The participants supported the factor, "farmers consult their neighbors before choosing a particular crop for planting." It was interesting to learn that some farmers used to observe their neighbor's fields before choosing their crop for planting though they do not consult their neighbors formally. For example, farmers have abstained from planting a rice crop after they found casuarina tree seedlings planted in their neighbor's farm. The farmers claimed that shade produced by the casuarina trees would result in poor tillering in the rice crop. According to the participant farmers, consulting with neighbors also contributed to minimize pest incidence and crop theft.

The participant farmers indicated that they used to plant tapioca and groundnuts on a community basis as a measure to check crop theft. These farmers felt if they plant any food crops on an individual basis, it would be vulnerable to theft. Stealing food crops such as maturing groundnut pods, sugarcane stems, and tapioca tubers, has almost become an accepted activity in the study villages. Richards (1986) also observed a similar social problem in Sierra Leone. Small-scale farm families who have grown-up boys did not have the crop theft problem since the boys took care of the crops during evenings and nights. According to the participants, the groundnuts need round the clock watch especially after the peg formation stage. It is important that these socio-cultural factors should be taken into consideration while conducting research at *Krishi Vidyan Kendra* (KVK), the regional agricultural research station for the Union Territory of Pondicherry.

Most of the large-scale farmers supported the factor, "access to irrigation influences monocropping of rice." According to them, the following reasons have attributed to their strong inclination towards monocropping of rice: (a) availability of permanent laborers; (b) contacts with rice merchants in the towns; (c) need food for permanent laborers;

and (d) adequate access to irrigation water since they own tubewells. Small-scale farmers preferred to diversify their cropping pattern in order to meet their food as well as cash requirements. For instance, small-scale farmers generally plant sugarcane in one parcel (to meet their cash requirements) and rice in another parcel (for food and cattle feed requirements). Farmers with sandy loam soils use a well-diversified cropping pattern when compared to their counterparts with clayey soils. Nikhade et al., (1987) supported these findings.

Small-scale farmers supported the factor, "need for fuel wood influences the planting of tapioca." This finding was in accordance with the findings of Schultz (1989). They asserted that tapioca stems harvested from one acre of land generally cater to fuelwood requirements for nine months. In addition, handling and use of tapioca stems are relatively easier for women while cooking. The following factors have influenced farmers to grow casuarina: (1) Fixing the price of casuarina is easier when compared to other crops. Since casuarina is a tree, one farmer expressed, "every day of delay in cutting the trees, increases its cash value." The same is not true in the case of any other food crops such as rice, sugarcane, groundnuts, or tapioca. Moreover, the farmers have to depend solely on merchants and middlemen in order to market the surplus rice or sugarcane; (2) Inadequate access to irrigation also influences farmers to plant casuarina.

The following socio-cultural factors appeared to have some influence on farmers' decision-making while choosing a particular crop or variety for planting: neighbors' crops, farm household requirements (food, fodder, and fuel), women's preferences, demand in the market, traditional food habits, cost of purchased inputs, crop theft problem, access to irrigation, and availability of labor. Nazara-Sandoval (1988) also identified several of these factors in her study. Hence, it is necessary for outsiders to have a thorough knowledge of the factors that impinge on farmers' decision-making systems. Reijntjes et al., (1992, p.112) supported the premise by stating that, "to help farmers develop farm systems that suit the local biophysical and human setting, outsiders must achieve some understanding of how decisions are reached by the farmers and the logic behind them."

Indigenous knowledge statements

Farmers are highly knowledgeable regarding the characteristics of different varieties of rice. Farmers in this study possessed almost uniform perception about the performance of different rice varieties. For instance, almost all the farmers perceived that "lodging is a major problem with rice variety *ponni*" and "cost of cultivation for rice variety *ponni* is low." Farmers also provided other interesting feedback information about rice varieties: (1) Severe pest infestation limits the use of rice variety *jawahar*; (2) Rice variety *mangala* is a moderately pest resistant variety; and (3) Rice variety CO.43 is suitable for alkaline soils. These findings are examples of feedback information regarding rice varietal characteristics for research/ extension.

Diffusion of rice varieties into the study villages was made possible by the efforts of farmers. Farmers such as Krishnan, Padmanaba Reddiyar, and Rangan Reddiyar have conducted informal varietal testing for rice varieties such as ADT 38, ADT 39, and *mangala* in the study villages. This finding was supported by Rhoades and Bebbington (1988) and Richards (1986) who stated that farmers are expert experimenters with genetic materials. Maurya (1989) also supported the findings by stating that the rice variety *mahsuri* spread from Andhra Pradesh to Madya Pradesh through farmer-to-farmer extension.

Indigenous cropping systems

The agricultural practice, "groundnuts are sown after the harvest of rice" was highly supported by farmers with clayey soil. According to these farmers, this practice has the following advantages: (1) By sowing groundnuts during the rice fallow, farmers skip the initial irrigation;

and (2) Groundnuts utilize the moisture left over by the previous rice crop. The agricultural practice, "sequential cropping of black gram, green gram, and sesamum in casuarina fields" was highly supported by marginal farmers. Inadequate irrigation facilities formed the rationale behind this practice. Moreover, marginal farmers with more family members indicated that they preferred to adopt sequential cropping of black gram, green gram and sesamum since these crops meet protein and vegetable oil requirements of their households. However, farmers with adequate irrigation facilities did not adopt sequential cropping. They felt that the sequential crops might interfere with their main crop, namely casuarina.

The cropping system, "intercropping of cotton and groundnuts" was supported moderately. Farmers with sandy loam soils practice intercropping of cotton and groundnuts. These farmers felt that the profits obtained from cotton and groundnuts were more or less equivalent to that of sugarcane, a cash crop that matures in ten month. Some farmers expressed the opinion that they practice intercropping to reduce pests in groundnuts. This finding was supported by Altieri (1990): intercropping can interfere with the population development and survival of insect pests because intercrops block their dispersal across the field. On the other hand, farmers whose soil type is clayey reported that practicing intercropping was difficult with their soils. Hence, it can be concluded that farmers with clayey soils did not practice intercropping.

The cropping system, "mixed cropping of black gram, green gram, and cow pea" was also supported moderately. This might be due to the fact that only farmers who own sandy loam soils with poor irrigational facilities preferred the mixed cropping system. These farmers claimed that mixed cropping is an insurance against risks. Some marginal farmers who also worked as laborers were also in favor of mixed cropping. They further indicated that this practice enabled them to assume off-farm labor activities. It was interesting to observe from the field that both groups of farmers use neither fertilizers nor pesticides for the intercrops. Their crop production strategy was to reap the harvest by keeping the cost at a minimum. However, few farmers felt that infestation of weeds was severe in mixed cropping fields. The farmers indicated that they save grain from mixed cropping for demand periods since they depend on their cash requirements from off-farm occupations.

The agricultural practice, "border cropping of legumes in the bunds of rice" was not supported by farmers. One might expect this reaction because of the socio-cultural problems such as crop thefts and cattle menace. The farmers feared that the crops grown in the field bunds would be more vulnerable to theft and cattle menace. Devaraj (1988) also observed similar fears elsewhere. Some other farmers opined that growing legumes in the rice bunds might interfere with farm operations such as application of fertilizers and pesticides.

Indigenous soil health care practices

Farmers who possessed more than 15-20 years of farming experience realized the importance of farm yard manure in maintaining soil fertility. According to them, the farm yard manure loosens the soil and is thus a good remedy for solving soil compaction problems. It also prevents soil erosion to a certain extent. Hence, experienced farmers strongly supported the application of farm yard manure. It was surprising to find that most of the large-scale farmers raised cattle more for the manure value than for the milk value. One large farmer casually expressed, "I can buy milk even at the village milk depot. Where can I go for farm yard manure?" However, a few large-scale farmers in Sivaranthakam purchase farm yard manure from landless laborers who rear cattle as an off-farm occupation.

One large-scale farmer in Sivaranthakam predicted that the rate of application of farm yard manure would be considerably reduced in the years to come since younger generations of labor families generally are reluctant to do menial jobs such as collecting and storing cattle dung from cattle stalls. Hence, the cattle population in large-scale farm households has considerably reduced in Sivaranthakam. On the other hand, the cattle population in Pillayarkuppam has considerably increased recently due to the efforts of a well-organized village-level milk cooperative society. This case illustrated the role of local organizations in sustainable agricultural projects at the village-level.

Irrespective of farmer type and village, farmers supported the practice, "aerating the soil helps to maintain and enrich the soil." According to the farmers, aerating the soil is an indigenous technique of exposing the soil to sunlight for 15 to 30 days after harvest. However, the number of days for aerating the soil greatly depends on availability of labor and availability of irrigation water for planting crops during the next season.

Some marginal farmers indicated that sheep manure was more effective than farm yard manure. They also reported that there were two sources of sheep manure. Some marginal farmers raised sheep for their market and manure value. Large-scale and small-scale farmers adopted the sheep panning activity. According to these farmers, there are chances that use of sheep panning would be reduced to a greater extent in the years to come. Others provided reasons for a possible reduction in the sheep panning activity: (1) younger generations of sheep herders are reluctant to take up sheep herding and (2) browsing of standing crops by sheep. These farmers also pinpointed a few occasions where the sheep menace created misunderstanding among host farm families and the farmers whose crops were browsed by sheep.

The farmers were not in favor of the practice, "application of neem leaves will correct soil alkalinity." This might be due to the fact that area under trees in the study villages were considerably reduced. The practice, "plowing Daincha *in situ*" was moderately supported. "Plowing Daincha *in situ* after 45 days from planting" was strongly supported by large-scale farmers since this practice increased the soil fertility significantly. However, small-scale and marginal farmers made it clear that they could not wait 45 days for Daincha to grow. In other words, they preferred to use these 45 days to grow food crops to meet the ever growing demands of food.

Indigenous rice seed selection and processing techniques

It is clear from the findings that farmers depend on informal local sources of seeds rather than the public seed distribution system for obtaining seeds. Rajasekaran and Warren (1992) gave an elaborate treatment on the causes for problems in obtaining quality rice seeds elsewhere. In Pillayarkuppam, farmers used rice seeds for the first three seasons and before the end of the third season, they looked for new seeds by making informal visits to their neighboring farms or friends in other villages. Most of the small-scale and marginal farmers depend on two or three large-scale farmers for seeds. These large-scale farmers are seed producers who meet 18 percent of seed requirements in Sivaranthakam and Kizhur villages. In spite of the existence of the informal farmer-to-farmer seed exchange system, a number of farmers face problems in obtaining quality seeds. Raising village-level seed farms in coordination with large-scale farmers might solve this problem. Richards (1986) supported this recommendation by stating that the formation of local-level seed multiplication units would solve the problems in the supply of quality rice seeds.

Large-scale farmers supported the indigenous seed processing technique, "removing the rogue plants 25 days before harvesting." They further stated that availability of permanent laborers would enable them to adopt such labor intensive practices. Marginal and small-scale farmers preferred to thresh rice seeds manually to maintain the seed quality. Irrespective of farmer types, most of the farmers believed that the indigenous rice seed processing techniques have contributed to: (1) prevention of admixture of weed seeds; (2) prevention of the admixture of other rice seed varieties; (3) increase in the germination potential of rice seeds.

Indigenous rice transplanting techniques

Most large-scale farmers supported the practice, "row planting of rice variety *ponni.*" Though small-scale farmers were also aware of the impact of row planting on tiller production, they could not adopt the practice due to problems in securing the labor since row planting is a labor intensive activity. Large-scale farmers, not surprisingly, had more control over laborers when compared to the other two groups of farmers. Most of the experienced farmers supported the practice, "planting aged seedlings of rice variety *ponni.*" This finding contradicts the recommendation of the research-extension system, 40-45 day old seedlings should be transplanted in the case of rice variety *ponni*. Some experienced farmers even use 60 day old seedlings for transplanting. These farmers argued that planting aged seedlings would prevent the crop from lodging during maturity.

It was interesting to find that irrespective of farmer type, farmers plant 21 day old seedlings of the rice variety *mangala*. On the other hand, the research-extension system recommended that 25-30 day old seedlings should be transplanted in the case of *mangala*. Many farmers claimed that they obtained at least one bag of additional paddy (1 bag=75 kilograms) if they plant 21 day old seedlings of *mangala*.

The indigenous rice transplanting techniques, pinch planting and clump planting, were moderately supported by farmers. Pinch planting, locally known as *killi poduthal,* is the process of transplanting rice using 3-5 seedlings per hill. Farmers used to adopt pinch planting under the following conditions: (1) if the season is *navarai*; (2) if wage labor arrangement is followed; and (3) if the seedlings are robust. On the other hand, clump planting locally known as *pudichi poduthal,* is the process of transplanting rice using 6-8 seedlings per hill. Farmers usually adopt clump planting under the following conditions: (1) if the season is *samba*; (2) if a contract labor arrangement is followed; and (3) if the seedlings are lean and lanky. The farmers comparing these two methods stated that the pinch planting method contributed to yield increase whereas the clump planting reduced their cost of production. The correlational analysis showed that pinch planting had a significant impact on increasing the number of productive tillers. Recently, farmers employed contract laborers to get the work done in time and also to avoid negotiations. Under the contract labor arrangements, laborers preferred to finish the work earlier and move out of the field. They are not willing to transplant by pinch planting. On the other hand, if farmers pay them on a daily basis, they tend to slow down the work. This ends up being more cost and strenuous for the farmers.

Agronomists who conduct on-farm research trials must take into account these socio-cultural factors imbedded in the rice transplanting practices. Normally, labor is not a problem in research stations. Researchers employ a band of permanent laborers working for them. The laborers in the research stations are paid relatively higher than on farms and are prepared to put in any amount of hard work. Hence, it is very difficult to comprehend the socio-cultural constraints prevailing in actual farming conditions.

Indigenous rice nutrient management practices

Small-scale and marginal farmers highly supported the nutrient management practices, "application of farm yard manure and "application of sheep manure." They observed significant increases in the yield of rice where farm yard manure or sheep manure was applied. Few marginal farmers indicated that they owned sheep dung mainly for the manure value. These farmers also reported that application of sheep manure enabled them to substitute chemical fertilizers basally.

Irrespective of farmer type, the participant farmers avoided top dressing of nitrogen during rainy days. They found that use of nitrogenous fertilizer during rainy days induced the vegetative growth of the rice crop that resulted in lodging of the whole crop during the maturity. This information shows that knowledge possessed by farmers regarding the inter-relationships between the rice crop and its environment should be taken into consideration while conducting fertilizer response trials. The participant farmers did not support the nutrient management practice, "application of *Teprosia populnea* leaves as a green manure." They further indicated that reduction in the area under trees did not allow them to apply the tree leaves as a green manure. However, a few large farmers grew *Teprosia* trees especially for their manure value.

Indigenous rice weed control techniques

Indigenous rice weed control techniques could be broadly classified into weed control in the nursery area and weed control in the main field. Water management in the nursery and in the main field played a key role in effective control of weeds. It was found that use of weed control techniques were greatly influenced by the type of irrigation. Farmers who own tubewells have controlled irrigation and hence, they adopted the weed control techniques at a higher rate. On the other hand, farmers who depend on rental irrigation could not adopt all the weed control techniques since they depend on tubewell owners for irrigation. Closer spacing as a strategy to control weeds was not supported by marginal and small-scale farmers since closer planting required more labor.

Indigenous rice pest management strategies

Use of the rice variety *mangala* was highly supported by farmers due to its pest resistance value. A few farmers found that practice of crop rotation significantly reduced the pest incidence in rice. Use of local rat traps to control rats was highly supported. Irrespective of farmer types, farmers use the rat traps to control the rats. The farmers asserted that the local traps are highly cost effective and also environmentally friendly. Farmers' strong support for the pest management strategies, "apply pesticides immediately when the first earhead is seen", "alternate wetting and drying reduces brown plant hopper incidence," and "providing aeration to manage the attack of brown plant hopper" showed their affinity towards integrated pest management (IPM) strategies (Gopalakrishnan and Vijayalakshmi, 1989). However, a significant number of farmers depends mainly on chemical pesticides.

Not surprisingly, experienced farmers possessed an in-depth knowledge of pest scouting and pest monitoring activities. These farmers were also familiar with the relationships between pest occurrence and weather pattern. For instance, one seventy-six year old farmer in Kizhur village indicated that the incidence of brown plant hopper would be severe before the occurrence of a north-east monsoon. Though the small-scale and marginal farmers adopted the practice of community spraying, the large-scale farmers were not interested in this practice. They perceived that it is below their social status and prestige to talk to the marginal farmers to discuss this situation. Entomologists who work on IPM research should conduct experiments to validate these indigenous pest management strategies.

Using rat traps was found to have a significant impact on rice productivity and sustainability of the agricultural system. Farmers indicated that approximately 32 percent of grain loss was due to rat damage and installation of local rat traps certainly saved their rice grains. At the same time, using local rat traps completely substituted rodenticides and thus contributed to the concept of low external-input agriculture.

Indigenous technical practices for groundnuts

The practice, "intercultural operations in groundnuts" was highly supported. It is interesting to understand the rationale behind the use of this practice and also its contribution to groundnut yield.

Some farmers in Kizhur village have innovated the practice of heaping and pressing the soil closer to groundnut plants up to a height of 3-4 inches from the soil surface. This practice results in increasing the rate of peg formation which consequently leads to higher yields in groundnuts. The practice of intercultural operation slowly diffused into Sivaranthakam and Pillayarkuppam villages. This is a good example to show how innovations diffused from farmer-to-farmer in an informal manner. The rationale behind farmers' practice of sowing groundnuts on the 15th of Tamil month *Karthigai* is that this practice significantly increased their yield.

A framework for Incorporating Indigenous Knowledge Systems into Agricultural Research and Extension Organizations

It is evident from the study that farmers possess a bountiful knowledge with respect to agricultural practices. The study also showed that some indigenous knowledge systems are found to contribute significantly to productivity and sustainability of the agricultural system. It is also essential that these knowledge systems should be systematically incorporated into research and extension organizations if we are to achieve sustainable agricultural development. Kaimowitz (1992: 112) stated that "as the velocity of technological change in the world's agriculture accelerates, extension services' existing stock of information becomes outdated much more rapidly, and greater attention will have to be paid to research on other sources of technology."

A conceptual framework incorporating indigenous knowledge systems is required if we are to intervene effectively in agricultural technology systems (Roling and Engel, 1992; Slikkerveer, 1992). A framework for incorporating indigenous knowledge systems into agricultural research organizations was developed based on certain principles laid out by Rhoades and Booth (1982), Collinson (1987), Chambers et al., (1989), Warren (1989), Biggs (1990), Fujisaka (1991), Rajasekaran et al., (1991), and den Biggelar (1991). The overall purpose of the framework is to strengthen the capacities of research at the regional level, public sector extension, and non-governmental organizations (NGOs) to develop and disseminate sustainable farmer-oriented agricultural technological options.The framework attempts to address certain research questions raised by Warren (1992c: 2): "How can indigenous agricultural knowledge be better integrated into FSR/E activities and the Training and Visit extension system? How can indigenous knowledge components be added into socio-economic soundness analyses for project identification and design exercises? What is the potential role of indigenous communication channels for the extension process?"

This framework is not intended to be a substitute for the existing transfer-of-technology model. Rather, it is a complementary process that aims at exploring methods to build on farmers' own knowledge while developing and disseminating sustainable agricultural technologies. In other words, the framework has not been designed to replace the existing research-extension system; rather it is an innovative interface among farmers, researchers, extensionists, and NGO representatives.

The framework is broadly divided into following components:

1. Rationale for the framework;
2. Training on indigenous knowledge systems;
3. Technology development by incorporating indigenous knowledge into agricultural research organizations;
4. Technology development by incorporating indigenous knowledge into agricultural extension organizations;
5. Strengthening indigenous organizations by utilizing NGOs;
6. Technology dissemination and utilization; and
7. Summary

Rationale for the Framework

Despite continuous importance given to linkages between research-extension-farmer while developing, disseminating, and utilizing sustainable agricultural technological options, several socio-political and institutional factors act as constraints for such an effective linkage (Oritz et al., 1991). After a decade of rhetoric about feedback of farmers' problems to extension workers and scientists, a large gap remains between the ideal and reality (Haugerud and Collinson, 1991). Kaimowitz (1992: 105) provided illustrations to support the above statement:

> Researchers perceived extension agents and institutions to be ineffective and unclear about their mandate, making researchers reluctant to work with extension. When researchers did work with extension agents, they tended to look down on them and view them as little more than available menial labor, an attitude strongly resented by the extension workers.

