Importance of Indigenous Knowledge for Food Security: In Relation to Paddy Cultivation

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FOREWORD

Sri Lanka is an island nation having a long agricultural history dating back to over 2500 years with a rich indigenous knowledge that can facilitate sustainable agricultural production in a cost-effective manner. Currently, there is an increasing trend for integrating indigenous knowledge and practices with modern science and technology for harnessing possibilities for sustainable agricultural development. Further, the present Sri Lankan government aims to use indigenous knowledge and practices in the modern agriculture scenario under the National Food Production Programme, 2016-2018. Therefore, there is a timely importance of finding the available indigenous knowledge among farmers, extent which they are practiced and assess the economic value of such practices.

Present study reveals that traditional farmers applied indigenous practices in all stages of paddy cultivation. These farmers determine the suitable time for land preparation by rainfall pattern, astrology and their farming experience. The rainfall pattern is predicted using various indicators such as tree phenology, animal behaviour, wind circulation, cloud patterns and other social indicators which differ from region to region. Further, there is a growing interest to use traditional pest management practices in paddy cultivation as well. Most noteworthy is the estimation that the paddy cultivation using IK practices have an economic value of 110,263.04 LKR.

In the light of this background my hope and expectation is that the findings and recommendations of this research will form a sound platform for promoting traditional paddy cultivation in Sri Lanka.

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EXECUTIVE SUMMARY

Indigenous Knowledge (IK) is a valuable national resource that can facilitate agricultural production to become more cost-effective and sustainable. In the present world, there is an increasing trend for integrating the approaches and methods derived from IK with modern science and technology towards sustainable agricultural development. Further, the present Sri Lankan government expects to make use of IK and practices in the modern agriculture under National Food Production Programme 2016-2018. Therefore, there is a timely importance of finding the available indigenous knowledge among farmers, extend which they are practiced and the economic value of those practices.

This study mainly focused on identifying the importance of IK practices in paddy cultivation with specific objectives; identifying existing IK practices in crop cultivation and barriers and constraints in using such, assessing the impact of IK practices in crop cultivation and providing policy recommendations on using IK in crop cultivation. In this study the primary data were collected by face to face interviews supported by a structured questionnaire with 60 purposively selected rice farmers from selected locations in Kalutara, Kurunegala, Badulla, Moneragala, Anuradhapura, Polonnaruwa, Matale, Kegalle, Ratnapura, Jaffna, Hambantota and Batticaloa districts.

The study aimed at identifying the importance of indigenous techniques in paddy cultivation as it was revealed that farmers apply indigenous practices in all stages of paddy cultivation. The traditional farmers determine the suitable time for land preparation by rainfall pattern, astrology and their farming experience. They predict the rainfall pattern by various indicators such as tree phenology, animal behaviour, wind circulation, cloud patterns and other social indicators which differ from region to region.

Further, there is a growing interest to use traditional pest management practices in paddy cultivation. The use of land preparation techniques and water management techniques are very common practices in weed management. The ingredients used in indigenous pest and disease control methods mainly comprise locally available resources and botanicals which are environment-friendly. Hence, these indigenous practices provide sustainable alternatives to farming. However, the water distribution mechanism currently practiced by the government officials in major and minor irrigated areas does not meets the water requirements of traditional rice farmers because the farmer organizations are not consulted before the water distribution plans are made. Therefore, the water management

techniques used for weed controlling cannot be performed in most of the areas surveyed.

IK practices are still existing in some rural communities in Sri Lanka despite the low adaptation by the new generation even though the cost of production is significantly low. The main reasons for the low adaptation rate are; traditional rice varieties have comparatively low yield per land area, their long age, scarcity of quality seeds when required, more labour usage, inadequate knowledge among younger generation on traditional method of farming, difficulties in finding animal power, unavailability or shortage of plant based materials that are used in traditional cultivating methods. Therefore, research and development (R&D) on traditional rice varieties and knowledge dissemination on traditional paddy cultivation methods are essential components in popularizing traditional techniques.

According to economic estimates the percent share of labour cost in total cost for paddy cultivation using IK accounts for 66.7 per cent. Paddy cultivation using IK have an insignificant requirement for inorganic pesticides and weedicides as inputs. However, the average yield of traditional rice varieties is comparatively low but the farm gate price is four-fold high when compared to improved rice varieties. The estimates reveal that the paddy cultivation using IK practices have an economic value of 110,263.04 LKR. The main contributor for this comparatively high economic value is the price gain at farm gate. This is due to the high market demand and comparatively low supply of traditional rice in the open market.