Keeping these potential field constraints in view, a framework has been developed with the following salient features:

1. strengthening the capacities of regional research and extension organizations;
2. building upon local people's knowledge that are acquired through various processes such as farmer-to-farmer communication, and farmer experimentation;
3. identifying the need for extension scientist/ social scientist in an interdisciplinary regional research team;
4. formation of a sustainable technology development consortium to bring farmers, researchers, NGOs, and extension workers together well ahead of the process of technology development;

5. generating technological options rather than fixed technical packages (Chambers et al., 1989);
6. working with the existing organization and management of research and public sector extension;
7. bringing research-extension-farmer together at all stages is practically difficult considering the existing bureaucracies and spatial as well as academic distances among the personnel belonging to these organizations;
8. utilization of the academic knowledge gained by some extension personnel (subject matter specialists) during the process of validating farmer experimentation;
9. outlining areas that research and extension organizations need to concentrate on during the process of working with farmers.
10. understanding that it is impractical to depend entirely on research stations for innovations considering the inadequate human resource capacity of the regional research system.

Chambers and Jiggins (1987, p.5) supported the need for such a framework:

1. The transfer of technology model fits badly with the needs and priorities of resource-poor farmers.

2. Agricultural extension programs are still biased towards techniques and strategies which are capital-intensive.

3. Resource-poor farmers are scattered and are not able to make their needs and priorities readily known and felt.

4. The TOT model cannot easily handle the complex interactions of RPF farming; links between crops, especially with intercropping and multiple tiers; agro-forestry and livestock-crop-tree complementaries; and the progressive

adjustments required in the field in the face of seasonal and inter-annual fluctuations.

Training on Indigenous Knowledge Systems

Establishing a national indigenous knowledge resource center forms the starting point for the entire framework (Warren, 1992a). The resource persons in the national IK resource center will provide training on the methodologies for recording indigenous knowledge systems. The concept of establishing national resource centers was developed by Professor Michael Warren, Director of the Center for Indigenous Knowledge for Agriculture and Rural Development (CIKARD). He has pioneered the establishment of 10 national indigenous knowledge resource centers so far in Nigeria, Mexico, Philippines, Indonesia, Ghana, Kenya, Sri Lanka, and the Netherlands. The functions of national IK resource centers include (Warren, 1992a):

1. Provide a national data management function where published and unpublished information on indigenous knowledge are systematically documented for use by development practitioners;
2. Design training materials on the methodologies for recording indigenous knowledge systems for use in national training institutes and universities;
3. Establish a link between the rural people of a country who are the originators of indigenous knowledge and the development community;
4. Facilitate the active participation of rural people in the conservation, utilization, and dissemination of their specialized knowledge through *in situ* knowledge banks, involvement in research and development activities, farmer-to-farmer training, and farmer consultancies; and

5. Act as a two-way conduit between the indigenous knowledge-based informal research and development systems and formal research.

Training on indigenous knowledge systems should be conducted in two stages. Initially, the resource persons of the national IK resource center will organize training of trainers workshops. Extension trainers of regional extension training institutes and extension education institutes of agricultural universities from various regions of the country form the target audiences for these workshops. As a second stage, regional extension trainers are expected to provide similar training programs for district-level subject matter specialists. In parallel, extension educators of extension education institutes of the agricultural universities should conduct training programs for research scientists on the methodologies for recording indigenous knowledge systems.

A training manual is essential for introducing the methodologies for identifying and recording indigenous knowledge systems. The methods and contents of training on recording IKSs should be based on the peasant forms of communication which are related to rural, everyday life, which has its own seasonal and life rhythms (Salas and Tillman, 1989; Frio, 1991). Monthly zonal workshops and bi-weekly training programs can be used as forums for conducting the training programs under the extension setting. Separate in-service training programs should be organized for research scientists either at the state-level or regional level. Kerr and Sanghi (1991) emphasized that training on IKSs has to be preceded by a change in attitudes and behavior towards the farmers. The process of attitude change has to start from

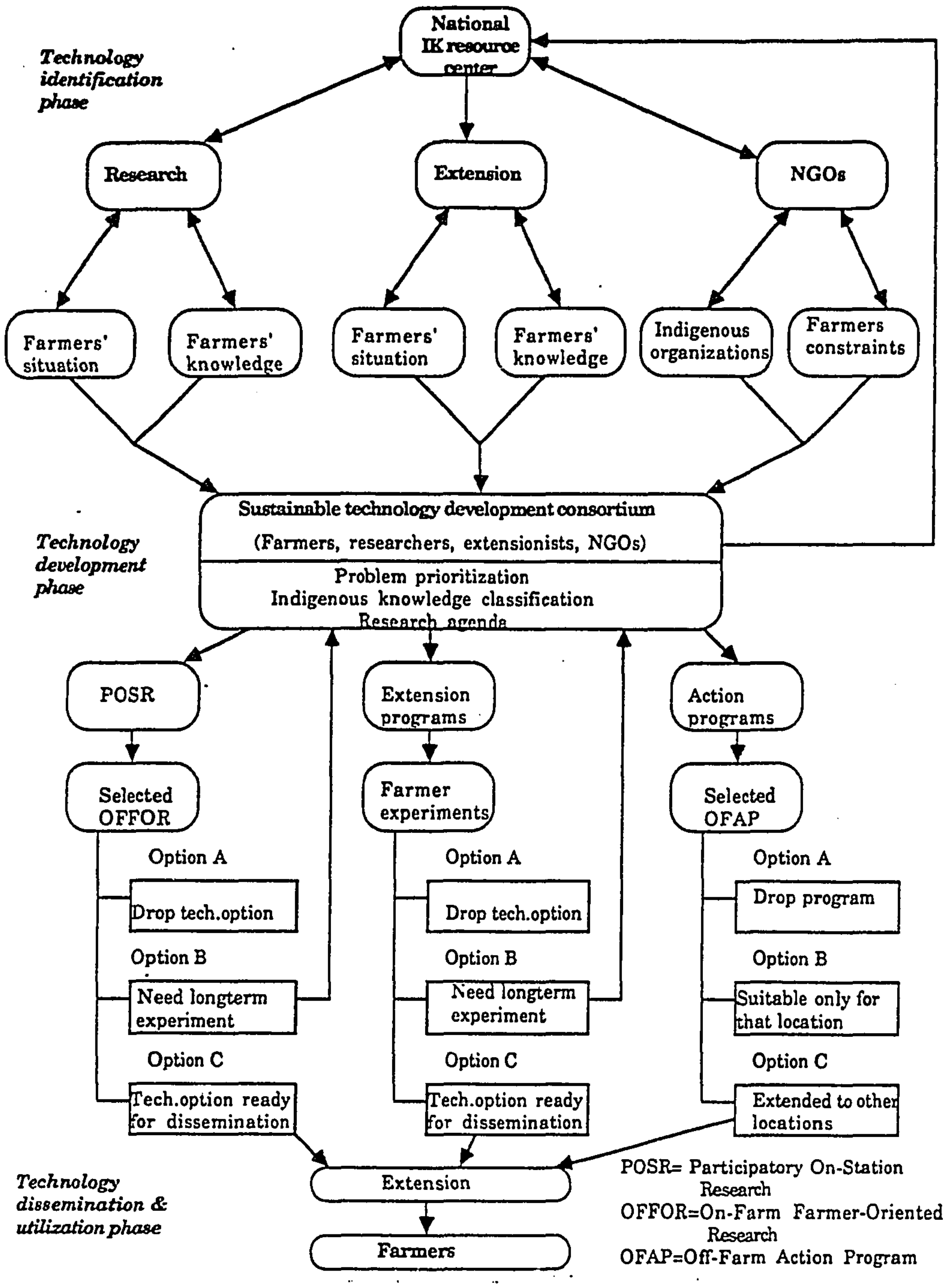

Figure 11. A framework for incorporating indigenous knowledge systems into agricultural research and extension organizations

the top, from teachers in universities to policy makers/ implementers in government.

Technology Development by Incorporating Indigenous Knowledge Systems into Agricultural Research Organizations

Need for an inter-disciplinary approach

Krishi Vidyan Kendra (KVK), the regional research station for the Union Territory of Pondicherry, is responsible for developing agricultural technologies related to disciplines such as plant breeding, agronomy, entomology, soil science, and plant pathology. There are approximately twenty agricultural scientists working in this station. There is no social scientist or extension scientist working in this station, nor, for that matter, in any other regional research station in south India. The proposed framework recommends that a social scientist/ extension scientist should be recruited to work with KVK. He/she is expected to play a key role in linking the research mandates with those based on farmers' perceptions. In the farmer-back-to-farmer model, Rhoades and Booth (1982) provided a specific case to show how incorporating social scientists in an interdisciplinary research team would bring farmers' perceived needs and problems into the research agenda.

Identifying problems

Problem identification forms the first step during the process of developing sustainable agricultural technologies. Problems are biological as well as socio-cultural limiting factors or inefficiencies in the use of resources that restrict the productivity or sustainability of a farming system (Tripp and Woolley, 1989). Problems should be identified jointly by biological scientists, and social scientists in consultation with farmers. During this stage, farmers' perceptions regarding needs and priorities should be taken into account. Farmers should be viewed as co-researchers, developers, and extensionists who can provide crucial inputs to determine what problems to address and how to proceed (Chambers et al., 1989).

Working with various groups of local people separately is important while identifying problems since each group of local people perceive the same problem differently. For instance, women laborers in the study area perceived that transplanting rice using 2-3 seedlings is a time-consuming as well as laborious process, hence they prefer to use more than 5 seedlings for transplanting. On the other hand, farmers perceived that transplanting rice using more than 5 seedlings reduces rice yield significantly.

The social scientist in coordination with disciplinary scientists, should define the identified problems in clear terms. The definition of problems requires a good understanding of the farming system, an appreciation of farmers' resources, perceptions, and priorities, and a continual dialogue between farmers and researchers (Tripp and Woolley, 1989). Rhoades and Booth (1982) have also provided examples for problem definition.

Recording relevant indigenous knowledge systems

Indigenous knowledge (IK) is the systematic body of knowledge acquired by local people through the accumulation of experiences, informal experiments, and intimate understanding of the environment in a given culture. IK is dynamic, changing through indigenous mechanisms of creativity and innovativeness as well as through contact with other local and international knowledge systems (Warren, 1990). In the process of technology development, knowledge of indigenous livelihoods is an indispensable resource (Haverkort and Zeeuw, 1992). Indigenous knowledge may not be as abstract as scientific knowledge. It is often concrete and always dynamic. It relies strongly on intuition, directly perceivable evidence, and an accumulation of historical experiences (Farrington and Martin, 1987). Indigenous knowledge reflects the dignity of the local community and puts its members on an equal footing with the outsiders involved in the process of technology development (Haverkort and Zeeuw, 1989). Indigenous knowledge systems also provide mechanisms for facilitating understanding and communications between outsiders (extensionists, researchers) and insiders (farmers). Improved understanding and communications enhance participatory approaches to problem identification (Warren, 1992c).

Once problems are identified, the next step during the process of developing sustainable agricultural technologies is to record the indigenous knowledge systems (IKSs) of farmers which contribute to the solution of the problem. In other words, how do farmers try to overcome or adapt the problems using their own knowledge? For instance, informal exchange of rice seeds from farmer-to-farmer is used as a strategy by farmers to solve the growing demands of quality rice seeds in the study villages. The social scientist in the regional research station in coordination with respective disciplinary scientists should record IKSs.

Forming a sustainable technology development consortium

The purpose of a sustainable technology development consortium is to bring farmers, researchers, extensionists, and NGO representatives together in order to classify the identified problems and IKSs and set agendas based on them. Kaimowitz (1992) emphasized the need for such a common forum to link researchers and extensionists. He also enumerated certain constraints in the existing research-extension linkages:

1. Researchers may have their research plans already established and may not really be open to inputs from extension;

2. Personnel representing the extension agencies may be regional or national officials who have little direct knowledge of conditions in the country side;
3. The objectives and agenda may not be clear and their mandate may be too broad to be feasibly addressed in the time alloted;
4. Even when extension workers' perceptions are accurate, researchers may perceive them to be uninformed or subjective; and
5. Researchers may be reluctant to accept them because of extension's lower status and researchers' low esteem for the extension agent's abilities.

Forming a technology development consortium is an attempt to overcome these potential constraints with its salient features such as (1) giving equal footing to problems and IKSs as recorded by researchers and extensionists; (2) bringing divisional-level SMSs who are familiar with both local conditions and extension headquarters; and (3) respecting extension workers' intimate contact with farmers.

In the consortium, research should be represented by all scientists of the regional research station, extension should be represented by regional-level extension administrators and subject matter specialists (SMSs), and NGOs by their representatives. Amanor and Farrington (1992) stated that complementary linkages between NGOs, research, and extension encourage interaction among many sources of technical innovation to arrive at dynamic technological options. The framework assumes that it takes no more than two days to classify problems and to decide on the agenda for each organization. The specific objectives of the consortium are to:

1. discuss all problems and IKSs as perceived by local people;
2. prioritize problems and IKSs with active participation from farmers; and
3. decide who should work on what problem area.

Problems and IKSs that need research station facilities and advanced academic training should go to researchers. SMSs of the extension organization should take care of problems and IKSs that do not require any on-station support. NGOs can concentrate on problems and IKSs related to strengthening and empowering indigenous organizations or local networks.

Developing a research agenda

Understanding farmers' problems and IKSs allows a framework for posing technical, scientific questions in research and also provides the basis for evolving technologies that are not imposed as alien 'packages' that contradict existing practices (Scoones, 1989). Once problems are identified and classified, the next step is to set research priorities. Conventionally, research priorities are determined by policy makers and researchers with little or no farmer participation (Doorman, 1991). This framework suggests a change in the normal tendency. Once certain problems are described in farmers' terms, they have to be 'translated' to match the definitions and concepts used by researchers. This indicates that sufficient knowledge of both the farmers' problems and related IKSs is necessary to translate the defined problems into research priorities. In setting research priorities, the essential starting point is for social scientists and disciplinary scientists to give close attention to the farmers' own detailed knowledge of existing practices (Haugerud and Collinson, 1991). Each area of research should indicate farmers' problems, relevant IKSs and proposed solutions by researchers.

Conducting participatory on-station research

It is not sufficient if farmers are involved only during problem identification and recording of IKSs. Participatory research is a two-way flow that both takes scientists to farmers' fields and brings farmers to research stations (Haugerud and Collinson, 1991). Hence, involving "research minded" farmers while conducting on-station research is essential and at the same time challenging. Since farmers and scientists each know and understand many things, but have little overlap between their domains of knowledge, farmer-scientist interaction should help both groups learn. Since both professions are constantly experimenting, more interaction should improve each other's experiments (Bentley and Andrews 1991; Bentley and Melara 1991).

Scientists have a wealth of knowledge concerning biological factors related to food production whereas small-scale farmers have a wealth of knowledge concerning the management of ecological, technological, and organizational factors related to food production under specific local conditions (Fernandez and Salvatierra, 1989). For instance, incorporating farmers into on-station germplasm screening can produce useful information at little cost (Haugerud and Collinson, 1991). Before conducting on-station research on cultivar selection, plant breeders should bring village-level seed producers (farmers) to the research station and listen to their criteria of varietal selection. For instance, one village-level seed producer indicated that coarse grain rice varieties never lodge during the earhead stage under irrigated conditions.

Conducting on-station research can be divided into two sub-components: (1) Developing new research station technologies based on IKSs. Prain (1992) found that farmers evaluated cultivars using a wide variety of criteria that can be of immense interest and value to crop breeders. In Zambia, the farmers evaluation of a high-yielding hybrid maize variety and description of the positive and negative characteristics of locally-adapted open-pollinated varieties led to a more effective national maize breeding program (Warren, 1989b). Hence, during the process of technology development, scientists at the research station should conduct research by building on the acquired IKSs.

Developing new varieties of food crops by restoring the traits of local landraces is one of the examples of this process. For instance, a local variety of chili crop used by farmers in one of the study villages is well adapted to agro-ecological and environmental conditions. Moreover, it is resistant to certain pests and diseases of chili. While introducing a variety from outside in order to obtain higher yields, farmers experienced new pest and disease problems. In this case, research station scientists can solve the farmers' problems by developing a new genotype by integrating the traits of local varieties (adapted to environmental stress and resistant to the fruit borer) and varieties from the research station. The new cultivars thus developed can be evaluated for their local adaptability using the procedures discussed in the latter stages.

(2) Integrating indigenous knowledge systems and existing research station technologies. In some cases, research can be conducted by matching the IKSs and existing research station technologies. For instance, casuarina farmers in the study villages conducted informal experiments by growing legumes such as blackgram or cowpea as intercrops in casuarina (a multipurpose tree) fields. But most of them faced problems such as the shattering of legume pods and spreading of legumes between casuarina trees. The research station scientists can conduct on-station research experiments with an objective to evaluate the performance of various legume varieties in casuarina fields and select certain legume varieties which are suitable for intercropping in casuarina fields.

The successful combinations of casuarina and legume varieties can be taken to farmer-oriented on-farm research for its validation under farmers' field conditions. Other examples where an integrated technology can be developed by blending IKSs and existing research station technologies are developing IPM strategies by blending indigenous crop pest management systems and selected chemical pest control methods, and conducting integrated crop nutrient research to formulate crop nutrient schedules by mixing cattle, sheep manures and chemical fertilizers.

Conducting on-farm farmer-oriented research (OFFOR)

Participatory on-station research formed the base-line for conducting on-farm farmer oriented research (OFFOR). The purpose of OFFOR is to validate the findings of the participatory on-station research. The primary role of the researchers is to match technological options that are developed from on-station research to selected farming conditions, and to provide leadership in designing the research (Baker, 1990). The disciplinary scientists should conduct the OFFOR in coordination with extension scientists.

The following are the salient features of OFFOR proposed in the model: (1) OFFOR keeps the indigenous knowledge system of farmers as a base; (2) It facilitates a rigorous farmer participation well ahead of the on-farm research process in order to generate a basket of technological options; (3) It can be taken to wider areas among a wider spectrum of farmers covering different castes and gender with minimum cost (Chand and Gurung, 1991); (4) It has enabled researchers to get direct and firsthand feedback that helps researchers to improve or modify technologies.

Research scientists must present the integrated technological options developed during partcipatory on-station research (POSR) stage for consideration of selected farmers. The selected farmers are encouraged to identify technological options that would fit into their individual problems and resource constraints. For example, farmers with soil alkalinity problems might select a soil reclamation trial. Marginal farmers who rear cattle as their off-farm occupation are very knowledgeable of fodder trees that can be grown on field bunds and hence might select a trial on fodder tree evaluation. Marginal farmers who own bullocks to plow other farmers' fields for labor possess a bountiful knowledge on indigenous soil classification and the fertility status of that location or village and hence may prefer to choose a fertilizer trial.

Instead of selecting experimental plots, the OFFOR utilizes the entire farm for OFFOR research. By selecting experimental plots, we are narrowing the focus to a particular crop (mainly cereals and millets) in the farm, while neglecting the value of associated crops, trees, and livestock. For instance, farmers in the study villages grow legumes such as black gram and green gram in rice bunds. Hence, selecting the entire farm for OFFOR is important. Such an effort would facilitate not only an in-depth understanding of the interactions among crops-trees-livestock but also their role in sustainable food production and resource conservation.

On-farm research should incorporate farmers' own methods of informal experimentation, their standards of judgement, and their suggestions concerning experimental design (Haugerud and Collinson, 1991). Baker (1990) provided certain essential guidelines that need to be given consideration while conducting OFFOR: (1) Management, not just implementation, should be left to farmers whenever possible; (2) Farmer assessment is an important component of overall analysis. Measurements need to be made in order to quantitatively analyze outcomes and to diagnose reasons for observed responses; (3) Farmer control is particularly important for site selection, plot sizes, seed rate, planting patterns, and timing of agronomic operations; and (4) Exploration and demonstration activities are required to stimulate awareness and interest in technological options.

Socio-cultural factors, e.g., local labor constraints should be taken into account while conducting OFFOR. In research stations, constraints in labor are not always recognized whereas complex labor problems prevail in on-farm conditions. Laborers are employed by research stations on a permanent basis, and they are willing to perform any amount of laborious work since they are highly paid when compared to their counterparts in the country-side. The extent of labor constraints varies from region to region and many times from village to village. For instance, "planting 2-3 seedlings in rice" is an economically viable rice technology. Since planting 2-3 seedlings in rice is a time consuming process, it is difficult for farmers to convince women laborers to adopt this practice. Solutions for these kinds of problems can be identified only at the local-level. Local organizations and informal networks must be geared up so that negotiations can be drawn between farmers and women laborers. Such negotiations might end up with an intermediary technology which is congenial to both the parties.