The findings of this recommend conducting R & D, for popularizing IK, developing suitable methods for sustainable paddy cultivation, and regulating water distribution mechanisms by the government in major and minor irrigated areas are needful for promoting traditional rice cultivation in Sri Lanka.

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ABBREVIATIONS

AD	Anno Domini
BC	Before Christ
FAO	Food and Agriculture Organization
GR	Green Revolution
IK	Indigenous Knowledge

CHAPTER ONE

Introduction

1.1 Indigenous Knowledge

Sri Lanka being an island nation is rich in biodiversity as well as cultural diversity. The ancient hydraulic civilization of Sri Lanka dates back to third century BC and possesses a rich heritage of Indigenous Knowledge (IK) (Senanayake, 2006). The rice cultivation was the base of the civilization for over two thousand years (Mahawansa, 1912, Deraniyagala, 1992) and the Sri Lankan history provides ample evidence on use of indigenous techniques in rice cultivation. These techniques have traditionally played an important role in generating household income, providing healthy and nutrient rich foods and ensuring country's food security (Irangani and Shiratake, 2013).

IK is considered as the main social asset of the agrarian societies (Ryser, 2011), specifically the indigenous practices, which were identified as social assets of farming communities, making the farmers self-reliant by non-dependency on market oriented inputs (Irangani and Shiratake, 2013). Further, IK refers to bodies of knowledge developed in local communities over time and traditionally transmitted by the word of mouth across and within generations. IK consists of skills, innovations, beliefs, experiences and insights of the people in their respective natural and cultural environments, accumulated over the years and applied to maintain livelihood (Dei, 1993). IK is also identified as a unique local knowledge existing within and developed around the local communities (Warren, 1991, Semeon *et al.*, 2013). It is generated through a systematic process of observing local conditions, experimenting with solutions and readapting previously identified solutions to modified environmental, socio-economic and technological situations (Brouwers, 1993).

The knowledge that has been collectively created and developed by various groups of people, communities or nations and transmitted from generation to generation, spread across diverse and many other human related aspects such as medicine, healing systems, biological diversity and agriculture is generally termed as "traditional knowledge" and sometimes "IK". When referring to IK, the term "traditional knowledge" appears to be more appropriated and justifiable for the Sri Lankan context because of the age long history, culture and traditions (Karunaratna, 2010).

1.2 Importance of IK

According to Warren (1991), IK is the basis of local-level decision making in agriculture, health care, food preparation, education, natural-resource management and many other activities in rural communities. Further, IK provides good insight into sustainable use of resources and environment conservation while offering strategies to mitigate negative consequences of natural disasters. It includes many aspects *viz.,* information, practices and technologies, beliefs, tools, materials, experimentation, biological resources, human resources, education and communication (Dharmasena, 2010).

IK is an important tool which holds promise for agriculture, food security and sustainable development, ably providing alternative development approaches by offering opportunities for climate change mitigation (Agrawal, 1995; UN Policy Brief, 2016).

A study conducted by Kumari (2016) revealed that in rice cultivation areas where traditional methods for pest and disease control have been practiced, the success was greater comparing to modern methods applied in rice cultivation. Traditional pest and disease control methods that account for reduced crop loss and low production cost added with high demand in the local and international markets showed an increasing trend in practice during the last two decades. Further, Kumari (2016) revealed that there is a growing interest for using traditional pest and disease control methods in Ulpotha traditional village in the Kurunegala District of Sri Lanka.

The *Bethma* practice as a response to water scarcity is a classic example of using IK in Sri Lanka. *Bethma* is a practice that temporarily redistributes plots of land among shareholders (being paddy landowners) in part of the command area of a tank during drought periods. It is practiced when there is an inadequate water to cultivate the entire command area (Senanayake, 2006).

Although the literature provides a significant insight into use of IK in Sri Lanka, the number of studies carried out on Traditional Knowledge or IK usage in Sri Lankan farming systems is limited. Traditional agricultural knowledge has aptly helped our ancestors to ensure agricultural sustainability in the country by facilitating agricultural systems to be cost-effective (Dharmasena, 2010).

1.3 Food Security and IK

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996). Food security, being one of the major concerns in the world, has been a priority in domestic economic policies of many developing countries and has also been in the agendas of many international organizations, especially of the Food and Agriculture Organization (FAO) (Kalansooriya and Chandrakumara, 2014).

The government of Sri Lanka has implemented several programmes in recent years for enhancing food security by utilizing the existing IK in the country. The national campaign for encouraging the production of indigenous food crops under "Api Wawamu – Rata Nagamu" (Let's grow – develop the country) programme is a noteworthy example of such, aimed at enhancing food security through use of IK (Ministry of Agriculture, 2012). Further, the contemporary national campaign for 2016-2018 is also promoting the use of IK practices as a means of achieving national food security with the objectives of conserving traditional knowledge and educating farmers on utilization and dissemination of traditional crop cultivation and pest controlling methods (Ministry of Agriculture, 2012).

However, at present IK is disappearing rapidly from farming communities replacing modern practices with the advancement of science (Chambers, 1994). As emphasized in contemporary agricultural history, indigenous techniques in rice cultivation have been replaced by modern techniques introduced after mid 1960's with the influence of the green revolution, which brought about fundamental changes in the country's rice sector (Farmer, 1986; Wilson, 2000).

1.4 Problem Statement

Food security, one of the major issues of the present development dialogue, has been the priority in domestic economic policies of most developing countries including Sri Lanka. Long history of cultivation, Sri Lankan cultural diversity and a wide range of ecological landscapes have collectively resulted in a wide variety of farming practices in Sri Lanka. In the past, the indigenous civilization widely known as the hydraulic civilization of Sri Lanka, was supported by indigenous agricultural practices, helping farmers to pacify limiting factors such as uncertainty of rainfall, fragility of ecosystems, erosion of topsoil, damages from pests, diseases and wild animals by adapting IK practices.

Currently, the agricultural and human values of indigenous methods are increasingly acknowledged worldwide because of the enormous potential to contribute towards sustainable agricultural production (Mascarenhas, 2003) and there is a trend in cultivation using IK as nature farming (Ministry of Agriculture, 2017). There are many studies that emphasize indigenous techniques in agriculture matters related to production, sustainability, ecologically soundness and social, economic, and cultural features of farmers (Mascarenhas, 2003).

However, the advent of the Green Revolution (GR) in the mid-20th century, has posed a serious challenge to traditional agriculture systems in Sri Lanka. The non-formalized traditional knowledge in agriculture has been largely lost and is being lost because of modernization. Vast amount of IK, preserved in the country by the word by mouth tradition does not exist in the modern society. The younger generation in particular, is reluctant to practice verbal traditional knowledge (Dharmasena, 2010).

Therefore, if immediate actions are not taken, it is inevitable that the verbal IK of Sri Lanka will be lost at the end of present generation of elders. More often the undocumented IK passes from generation to generation as unrevealed family secrets (Dharmasena, 2010), and even most of the existing IK are not practiced (Ministry of Agriculture, 2017). In view of the fact that IK in the community is the risk of extinction, there is an urgent need to collect, record, preserve and make those available to future generations. Otherwise the risk remain that IK will be lost within the next generation (Dharmasena, 2010).

Even though, the past literature provides a significant insight into practice of IK in Sri Lankan farming systems, no efforts have been made to find its contribution to food production. The paucity of empirical research on the indigenous techniques of rice farming has created a knowledge gap making it difficult to track the problem in the modern rice sector originating from the Green Revolution (Irangani and Shiratake, 2013). In order to identify IK through technical and social analysis, it is essential to analyze by means of scientific background and relevance, reliability, functionality, effectiveness and transferability and recording and documenting by using modern tools for dissemination. As IK is believed to be a precious national resource that can facilitate agricultural production in a cost-effective and a sustainable manner (Dharmasena, 2010), finding the available traditional knowledge among farmers, the extent to which they are practiced and the economic value of those practices is of timely requirement. Awareness of such could be a mind shift in a society that has been exposed solely to the modernized world (Kharti, 1997).

1.5 Objectives

1.5.1 General Objective

To identify the importance of IK practices in paddy cultivation.