Data pertaining to the following should be recorded from OFFOR farms:

1. Crops grown including homestead gardens;
2. Crops grown in marginal areas;
3. Direct and indirect costs involved;
4. Indigenous technical practices of farmers and their impact on productivity and sustainability of agricultural system;
5. Resource allocation due to the interaction of indigenous knowledge and research station technologies;
6. Interaction among crops, trees, livestock, and fish; and
7. Short-term benefits accrued and long-term benefits expected.

Evaluating the technological options is an essential component while conducting OFFOR. The extension scientist should evaluate the performance of technological options:

1. Compatibility with agro-ecological conditions
2. Compatibility with socio-cultural environments
3. Usage of labor
4. Usage of cash
5. Profitability
6. Need for institutional support
7. Contribution to reducing risk

Feedback from on-farm research to research station is one of the weakest linkages in on-farm research programs (Merrill-Sands and McAllister, 1988). Conducting OFFOR might contribute significantly to overcome this constraint.

Evaluating technological options

Finally, extension scientists with input from farmers should evaluate the technologies that have been tested during the OFFOR in terms of their contribution to: (a) productivity of crops and associated livestocks, (b) sustainability of the agricultural system, (c) complexity (e.g., ease of experimentation), and (d) labor intensity. They are expected to arrive at any one of the following decisions:

1. Drop the technological option that has been tested
2. Technological options need long-term research
3. Technological option is ready for further dissemination.

The technological options that are proved to be viable after the on-farm research should be disseminated to farmers using procedures outlined under the section, "process of disseminating sustainable agricultural technology to farmers by collaborating with research, extension and NGOs."

Technology development by Incorporating Indigenous Knowledge Systems into Agricultural Extension Organizations

The need for researcher-farmer involvement was given high priority in the recent farming systems research/ extension literature. However, it is practically difficult for research station scientists to conduct research involving farmers all the time due to the insufficient human resource capacity of regional research stations (Rajasekaran and Martin, 1990; Warren, 1991b). For instance, there is only one research station in Pondicherry region which is expected to cater to the entire agricultural research needs of the entire region. There are approximately twenty scientists working in this station. This number is far too low when compared to the number of farming communities in the region. Keeping this low researcher-farm family ratio in view, the framework advocates the use of academically well-trained and "research minded" extension personnel to validate farmer experiments.

Subject matter specialists as researchers

Recent statistics show that most of the divisional-level subject matter specialists (SMSs) are post-graduates in different disciplines such as agronomy, soil science, entomology, and plant breeding. Moreover, the department of agriculture is sponsoring extension personnel to undergo post-graduate training in the specialized disciplines mentioned above. The advanced knowledge they acquire during this training period along with their field experience as SMSs should be used for validating farmer experimentation.

It was found that SMSs spend most of their time in headquarters assisting their heads of offices, and preparing periodical reports to be sent to their higher authorities (Rajasekaran and Martin, 1990). In other words, the academic training acquired by the SMSs is rarely exploited. They should spend at least one day in a week on activities such as: (1) problem identification; (2) recording relevant IKSs; and (3) presenting the problems and IKSs to the technology development consortium. The procedures explained under research organizations also hold good for SMSs.

Developing extension programs to validate farmer experimentation

There are farmers who are always experimenting and are involved in informal research and development activities (Biggs, 1990). Roling and Engel (1992, p.127) warned that, "to look at farmers only as users neglects the important fact that farmers are experimenters and that farmers have developed most of the technology used on the farm today." Specific extension programs should be targeted towards strengthening what farmers are already experimenting. Farmer experimenters are those farmers who conduct experiments in order to evaluate certain indigenous technical practices in their own way. Validating farmer experiments is an extension process in which SMSs encourage farmers to replicate their own experiments in their own environment in order to: (1) understand experiments in the socio-cultural and agro-ecological environments, and (2) determine the impact of the experiments on productivity, profitability, and sustainability of the agricultural system.

During bi-weekly training programs, separate sessions should be alloted to develop extension programs for validating farmer experiments. The various steps involved in the process of developing the extension programs are: (1) selecting "research minded" village extension workers; (2) identifying "research minded" farmers who are already involved in farmer experiments; and (3) establishing programs for validating farmer experiments.

Validating farmer experiments

Selection of farmers is one of the crucial activities during the process of validating farmer experiments. The various steps involved during the process of validating farmer experiments are: (1) Understand the rationale behind farmer experimentation. Examples are testing varieties for yield increase, blending local and external inputs, avoiding risks by adjusting sowing and harvesting periods, and testing new varieties for local adaptation; (2) Recording the mode of conducting experiments. For instance, some farmers conduct varietal trials by raising local and high yielding varieties in two different plots. Others establish experiments by planting the local and new varieties in alternate rows; and (3) Identifying farmers' evaluation criteria. The criteria used by farmers to evaluate their own experiments differ from farmer to farmer and also for the same farmer, from crop to crop. Physical stand of the crop and the way it bears the earheads is one of the major criteria for rice farmers in the Eastern Visayas region of Philippines (Tung, 1992). In the study villages, farmers randomly uproot one or two groundnut crops and shake the pods by holding them close to their ears. If they hear any sound, it indicates that the pods are unfilled. If they do not hear any sound, it indicates that the pods are filled.

Understanding, identifying, recording, and evaluating farmer experiments form the various stages of validating farmer experiments. It is important that extension personnel must understand the farmers' own criteria when they explore indigenous approaches to farmer experimentation.

Facilitating village-level experimenter workshops

Experimenter workshops should be conducted immediately after validating farmer experiments. The village extension workers should facilitate the experimenter workshops by involving farmer experimenters as resource persons. The SMSs should act as semi-silent observers during these workshops. This process is a way of empowering and respecting village-level extension workers and farmers. Farmer experimenters should be encouraged to share their experiences while conducting the experiments. They are expected to answer specific questions raised by other participant farmers. After the formal discussion, the SMSs should wrap up the workshop by sharing their experiences during the process of validating farmer experiments. The village extension worker should act as a facilitator by bringing farmers to the subject of discussion when conflicts arise and also monitor the time.

Evaluating technological options

Finally, farmer experimenters with inputs from other farmers should evaluate the technologies that have been tested during the farmer experimentation procedure in terms of their contribution to: (a) productivity of crops and associated livestocks, (b) sustainability of the agricultural system, (c) complexity (e.g., ease of experimentation), and (d) labor intensity. They are expected to arrive at any one of the following decisions:

1. Drop the technological option that has been tested;
2. Technological option needs long-term research; and
3. Technological option is ready for further dissemination.

Technological options that need long-term research should be communicated to researchers through the technology development consortium. Technological options that are ready for further dissemination but require additional resources and infrastructural facilities should be discussed with appropriate departments. Technological options that are ready for further dissemination can be communicated to their colleagues through zonal workshops.

Strengthening Indigenous Organizations by Utilizing Non-Governmental Organizations

Indigenous organizations are found to play important roles in facilitating non-agronomic activities such as the following:

1. Off-farm income-generating activities, especially for landless laborers including women;
2. Cooperative marketing of agricultural produce, e.g., tapioca and sugarcane;
3. Farmer-to-farmer seed exchange;
4. Cooperative marketing of milk;
5. Fodder tree planting;
6. Raising and marketing of flower seedlings; and
7. Maintenance of irrigation tanks.

Identifying indigenous organizations

Indigenous organizations play a developmental function within the community. Strengthening the capacity of these existing organizations can greatly facilitate sustainable approaches to development (Warren, 1992d; Atteh, 1989). Identifying and strengthening indigenous organizations are challenging tasks for sustainable development of the Indian villages. Landless laborers including women who represent more than 50 percent of village population always keep their eyes open in identifying off-farm income generating activities. These activities are carried out either through formally established indigenous organizations or informal networks. Hence, it is essential to strengthen the indigenous organizations and informal networks that support and encourage these activities. Non-governmental organizations (NGOs) are found to play significant roles in strengthening informal local networks as well as indigenous organizations of local people.

Locally managed projects are often implemented by local people through informal networks. For instance, groups of women laborers in the study villages organized a duck-rearing activity using common property resources. Women's role in off-farm agricultural activities has been discussed in detail elsewhere (Poats et al. 1986). A formally established milk cooperative society in the study villages pooled and transfered the milk to central freezing plant located in Pondicherry city. NGOs can concentrate on identifying these indigenous organizations and informal networks.

Analyzing the structure and functions of indigenous organizations

The second step is to analyze the structure and function of the indigenous organizations. Well-established indigenous organizations have a clearly defined organizational structure. For instance, the village-level milk cooperative society has a president and locally elected governing body. Farmers and farm laborers who rear cattle form the members of the organization. They are formally linked to the Central Milk Cooperative Society located at Pondicherry city.

There are also informal networks without any formally organized structure that still possess well-defined functions. For instance, the women laborers joined together to form a loosely structured informal network. They jointly obtained credit from one of the large-scale farmers for whom they work as laborers. They raise ducks on a rotational basis, each member taking care of the ducks for one day. The large-scale farmers provide initial investments for the purchase of ducklings and maintenance support such as provision of shelter for the ducks during night times. Thirty percent of the output goes to the large-scale farmers and the rest is shared among the women members. Common property resources such as water streams and public lands are used to search for feed for the ducks. There exists a mutual understanding between the women laborers and large-scale farmers. By helping these women laborers to find such off-farm income sources, large farmers secure their labor resources. In other words, the large-scale farmers do not face labor problems since these women laborers come to their rescue especially during peak labor demand periods. Hence, understanding the structure and function of indigenous organizations and how they fit into the socio-cultural environments of the villages needs indepth investigation.

Identifying constraints in indigenous organizations

Identifying the constraints of the indigenous organizations form the next step of the process. NGOs can participate in informal as well as formal meetings of the indigenous organization to identify the constraints faced by the organizations. Followed by this, NGOs can work with individual members to identify their own perceptions about their problems. Examples of constraints in indigenous organizations include the following:

1. Conflicts due to social groupings in the organization, e.g., caste groups;
2. Influence of power brokers on the decision-making systems of the organization, e.g., large-scale farmers have a profound influence on the women's informal duck keeping network;
3. Non-availability of sufficient funds to run the organization; and
4. Cultural change inhibits the growth of some organizations, e.g., younger generations of cattle rearers who have some years of formal education are not willing to become members of the village-level milk cooperative society.

Developing action programs

The purpose of this stage is to develop specific action programs to overcome potential constraints in the indigenous organizations and informal networks. Action programs can be developed to strengthen and empower indigenous organizations by effectively mobilizing resources from the outside. For instance, women laborer networks in the study villages face severe constraints in obtaining credit for duck rearing activity. They have to depend entirely on large-scale farmers. Action programs can also identify locally-manageable projects, such as off-farm income-generating activities for men laborers during the lean periods.

Implementing action programs

Implementing action programs on a pilot-basis is one of the most challenging tasks for NGOs. Only during actual implementation, can constraints that have not been identified in the earlier stages be understood. The members of the indigenous organizations and informal networks should be encouraged to actively participate during the process of implementation. NGOs should provide supportive roles by linking external institutions with indigenous organizations. For instance, NGOs can work with women laborers to obtain credit from credit institutions such as lending banks for purchasing ducklings. The NGOs can also help the indigenous organizations to identify profitable outlets for marketing the ducks, e.g., cooperative societies.

Evaluating action programs

Evaluating the action programs forms the final stage of strengthening indigenous organizations. Representatives of NGOs should evaluate the program in terms of its contribution to: (a) sustainable off-farm income, (b) ease of implementation, (c) limited dependence on external institutions, e.g., lending banks and marketing societies, (d) minimal social conflicts, (e) low interference with farm labor, i.e., the activities should not hinder their on-farm labor activities, (f) equity, and (g) social profitability. As a final part of the evaluation, the NGOs, in coordination with the members of indigenous organizations, should arrive at one of the following decisions:

1. Drop the program;
2. Extend the program to the rest of the population in the village; or
3. Extend the program to the rest of the population in the same village as well as implement the program in other villages provided similar agro-ecological and socio-cultural environments exist.

The NGOs are expected to share their experiences in zonal workshops if the program falls under category two or three.

Technology Dissemination by Linking Research, Extension, and NGOs

Technologies that are identified, developed, modified, and evaluated should be transferred using two mechanisms: (1) informal farmer-to-farmer communication and (2) the agricultural extension system.

Informal farmer-to-farmer communication

Informal farmer-to-farmer communication forms the major source of technology dissemination in the same village and neighboring villages where technologies are developed. Informal indigenous communication systems in agricultural communities work incredibly well for the spread of farmer-selected rice and cotton varieties in India (Antholt, 1992). Nayman (1988) reported that 91 percent of the farmers in Punjab, India, sought other farmers as a source of agricultural innovation. Outsiders will play less of a role in this process. Extension has a role to play during the process of informal communication by organizing field days where on-farm research and validation of farmer experiments were conducted.

Technology dissemination through the agricultural extension system

Compton (1989) stated that extension personnel blanket the countryside. This enormous human resource capacity should be effectively utilized for disseminating technologies to distant locations and other villages. In spite of the continuous debate regarding the effectiveness of the Training and Visit (T&V) extension system, the T&V stands as the single major source for formal technology dissemination in many developing countries. The T&V system of extension has sought to operationalize a strong and regular link between research and extension, and between extension and farmers (World Bank, 1990). The salient features of the T&V such as (1) monthly zonal workshops; (2) biweekly training programs; (3) village extension workers contact with farmers; and (4) maintaining extension worker-farm family ratio can be effectively utilized. The potential of the T&V system of extension in increasing agricultural productivity has been clearly demonstrated (Antholt 1992; Feder, Slade and Sundaram, 1986).

Reorienting monthly zonal workshops

Presently, the extension personnel are entirely dependent on research station scientists for technologies. As explained earlier, it is practically difficult to rely on research stations alone for technological innovations. Moreover, NGOs, in spite of their contribution to strengthening of local networks and indigenous organizations, never form part of the monthly zonal workshops, the meeting point of researchers and extensionists. The framework aims at bringing the NGOs into the zonal workshop.

The technological options that are developed by research, extension, and NGOs should be communicated to the extension system during the zonal workshops. Research station scientists should present the technological options that are finalized from OFFOR. SMSs of extension should share the technological options that are developed by validating farmer experiments. Representatives of NGOs should share their experiences in strengthening and empowering indigenous organizations.

Bringing original innovators to zonal workshops

Monthly zonal workshops are the important points where farmer experimenters as original innovators of technologies need to be recognized. It is essential for agricultural extension personnel to listen to the farmer experimenters whose raw materials (IKSs) contributed to the development of finished products (technological options). Encouraging the farmer experimenters by offering cash prizes is one of several ways of providing recognition and compensation for their contribution to the development of technologies. Such rewards also encourage their colleagues to share their knowledge by participating in the process of developing technological options.

Screening technological options

The SMSs receive technologies from zonal workshops and relay them to their village-level extension workers without tailoring these technologies to the agro-ecological and socio-cultural conditions of their own division (Rajasekaran and Warren, 1992). Once the technological options are disseminated to extension personnel, it is their responsibility to screen those options by considering the following factors:

1. SMSs should select those technological options that fit into agro-ecological environments of their division; and
2. SMSs should work with village-level extension workers in understanding the socio-cultural factors that have a negative impact on selected technological options.

Disseminating technological options to village extension workers

After screening, the technological options should be disseminated to village extension workers. During the process of dissemination, SMSs should act as facilitators rather than simply conducting training programs for the village extension workers. The adaptability of technological options should be discussed with village extension workers. The technological options that are disseminated to village-level extension workers using these steps differ from the existing system of delivering technologies in the following ways:

1. Technologies delivered by existing research-extension system are fixed packages and rarely provide any options to farmers. The system expects the farmers to adopt an entire package. On the other hand, the technologies that are developed using the proposed framework provides diversified technological options which enable farmers to choose using their own decision-making system;
2. Presently technologies rarely build on IKSs of farmers. In the new approach, technological options presented to farmers originate from the farmers' own knowledge; and

3. Under the conventional system, technologies come from only one source, the research stations. In the suggested system, the technological options are developed using diversified sources such as extension agents, NGOs, farmers, and research stations in active participation with "research minded" farmers.

Disseminating technologies to farmers using indigenous communication channels

Village extension workers should be encouraged to follow certain guidelines while disseminating the technological options. The agricultural officers should be made responsible for providing institutional support for the village extension workers during the process of disseminating the technologies. Organizing training programs to explore indigenous communication channels for disseminating the selected technological options is essential (Mundy and Compton, 1991). Village extension workers should be encouraged to use delivery points other than farms such as *shandis* (market days), *koil thiruvizha* (village temple days), *magalir mandram* (a village-level women's society), and cooperative marketing points.

The following guidelines are necessary for the village extension workers while disseminating the technologies:

1. Decisions to choose a particular technology from the set of technological options should be left to the farmers;
2. If the farmers are not choosing an option from the technologies, the extension worker should encourage the adoption of the farmers' own practices since there may be some rationale behind it; and
3. The extension workers should provide relevant information to the farmers who decide to choose a technology from the technological options provided to them.

Evaluation

Evaluating technologies is the last but essential stage of the technology dissemination process. The agricultural officers should conduct the evaluation. Under the conventional system, the monitoring and evaluation (M&E) unit conducts this evaluation. Three major constraints of the existing evaluation process are (Rajasekaran and Martin, 1989):

1. Results of evaluation are rarely communicated to the field-level extension personnel. Most of the evaluation reports are circulated to extension administrators working at headquarters;
2. The M&E officials have a special status since they evaluate the work of extension personnel, thus creating fear among village-level extension workers;
3. Crop yield is the only factor considered for evaluation.

Evaluation should be conducted by middle-level extension personnel. The results should be used to refine technologies and not used merely for writing reports. The following factors should be taken into consideration during the process of evaluation:

1. Productivity (both land and labor)
2. Profitability
3. Compatibility of technologies with the farming system
4. Risk
5. Need for external resources
6. Need for institutional support (extension, credit, cooperatives)
7. Ease of testing by farmers
8. Labor intensity
9. Sustainability of agricultural system.

Conclusion

This framework is just a 'starting point' in the process of identifying and developing sustainable agricultural technological options by keeping farmers' knowledge as the focal point. This framework is not a rigid 'blue print' that needs to be implemented but provides essential principles to be followed during the process of sustainable agricultural technology development. The framework will be of immense value to extension administrators and research policy makers while preparing their extension programs and research agendas for a 21st century focused on sustainable agricultural development. Moreover, this framework is an attempt to narrow the existing gap between researchers involved in indigenous knowledge systems and development practitioners.

CHAPTER VI. SUMMARY AND RECOMMENDATIONS

Introduction

Indigenous knowledge is the systematic body of knowledge acquired by local people through the accumulation of experiences, informal experiments, and intimate understanding of the environment in a given culture. IK is dynamic, changing through indigenous mechanisms of creativity and innovativeness as well as through contact with other local and international knowledge systems (Warren, 1988). IK is the actual knowledge of a given population that reflects the experiences based on traditions and includes more recent experiences with modern technologies (Haverkort, 1991). Local people, including farmers, landless laborers, women, rural artisans, and cattle rearers, are the custodians of indigenous knowledge systems (IKSs). These indigenous knowledge systems may appear simple to outsiders but they represent mechanisms to ensure minimal livelihoods for the rural resource-poor people in India.

Problem

Technological efforts to increase food production through modern technologies have rarely considered indigenous knowledge systems around which resource-poor farmers normally operate. The agricultural research-extension system in India in the past has overlooked indigenous agricultural knowledge. Moreover, attitudes generated by the top-down transfer of technology (TOT) paradigm have precluded researchers and extensionists from learning indigenous knowledge systems.

During the process of technology development, farmers' informal experimentation were not considered as a source of innovation. In spite of increased coordination between research and extension through periodical extension-scientific workers' conferences, it is found that farmers' innovations are not considered while conducting on-farm research trials (Rajasekaran and Martin, 1990). On-farm trials conducted by researchers and extensionists mostly concentrate on crop varietal comparison, fertilizer response, and testing of different packages of practices for cereals and millets. In contrast, farmers experiment on alternative coping strategies to avoid extreme conditions such as droughts and floods, research diversified food production techniques such as intercropping and border cropping in order to broaden their food and fodder requirements, adjusting their sowing and harvesting periods to meet the local market demand.

During the process of technology dissemination, feedback information from farmers after the introduction of technologies is rarely recorded. Development of technologies in research stations has become a continuous process without looking at what is happening in the field. In summary, farmers' needs, priorities and innovations are not considered while developing and disseminating technologies from the research-extension pipeline.

Certain potential limitations in IKSs have strengthened the attitudes of outsiders that IKSs are 'primitive', 'unproductive' and 'irrelevant': (1) IKSs are of oral in nature; (2) IKSs are not documented; (3) Each individual possesses only a part of the community's IKSs; (4) IKSs may be implicit within local people's practices, actions, and reactions, rather than a conscious resource; and (5) Finally, farmers' rarely recall information on quantitative data pertaining to their IKSs (Reijntjes et al., 1992).

Identifying and documenting IKSs are, therefore, the first steps towards understanding and learning from local people. The IKSs exist in numerous forms such as indigenous decision-making systems, indigenous agricultural practices, and indigenous beliefs. As a second step, it is necessary to determine the extent to which IKSs are currently utilized by local farmers. This step also enables one to analyze IKSs in terms of their contribution to productivity and sustainability of the agricultural system. As a final step, certain invaluable IKSs need to be integrated into research station technologies. These systematic people-oriented approaches would provide a major reorientation in the attitudes and approaches of extensionists, researchers, policy makers, and in the mode of operation of research and extension organizations.

Keeping these theoretical foundations in perspective, certain research questions were formulated:

1. To what extent are selected statements regarding indigenous decision-making systems agreeable to farmers?
2. To what extent are selected statements regarding indigenous knowledge systems believed to be true by farmers?
3. To what extent are selected indigenous technical practices currently utilized by farmers?
4. What is the influence of IKSs on productivity?
5. What is the influence of IKSs on sustainability?
6. How can IKSs be integrated into the research-extension system?

Purpose and Objectives

The purpose of the study was to formulate a methodological framework to incorporate indigenous knowledge systems into agricultural research and extension organizations for sustainable agricultural development in India.

The specific objectives of the study were:

1. To determine the extent to which farmers agreed with selected indigenous decision-making systems;
2. To determine the extent to which statements regarding indigenous knowledge systems are believed to be true by farmers;

3. To determine the extent to which selected indigenous technical practices are being used by farmers;
4. To determine the relationship between selected demographic and indigenous technical practices;
5. To determine the influence of selected indigenous technical practices on productivity;
6. To determine the influence of selected indigenous technical practices on sustainability; and
7. To develop a methodological framework for incorporating indigenous knowledge systems into agricultural research and extension organizations.

Procedures

This research study was conducted using a variety of farmer participatory rural appraisal methods. Though these approaches are time-consuming, using these methods are highly valid and reliable for elucidating the indigenous knowledge systems of farmers. Living in the farming community, maintaining constant interaction with farmers by listening, observing, recording, and working with farmers formed the essential principles undergirding these methods. These methods have helped the researcher to understand the psycho-cultural and socio-economic environments of local farmers.

Participatory rural appraisal methods such as transecting, participant observations, and unstructured interactions, followed by instrumentation were used to collect data for this study. Maps and transects were constructed by walking through the study villages to demarcate the agro-ecological zones. *Adangal*, the base-line village record maintained by village accountants, was consulted to cross-check while constructing the transects. Participant observation formed the second stage of the research resign. Participant observations were conducted by the researcher using the transects to identify and document various indigenous technical practices adopted by farmers. Indigenous technical practices (ITPs) documented during the participant observation stage formed the basis for conducting unstructured interactions. The purpose of unstructured interactions was to elucidate relevant information pertaining to ITPs that were documented during the participant observation stage: (1) farmers' beliefs, values, and customs related to the ITPs, and (2) the process of decision-making while selecting the ITPs.

A list of 106 statements on indigenous decision-making systems, indigenous knowledge, and indigenous technical practices, was compiled based on the qualitative information collected from the participant observation and unstructured interaction stages. These ITPs were divided into the following ten sub-sections based on the crops and characteristics of the practices involved: (1) indigenous cropping systems, (2) indigenous soil health care practices, (3) indigenous rice seed processing techniques, (4) indigenous rice planting techniques, (5) indigenous rice nutrient management strategies, (6) indigenous weed control techniques in rice, (7) indigenous water management practices in rice, (8) indigenous pest management practices in rice, (9) indigenous agronomic practices in groundnuts, and (10) indigenous agronomic practices in tapioca.

The survey instrument utilized a Likert-type scale with points ranging from 1 to 5 as the method for obtaining the data. The scale was used to collect information regarding perceptions of farmers in the following areas:

a. Extent to which factors influencing indigenous decision-making systems are agreeable to farmers;
b. Extent to which indigenous knowledge is believed to be true by farmers; and
c. Extent to which indigenous technical practices are currently utilized by farmers.

Once the survey instrument was completed, it was reviewed by an interdisciplinary team of scientists at the M.S. Swaminathan Research Foundation, Madras, India.

The study was regional in scope. The study was conducted in the Union Territory of Pondicherry, India. The target population for the study was 15,753 farm households of the Union Territory of Pondicherry. A cluster sampling procedure was adopted in order to select the sample. Three villages---Sivaranthakam, Kizhur, and Pillayarkuppam---belonging to the Union Territory of Pondicherry were selected as cluster samples. All the farmers in these villages (clusters) were involved in the study, however, at different stages. The sample size was 263.

The researcher, assisted by one research assistant of the M.S. Swaminathan Research Foundation, contacted the sample farmers at their houses as well as farms to collect the data. Fifty percent of the farmers who had not participated in the earlier stages were contacted for response. If the selected farmers were not available during the first time, repeated visits were made to contact them. A response rate of ninety seven percent was achieved while collecting the data.

Analysis of Data

In analysis of the data, mean scores and standard deviations were computed for all the statements regarding indigenous decision- making systems, indigenous knowledge systems, and indigenous technical practices to determine the extent of agreement, belief, and utilization respectively. The Pearson Product Moment Correlation Coefficient was used to establish relationships between demographic factors and level of utilization of indigenous technical practices. A multiple regression analysis was computed to identify the combination of demographic factors which were the best predictor of the utilization of indigenous technical practices. The same procedure was repeated to predict which one of the indigenous technical practice is the best predictor of productivity as well as sustainability.

Findings

While analyzing the data, the researcher found various tendencies and trends which indicated a pattern of agreement or disagreement. Major categories or groups of data were identified and prioritized. Participant farmers agreed most on the factor influencing indigenous decision-making that "farmers consult their neighbors before choosing a particular crop for planting." Seven out of ten factors influencing indigenous decision-making systems received a moderate support from the farmers. Participant farmers supported fifteen out of nineteen statements pertaining to indigenous knowledge.

With respect to indigenous technical practices, the participant farmers supported most of the statements in the areas of "indigenous crop nutrient management strategies" and "indigenous rice weed control techniques." Most of the indigenous technical practices pertaining to "indigenous rice seed selection and processing technique" received moderate support. The participant farmers did not support three out of ten statements regarding "indigenous rice pest management strategies." The type of participant farmers was found to have a significant relationship with the perceptions of participant farmers regarding the use of indigenous technical practices.

As the use of sheep panning increased, the productivity of rice also increased. With respect to groundnuts, as the use of indigenous intercultural operations increased, the productivity of groundnuts also increased. Sheep panning was the best predictor to explain the variabilities in the sustainability factor, soil fertility. Using rat traps significantly contributed to the explanation of the variations in the sustainability factor, external input usage. On the other hand, using stream water for irrigation was the best predictor to explain the variabilities in the sustainability factor, sustaining groundwater resources.

Conclusions

The following conclusions were made based on this research study:

1. There is much to be learned from IKSs of local people;
2. Devaluing indigenous knowledge systems as "low productive," "primitive," and "old" is no longer a useful attitude;
3. Recording IKSs is timely before they are lost completely. If we are to move towards interactive technology dissemination from the conventional transfer of technology approach, it is feasible, efficient, and cost-effective to learn from these village-level experts;
4. Identifying IKSs can help to strengthen the capacities of regional research and extension organizations; and
5. Incorporating IKSs with research station technologies would lead to an environment which respects local people thus leading to their increased participation and empowerment.

Hence, as a next step, we need to incorporate IKSs into research and extension organizations after a systematic evaluation of their contribution towards productivity, food security, genetic diversity, and sustainability. Otherwise, our efforts to achieve sustainable agricultural development in the years to come will not be fruitful.

General Recommendations

The following general recommendations were extrapolated from the findings of the study that hold good for the Union Territory of Pondicherry as well as other Union Territories and States of India:

1. Agricultural research scientists and extension professionals must be provided opportunities to learn the methodologies for systematically recording the indigenous agricultural knowledge available in every community;
2. A training manual is essential for introducing the methodologies for identifying and recording indigenous knowledge systems into research and extension programs. The extension workers must be considered as rich resources of local knowledge and extension program decisions should be made by involving them;
3. A global-level training manual illustrating the methodologies of recording IKSs should be designed with the following components: (a) recording IKSs, (b) communicating IKSs, (c) evaluating IKSs, (d) integrating IKSs, and (e) disseminating and utilizing IKSs. Case examples should be provided on commodities (crops, livestock, trees, fisheries) and agricultural practices (from sowing to harvest);
4. At the regional level, extension trainers should design lesson plans by incorporating case illustrations that are specifically drawn from their own region;
5. Indigenous knowledge systems should be systematically recorded under the following categories: (a) indigenous decision-making systems, (b) indigenous agricultural practices, (c) indigenous beliefs, (d) indigenous risk aversion

strategies, and (e) structure and functions of indigenous organizations;

6. Identifying local people with specialized knowledge is important. It is essential to understand that a farmer may not be aware of all IKSs existing in his/her community. One farmer may be very knowledgeable about local landraces of food crops, their characteristics, and performance in his/her village. Another farmer may be highly knowledgeable about fodder trees and their performance in the village. A women laborer may be highly knowledgeable about various transplanting techniques;
7. Regional/ national/ international agricultural research stations should give serious consideration to farmers' knowledge while developing their research agenda;
8. Socio-cultural factors as perceived by farmers ('emic' perspectives) should be seriously considered while developing and disseminating on-station and on-farm research technologies; and
9. Extension policy makers should develop strategies to cover more agricultural areas by incorporating IKSs. For instance, specific targets may be assigned to regional extension administrators on the production, distribution, and application of farm yard manure.

Specific Recommendations

The following specific recommendations were made keeping in mind the irrigated regions of the Union Territory of Pondicherry:

1. Regional-level research-extension policy makers should consider the evaluation and implementation of the framework developed in this study on a pilot-scale;

2. Educating the younger generations of farmers and farm laborers on the values of agriculture as an occupation is essential. This would significantly improve the value of agriculture and allied activities such as manure collection and sheep panning;
3. Formation of local-level seed multiplication farms will solve problems in obtaining quality seeds. Specific extension educational programs must be developed to train extension workers regarding the methods to identify local seed growers, identification of appropriate varieties of seeds, and local procedures in managing the seed farms;
4. Extension training for the region of Pondicherry should concentrate on: (a) introduction of new crops or varieties considering local problems and needs. Since crop theft is one of the major social problems, extension personnel should be trained in farmer group participatory methods while introducing new crops or varieties; (b) sustaining groundwater resources; and (c) identifying participatory activities for tubewell owners and water receivers for strengthening their relationships;
5. The problem of crop thefts should be seriously dealt with. NGOs can play a leading role in this activity. Though farmers in the study villages are interested in diversifying their crop production from monocropping to multiple crop enterprises, crop theft acts as a great barrier for such a diversification;
6. Developing policy interventions to encourage farm yard manure trading activity at the village-level is timely. This process would benefit both farmers and landless laborers. Above all, this contributes to reducing the dependency on chemical fertilizers;

7. Policy interventions to identify sheep herders and to encourage sheep panning activity is important. Younger generations of sheep herders need to be educated on the values of traditional sheep herding as an occupation. Local organizations must be geared up so that negotiations are carried out between farmers and sheep herders to avoid browsing problems; and
8. Government policies should encourage local credit organizations such as credit cooperative societies since these organizations maintain a close link with the local people.

Recommendations for Further Study

1. A study should be conducted to determine how much external inputs (chemical fertilizers) can be reduced if local inputs (farm yard manure) would be used by farmers assuming that there exist a farm yard manure trade in the study villages. This study would help policy makers to invest public funds in encouraging laborers to produce and trade farm yard manure;
2. A study should be conducted to identify and compare the perceptions of extensionists and researchers regarding some of the indigenous knowledge recorded in this investigation;
3. A study should be conducted to evaluate farmer experiments by selecting "research minded" farmers in the region. The impact of farmer experiments on maintaining genetic diversity, food security, productivity, and sustainability needs to be studied; and
4. A pretest-posttest should be conducted to compare the perceptions of village extension workers regarding indigenous knowledge systems before and after receiving

training on the methodologies for recording indigenous knowledge systems.

Implications

Farmers possess diversified knowledge regarding indigenous agricultural practices. In addition, farmers currently utilize these indigenous agricultural practices, however, in varying degrees. This research study made a significant attempt to quantify the ITPs in terms of their utilization, impact on productivity, and impact on sustainability. Such a quantitative evaluation of IKSs is a starting point to determine the role of IKSs in sustainable agricultural development.

Farmers' socio-cultural and economic factors such as labor availability, accessibility to resources (seeds, irrigation), and farm type have a profound influence on the utilization of indigenous agricultural practices. Some indigenous agricultural practices have a significant impact on increasing agricultural production. Other practices played a significant role in reducing the dependency on external inputs, sustaining groundwater resources, and restoring soil fertility.

The findings of the study led the researcher to the development of a framework for incorporating indigenous knowledge systems into agricultural research and extension organizations. The framework provides essential insights for research, extension, and non-governmental organizations (NGOs) for developing and disseminating sustainable farmer-oriented agricultural technological options. This framework is not intended to be a substitute for the existing transfer-of-technology model. Rather, it is a complementary process that aims at exploring methods to build on farmers' original knowledge while developing and disseminating sustainable agricultural technologies. Though this study was regional in scope, the framework developed in this study could be used as a basis for other regions of the country and even to other developing countries where similar agroecological and socio-economic conditions exist.

BIBLIOGRAPHY

Abedin, M.Z. and M. Chowdhury. 1989. "Organizational and Managerial Innovations for Research and Extension Linkages in Bangladesh." Paper presented at the International Workshop on Making the link between Agricultural Research and Technology Users. The International Service for National Agricultural Research, The Hague, Netherlands, November 20-25, 1989.

Alcorn, J. 1988. "Making Use of Traditional Farmers' Wisdom." Paper presented at Common Futures: An International Forum on Sustainable Development. Toronto, Canada, June 1988.

Alcorn, J. 1992. "Ethnobotanical Knowledge Systems: A Resource for Meeting Goals in Rural Development." In D.M. Warren, D. Brokensha, and L.J. Slikkerveer, (Eds.), Indigenous Knowledge Systems: The Cultural Dimensions of Development. London: Kegan Paul International. (forthcoming).

Alders, C., W. Bruinsma., B. Haverkort., W. Hiemstra., C. Reijntjes and A. Waters-Bayer. 1991. "Strategies for Integrated Systems." ILEIA Newsletter 7(4): 9-12.

Altieri, M. 1990. "Why Study Traditional Agriculture?" pp. 551-564, In C.R. Carroll, J.H. Vandermeer and P. Roset, (Eds.), Agro-ecology. New York: McGraw Hill.

Altieri, M. and M.K. Anderson. 1986. "An Ecological Basis for the Development of Alternative Agricultural Systems for Small Farmers in the Third World." American Journal of Alternative Agriculture 1 (1): 30-35.

Altieri, M., D. Letourneau and J. Davis. 1983. "Developing Sustainable Agroecosystems." BioScience 33 (2): 45-49.

Altieri, M. and L.C. Merrick. 1988. "Agroecology and in situ Conservation of Native Crop Diversity in the Third World." pp.15-23, In E.O. Wilson and F.M. Peter, (Eds.), Biodiversity. Washington, D.C.: National Academy Press.

Amanor, K. and J. Farrington. 1992. "NGOs and Agricultural Technology Development." pp.243-256, In W.M. Rivera and D.J. Gustafson (Eds.), Agricultural Extension: Worldwide Institutional Evolution and Forces for Change. New York: Elsevier Science Publishing Company.

Anon. 1990. "Ecological Way for Agricultural Production: An International Meeting in Malaysia Took the View that Asian Agriculture is in a Severe State of Crisis." International Agricultural Development 10 (2): 5-6.

Antholt, C. 1992. "Agricultural Extension in the 21st Century: Lessons from South Asia." pp.203-216, In W.M. Rivera and D.J. Gustafson (Eds.), Agricultural Extension: Worldwide Institutional Evolution and Forces for Change. New York: Elsevier Science Publishing Company.

Ashby, J. 1986. "Methodology for the Participation of Small Farmers in the Design of On-Farm Trials." Agricultural Administration and Extension 22 : 1-19.

Ashby, J. 1987. Farmer Participation in On-farm Varietal Trials. ODI Agricultural Administration (Research and Extension) Network Discussion Paper No. 22. London: Overseas Development Institute.

Atteh, D. 1989. "Indigenous Local Knowledge as Key to Local-level Development: Possibilities, Constraints and Planning Issues in the Context of Africa." Paper presented at the Seminar on Reviving Local Self-reliance: Challenges for Rural/Regional Development in Eastern and Southern Africa. Arusha, Tanzania, February 21-24,1989.

Baker, D. 1990. "Reorientation, Not Reversal: African Farmer-Based Experimentation." Paper presented at Tenth Annual Farming Systems Research/ Extension Conference. East Lansing, Michigan, October 14-17, 1990.

Balasubramanian, A. 1987. "Microclimate and its Utilization in Farming." ILEIA Newsletter 3 (3): 9.

Balasubramanian, A. 1989. "Traditional Plant Protection Methods in Tamil Nadu." pp. 34-38, In K. Vijayalakshmi (Ed.), Biological Methods of Pest Control. Madras, India: PPST Foundation.

Bebbington, A. 1989. Institutional Options and Multiple Sources of Agricultural Innovation: Evidence from an Ecudorian Case Study. ODI Agricultural Administration (Research and Extension) Network Discussion Paper No. 11. London: Overseas Development Institute.

den Biggelar, C. 1991. "Farming Systems Development: Synthesizing Indigenous and Scientific Knowledge Systems." Agriculture and Human Values 8 (1&2): 25-37.

Biggs, S. 1988. Resource-Poor Farmer Participation in Research: A Synthesis of Experiences from Nine National Agricultural Research Systems. International Service for National Agricultural Research: The Hague.

Biggs, S. 1990. "A Multiple Source of Innovation Model of Agricultural Research and Technology Promotion." World Development 18 (11): 1481-1499.

Bentley, J. and W. Melara. 1991. Experimenting with Honduran Farmer-Experimenters. ODI Agricultural Administration (Research and Extension) Network Newsletter 24: 31-48. London: Overseas Development Institute.

Bentley, J. and K.Andrews. 1991. "Pests, Peasants and Publications: Anthropological and Entomological Views of an Integrated Pest Management Program for Small-scale Honduran Farmers." Human Organization 50 (2): 113-124.

Box, L. 1987. Experimenting Cultivators: A Methodology for Adaptive Agricultural Research. ODI Agricultural Administration (Research and Extension) Network Discussion Paper No. 23. London: Overseas Development Institute.

Box, L. 1989. "Virgilio's Theorem: A Method for Adaptive Agricultural Research." pp.61-67, In R. Chambers, A. Pacey and L. Thrupp (Eds.), Farmer First: Farmer Innovation and Agricultural Research. London: Intermediate Technology Publications.

Brookfield, S.D. 1987. Understanding and facilitating adult learning. San Fransisco: Jossey-Bass, Inc.

Butler, L. and J. Waud. 1990. "Strengthening Extension Through the Concepts of Farming Systems Research and Extension (FSR/E) and Sustainability." Journal of Farming Systems Research-Extension 1(1): 77-98.

Byerlee, D. 1987. "From Adaptive Research to Farmer Recommendations and Extension Advice." Agricultural Administration and Extension 27(4): 231-244.

Cape, N. 1990. "The Education of an Extension Worker." International Agricultural Development 10 (4): 16-17.

Chambers, R., A. Pacey and L. Thrupp. (Eds.) 1989. Farmer First: Farmer Innovation and Agricultural Research. London: Intermediate Technology Publications.

Chambers, R. 1989. "Reversals, Institutions and Change." pp.181-195, In R. Chambers, A. Pacey and L. Thrupp (Eds.), Farmer First: Farmer Innovation and Agricultural Research. London: Intermediate Technology Publications.

Chambers, R. 1990. Micro-Environments Unobserved. IIED Gatekeeper Series No. 22. London: International Institute of Environment and Development.