1.5.2 Specific Objectives

1. To identify existing IK practices in paddy cultivation.
2. To identify the barriers and constraints in using IK.
3. To assess the impact of IK practices in paddy cultivation.
4. To provide policy recommendations on the use of IK in paddy cultivation.

1.6 Organization of the Report

This report consists of six chapters; first provides an introduction to the study, second gives a comprehensive review of literature on IK practices in paddy cultivation, third discusses the methodology of the research study, fourth describes the IK practices in Sri Lankan paddy cultivation, fifth deals with barriers, constraints and economic impact of IK practices and sixth, the final summarizes the findings of the study along with recommendations.

CHAPTER TWO

Literature Review

This chapter provides a comprehensive review on IK related literature mentioned in local and international journal articles, reports and other publications highlighting some classic examples on the usage of IK practices to give a clear understanding on the status of IK practices in global, regional and local contexts.

2.1 Indigenous Knowledge Practices: Global Context

IK has recently become an interesting topic and a growing area of investigation throughout the world in order to achieve sustainable development goals, particularly in agriculture. About, 60 per cent of the total cultivated lands around the world are still cultivated by farmers using traditional and subsistence farming methods (Gliessman, 1998). Consequently, there are ample literature that substantiate evidence on the usage of IK practices worldwide.

A study conducted by Rankoana, (2017) in the Northern Sotho of Dikgale community in Capricorn District of the Limpopo Province, South Africa, revealed that IK is still valuable in that farming community. According to the study the farmers have used their knowledge on plant phenology, the appearance and shape of the moon and stars to plan the planting season. Further, the study concluded that subsistence farming is sustained by indigenous farming practices and rainfall prediction. They have also used indigenous farming practices on other aspects of farming such as improvement of soil structure, maintenance of crops, and selection and storage of seeds for replanting. The study further concluded that the rainfall prediction helps farmers to plan the planting season while overall IK benefits in the achievement of food security at the household level.

Another recent study conducted in South Africa by Muyambo *et al.*, (2017) observed that most of the farmers rely on IK in their farming practices considering it as an integral part of agricultural practices, drought risk management, and building resilience against disasters. However, the findings revealed that the present generation in that region does not believe in age old rituals associated with IK practices that are used to curtail incidents of drought. In addition, poor documentation was also mentioned as a challenge for the widespread use of IK.

2.2 Indigenous Knowledge Practices: Regional Context

The research study conducted in the southern part of Bastar District, Chhattisgarh, India by Singh, (2007) concluded that farmers by the experiential wisdom obtained over years, have the knowhow to conserve and select location specific indigenous paddy varieties for obtaining sustainable yields. They have succeeded in conserving traditional varieties which are tolerant against diseases and insect pests, and thereby reduced the expenditure on farming. Consequently, these indigenous farming practices provide opportunities to manage the gene flow between different plant varieties and conserve useful genes for future crop improvement. Further, farmers in that study area also had IK on predicting rainfall and weather. Rainfall was mainly forecasted by elderly men based on various biophysical indicators such as fruiting of mango trees, movement of ants, other insects and birds and also considering certain spiritual indicators. When a good rainfall is forecasted, the farmers collect more rice and maize seeds of varieties that have short duration. During drought periods they cultivate more drought resistant plants, such as stalked foxtail millet, finger millets, and sorghum varieties. Further, the study revealed that the traditional patterns and practices provide mechanisms to obtain a stable production in a risk-prone environment without external subsidies and also to reduce environmental degradation. Therefore, preserving of such knowledge and practices is beneficial for achieving development goals in the agriculture sector.

Nicolas and Carbarogias (2015) conducted a study on IK in sustainable pest management in rice farming communities of Southeastern Luzon, in the Philippines. According to the findings of the study, most peasants or marginal farmers still follow IK practices in their paddy fields despite the increasing modernization and commercialization of agriculture. The various indigenous pest management practices applied by these farmers falls into a number of categories such as cultural, physical, biological, mechanical, and chemical. Further, these IK practices have helped farmers to control and manage pest problems in sustainable ways in order to meet their subsistence needs without depending on costly energy based inputs. Therefore, it is important to record these IK practices to formulate innovative researches for sustainable pest management before this precious practical knowledge is dead and gone, since most of the indigenous pest management practices in rice cultivation are rapidly disappearing due to social, economic and political pressures. IK practices provide alternatives to improve and integrate a pest management system with greater opportunities for achieving successes and sustenance.