Chambers, R. 1991. "Participatory Rural Appraisal Notes on Practical Approaches and Methods." Unpublished Manuscript. Hyderabad, India: Administrative Staff College of India.

Cernea, M., J. Coulter and J. Russel. (Eds.) 1985. Research-Extension-Farmer: A Two-Way Continuum for Agricultural Development. Washington, D.C.: The World Bank.

Chambers, R. and B.P. Ghildyal. 1985. "Agricultural Research for Resource-Poor Farmers: the Farmer-First-and-Last Model." Agricultural Administration and Extension 20: 1-30.

Chambers, R. and J. Jiggins. 1987. Agricultural Research for Resource Poor Farmers: A Parsimonious Paradigm. IDS Discussion Paper No. 220. London: International Development Studies.

Chand, S.P. and B.D. Gurung. 1991. "Informal Research in Nepal." Journal for Farming Systems Research-Extension 2(2): 69-80.

Colfer, C., J. Pierce., D.W. Gill and F. Agus. 1988. "An Indigenous Agricultural Model from West Sumatra: A Source of Scientific Thought." Agricultural Systems 26 (2): 191-209.

Collinson, M. 1987. "Farming Systems Research: Procedures for Technology Development." Experimental Agriculture 23 (7): 365-386.

Compton, L. 1989. "Strategies and Methods for the Access, Integration, and Utilization of Indigenous Knowledge in Agriculture and Rural Development." pp. 21-32, In D.M. Warren, L.J. Slikkerveer and S.O. Titilola (Eds.), Indigenous Knowledge Systems: Implications for Agriculture and International Development. Studies in Technology and Social Change Series, No. 11 . Ames, Iowa: Technology and Social Change Program, Iowa State University.

Conway, G. 1987. "Rapid Rural Appraisal and Agro-ecosystem Analysis: A Case Study from Northern Pakistan." Proceedings of the 1985 International Conference on Rapid Rural Appraisal. Thailand: Khon Kaen University, Khon Kaen.

Conway, G. and E. Barbier. 1990. After the Green Revolution: Sustainable Agricultural Development. London: Earthscan Publications.

Cook, C. and M. Grut 1989. Agro-forestry in Sub-Saharan Africa - A Farmers' Perspective. World Bank Technical Paper No. 112. Washington, D.C.: The World Bank.

Crewell, J.L. 1990. An Identification and Assessment of Extension Education Delivery Systems for Training of Private Pesticide Applicators. Ph.D. Dissertation. Ames, Iowa: Iowa State University.

Cross, K.P. 1981. Adults as Learners: Increasing Participation and Facilitating Learning. San Francisco: Jossey-Bass, Inc.

Dangbegnon, C. and J. Brouwers. 1990. "Maize Farmers' Informal R&D." ILEIA Newsletter 6(3): 24-25.

Devaraj, A.C.N. 1988. Personal Communication. Madurai, Tamilnadu, India.

Dharampal, P. 1983. Indian Science and Technology in the Eighteenth Century: Some Contemporary European Account. Hyderabad, India: Academy of Gandhian Studies.

Doorman, F. 1991. "Linkages between Research, Extension and Farmers: The Case of Rice in the Dominican Republic." Agricultural Systems 37: 107-118.

Dvorak, K.A. 1988. Indigenous Soil Classification in Semi-Arid Tropical India. A Progress Report. Patencheru, India: International Crops Research Institute for Semi-arid Tropics (ICRISAT).

Edwards, C., D. Thurston and R. Janke. 1990. Integrated Pest Management for Sustainability in Developing Countries. Unpublished Document. Columbus, Ohio: The Ohio State University.

Ewell, P. 1989. Linkages between On-Farm Research and Extension in Nine Countries. OFCOR Comparative Study Paper No. 4. The Hague: International Service for National Agricultural Research (ISNAR).

Ezaza, W.P. 1989. "The Main Environmental Issues and Options for the Sustainable Development of Agriculture Associated with the Use of Mineral Fertilizer and Agro-Chemicals." Journal of Eastern African Research and Development 19: 73-82.

Farrington, J. and A. Martin. 1987. Farmer Participatory Research: A Review of Concepts and Practices. ODI Agricultural Administration (Research and Extension) Network Discussion Paper No. 19. London: Overseas Development Institute.

Farquhar, I. 1990. "Agroecology: New Science of Old Agriculture." Food Matters 7: 19-26.

Feder, G., R. Slade and A.K. Sundaram. 1986. "The Training and Visit Extension: An Analysis of Operation and Effects." Agricultural Administration and Extension 21: 33-59.

Fernandez, M. and H. Salvatierra. 1989. "Participatory Technology Validation in Highland Communities of Peru." pp.146-150, In R. Chambers, A. Pacey and L. Thrupp (Eds.), Farmer First: Farmer Innovation and Agricultural Research. London: Intermediate Technology Publications.

Fisher, R.J. 1989. Indigenous Systems of Common Property Management in Nepal. Working Paper No. 18. Honolulu: Environment and Policy Institute, East West Center.

Frio, A.L. 1991. "Gender Analysis: The Farming Systems Research-Extension Training Experience." Journal for Farming Systems Research-Extension 2(3): 1-10.

Fujisaka, S. 1986. Participation by Farmers, Researchers, and Extension Workers in Soil Conservation. IIED Gatekeeper Series No. 16. London: International Institute of Environment and Development.

Fujisaka, S. 1991. "What Does Build on Farmer Practice Mean? Rice Crop Establishment (*Beusani*) in Eastern India As An Illustration." Agriculture and Human Values 8 (1&2): 93-98.

Fujisaka, S., P. Elliot, E. Jayson and A. Dapusala. 1992. "Where There has been No Green Revolution: Farmers Upland Rices and Related Knowledge in Mindanao, Philippines." Paper presented at the International Symposium on Indigenous Knowledge and Sustainable Development. Silang, Cavite, Philippines, September 20-26, 1992.

Fujisaka, S. 1992. "Taking Farmers' Knowledge and Technology Seriously: Upland Rice Production in the Philippines." In D.M. Warren, David Brokensha, and L. Jan Slikkerveer, (Eds.), Indigenous Knowledge Systems: The Cultural Dimensions of Development. London: Kegan Paul International. (forthcoming).

Gnanadeepa, A. 1991. Techno-Cultural Profile of Rice Farmers. Unpublished M.Sc.(Ag) Thesis. Coimbatore, India: Tamil Nadu Agricultural University.

Gopalakrishnan, M and K. Vijayalakshmi. 1989. "Pest Control: Leave it to Nature." In K. Vijayalakshmi (Ed.), Biological Methods of Pest Control. Madras, India: PPST Foundation.

Grandstaff, G.W., T.B. Grandstaff and G.W. Lovelace. 1987. "Summary Report." Proceedings of the 1985 International Conference on Rapid Rural Appraisal. Khon Kaen, Thailand: Khon Kaen University.

Groenfeldt, D. 1990. "Building on Tradition: Indigenous Irrigation and Sustainable Development in Asia." Agriculture and Human Values 8 (1&2): 114-121.

Gupta, A. 1985. Field Notes of Village Kirtan, Hissar, India. as cited in Anil Gupta, Jyoti Capoor and Rekha Shah. 1990. Inventory of Peasant Innovations for Sustainable Development: an annotated bibliography. Ahmedabad, India: Center for Management in Agriculture, Indian Institute of Management.

Gupta, A. 1987. "Organizing the Poor Client Responsive Research System: Can Tail Wag the Dog?" IDS Workshop, London.

Gupta, A. and M. Saha. 1989. "Local Innovations and Farming Practices in Rainfed Eastern Uttar Pradesh: An Annotated List of Farmers' Knowledge." as cited in A. Gupta, J. Capoor and R. Shah. 1990. Inventory of Peasant Innovations for Sustainable Development: an annotated bibliography. Ahmedabad, India: Center for Management in Agriculture, Indian Institute of Management.

Gupta, A., J. Capoor and R. Shah. 1990. Inventory of Peasant Innovations for Sustainable Development: an Annotated Bibliography. Ahmedabad, India: Center for Management in Agriculture, Indian Institute of Management.

Gupta, A. 1990. "Documenting Farmers' Innovations: or How do People Survive through Innovations in Risky Regions." Unpublished Paper. Ahmedabad: Indian Institute of Management.

Gupta, A. 1991. "Experimenting Farmers, Pastoralists, and Artisans: Report of a Survey of Local Innovations in Dry Regions of Gujarat." Honey Bee 2(1); 13-17.

Gupta, A. 1992. "Survival under Stress: Socio-Ecological Perspectives on Farmers' Innovations and Risk Adjustments." In D.M. Warren, David Brokensha, and L. Jan Slikkerveer, (Eds.), Indigenous Knowledge Systems: The Cultural Dimensions of Development. London: Kegan Paul International. (forthcoming).

Gupta, S.K. 1985. The Scheduled Castes in Modern Indian Politics: Their Emergence as a Political Power. New Delhi, India: Munshiram Manoharlal Publishers.

Harris, M. 1979. Cultural Materialism: The Struggle for a Science of Culture. New York: Random House.

Hayward, J. 1987. "Commitment to Agricultural Extension." Office Memorandum. Agricultural Production and Services Division. Washington, D.C.: The World Bank.

Haverkort, B. 1992. "Agricultural Development with a Focus on Local Resources: ILEIA's View on Indigenous Knowledge." In D.M. Warren, D. Brokensha, and L.J. Slikkerveer, (Eds.), Indigenous Knowledge Systems: The Cultural Dimensions of Development. London: Kegan Paul International. (forthcoming).

Haverkort, B. and H de Zeeuw. 1992. "Development of Technologies towards Sustainable Agriculture: Institutional Implications." pp.231-242, In W.M. Rivera and D.J. Gustafson (Eds.), Agricultural Extension: Worldwide Institutional Evolution and Forces for Change. New York: Elsevier Science Publishing Company.

Haugerud, A. and M. Collinson. 1991. Plants, Genes, and People: Improving the Relevance of Plant Breeding. IIED Gatekeeper Series No. 30. London: International Institute of Environment and Development.

Hinkle, D., W. Wiersma and S. Jurs. 1986. Applied Statistics for the Behavioral Sciences. Boston: Houghton Mifflin Company.

Hoffmann-Kuehnel, M. 1989. "African Women Farmers: Utilizing Local Knowledge." ILEIA Newsletter 5(4): 8-9.

Hoque, M.L. 1984. "Cropping Systems in Asia: On-Farm Research and Management." Manila, Philippines: International Rice Research Institute.

IDS Workshop, 1989. "Final Reflections about On-Farm Research Methods." pp.157-161, In R. Chambers, A. Pacey and L. Thrupp (Eds.), Farmer First: Farmer Innovation and Agricultural Research. London: Intermediate Technology Publications

IFAP, 1990. Sustainable Farming and the Role of Farmers' Organizations. Wageningen, The Netherlands: International Federation of Agricultural Producers.

Jhunjunwala, A. and P. Deshingkar. 1984. "Organic Farming Method in Wardha." as cited in Gupta, Anil, Jyoti Capoor and Rekha Shah. 1990. Inventory of Peasant Innovations for Sustainable Development: An Annotated bibliography. Ahmedabad, India: Center for Management in Agriculture: Indian Institute of Management.

Jodha, N.S. 1979. "Intercropping in Traditional Farming Systems." pp.282-291. In ICRISAT. Proceedings of the International Workshop on Intercropping for the Semi-Arid Tropics, ICRISAT, Hyderabad, India.

Jodha, N.S. 1990. "Mountain Agriculture: the Search for Sustainability," Journal of Farming Systems Research-Extension 1(1): 55-76.

Jorgensen, D.L. 1989. Participant Observation: The Methodology for Human Studies. London: Sage Publications.

Kaimowitz, D. 1992. "The Evolution of Links between Research and Extension in Developing Countries." pp. 101-112, In W.M. Rivera and D.J. Gustafson (Eds.), Agricultural Extension: Worldwide Institutional Evolution and Forces for Change. New York: Elsevier Science Publishing Company.

Kandaswamy, L.S. 1978. *"Velanmai Pazamozigal"* (Proverbs in Agriculture). Madras, India: *Saiva Sidhantha Noorpathippu Kazhagam.*

Kerr, J. and N.K. Sanghi. 1992. Indigenous Soil and Water Conservation in India's Semi-Arid Tropics. IIED Gatekeeper Series No.34. London: International Institute of Environment and Development.

Kerven, C., H. Dolva, and R. Ragnhild. 1992."Indigenous Systems of Soil Classification in Northern Zambia." In D.M. Warren, D. Brokensha, and L. J. Slikkerveer, (Eds.), Indigenous Knowledge Systems: The Cultural Dimensions of Development. London: Kegan Paul International. (forthcoming).

Kotschi, J. 1989. "Ecofarming Practices for Tropical Smallholdings: Research and Development in Technical Cooperation." Working Papers for Rural Development No. 14. Eschborn: GTZ.

Krishnamoorthy, K. 1986. Personal Communication. Coimbatore, India. dt. 6.12.86.

Kurien, V. 1989. "Co-operatives are Still Possible: Kurien's Success in Milk, Edible Oils, and Tree Growing." Kisanworld 12:13-15.

Lightfoot, C. 1992. "Using Indigenous Knowledge Systems in the Design of On-Farm Experiments: A Philippine Case." In D.M. Warren, D. Brokensha, and L. J.Slikkerveer, (Eds.), Indigenous Knowledge Systems: The Cultural Dimensions of Development. London: Kegan Paul International. (forthcoming).

Lovejoy, T. 1989. Foreword. pp.2-3, In Browder, J.O. (Ed.), Fragile Lands of Latin America: Strategies for Sustainable Development. Boulder, Colorado: Westview Press. pp. 2-3.

Mahapatra, L.K. 1983. Swidden Cultivation in Asia. Bangkok: UNESCO, Regional Office for Education in Asia and the Pacific.

Maheshwari, J.K. 1988. "Ethnobotanical Research and Documentation." Proceedings of the 1987 'Natur och Kultursymposium' held at Stockholm and Uppsala, Sweden, September 14-17, 1987.

Mane, P.M. 1989. "Study of Traditional Agricultural Practices., Aga Khan Rural Support Programme." as cited in A. Gupta, Anil, J. Capoor and R. Shah. 1990. Inventory of Peasant Innovations for Sustainable Development: an annotated bibliography. Ahmedabad, India: Center for Management in Agriculture: Indian Institute of Management.

Maurya, D.M. 1989. "The Innovative Approach of Indian Farmers." pp.9-14, In R. Chambers, A. Pacey and L. Thrupp (Eds.), Farmer First: Farmer Innovation and Agricultural Research. London: Intermediate Technology Publications.

McClure, G. 1989. "Introduction." pp.1-2, In D.M. Warren, D.M., L.J. Slikkerveer, and S.O. Titilola (Eds.), Indigenous Knowledge Systems: Implications for Agriculture and International Development. Studies in Technology and Social Change Series, No. 11. Ames, Iowa: Technology and Social Change Program, Iowa State University.

Merrill-Sands, D. and J.McAllister. 1988. Strengthening the Integration of On-Farm Client Oriented Research and Experiment Station Research in National Agricultural Systems: Management Lessons from Nine Country Studies. OFCOR Comparative Study Paper. No. 1. The Hague: International Service for National Agricultural Research.

Merrill-Sands, D., and Kaimowitz, D. 1990. The Technology Triangle: Linking Farmers, Technology Transfer Agents, and Researchers. The Hague: International Service for National Agricultural Research.

Merrill-Sands, D., S.D. Biggs., R.J. Bingen., P.T. Ewell., J.L. McAllister and S.V. Poats. 1991. "Institutional Considerations in Strengthening On-Farm Client Oriented Research in National Agricultural Research Systems: Lessons from a Nine Country Study." Experimental Agriculture 27 : 343-373.

Ministry of Information and Broadcasting, 1982. India: A Reference Manual. New Delhi, India: Ministry of Information and Broadcasting.

Moris, J.1991. Extension Alternatives in Tropical Africa. London: Overseas Development Institute.

M.S. Swaminathan Research Foundation, 1991. First Annual Report of the Center for Research on Sustainable Agricultural and Rural Development. Madras, India: M.S. Swaminathan Research Foundation.

Mundy, P. and L. Compton. 1991. Indigenous Communication and Indigenous Knowledge. Development Communication Report 74 (3): 1-3.

Nayman, O.B. 1988. Distant Cousins: An Evaluation of Official and Non-official Sources of Agricultural Information. Unpublished Manuscript. Punjab, Pakistan.

Nazara-Sandoval, V.D. 1988. "Philippines Rural Cultivators in Transition: Operational Reality and Cognized Models in Agricultural Decision-Making." Ph.D. Dissertation. Lexington, Kentucky: University of Kentucky.

Nikhade, D.M., M.S. Agale and S.C. Thote. 1987. "Impact of Agricultural Beliefs on Adoption of Improved Farm Practices." Maharashtra Journal of Extension Education 6: 39-43.

Norgaard, R.B. 1984. "Traditional Agricultural Knowledge: Past Performance, Future Prospects, and Institutional Implications." American Journal of Agricultural Economics 66:874-878.

Norman, D. 1989. "Accountability: A Dilemma in Farming Systems Research." Culture and Agriculture 3: (8): 11-14.

Olofson, H. 1983. "Indigenous Agroforestry Systems." Philippines Quarterly Journal of Culture and Society 11:149-174.

Oritz, R., S. Ruano., H.Juarez., F.Oliver and A. Meneses. 1991. A New Model for Technology Transfer in Guatemala: Closing the Gap between Research and Extension. OFCOR Discussion Paper, No. 2. The Hague: International Service for National Agricultural Research.

Palti, J. 1981. Cultural Practices and Infectious Crop Diseases. Berlin: Springer-Verlag.

Poats, S., A. Spring and L. Schmidt. 1986. Gender Issues in Farming Systems Research and Extension. Boulder, Colorado: Westview Press.

Prain, G. 1992. "Local Knowledge and Global Resources: User Participation in Crop Germplasm Research." Paper presented at the International Symposium on Indigenous Knowledge and Sustainable Development. Silang, Cavite, Philippines, September 20-26, 1992.

Pretty, J. 1991. "Farmers Extension Practice and Technology Adaptation: Agricultural Revolution in the 17th-19th Century Britain." Agriculture and Human Values 8 (1&2): 132-148.

Pretty, J. and R. Sandbrook, 1991. "Operationalising Sustainable Development at the Community Level: Primary Environmental Care." Paper presented at the DAC Working Party on Development Assistance and the Environment, London, October 1991

Radcliffe, E., G. Ouedraogo., S.E. Patten., D.W. Ragsdale., and P. Strzok 1992. "Neem in Niger: A New Context for a System of Indigenous Knowledge." In D.M. Warren, D. Brokensha, and L.J. Slikkerveer, (Eds.), Indigenous Knowledge Systems: The Cultural Dimensions of Development. London: Kegan Paul International. (forthcoming).

Rajasekaran, B. 1987. An Agricultural Extension Officer's Field Reports (1980-1987). Madras, Tamilnadu, India: Joint Directorate of Agriculture.

Rajasekaran, B. 1991. Mission of Agricultural Extension in the Next Decade in India. Unpublished Manuscript. Ames: Iowa State University, CIKARD.

Rajasekaran, B. and R. A. Martin. 1988. "Incorporating Intra-household Dynamics into the Training and Visit Extension in India." Paper presented at the Eighth Farming Systems Research/ Extension Conference. Fayetteville, Arkansas, September 18-21, 1988.

Rajasekaran, B. and R. A. Martin. 1989. "Organization and Management of Training and Visit Extension System in Developing Countries." Paper presented at the Ninth Farming Systems Research/ Extension Conference. Fayetteville, Arkansas, October 18-21, 1989.

Rajasekaran, B. and R.A. Martin. 1990. "Evaluating the Role of Farmers in Training and Visit Extension System in India." Paper presented at the Tenth Farming Systems Research/Conference. East Lansing, Michigan, October 14-18, 1990.

Rajasekaran, B., D.M. Warren and S.C. Babu. 1991. "Indigenous Natural-Resource Management Systems for Sustainable Agricultural Development - A Global Perspective." Journal of International Development 3 (4): 387-402.

Rajasekaran, B. and D.M. Warren. 1992. "Indigenous Rice Taxonomies and Farmers' Rice Production Decision-Making Systems in South India." In D.M. Warren, D. Brokensha, and L.J. Slikkerveer, (Eds.), Indigenous Knowledge Systems: The Cultural Dimensions of Development. London: Kegan Paul International. (forthcoming).

Randhawa, M.S. 1983. A History of Agriculture in India. New Delhi, India: Indian Council of Agricultural Research.

Raman, K.V. 1989. "Scientists' Training and Interactions with Farmers in India." pp.169-174, In R. Chambers, A. Pacey and L. Thrupp (Eds.), Farmer First: Farmer Innovation and Agricultural Research. London: Intermediate Technology Publications.

Raman, K.V. and T. Balaguru. 1990. "Human Resources Development as a Key to the Success of Farming Systems Research in India." Journal of Farming Systems Research-Extension 1 (1): 153-164.

Raychaudhuri, S. 1964. Agriculture in Ancient India. New Delhi, India: Indian Council of Agricultural Research.

Reddy, N. 1988. Experience with Natural Farming. pp.49-51, In K. Vijayalakshmi (Ed.), Biological Methods of Pest Control, Madras, India: PPST Foundation.

Reij, C. 1991. Indigenous Soil and Water Conservation in Africa. IIED Gatekeeper Series No.27. London: International Institute of Environment and Development.

Reijntjes, C., B. Haverkort and A. Waters-Bayer. 1992. Farming for the Future: An Introduction to Low-External Input and Sustainable Agriculture. London: Macmillan.

Richards, P. 1985. Indigenous Agricultural Revolution: Ecology and Food Production in West Africa. London: Hutchinson.

Richards, P. 1986. Coping with Hunger: Hazards and Experiment in an African Rice-Farming System. London: London Research Series in Geography 11.

Richards, P. 1989. "Agriculture as a Performance." pp.39-42, In R. Chambers, A. Pacey and L. Thrupp (Eds.), Farmer First: Farmer Innovation and Agricultural Research. London: Intermediate Technology Publications.

Rhoades, R. and A. Bebbington. 1988. "Farmers who Experiment: an untapped resource for agricultural research and development." Paper presented at the International Congress on Plant Physiology, New Delhi, 15-20 February.

Rhoades, R. and R. Booth. 1982. "Farmer-Back-to-Farmer: A Model for Generating Acceptable Agricultural Technology." Agricultural Administration 11 (1): 127-137.

Rhoades, R. and P. Bidegaray. 1987. The Farmers of Yurimaguas: Landuse and Cropping Strategies in the Peruvian Jungle. Lima: International Potato Center (CIP).

Rocheleau, D. 1987. "The User Perspective and the Agroforestry Research and Action Agenda." Paper presented at Workshop on Farmers and Agricultural Research: Complementary Methods. Institute of Development Studies, University of Sussex, July 28-31, 1987.

Roling, N. 1989. "Misleading Metaphors." In D. Merrill-Sands, and D. Kaimowitz (Eds.), Technology Triangle: Linking Farmers, Technology Transfer Agents and Agricultural Researchers, The Hague: ISNAR.

Roling, N. and P. Engel. 1988. "Indigenous Knowledge Systems and Knowledge Management: Utilizing Indigenous Knowledge in Institutional Knowledge Systems." pp. 101-115, In D.M. Warren, L.J. Slikkerveer, and S.O. Titilola (Eds.), Indigenous Knowledge Systems: Implications for Agriculture and International Development. Studies in Technology and Social Change No. 11. Ames, Iowa: Technology and Social Change Program, Iowa State University.

Roling, N. and P. Engel. 1992. "The Development of the Concept of Agricultural Knowledge Information Systems (AKIS): Implications for Extension." pp.125-138, In W.M. Rivera and D.J. Gustafson (Eds.), Agricultural Extension: Worldwide Institutional Evolution and Forces for Change. New York: Elsevier Science Publishing Company.

Rusten, E. and M. Gold. 1992. Indigenous Knowledge Systems in Planning Agroforestry Projects in the Central Hills of Nepal. In D.M. Warren, D. Brokensha, and L.J. Slikkerveer, (Eds.), Indigenous Knowledge Systems: The Cultural Dimensions of Development. London: Kegan Paul International. (forthcoming).

Sainju, M.M. 1989. "Key Note Address." Nineth Annual Farming Systems Research/ Extension Symposium. Fayetteville, Arkansas, Oct. 8-11, 1989.

Salas, M.A. and J. Tillman. 1989. "What Should be Taken into Consideration in Training and Extension? Example Thoughts on Training Programmes for Small Farmers in Peru." Entwicklung-Landlicher-Raum (in German) 23(5): 25-28.

Sanghi, N.K. and J. Kerr. 1991. "The Logic of Recommended and Indigenous Soil and Moisture Conservation Practices." Paper presented at the Workshop on Farmers' Practices and Soil and Water Conservation Programmes held at ICRISAT, Patencheru, India, June 19-21, 1991.

Sankaram, A. 1991. "Green Revolution: Unfinished Tasks and Promise of the Nineties." Kisanworld 5:10-12.

Sashi, S. and B. D'Silva, 1989. "Catch a Moth and You Will Kill a Caterpillar." ILEIA Newsletter 4(3):29-30.

Shankaran, V. 1988. "A Case Study of Bhil Grasia in Western India." Paper presented at Seventh World Congress on Rural Sociology, Italy. as cited in A. Gupta, J. Capoor and R. Shah. 1990. Inventory of Peasant Innovations for Sustainable Development: An Annotated Bibliography. Ahmedabad, India: Center for Management in Agriculture: Indian Institute of Management.

Shekhawat, G.S., A.V. Gadewar, V.K. Bahal, and R.K. Verma. 1988. "Cultural Practices for Managing Bacterial Wilt of Potatoes." pp.65-84. In International Potato Center (CIP). Report of Planning Conference on Bacterial Diseases of the Potato. Lima, Peru: CIP.

Schafer, J. 1989. "Utilizing Indigenous Agricultural Knowledge in the Planning of Agricultural Research Projects Designed to Aid Small-scale Farmers."pp. 116-120, In D.M. Warren, L.J. Slikkerveer, and S.O. Titilola (Eds.), Indigenous Knowledge Systems: Implications for Agriculture and International Development. Studies in Technology and Social Change No. 11. Ames, Iowa: Technology and Social Change Program, Iowa State University.

Schultz, E. 1989. "A Root for the Fuel Problem." International Ag-Sieve 2(6): 2.

Scoones, I. 1989. Patch Use by Cattle in Dryland Zimbabwe: Farmer Knowledge and Ecological Theory. ODI Pastoral Development Network Paper No. 28. London: Overseas Development Institute.

Selvanayagam, M. 1986. Techno-Cultural Profile of Dryland Farming. Unpublished M.Sc.(Ag) Thesis. Coimbatore, India: Tamil Nadu Agricultural University.

Slikkerveer, L.J. 1992. Personal Communication. 4.18.92.

Smith, R.M. 1982. Learing How to Learn: Applied Learning Theory for Adults. New York: Cambridge Books.

Technical Advisory Committee, 1990. A Possible Expansion of the CGIAR. Washington, D.C.: Consultative Group for International Agricultural Research.

Thrupp, L. 1989. "Legitimizing Local Knowledge: Scientized Packages or Empowerment for Third World People." pp.138-153, In D.M. Warren, L. J. Slikkerveer, and S.O. Titilola, Indigenous Knowledge Systems: Implications for Agriculture and International Development. Studies in Technology and Social Change No. 11. Ames: Iowa State University.

Thurston, D. 1992. Sustainable Practices for Plant Disease Management in Traditional Farming Systems. Boulder, Colorado: Westview Press.

Tripp, R. and J. Woolley. 1989. The Planning Stage of On-Farm Research: Identifying Factors for Experimentation. Mexico, Colombia: CIMMYT and CIAT.

Tung, L. 1992. "Farmer Experimentation." On-Farm Research Notes 11:2.

Upawansa, G.K. 1989. "Ancient Methods for Modern Dilemmas." ILEIA Newsletter 4(3): 9-11.

Vellve, R. 1989. "Grass Roots Alternatives for Conserving Genetic Diversity." ILEIA Newsletter 5(4): 28-30.

Venkataratnam, L. 1990. "Farmers' Wisdom for a Sustainable Agriculture." Kisanworld 7(12): 22

Vietmeyer, S. 1989. "Biodiversity and Underexploited Species." International Ag-Sieve 2(6): 4.

Vijayalakshmi, K. 1991. "Farmers and Proverbs." Thenikal 1(1): 2.

Wang, G.H. 1988. "Indigenous Communication Systems in Research and Development." Journal of Extension Systems 4(2): 75-86.

Warren, D. M. 1987. "Editor's Notes." CIKARD News 1(1): 5.

Warren, D.M. 1989. "Linking Scientific and Indigenous Agricultural Systems." pp. 153-170, In J.L. Compton, (Ed.), The Transformation of International Agricultural Research and Development. Boulder: Lynne Rienner Publishers.

Warren, D.M. 1990. "Indigenous Knowledge Systems and Development." Background paper for Seminar Series on Sociology and Natural Resource Management. The World Bank, Washington, D.C. December 3, 1990.

Warren, D.M. 1991a. "Indigenous Knowledge Systems for Sustainable Agriculture in Africa." In Proceedings of the 1990 International Conference on Sustainable Agriculture in Africa. Columbus, Ohio: The Ohio State University, Center for African Studies.

Warren, D.M. 1991b. The Role of Indigenous Knowledge in Facilitating the Agricultural Extension Process. Paper presented at International Workshop on Agricultural Knowledge Systems and the Role of Extension. Bad Boll, Germany, May 21-24, 1991.

Warren, D.M. 1991c. Using Indigenous Knowledge in Agricultural Development. World Bank Discussion Paper No. 127. Washington, D.C. : The World Bank.

Warren, D.M. 1992a. "Indigenous knowledge, Biodiversity Conservation and Development." Keynote Address at International Conference on Conservation of Biodiversity in Africa: Local Initiatives and Institutional Roles. Nairobi, Kenya August 30 - September 3, 1992.

Warren, D.M. 1992b. "Using Indigenous Knowledge for Agriculture and Rural Development." A Concept Paper for Exploring the Potential Utility of The Global Network of Indigenous Knowledge Resource Centers for International and National Agricultural Research Centers. Ames, Iowa: CIKARD, Iowa State University.

Warren, D.M. 1992c. "Indigenous Knowledge and Sustainable Development: A Review of Critical Research Areas and Policy Issues."Paper presented at the International Symposium on Indigenous Knowledge and Sustainable Development. Silang, Cavite, Philippines, September 20-26, 1992.

Warren, D.M. 1992d. Strengthening Indigenous Nigerian Organizations and Associations for Rural Development: The Case of Ara Community. Occasional Paper No. 1. Ibadan: African Resource Centre for Indigenous Knowledge.

Warren, D.M. 1992e. A Preliminary Analysis of Indigenous Soil Classification and Management Systems in Four Ecozones of Nigeria. Discussion Paper RCMD 92/1. Ibadan, Nigeria: Resources and Crop Management Division (RCMD), International Institute of Tropical Agriculture.

Warren, D.M., L.J. Slikkerveer and S.O. Titilola. (Eds). 1989. Indigenous Knowledge Systems: Implications for Agriculture and International Development. Studies in Technology and Social Change No. 11. Ames, Iowa: Technology and Social Change Program, Iowa State University.

Warren, D.M.and B. Rajasekaran. 1991. Utilizing and Integrating Indigenous Knowledge Systems for Agricultural and Rural Development: Training Manual and Guide for Extension Workers. Ames, Iowa: CIKARD, Iowa State University.

Waters-Bayer, A. 1987. Participatory Technology Development in Ecologically Oriented Agriculture: Some Approaches. ODI Agricultural Administration (Research and Extension) Network Discussion Paper No. 7. London: Overseas Development Institute.

Waters-Bayer, A. and J. Farrington, 1990. "Supporting Farmers Research and Communication: The Role of Grass-roots Agricultural Advisors." Paper presented at the 10th Annual Conference of the Association for Farming Systems Research/ Extension. East Lansing, Michigan. Oct.14-17. 1990.

Wilson, E.O. and F.M. Peter, F.M. (Eds.) 1988. Biodiversity. Washington, D.C.: National Academy Press.

Wiersum, K.F. and C. Veer. 1983. "Loan Financing of Smallholder Tree Farming in Ilocos: A Comment." Agroforestry Systems 1:361-365

Wolf, E.C. 1987. "Beyond the Green Revolution." Economic Impact 58: 68-73.

World Bank 1990. Agricultural Extension: The Next Step. Policy and Research Paper No. 13. Washington, D.C. : The World Bank.

Worman, F., G. Heinrich and D. Norman. 1991. "Some Organizational Considerations in Implementing FSR in a Harsh Environment: Increasing Farmer Involvement in Botswana." Journal of Farming Systems Research-Extension 2(3): 119-138.

ACKNOWLEDGEMENTS

My deep sense of gratitude is due to every one of the participant farmers of the Union Territory of Pondicherry, India for their profound contribution to the study. But for their invaluable knowledge, input, active participation, and precious time, this study would have been beyond imagination.

I am extremely grateful to my Co-Major Professor, Dr. Robert A. Martin, Associate Professor, Department of Agricultural Education and Studies, for his invaluable guidance, financial support, and encouragement. Dr. Martin's suggestions and input were invaluable throughout the period of this study. I especially appreciated the lengthy discussions we had while developing a model based on the results of this study. I will always keep his teaching skills and delivery techniques in high esteem.

I am indebted to my Co-Major Professor, Dr. D. Michael Warren, Director, Center for Indigenous Knowledge for Agriculture and Rural Development (CIKARD), who inculcated in me the value of and need for learning from rural people. Prior to joining CIKARD in 1987, I held the following perception while serving as an extensionist for about seven years: "my knowledge is always superior to that of rural people and they should always listen to me." Hence, the credit for changing the behavior of a top-down extensionist goes to Dr. Warren and to CIKARD. I would especially like thank Dr. Warren for providing me the financial support, office space, computer and supplies that I needed to complete this study. Dr. Warren's suggestions and input were invaluable throughout the period of this study. I will never forget his untiring support and encouragement.

It is a great honor for me to have worked, during the course of the study, as a visiting scientist under Professor M.S. Swaminathan, the World's renowned food and agriculture scientist and the architect of Indian agriculture. Professor Swaminathan was the first recipient of the World Food Prize. I am highly grateful for his precious time and invaluable suggestions and for providing me an opportunity to work with an interdisciplinary team of high calibre scientists. I am also thankful to Mrs. Mina Swaminathan for her encouragement and suggestions especially while conducting participatory meetings with rural men and women of the study villages.

I am highly thankful to Dr. David L. Williams, Assistant Dean, College of Education for serving on my doctoral committee. His continued support and encouragement is gratefully regarded. My sincere thanks are also due to Dr. Julia Gamon and Professor Jerry Knox for serving on my doctoral committee and for their encouragement. My sincere appreciation also goes to Professor Gerard McKiernan, Coordinator, CIKARD Documentation Unit and Library for constantly updating me with information on recent literature in the field. I am grateful to the World Food Institute, Iowa State University, for having provided me with a research assistantship for the year 1992-93.

I am highly grateful to my parents for their ceaseless love, unending support, and, finally, for inculcating in me the value of "hard work." I am also thankful to my parents-in-law for their love and support. I am highly thankful to my uncle Mr. G. Varadan and his family for their love and support. A special note of thanks to Suresh and Chitra for their love and encouragement.

My sincere appreciation is due to Dr. R.S. Santhakumar Hopper, Coordinator and Chief Scientist of the Biovillage Project, M.S. Swaminathan Research Foundation, for helped me in so many ways to complete the data collection process successfully. Santhakumar is a role model for biological scientists who also wish to work as social scientists. His friendship will always be remembered. I reserve special thanks to Dr. Sanjay Deshmukh, Scientist, Biodiversity Project, for his friendship and encouragement during the study period.

My sincere thanks and appreciations are also due to the following people:

To the farmers of the study villages: Ms. Maninder Pal, Rangan Reddiyar, Arumugam, Mahalingam, Govindasamy, Krishnan, Sarangapani, Rajavelu, Krishnan, Manad, Padmanaba Reddiyar, Kanagaraj, Padnamaba Reddiyar, Ramanujam, Sivasankaran, Velayudam, and Kandasamy who served as key informants and provided me with information about and interpretation of their farming experiences and the indigenous knowledge roots behind them.

To Miss Palani, Research Assistant, M.S. Swaminathan Research Foundation for assisted me during the process of data collection.

To Mr. Benedictus, Director of Agriculture, Pondicherry, for providing logistical support during the study period.

To Drs. Balaji, Raju, Saleth, and Mohan, Scientists, M.S. Swaminathan Research Foundation, for their kind cooperation.

To the farmers: Rangan Reddiyar, Padmanabha Reddiyar, Arumuga Mudaliyar, Jayaraman, Maninder Pal, and Manad Pillai for having hosted me lunch for a number of days during the study period.

To Mr. Boominathan, Agricultural Officer, Villianoor Commune, Pondicherry, for his assistance in data collection.

To Anthony Willett and Corrin Dekker, CIKARD Research Associates, for their friendship and exchange of ideas.

To Dr. Mike Whiteford, Dr. Norma Wolf, and Linda Haglund, Anthropology Department, ISU, for their cooperation.

Last but not the least, to my loving wife, Bharathi, for her understanding and support which providing me great strength and encouragement during every step of this project. Sarvesh, my son, deserves a special mention for having missed his mother for a continuous period of six months during the study period. He has also had to adjust twice to changing environments and missed me a number of evenings and nights as I completed this study.

APPENDIX

Description of Key Terms

I. Indigenous cropping systems

Indigenous cropping systems are those cropping systems that have been practiced for generations and still hold promise in meeting the food requirements of a growing population. Most of the cropping systems re well suited to the diversified agro-ecological conditions.

Sequential cropping is a system of cropping in which farmers sow two or three short duration crops in succession, especially legumes or oilseeds in lines between trees. Sequential cropping is adopted in marginal lands or dry lands. Sequential cropping contributes significantly to protein production for marginal and small-scale farmers.

Mixed cropping is a system of cropping in which farmers sow more than two crops at the same time. Farmers normally sow a mixture of legume and oilseed crops with an objective to meet protein and fat requirements. By sowing more than two crops, farmers try to avoid risks due to failure of any one crop. Mixed cropping is usually followed under rainfed conditions.

Monocropping is a system of cropping in which farmers cultivate the same crop in all three seasons in a year. Large-scale farmers who have access to irrigation prefer monocropping.

Intercropping is a system of cropping in which farmers cultivate two crops of different statures in alternate rows. Growing groundnuts and black gram or red gram and groundnuts are good examples.

Border cropping is a system of cropping in which farmers cultivate a major crop in the fields and a minor crop along the borders the fields. Rice and black gram are examples.

II. Indigenous soil health care practices

Indigenous soil health care practices are those practices evolved, adopted, and modified by farmers based on their own informal experiments with an objective to maintaining the fertility and productivity of the soil.

Crop rotation is a practice in which farmers grow different types of crops in various seasons. Crop rotation also implies that at least one legume crop should be incorporated in the cropping pattern in a year.

Fallowing is an indigenous soil health care practice in which farmers let cultivated land rest for a certain period of time before using it again.

Farm yard manure is a mixture of cow dung, cow urine, and paddy straw. Farmers apply farm yard manure especially to cereal crops such as rice, finger millets, and oilseeds such as groundnuts. Farm yard manure regulates the supply of nitrogen. Farm yard manure changes the color of the soil which is essential for absorbing sunlight. Farmers refer to this process as *mann matram* in Tamil.

Casuarina leaves: Farmers harvest *Casuarina equisetifolia*, a fuelwood tree, collecting the leaves and applying them to problem soils to counteract soil alkalinity.

Riverbed sand: Farmers apply sand that is collected from river beds if the problem of soil alkalinity is severe. There are some experienced farmers in the villages who can identify the severity of the soil alkalinity problem. Farmers facing alkalinity problems contact the experienced farmers for advise to correcting this problem.

Plowing Daincha *in situ* : Daincha is a root nodule shrub. Farmers with clayey soils, before planting rice, sow the Daincha seeds and plow the plants *in situ* when the plants become 45 days old.

Mulching consists of leaving crop residues in the field, or bringing in other materials such as foliage from elsewhere.

Teprosia leaves: Farmers grow *Teprosia populnea* trees near the irrigation pump sheds. After second or third plowing, they cut the leaves of *Teprosia* and spread them over the plowed fields for one night. During the next day, they plow these leaves into the soil. After this operation, they puddle the field for planting.

III. Indigenous rice seed selection and processing techniques

Removing rogue plants: Rogues are different varieties of the same crop. Identifying and removing the rogue plants is a skillful technique. Farmers remove rogue plants at least 25 days before harvesting in order to avoid admixtures and also to maintain the genetic purity of a particular variety of a rice crop. Farmers claim that rogue plants mature first.