2.3 Indigenous Knowledge Practices: Sri Lankan Context

In the Sri Lankan agriculture, IK has helped the ancestors to keep the country agriculturally sustainable. Being an island nation, the IK has passed over from generation to generation by means of practical knowledge, evolving over several centuries in the country's farming community. According to existing literature, rice cultivation has been there even before 800 B.C. as the hydraulic civilization in Sri Lanka, mainly based on rice cultivation is as old as two thousand years. According to Dharmasena, (2010) the farming system comprising *chena,* paddy and home garden cultivation has evolved with the interaction of man and the environment and developed in harmony with natural ecosystems, their experience, observations on rainfall pattern, wind, temperature, humidity and soil behaviours. Among all agricultural activities rice cultivation is the dominant activity since rice is the staple food in Sri Lanka.

Historically in Sri Lanka, food security has been secured by adopting IK practices over many years by supplying all the food requirements locally. There are many historical evidences, proving that the ancient food security in Sri Lanka was attained in terms of self-sufficiency and even with excess production of rice for exportation to other countries. In the agrarian culture of Sri Lanka, there have been two valuable concepts, *beda hada geneema* (share and grow), meaning when somebody finds an interesting plant material which is rare and valuable, he shares it with others to cultivate and propagate. Other concept has been *hada beda geneema* (cultivate and share), meaning that whatever cultivated will share among the community. These traditions clearly express the awareness of people on food security and their concerns about the food requirements of others in the community. As a traditional practice farmers leave a part of the rice field, called *kurulu paaluwa,* without harvesting for birds to consume (Perera, 2008). Further, the farmers in the past did not sell their excess crop, rice or any other, instead they shared those with the needy people of the neighbourhood. After every harvest, the storage bins called *bissa*, or *atuwa* were filled with the harvest. The number of *bissas* or *atuwas* that one possesses is an indication of his wealth and the social status in the ancient society (Dalupotha, 2001). Similarly, as stated by Vitebsky (1992), the core symbol of the living household and especially its self-sufficiency is the *atuwa* (granary, grainbin).

According to the existing literature the traditional farmers in Sri Lanka had an in depth knowledge on weather patterns and other climatic changes. When cultivating, they selected crops according to a plan, mostly based on weather patterns and cropping seasons. This practice was known as *kal yal*

balaa govithena (cultivation at right season, right time). The traditional farmers followed this technique to minimize crop damages while gaining a bumper harvest from their cultivations (Perera, 2008). Moreover, their traditions, agricultural practices and land use systems have evolved over centuries facing the challenges imposed by the nature (Dharmasena, 2010). Hence it can say that the involvement of IK in agricultural practices have helped people to survive through harsh environment conditions while conserving their food security and environment sustainability over many years and generations. The indigenous techniques practiced in rice cultivation throughout the Sri Lanka's history *viz.*, rainfall patterns, lunar calendar, and agricultural rituals farming entirely depend on local resources which are non-destructive to human health and the environment, economically favourable and accessible to all (Irangani and Shiratake, 2013). Traditional farming systems in Sri Lanka synchronize with the weather patterns. For instance, more flowers in wood apple is a sign of good rain, occurrence of heavy rains in the *Binara* (September) indicates poor rains in the following a *maha* season (Dharmasena, 2007). Further, traditional farmers possessed a good knowledge on identification of the soil type for their cultivations. As noted by Dharmasena, (2010) rural farmers knew the salinity status of soil by observing salinity tolerant plants found in an area. For instance, diwul *(Limonia acidissima* L*),* keeriya *(Acacia chundra),* indi *(Phoenix zeylanica),* ikiriya (*Hygrophila spinosa),* pothu-pan *(Scleria poaeformis),* wetakeiya *(Pandanus kaida),* illuk *(Imperata cylindrica)* are some plant species that can tolerate saline soils.

Moreover, in the Sri Lankan traditional farming, eco-friendly crop protection measures such as biological control methods, *kems*, rituals and use of plants or plant extracts (botanicals) were practiced. These traditional agricultural practices have shown promise in pests and diseases management in rice fields of the country. The winnow method is one other popular traditional method applied to control insects. In this method mucilage (*Koholle*) from jack fruits is applied on the back of the winnowing basket, which is used to winnow rice, and slowly drags across maturing paddy. Traditional farmers know the trees that can be applied for pest control. For instance, Mee (*Madhucha longifolia*), is the one of the popular trees grown in the vicinity of paddy fields for controlling pests (Kumari, 2016). Moreover, farmers offer *Irima Pideema* (offering of milk rice) and do *Alu Saaththuwa* (broadcasting of wood ash to the paddy field) for controlling leaf eating caterpillars in paddy fields (Senanayake, 2006). In addition, charming sand and water is also one of the traditional methods practiced for crop protection against pests. According to Kumari (2016) many farmers who adopt IK practices claim that these traditional religious practices are more effective in controlling pests than modern practices, using chemical pesticides**.**

Presumably Weeramunda and Damayanthi (2011) states that even though traditional varieties yield low compared to newly improved varieties, *kems* or protection methods used in IK based agriculture reduce costs of cultivation and thereby results in increasing the profit margin. However, according to Dharmasena, (2010) IK, is tacit or embedded in the practices and experiences and hence a vast amount of true IK of the country, especially the oral knowledge has diminished over the years. Therefore, it is of timely importance to preserve these indigenous practices as they are eco-friendly and sustainably sound.

CHAPTER THREE

Methodology

This chapter describes the study locations, data collection methods, sampling procedures and data analytical techniques pertaining to the investigation.

3.1 Study Locations

The study was conducted in purposively selected 12 Districts representing all provinces in Sri Lanka. Districts were selected on the basis of IK usage in crop cultivation and the number of farmers adopting IK practices in paddy cultivation.

Table 3.1: Study Locations

Province	Districts
Western	Kalutara
North Western	Kurunegala
Uva	Badulla, Moneragala
North Central	Anuradhapura, Polonnaruwa
Central	Matale
Sabaragamuwa	Kegalle, Ratnapura
Northern	Jaffna
Southern	Hambantota
Eastern	Batticaloa

3.2 Data Collection Methods

3.2.1 Secondary Data Collection

The secondary data were collected from sources such as books, journals, articles, reports, data bases at the Department of Census and Statistics, publications in Department of Agriculture and its affiliated institutions.

3.2.2 Primary Data Collection - Key Informant Survey

The key informants were purposely selected considering farmers who are aware of IK, and practicing in paddy cultivation. The farmers were interviewed to collect the relevant information on IK and practices in crop cultivation.

3.3 Sampling Procedure

The farmers were selected by adopting purposive sampling method in order to capture farmers who possess experience in practicing IK. The sample comprised 30 such selected traditional paddy farmers and another thirty in the neighbourhood who were not applying IK in their fields.

3.4 Data Analysis and Analytical Techniques

3.4.1 Objective 1: To Identify Existing Indigenous Knowledge Practices in Paddy Cultivation.

For achieving this objective, data were collected by conducting interviews with key informants. Following interviews and data were compiled by districts and farming practices in order to identify the unique practices in each district and the similarities. Comparisons were made across paddy farming systems *viz.,* major irrigated, minor irrigated and rain-fed.

3.4.2 Objective 2: To Identify the Barriers and Constraints in Using Indigenous Knowledge.

The data relevant to this objective was analyzed using descriptive statistical procedures.

3.4.3 Objective 3: To Assess the Impact of Indigenous Knowledge Practices in Paddy Cultivation.

In order to achieve this objective a comparative analysis was made on data gathered from farmers who adopt IK in their crop cultivation and those who are not adopting such.

CHAPTER FOUR

Indigenous Knowledge Practices in Sri Lankan Paddy Cultivation

This chapter focuses on providing a descriptive analysis of the sample assessed with a detailed compilation on existing IK practices in the surveyed locations with a comprehensive comparison among irrigation systems, *viz.*, major irrigated, minor irrigated and rain-fed. The findings were compared and validated with previously documented literature.