Spreading *notchi* leaves over the rice seeds: Once rice seeds are processed and stored, farmers spread *notchi* leaves over the rice seeds to prevent infestation by stored pests.

Sieving rice seeds: Before sowing, farmers sieve rice seeds in order to separate the seeds of weeds. Since most of the weed seeds are bigger than rice seeds, they are filtered out in the sieves.

Manual threshing of rice seeds: By threshing rice seeds manually, farmers claim that the plumule area of rice seeds are protected. Many farmers are of the opinion that tractor threshed rice seeds are of poor germination potential.

Selecting healthy plots: Farmers by physical observation demarcate a small plot for seed purposes. This is usually done one month prior to harvesting. Healthy plots that are free from pests or diseases attack are selected. Farmers also hold certain beliefs while selecting the rice seed plots. During the *samba* season, they select a plot from the north east corner of the field. This is locally termed as *sani moolai*. During the *navarai* season, they select a plot from the southwest corner of the field, locally termed as *pillayar moolai*.

Farmer-to-farmer seed exchange: Farmers practice their own system of obtaining quality seeds. They form an informal network wherein they visit each other's fields before harvest. They judge the quality of the seeds by observation. If they are satisfied, they buy from each other. There are some large-scale farmers in the village who raise one to two acre seed farms every season. Many small-scale and marginal farmers reported that these seed grower are more reliable than the public seed distribution system.

IV. Indigenous crop nutrient management practices

Indigenous crop nutrient management practices are those manuring and fertilizing practices developed by farmers through judicious mixing of organic manures and chemical fertilizers.
Sheep manure: Some marginal farmers rear sheeps especially for their manure value. According to them, five to six sheeps are sufficient to cater to the manure needs of one acre of rice. Sheep manure is usually applied once in a year. Farmers who apply sheep manure usually skip the basal application of chemical fertilizers. Sheep manure is powdered and mixed with urea for top dressing. Sheep manure releases the nitrogen quickly when compared to farm yard manure.
Farm yard manure: Farm yard manure is a mixture of straw, cow dung, urine, and other plant materials. Pure cow dung is not good for the rice crop. According to farmers, the farm yard manure has certain specific advantages: (1) Farm yard manure increases yield by at least two bags (1 bag=75 kgs.); (2) Farm yard manure increases the grain weight of rice; (3) Robust seedlings can be obtained by the application of farm yard manure; (4) Top dressing of nitrogen can be reduced if farm yard manure is applied basally; and (5) Farm yard manure adds roughness to the crop surface thus minimizing pest incidence.

V. Indigenous rice transplanting techniques

Row planting: Planting in rows significantly increases the production of tillers in rice variety *ponni*. This practice also enables the farmers to undertake intercultural operations such as application of fertilizers and pesticides. This practice yields an additional two bags of rice per acre.
Pinch planting: During *navarai* season, farmers ask the laborers to plant only 2-3 seedling per hill. This is locally referred to as *killi poduthal* (pinch planting).
Clump planting: During *samba* season, farmers ask laborers to plant 4-5 seedlings per hill, This practice is locally referred to as *pudichi poduthal* (clump planting).

VI. Indigenous rice weed management strategies

Indigenous rice weed management strategies are those strategies adopted by farmers to minimize the growth of weeds in rice fields.
Puddling rice nurseries followed by drying: Farmers irrigate the rice nurseries on the first day. This irrigation enables the weed seeds to germinate. They store the water for three-four days. Some farmers wait even for one week. The water slowly dries up leaving the weeds. Then they plough the fields by turning the soil upside down. Thus, the germinated weeds are killed. Again, they irrigate the nursery area and repeat the entire practice. Farmers claim that meticulous practice of alternative wetting and drying of rice nurseries helps them to minimize weeding.
Weed management in rice main field: THe ollowing management practices are being followed by the farmers in order to manage the weeds effectively in the main field: (1) Preparing and levelling the main fields uniformly without undulations; (2) Maintaining the heights of the field bunds at one inch; (3) Storing water continuously up to 15 days

from planting. Draining of water especially during the first 20 days from planting leads to emergence of the weeds; (4) Maintaining the water level 1 inch; (5) Closer planting is necessary especially during the *navarai* and *sornawari* seasons; and (6) Applying neem cake to control *korai* weeds.

VII. Indigenous rice pest management strategies

Pest monitoring: Most of the farmers apply pesticides after a thorough pest monitoring. Farmers look for pest symptoms in rice tillers. For each rice pest, farmers have their own economic injury levels. They apply pesticides only if the infestation crosses economic injury levels. Only for earhead bug, do they apply pesticide immediately even if only one bug is seen.

Proper aeration to manage the attack of brown plant hopper: In order to minimize the attack of the brown plant hopper, farmers fold the rice crop once in eight feet. This practice not only provides aeration for the rice tillers but also exposes the culms of the rice crop where the brown plant hopper is usually found.

Local rat traps: Farmers invented these rat traps to kill rats in the rice fields. Rats are one of the major non-insect pests and contribute to 35% of grain loss. The damage is severe during the milky stage and grain formation stage. Farmers install these traps along the bunds to kill the rats during night times. The infestation is severe only during the night times. These traps are effective than chemical rodenticides. Moreover, rodenticides are known for polluting the environment as well as groundwater.

VIII. Indigenous technical practices for groundnuts

Sowing groundnuts in rice fallows: During the last week of December, after the harvest of *samba* paddy, utilizing the available moisture, farmers sow groundnut seeds using hand hoes. Sowing of groundnuts normally completed within three to five days to utilize the moisture effectively. The following are the significant advantages of this practice over the conventional method of sowing the groundnut seeds after the field preparation:

1. Efficient use of time since land preparation for the next season is not required;
2. Saves cost of labor for the land preparation;
3. Infestation of *Prodenia* is below the economic threshold level;
4. Two weedings are sufficient; and
5. No significant difference in the yield.

Intercultural operation in groundnuts: Some farmers in Kizhur village turn the soil using hand hoes immediately after the second weeding of the groundnut crop. This should be followed by pressing the soil closer to the groundnut plant up to a height of 3-4 inches from the surface of the soil. This practice results in increasing the rate of peg formation that consequently leads to higher yields in groundnuts. In spite of increased labor input for this activity, the farmers found a significant difference in the net profits.

Survey Instrument (in English)

Incorporating Indigenous Knowledge Systems into Agricultural Research and Extension Organizations in India

Section one: Extent to which farmers believe selected indigenous knowledge statements regarding food production are true

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.	Severe pest infestation limits the use of rice var. *Jawahar*	1	2	3	4	5
2.	Grain shedding is a major problem with rice var. *Ponmani*	1	2	3	4	5
3.	Low relative humidity influences pest infestation in rice var. IR.50	1	2	3	4	5
4.	*Mangala* is a moderately pest resistant rice variety	1	2	3	4	5
5.	Rice var. *Mangala* produces good yield	1	2	3	4	5
6.	Yield of rice var. *Ponni* is comparatively low	1	2	3	4	5
7.	Cost of cultivation of rice var. *Ponni* is low	1	2	3	4	5
8.	Lodging in rice var. *Ponni* leads to chaffy grains	1	2	3	4	5
9.	Yields of rice var. *Jawahar* is good	1	2	3	4	5
10.	Coarse grain rice varieties generally do not lodge	1	2	3	4	5
11.	Repeated planting of rice var. *Mangala* results in delayed maturity	1	2	3	4	5
12.	Clayey soil is suitable for rice var. CO.43	1	2	3	4	5
13.	Rice var. *Mangala* is preferable because of its short duration	1	2	3	4	5
14.	Rice var. CO.43 is suitable for alkaline soils	1	2	3	4	5
15.	Rice var. *Ponni* requires long photo periods	1	2	3	4	5
16.	Planting in rows prevents lodging in rice var. *Ponni*	1	2	3	4	5

17.	Row planting increases yields of rice var. *Ponni*	1	2	3	4	5
18.	Stunted growth of the rice crop indicates alkalinity in the soil	1	2	3	4	5
19.	Farmyard manure gives roughness to rice tillers	1	2	3	4	5
20.	Farmyard manure increases weight of rice grains	1	2	3	4	5
21.	Farmyard manure should be a mixture of straw, cow dung and urine	1	2	3	4	5
22.	Pure cow dung is not effective for the crops	1	2	3	4	5
23.	Sheep manure is more effective than cattle manure	1	2	3	4	5
24.	Production of greenish tillers leads to poor yield in rice	1	2	3	4	5
25.	Brown plant hoppers are found only on the culms of rice crop	1	2	3	4	5
26.	Stem borers do not pass from one shoot to another	1	2	3	4	5
27.	Increased nitrogen levels leads to an increase in leaf roller incidence	1	2	3	4	5
28.	Ear head bug can be identified from rogues in the beginning	1	2	3	4	5

Section Two: Extent to which farmers are using selected indigenous technical practices regarding food production

		Very Low	Low	Moderate	High	Very High
	<u>I. Indigenous Cropping Systems:</u>					
1.	Monocropping of rice is practiced in all the three seasons	1	2	3	4	5
2.	Fallowing is practiced before cultivating groundnut	1	2	3	4	5
3.	Groundnut is sown after the harvest of rice	1	2	3	4	5
4.	Intercropping cotton and groundnut is practiced	1	2	3	4	5
5.	Cotton is grown as a solution to irrigation scarcity	1	2	3	4	5

II. Indigenous Soil Health Care Practices:

6.	Application of calotropis to correct soil alkalinity	1 2 3 4 5
7.	Application of neem leaves to correct soil alkalinity	1 2 3 4 5
8.	Application of *odian* leaves to correct soil alkalinity	1 2 3 4 5
9.	Application of casuarina leaves to correct soil alkalinity	1 2 3 4 5
10.	Crop rotation is practiced to maintain soil fertility	1 2 3 4 5
11.	Application of sand to neutralize soil alkalinity	1 2 3 4 5
12.	Leaving sufficient gaps between crops maintain the soil fertile	1 2 3 4 5
13.	Fallowing for at least one season to maintain soil fertility	1 2 3 4 5
14.	Application of farm yard manure loosens the soil	1 2 3 4 5

III. Indigenous Rice Seed Processing Strategies:

15.	Drying rice seeds for one month before storing	1 2 3 4 5
16.	Threshing of rice seeds manually to maintain seed quality	1 2 3 4 5
17.	Sieving rice seeds to separate the seeds of weeds	1 2 3 4 5
18.	Rice seeds once processed, and stored will be used only during next sowing	1 2 3 4 5
19.	Spreading *notchi* leaves over the rice seeds to prevent stored pests	1 2 3 4 5
20.	Usage of common threshing floor leads to admixture of rice seeds	1 2 3 4 5
21.	Removing the rogues at least 25 days before harvesting	1 2 3 4 5
22.	Changing rice seeds once in every two seasons to maintain seed seed quality	1 2 3 4 5

IV. Indigenous Rice Planting Techniques

23.	Planting aged seedlings of rice var. Ponni to prevent lodging	1 2 3 4 5
24.	Row planting results in increased tillers in rice var. Ponni	1 2 3 4 5
26.	Planting 55-60 day old seedlings of rice var,Ponni to conserve nutrients	1 2 3 4 5

27.	E.S.18 produces good yield if planted on 21st day	1	2	3	4	5

V. Indigenous Crop Nutrient Management Strategies in Rice:

28.	Farm yard manure is applied once in every year	1	2	3	4	5
29.	Reducing the amount of fertilizers while applied as top dressing	1	2	3	4	5
30.	Application of *Teprosia populnea* leaves as a green leaf manure	1	2	3	4	5
31.	Restrain from top dressing of nitrogen during rainy days	1	2	3	4	5

VI. Indigenous Weed Control Strategies in Rice

32.	Puddling of rice nurseries followed by drying to controls weeds	1	2	3	4	5
33.	Alternative puddling and drying of rice nurseries to control weeds	1	2	3	4	5
34.	Levelling of rice nurseries without undulations minimizes weeds	1	2	3	4	5
36.	Storing the water for 15 days from planting controls weeds	1	2	3	4	5
37.	Raising the bunds of main fields controls weeds	1	2	3	4	5
38.	Water level should be maintained at least at 1"	1	2	3	4	5
39.	Closer planting controls rice weeds	1	2	3	4	5

VII. Indigenous Water Management Strategies in Rice:

40.	Irrigate the clayey soils once in a week	1	2	3	4	5
41.	Irrigate the loamy soils once in three to four days	1	2	3	4	5
42.	Irrigate frequently during milky stage of the rice crop	1	2	3	4	5
43.	Irrigate once in fifteen days after milky stage of the rice crop	1	2	3	4	5
44.	Stop irrigation 15 days before harvesting the rice crop	1	2	3	4	5

VIII. Indigenous Pest Management Strategies in Rice:

45.	Application of farm yard manure reduces the incidence of pests	1	2	3	4	5
46.	Providing proper aeration manages the attack of brown plant hopper	1	2	3	4	5

47.	Alternative wetting and drying reduces brown plant hopper attack	1	2	3	4	5
48.	Application of pesticides immediately when the first earhead is seen	1	2	3	4	5
49.	Ploughing and exposing the soil to sunlight destroys eggs of pests	1	2	3	4	5
51.	Delaying the top dressing reduces the pest incidence	1	2	3	4	5
52.	Crop rotation minimizes pest incidence	1	2	3	4	5

IX. Indigenous Technical Practices in Groundnut

53.	Groundnut is sown on 15th of Tamil month *Karthigai*	1	2	3	4	5
54.	Groundnut is sown in rice fallows in clayey soils	1	2	3	4	5
55.	Hoeing in groundnut to increase yield	1	2	3	4	5
56.	Firing crackers to scare birds and fox attack	1	2	3	4	5
57.	Application of gypsum while sowing	1	2	3	4	5

X. Indigenous Technical Practices in Tapioca:

58.	Draining the tapioca fields frequently to prevent rotting of tubers	1	2	3	4	5
59.	Reducing the frequency of irrigation for tapioca in clayey soils	1	2	3	4	5
60.	Application of green manure to increase the size of tapioca tubers	1	2	3	4	5
61.	Irrigating the tapioca while harvesting	1	2	3	4	5
62.	Cultivating tapioca in sandy soils increases its yield	1	2	3	4	5
63.	Dipping the tubers in clayey solution to protect tubers from rotting	1	2	3	4	5

Section Three: Adoption of Station Research Technologies

		Very High	High	Moderate	Low	Very Low
1.	Raising rice seedlings before January 31 for navarai season	1	2	3	4	5
2.	Planting 2-3 rice seedling per hill	1	2	3	4	5
3.	Planting 50 rice seedlings per square meter	1	2	3	4	5
4.	Applying fertilizers to crops based on soil test recommendations	1	2	3	4	5
5.	Applying top dressing to rice in three split doses	1	2	3	4	5
6.	Mixing urea with neem cake for slow release of nitrogen in rice	1	2	3	4	5
7.	Applying potash to increase the grain weight in rice	1	2	3	4	5
8.	Applying blue green algae and azolla to substitute chemical fertilizers	1	2	3	4	5
9.	Applying gypsum to correct soil alkalinity	1	2	3	4	5
10.	Applying zinc sulphate to correct soil alkalinity	1	2	3	4	5
11.	Applying weedicides to control weeds	1	2	3	4	5
12.	Pesticides are mixed with neem oil	1	2	3	4	5
13.	Gypsum is applied to groundnut after hoeing and weeding	1	2	3	4	5

Section Four: Demographic Information

1. Name:
2. Size of holding:
3. Village:
4. Age:
5. Education:
6. Agricultural experience (in years):
7. Soil type: Clayey ( ) Loamy ( ) Sandy ( )
   Sandy loam ( )
8. Size of the family:
9. Irrigation type: Tube wells ( ) Canals ( ) Rental water ( )
10. Level of water in the tube wells (in feet):
11. Power of motor engines (in HP):
12. Time taken to irrigate one acre (in hours):
13. Relationship with tubewell owners: Good ( ) Moderate ( ) Poor ( )
14. Type of agricultural labor: Family ( ) Colony ( )
    Outside ( ) Women ( )
15. Agricultural priorities: Home consumption ( ) Market ( )
    Cattle feed ( ) Fuel ( )
16. Number of livestock: Cows ( ) Bulls ( ) Goats ( )
17. Seed source:
    Credit source:
18. Technological information source:

		IKS	SRT
1.	Assistant Agricultural officer	( )	( )
2.	Own experience	( )	( )
3.	Family experience	( )	( )
4.	Neighboring farmers	( )	( )

5.	Friends		( )	( )
6.	Relatives		( )	( )
7.	Progressive farmers		( )	( )
8.	Input distribution center		( )	( )
9.	Co-operative society		( )	( )
10.	Others		( )	( )

19. Mass media contact:

		Frequent	Occasional	Never
1.	News paper	( )	( )	( )
2.	Radio	( )	( )	( )
3.	Television	( )	( )	( )

Survey Instrument (in *Tamil*)

உயிர் கிராமங்களில் விவசாயிகளிடம் ஓர் கருத்தாய்வு

எம்.எஸ். சுவாமிநாதன் ஆராய்ச்சி நிலையம்

பகுதி ஒன்று: விவசாயிகளின் அறிவுத்திறன்

பின்வரும் வேளாண் சம்பந்தப்பட்ட அறிவுத்திறன்களின் தங்களின் ஏற்பு/மறுப்பு கருத்துக்கூற இயலாமையை தெரிவிக்கவும்

	விவசாயிகளின் அறிவுத்திறன்	உ.ஏ	ஏ	க.இ	ம	உ.ம
	அ. தேவைகள் மற்றும் பிரச்சினைகள்					
1.	தண்ணீர் கிடைக்கும் தருவாயில் நெற்பயிர் தான் பயிரிடுவோம்	5	4	3	2	1
2.	கரும்பு பயிரிட்டால் சாப்பாடு மற்றும் தீவனத்திற்கு கஷ்டம்	5	4	3	2	1
3.	பொதுவாக மல்லாட்டை விதையை அடுத்த வருடத்திற்கு உபயோகிப்பதில்லை	5	4	3	2	1
4.	தண்ணீர் பற்றாக்குறை காரணமாக சவுக்கு பயிரிடுகிறேன்	5	4	3	2	1
5.	கேழ்வரகு உணவு உண்ணும் பழக்கம் உள்ளவர்கள் நெல்லுக்கு அடுத்தது கேழ்வரகு பயிரிடுகிறார்கள்	5	4	3	2	1
6.	பொன்னிக்கு அடுத்தபடி நல்ல விலை கிடைப்பதால் நெரு ரகம் பயிரிடுகிறேன்	5	4	3	2	1
7.	சவுக்கின் விலையை எங்களால் நிர்ணயிக்க முடிகிறது	5	4	3	2	1
8.	பொன்னி பயிர்செய்தாலும் நெருவையே சாப்பாட்டிற்கு வைத்துக்கொள்வோம்.	5	4	3	2	1
9.	பொன்னியை சாப்பாட்டிற்கு உபயோகிக்கிறோம்	5	4	3	2	1
10.	மரவள்ளி பயிர் செய்தால் விறகு பிரச்சினை இல்லை	5	4	3	2	1
11.	காவலுக்கு ஆள் இல்லாததால் மல்லாட்டை போட முடிவதில்லை	5	4	3	2	1
12.	நெல் எல்லா பருவத்திலும் மாட்டுத் தீனிக்காக போடவேண்டியிருக்கிறது	5	4	3	2	1
13.	பக்கத்தில் இருப்பவர்கள் என்ன பயிர் செய்கிறார்களோ அதை தான் நாமும் செய்ய வேண்டும்	5	4	3	2	1
14.	நாங்களே சில பண்ணை வேலைகளை செய்வதால் செலவு குறைகிறது	5	4	3	2	1

15. உர விலை ஏறியதால்தான் சவுக்கு பயிரிடுகிறேன் 5 4 3 2 1

16.

17.

ஆ. பயிர் முறைகள்

18. நெல்லைத்தான் மூன்று போகத்திற்கும் பயிரிடுகிறேன் 5 4 3 2 1

19. ஒரு போகம் தரம்பாக விட்டு மல்லாட்டை பயிரிடுவேன் 5 4 3 2 1

20. நெற்பயிருக்கு முன்போகம் மல்லாட்டைப் போட்டால் நெல் மகசூல் அதிகரிக்கும் 5 4 3 2 1

21. பருத்தி + மல்லாட்டை ஊடு பயிர் செய்தால் கரும்பில் கிடைக்கும் பணத்தை எடுத்துவிடலாம் 5 4 3 2 1

22. சவுக்குத் தோட்டத்தில் முதல் வருடத்தில் உளுந்து, பச்சைப்பயிறு, எள் முதலிய பயிர்களை ஒன்றன் பின் ஒன்றாக பயிரிடுவேன் 5 4 3 2 1

23. பருத்தி, உளுந்து, எள் முதலியவற்றை கலப்புப்பயிர் ஆக நன்செய்யில் பயிரிடுவேன் 5 4 3 2 1

24. தண்ணீர் தட்டுப்பாடு இருந்தால் பருத்தி பயிரிடுவேன் 5 4 3 2 1

25.

26.

இ. மண் பராமரிப்பு முறைகள்

27. களரை முறிக்க எருக்கன் தழை போடுவேன் 5 4 3 2 1

28. களரை முறிக்க வேப்பன் தழை போடுவேன் 5 4 3 2 1

29. களரை முறிக்க ஒதியன் தழை போடுவேன் 5 4 3 2 1

30. களரை முறிக்க சவுக்கு தழை போடுவேன் 5 4 3 2 1

31. பயிர் குன்றி காணப்பட்டால் அது களருக்கு அறிகுறி 5 4 3 2 1

32. மண் வளத்தைப் பராமரிக்க தாளை மாற்றுவேன் 5 4 3 2 1

33. மணல் போட்டால் களர் முறியும் 5 4 3 2 1

34. மண் வளத்தைப் பாதுகாக்க மண்ணை நன்றாக ஆறப் போடுவேன் 5 4 3 2 1

35. ஒரு போகமாவது தரம்பாக விட்டால் மண் வளம் அதிகரிக்கும் 5 4 3 2 1

36. தொழுஉரம் இடவில்லை என்றால் மண் பொசபொசப்பு கொடுப்பதில்லை

38.

39.

ஈ. நெல்

1. ரகங்களும் அதன் தன்மைகளும்

40.	நெரு ரகத்தில் பூச்சித்தாக்குதல் அதிகம்	5	4	3	2	1
41.	அறுவடையின் போது மணி கொட்டுதல் பொன்மணி ரகத்தில் ஒரு பிரச்சினை	5	4	3	2	1
42.	ஐ.ஆர்.50 ரகத்திற்கு பனி ஆகாது	5	4	3	2	1
43.	இ.எல்.18 ரகம் பூச்சித்தாக்குதலை தாங்கி வளரக்கூடியது	5	4	3	2	1
44.	இ.எல்.18 நல்ல ஒப்படி தருவதால் அதை பயிரிடுகிறேன்	5	4	3	2	1
45.	பொன்னியின் ஒப்படி திருப்தி அளிக்கவில்லை	5	4	3	2	1
46.	பொன்னிக்கு செலவு குறைவுதான்	5	4	3	2	1
47.	பொன்னி பால் எழும்போது சாய்ந்து விட்டால் சாவி ஆகிவிடும்	5	4	3	2	1
48.	நெரு நல்ல ஒப்படி ஆவதால் அதை பயிரிடுகிறேன்	5	4	3	2	1
49.	மோட்டா நெல் ரகங்கள் சாய்வதில்லை	5	4	3	2	1
50.	ஐ.ஆர்.50 -இல் புகையான் தாக்குதல் அதிகம்	5	4	3	2	1
51.	இ.எல்.18 ரகத்தை அடுத்தடுத்து பயிர் இடும் போது அதன் வயது கூடுகிறது	5	4	3	2	1
52.	கோ.43 கருவடை மண்ணில் நன்றாக வளர்கிறது	5	4	3	2	1
53.	இ.எல்.18 ரகம் குறைந்த வயதுடையதால் அதனை பயிரிடுகிறேன்	5	4	3	2	1
54.	கோ.43 களர் மண்ணிற்கு ஏற்ற ரகம்	5	4	3	2	1
55.	பொன்னிக்கு வெயில் அதிகம் தேவைப்படுகிறது	5	4	3	2	1
56.						
57.						

2. விதை மற்றும் விதை சுத்திகரிப்பு

58.	நெல் விதையை மாதத்திற்கு ஒரு முறை காயப்போடுவோம்	5	4	3	2	1
59.	விதை நெல்லை கையால் அடித்து எடுப்போம்	5	4	3	2	1
60.	விதை நெல்லை சல்லடையில் சலித்து புல்விதையை பிரித்துவிடுவோம்	5	4	3	2	1

61.	விதை நெல்லை ஒரு முறை சுத்தம் செய்து, எடுத்து வைத்து விட்டால் அதோடு விதைக்கும் போதுதான் அதை எடுப்போம்	5	4	3	2	1
62.	விதை நெல் பானையில் நொச்சித்தழைப் போட்டால் வண்டுகள் வராது	5	4	3	2	1
63.	விதை நெல்லில் பி.எச்.சி.10 சதத்தூள் தூவுவோம்	5	4	3	2	1
64.	பொத் களத்தை உபயோகிப்பதால் அதிக கலப்பு ஏற்படுகிறது	5	4	3	2	1
65.	கலப்பு பயிரை அறுவடைக்கு குறைந்தது 25 நாட்களுக்கு முன் நீக்கிவிட வேண்டும்	5	4	3	2	1
66.	சொந்த விதையை இரண்டு போகத்திற்கு மேல் உபயோகிக்கக்கூடாது	5	4	3	2	1
67.						
68.						

<u>3. நடும் முறைகள்</u>

69.	ஒரு இடத்தில் பயிர் செய்யும் விவசாயிகள், ஒரே நேரத்தில் பயிர் செய்தால் தான் நல்லது.	5	4	3	2	1
70.	சாலை நடவு நட்டால் பொன்னியில் அதிக கிளைப்பு ஏற்படும்	5	4	3	2	1
71.	பொன்னி பயிரை சாலையில்தான் நடுவேன்	5	4	3	2	1
72.	சாலையில் நட்டால், பொன்னி பயிர் சாயாது	5	4	3	2	1
73.	சாலையில் நட்டால், பொன்னி அதிக ஒப்பிடி ஆகும்	5	4	3	2	1
74.	55-60 நாள் பொன்னி நாற்று நட்டால், சாயாது	5	4	3	2	1
75.	இ.எஸ். 18 ரகத்தி 21ம் நாளில் நட்டால், நன்றாக ஒப்பிடி ஆகும்.	5	4	3	2	1
76.	பண்ணையாட்கள் கைக்கு வந்த நாற்றை நடுகிறார்கள்	5	4	3	2	1
77.						
78.						

<u>4. பயிர் சத்துக்கள் மற்றும் அதனை இடும் முறைகள்</u>

79.	தொழுவுரத்தை வருடத்திற்கு ஒரு முறை இடுவோம்	5	4	3	2	1
80.	தொழுவுரம் இடுவதால் பயிர் திடமாக வருகிறது	5	4	3	2	1
81.	தொழுவுரம் இடுவதால் [illegible]					

82. தொழுவுரம் செத்தையும், சொருமாக இருக்க வேண்டும்.	5	4	3	2	1
83. வெறும் சாணத்தில் பிரயோசனம் இல்லை	5	4	3	2	1
84. தொழுவுரம் இட்டு மேலுரத்தை குறைத்துகொள்வோம்	5	4	3	2	1
85. இரசாயன உரம் தொடர்ந்து இடுவதால் ஒப்பிடி குறைகிறது	5	4	3	2	1
86. அதிக கூலி ஆவதால், யூரசுத்தழை கழித்து போட முடிவதில்லை	5	4	3	2	1
87. ஆட்டுவுரம், தொழுவுரத்தைவிட சக்தி வாய்ந்தது	5	4	3	2	1
88. நாற்றல்நாளில் பொன்னி பயிருக்கு உரம் இடமாட்டோம்	5	4	3	2	1
89. பயிர் பசுமையாக இருந்தால் ஒப்படி குறையும்	5	4	3	2	1
90.					
91.					

5. களைகளை கட்டுப்படுத்துதல்

92. நாற்றங்காலை நன்றாக காயப்போட்டால் களை குறையும்	5	4	3	2	1
93. இரண்டு நாளைக்கு ஒரு முறை ஒட்டினால் களைகளை கட்டுப்படுத்தலாம்	5	4	3	2	1
94. களைகளை கட்டுபடுத்த நடவு வயலை மேடு, பள்ளம் இல்லாமல் சமமாக ஒட்டுவோம்	5	4	3	2	1
95. மேட்டுப்பகுதிகளில் களைகள் சீக்கிரம் முளைத்துவிடும்	5	4	3	2	1
96. களைகளை கட்டுப்படுத்த 15ம்நாள் வரை தண்ணீர் கட்டுவோம்	5	4	3	2	1
97. வரப்பை உயர்த்தினால், களைகளை குறைக்கலாம்	5	4	3	2	1
98. ஒரு அங்குலம் வரை தண்ணீர் கட்ட வேண்டும்	5	4	3	2	1
99. உழும் போதும், தண்ணீர் கட்டும் போதும், கவனமாக இருந்தால், ஒரு களை எடுத்தால் போதும்	5	4	3	2	1
100. தண்ணீர் காய்ந்தால் களை முளைத்துவிடும்	5	4	3	2	1
101. நெருக்கி நட்டு களைகளை கட்டுப்படுத்துவோம்	5	4	3	2	1
102.					
103.					

6. நீர் பாரமரிப்பு முறைகள்

104.	களிப்பு நிலத்தில் மூன்று நாளைக்கு ஒரு முறை நீர் பாய்ச்சுவோம்	5	4	3	2	1
105.	மணமேறியில் ஒரு நாள் விட்டு ஒரு நாள் நீர் பாய்ச்சுவோம்	5	4	3	2	1
106.	சித்திரை மாதத்தில் நீர் மட்டம் குறைந்துவிடும்	5	4	3	2	1
107.	பால்பிடித்தபிறகு இருவாரத்திற்கு ஒரு முறை நீர் பாய்ச்சினால் போதும்	5	4	3	2	1
108.						
109.						
110.						

7. பயிர் பாதுகாப்பு முறைகள்

111.	பயிர் பச்சையாக இருந்தால் சோலை பூச்சி அதிகம் தாக்கும்	5	4	3	2	1
112.	தொழுவுரம் பூச்சி தாக்குதலை குறைக்கிறது	5	4	3	2	1
113.	காற்றோட்டம் இருந்தால் புகையான் வராது	5	4	3	2	1
114.	காய்ச்சலும், பாய்ச்சலுமாக இருந்தால் புகையானை கட்டுப்படுத்தலாம்	5	4	3	2	1
115.	பயிர் இல்லாத நேரத்தில், அன்னப்பூச்சி சவுக்கில் காணப்படும்	5	4	3	2	1
116.	அன்னப்பூச்சியை பார்த்த உடனேயே மருந்து அடிப்போம்	5	4	3	2	1
117.	களைப்பயிரிலிருந்துதான், அன்னப்பூச்சியை கண்டுபிடிப்போம்	5	4	3	2	1
118.	சம்பாவில் புகையான் தாக்குதல் அதிகம் காணப்படுகிறது	5	4	3	2	1
119.	அறுவடை முடிந்ததும் புழுதிஓட்டி காயப்போடுவோம்	5	4	3	2	1
120.	அன்னப்பூச்சி மருந்து வாசனை குறைந்ததும், மறுபடியும் வந்துவிடும்	5	4	3	2	1
121.	இ.எஸ். 18ல் பூச்சி தாக்குதல் குறைவு	5	4	3	2	1
122.	அனைவரும் ஒரே நேரத்தில் மருந்து அடிக்க வேண்டும்	5	4	3	2	1
123.	தொழுவுரம் இடுவதால் பூச்சி தாக்குதல் குறைகிறது	5	4	3	2	1
124.	மேலுரம் நாள் கடந்து போட்டால் பூச்சி தாக்குதல் குறைகிறது	5	4	3	2	1

125.	தாள் மாற்றுவதால் புச்சி தொல்லை குறைகிறது	5	4	3	2	1
126.						
127.						

உ. சவுக்கு

128.	வேலைக்கு ஆள் கிடைப்பது கடினமாதலால் சவுக்கு பயிர் வைக்கிறோம்	5	4	3	2	1
129.	மொத்தமாக பணம் கிடைப்பதால் சவுக்கு பயிர் வைக்கிறோம்	5	4	3	2	1
130.	தண்ணீர் கிடைக்காததால் சவுக்கு பயிர் வைக்கிறோம்	5	4	3	2	1
131.	சவுக்கில் ஊடுபயிர் செய்வது தண்ணீரை பொறுத்ததாக்	5	4	3	2	1
132.	சவுக்கு பயிரிடுவதால் பக்கத்தில் பயிர் வைப்பவர்கள் பாதிக்கப்படுகிறார்கள்	5	4	3	2	1
133.	சவுக்கு காண்டிராக்ட் விட்டுவிடுவதால் அறுவடை செய்வது சுலபம்	5	4	3	2	1
134.	சவுக்கு நாள் ஆக ஆக, அதிக பணம் தான்	5	4	3	2	1
135.	சவுக்கு மண் வளத்தை அதிகரிக்கிறது	5	4	3	2	1
136.						

ஊ. மல்லாட்டை

137.	கார்த்திகை 15ம் தேதி மல்லாட்டை விதைப்பிற்கு ஏற்ற பருவம்	5	4	3	2	1
138.	நெல்தரிசில் மல்லாட்டை விதைப்பு செய்வோம்	5	4	3	2	1
139.	நெல் தரிசில் மல்லாட்டை விதைத்தால் நல்ல ஒப்பிடியாகும்	5	4	3	2	1
140.	நெல் தரிசில் மல்லாட்டை விதைப்பிற்கு ஏற்றது களி மண்	5	4	3	2	1
141.	தண்ணீர் பற்றாக்குறையை சமாளிக்க மல்லாட்டை போடுவேன்	5	4	3	2	1
142.	மல்லாட்டை களிப்பு நிலத்தில் வேர்கள் அடி படும்	5	4	3	2	1
143.	மண் அணைத்தால் அதிக ஒப்பிடி ஆகும்	5	4	3	2	1
144.	நரி, பறவைகளை கட்டுப்படுத்த பட்டாசு கொளுத்துவோம்	5	4	3	2	1
145.	விதைக்கும் போது, ஜிப்சம் இட்டால் நன்றாக எடுத்துக் கொள்ளும்	5	4	3	2	1

146.

147.

ஏ. மற்ற பயிர்கள் : மரவள்ளி, பருத்தி, மிளகாய்

148.	மரவள்ளி பயிரில் தண்ணீர் தேங்கினால் கிழங்கு அழுகிவிடும்	5	4	3	2	1
149.	மரவள்ளிக்கு களிமண்ணில் அடிக்கடி தண்ணீர் பாய்ச்சக் கூடாது	5	4	3	2	1
150.	மரவள்ளியில் நன்றாக கிழங்கு பிடிக்க பசுந்தழை போடுவோம்	5	4	3	2	1
151.	கிழங்கு பிடிக்கும் போது மரவள்ளிக்கு தண்ணீர் பாய்ச்ச வேண்டும்	5	4	3	2	1
152.	மணமேறியில் தான் கிழங்கு பயிரிடுவோம்	5	4	3	2	1
153.	மரவள்ளி கிழங்கு அழுகாமல் இருப்பதற்கு சேற்றில் மூழ்கி எடுப்போம்	5	4	3	2	1
154.	அதிக வேலையாவதால் மிளகாய் பயிரிடுவதில்லை	5	4	3	2	1
155.	நல்ல ரகம் கிடைக்காததால் மிளகாய் பயிரிடுவதில்லை	5	4	3	2	1
156.	மிளகாயை வீட்டு உபயோகத்திற்கு மட்டும் தான் பயிரிடுவேன்	5	4	3	2	1
157.	மிளகாயை வீட்டு உபயோகத்திற்க்கும், சந்தையில் விற்பதற்க்கும் பயிரிடுவேன்	5	4	3	2	1

158.

159.

160.

பகுதி இரண்டு : தொழில் நுட்ப செய்திகள்

161.	நவரைக்கு நாற்று ஜனவரி 31க்குள் விட்டு விட வேண்டும்	5	4	3	2	1
162.	2-3 நாற்று ஒரு குத்தில் நடவு செய்ய வேண்டும்	5	4	3	2	1
163.	ஒரு சதுர மீட்டருக்கு 50 குத்துக்கள் இருக்க வேண்டும்	5	4	3	2	1
164.	மண் பரிசோதனைப்படி ரசாயன உரமிட வேண்டும்	5	4	3	2	1
165.	மணமேறியில் மேலுரத்தை மூன்று முறையாக பிரித்து இட வேண்டும்	5	4	3	2	1
166.	வேப்பம் புண்ணாக்கு யூரியாவுடன் கலந்து இடுவதால் சத்து ஒரே சீராக கொடுக்கபடுகிறது	5	4	3	2	1

June 19, 1991

Dr. M. S. Swaminathan, President
The World Conservation Union
11 Rathna Nagar
Teynampet, Madras 600 018
India

Dear Sir:

I hope by this time you might have received a letter from Dr. Robert A. Martin, one of my colleagues, requesting institutional support for Mr. B. Rajasekaran, a doctoral candidate in the Department of Agricultural Education and Studies and a research associate at the Center for Indigenous Knowledge for Agriculture and Rural Development (CIKARD). Mr. Rajasekaran arrived at Iowa State University in 1987 for his M.S. in Agricultural Education after having spend eight years working in agricultural extension and rural development in India. He completed his M.S. in 1989 and continued his Ph.D. program.

I am serving as a member of Mr. Rajasekaran's doctoral committee. I am very familiar with his scholarly activities and research achievements. Since coming to Iowa State, Mr. Rajasekaran has published several journal articles, has served as a reviewer and discussant for a session at the Fifth Annual Conference of the International Agricultural and Extension Education, has received Ford Foundation travel grants for three successive years to present papers at the Annual Farming Systems Research/Extension Symposia, served as a referee for the Journal of Farming Systems Research/Extension and Agriculture and Human Values. He has recently completed a summer internship in the Sahelian Agriculture Division of the World Bank where he completed a study report on the economics of irrigated rice projects in Mali.

I am very impressed with Mr. Rajasekaran's research proposal. His research focuses on analyzing indigenous knowledge systems at the grass roots level. Institutional support from a reputed research organization like yours would add practical value to the research.

I strongly recommend you offer institutional support to Mr. Rajasekaran.

Thank you for your help in this special way.

Sincerely,

David L. Williams
Professor and Head

M.S. SWAMINATHAN RESEARCH FOUNDATION

M.S. SWAMINATHAN
Chairman

January 25, 1992

TESTIMONIAL

This is to certify that Mr. B. Rajasekaran of the Iowa State University, U.S.A. worked with us during the period 18th August 1991 to 25th January 1992. During this period, he did some outstanding work in our biovillages project in Pondicherry. I found him to be a highly dedicated and competent research worker. His humility and personal charm endeared him to the rural men and women. He established an excellent rapport with them. Consequently he gained detailed information on indegenious knowledge systems.

I enclose a brief account of his stay with us. It has been a real pleasure having him as a Visiting Scientist at our Centre.

M.S. Swaminathan

M.S. Swaminathan

14, 2nd Main Road
Kottur Gardens
Kotturpuram

Telephone : (044) 416923 / 410031
Telex : 91 - 41 - 5119 SARD IN

Last Name of Principal Investigator Rajasekaran

Checklist for Attachments and Time Schedule

The following are attached (please check):

12. [x] Letter or written statement to subjects indicating clearly:
    - a) purpose of the research
    - b) the use of any identifier codes (names, #'s), how they will be used, and when they will be removed (see Item 17)
    - c) an estimate of time needed for participation in the research and the place
    - d) if applicable, location of the research activity
    - e) how you will ensure confidentiality
    - f) in a longitudinal study, note when and how you will contact subjects later
    - g) participation is voluntary; nonparticipation will not affect evaluations of the subject

13. [ ] Consent form (if applicable)

14. [ ] Letter of approval for research from cooperating organizations or institutions (if applicable)

15. [x] Data-gathering instruments

16. Anticipated dates for contact with subjects:

First Contact	Last Contact
9-15-92	10-15-92
Month / Day / Year	Month / Day / Year

17. If applicable: anticipated date that identifiers will be removed from completed survey instruments and/or audio or visual tapes will be erased:

10-15-92
Month / Day / Year

18. Signature of Departmental Executive Officer — Richard H. Carter; Date — 8/28/92; Department or Administrative Unit — Agric. Ed. & Studies

19. Decision of the University Human Subjects Review Committee:

X Project Approved ___ Project Not Approved ___ No Action Required

Patricia M. Keith — Name of Committee Chairperson
10-30-92 — Date
PMKeith — Signature of Committee Chairperson

GC:1/90