4.1 History of Paddy Cultivation in Sri Lanka

According to the records, paddy cultivation has been prevailing in Sri Lanka since 800 BC and the first extensive settlements along rivers were found in the dry Northern zone. Further records indicate that there were massive irrigation structures since 390 BC. As cultivation of wet land rice depends on monsoon rains, which are not reliable, these structures were constructed in the form of canals, water storage tanks and reservoirs, in order to mitigate the risk of periodic droughts (Jayawardena, 2010; Dharmasena, 2010). In ancient times paddy cultivation influenced the country's economy as well as its social and political aspects, because of its close bond with religion, culture and lifestyle. Rice cultivation was adversely affected by foreign invasions from time to time dating back to 210-161 BC and even more recently since the Europeans mainly focused on plantation crops (Jayawardena, 2010). As a consequence of the food crisis caused by the World War II, colonial rulers began to focus on rice cultivation and afterwards modern agriculture came into being with the onset of green revolution in the global context. As a result, the farmers became more production oriented (Jayawardena, 2010; Kumari, 2016).

4.2 IK, Green Revolution and Sri Lankan Paddy Cultivation

Indigenous knowledge is defined as the local knowledge unique to a given culture or society which is orally transferred from generation to generation. Traditional farmers with indigenous knowledge hold centuries of experience, which has the potential of sustainability (Ulluwishewa, 1992).

According to documentary evidence, there had been more than 3,000 traditional varieties of rice cultivated in Sri Lanka. These rice varieties were cultivated in different climatic zones and seasons by considering the soil condition, water availability and drainage level. These traditional rice

varieties possess properties of high medicinal value prescribed for several ailments in Ayurveda, for instance diabetes, hepatitis, gangrene, jaundice and many other. These traditional rice varieties are also highly rich in nutritive value (Seneviruwan, 2010).

Traditional paddy farmers used indigenous techniques in soil fertility management, seed selection, water management and pest and disease control according to natural features of the region such as rainfall pattern, soil condition, humidity and temperature (Irangani and Shiratake, 2013).

Traditional paddy farming systems in Sri Lanka has been divided into lowland and upland paddy farming of which former has been the most prevalent. Paddy cultivation starts with deep ploughing followed by harrowing and levelling with onset of rain or irrigation under submerged conditions. Sowing, transplanting, weeding, water management, fertilizer application and pest and disease management and harvesting are processes that follow after land preparation. Farmers practicing IK follow auspicious time and ceremonially begin activities such as ploughing and harvesting (Helvetas, 2001).

Upland paddy farming is the cultivation of paddy above the level of water resources and therefore the water management is entirely dependent on the rainfall. This farming system is facilitated either as rain-fed or irrigated by lifting water. Usually upland paddy cultivation is carried out in the *Maha* season. Land is ploughed using buffalos and the traditional plough. Soil is mixed using the fork to enhance nutrient and water retention. Overnight soaked paddy is sowed with the onset of rain. Hence, water and fertilizer requirement, pest and disease management is less intensive in this farming system (Helvetas, 2001).

When GR affected the agriculture around 1960, farmers became production oriented and inputs were intensified to maximize the production. With subsidized fertilizer and establishment of irrigation schemes, farmers were motivated to become production oriented (Wiggins and Brooks, 2010). Department of Agriculture introduced the first hybrid variety “H4” in 1959 and starting from that, farmers began to use modern varieties, which are high yielding, shorter in stature and less in duration, ignoring the traditional varieties (Seneviruwan, 2010). High production paddy farming was supported by improved high yielding varieties, machineries, pesticides and inorganic fertilizer (Kumari, 2016). With the introduction of GR, modern farming techniques played a vital role in increasing the rice production in the country. However, due to the influence of modern techniques the cultivation area of indigenous rice varieties declined drastically, creating

controversial thoughts in the academic discussions regarding the adverse effects of neglecting indigenous techniques in paddy cultivation (Irangani and Shiratake, 2013).

4.3 General Description of the Surveyed Sample

The survey conducted in twelve districts revealed that the average of years of farming is 37 years. This implies that the farmers engaged in IK based paddy cultivation are of the old aged group of the population. Considering the objective of farming, majority (40%) engage in paddy cultivation as a means of subsistence and commercial farming. Only 16 per cent engaged in subsistence farming (Table 4.1).

Table 4.1: Objectives of Paddy Cultivation

Objective of Farming	Frequency	Percentage
HH consumption	16	28.57
Household consumption and commercial use	40	71.43
Total	56	100

Source: Authors' own compilation based on field survey (2017)

A greater percentage (70%) of farmers in the sample cultivate paddy in both seasons, *Yala* and *Maha* while 27 per cent engage only in the *Maha* season and just four per cent engage in the *Yala* season (Table 4.2).

Table 4.2: Seasons of Paddy Cultivation vs. Farmers

Cultivation Season	Frequency	Percentage
Yala	2	3.57
Maha	15	26.78
Yala and Maha	39	69.64
Total	56	100

Source: Authors' own compilation based on field survey (2017)

When selecting a paddy variety for cultivation 55.35 per cent of the farmers consider the suitability to the region. A good proportion of the sample (50%) considers availability of seed varieties. The influence of the neighbouring farmers or the varieties used by neighboring farmers is also very high (46.43%). The other selecting criteria include high price expectation, market demand, and method of cultivation (Table 4.3).

Table 4.3: Factors Consider in Paddy Varieties Selection

Description	Frequency	Percentage
Suitability to the region	31	55.35
Influence of other farmers	26	46.43
High price expectation	08	14.29
Availability of seed varieties	28	50.00
Market demand	05	8.93
Cultivation method	18	32.14
Other	08	0.14

Source: Authors' own compilation based on field survey (2017)

Among the farmers in the sample 44.64 per cent are fully engaged in IK practices. In majority as high as 73.21 per cent of farmer-families, children are engaged in paddy cultivation. Around 62.5 per cent of the farmers have legal inherent who already engaged in paddy cultivation to hand over their land. Majority (57.14 %) of farmers has not shown an interest to transfer IK possessed by them, to their next generation because of the lack of interest among the inherent or they are employed in other jobs. Nearly a half of the population (42.85%) has transferred their IK related to paddy cultivation by getting their inherent involved in farming (35.71%) as well as by word of mouth (35.71%). Among children of farmer-families 26.78 per cent do not engage in paddy cultivation due to various reasons such as employed in non-agricultural sector (37.50 %), lack of interest (19.64%), engaged in formal education (25.00%) or living away from the location (1.78%).

4.4 Indigenous Knowledge Practices

4.4.1 Beginning of the Cultivation Season

In paddy cultivation, irrespective of irrigated or rain-fed, farmers decide the cultivation period during the *kanna* meeting (pre-seasonal meeting of farmers). *Kanna* meeting is held before starting every cultivation season to decide when to start the cultivation. At this meeting a major decision is made regarding the restoration and maintenance of the tank bund. Similarly, in the past, under the supervision of *Vel Vidane* (Irrigation Headman), the paddy farmers held a meeting before beginning of each cultivation season to agree on the dates for releasing water from the tank (Moore and Wickramasinghe,1980). Further, *Vel Vidane* assigns an area for cleaning and maintaining the bund to each farmer on the basis of the extent of the land holding. If any farmer fails to fulfill the allotted task will be reprimanded by the *Vel Vidane*. Villagers appreciate the service of *Vel Vidane* by paying him an honorarium in kind, half a bushel of paddy per acre (Weeramunda and Damayanthi, 2011). Before every cultivation season,

traditional farmers make a well-prepared plan, by meeting all the farmers and the village authorities and discussing to make decisions. Therefore, traditional rice cultivation synchronizes with the weather and the season. According to literature, the cropping pattern and the crops were selected according to a plan in the past. This practice was called *kalyal balaa govithena* (cultivation at right season, right time). Every farmer in the village, including the Buddhist priest, involve in this process and therefore, chances of crop failures become minimal, assuring bumper harvests (Perera, 2008). Similarly, in the present also, suitable cultivation time is decided by some traditional farmers in order to reduce pest damages. For instance, farmers in the Kalutara District believes that pest attacks can be reduced if seeds are sown in *mul kaluwara* (the time period after new moon day and prior to full moon day). This is one instance of evidence that the farmers traditionally knew the suitable time period for cultivation in order to minimize pest attacks and obtain higher yields.

In *Maha* season, generally cultivation begins in the October, which is also known as *Wap* month. The farmers begin the paddy cultivation season after *Binora Maha Konaya*. According to astrology *Binora Maha Konaya* is the period from September 15th to October 15th and this period is not considered suitable for initiating cultivation. Therefore, farmers in major irrigated areas begin cultivation practices in the *Maha* season after 15th of October. In contrast farmers in minor irrigated areas begin their cultivation with *Ak* rain (*Ak wessa*), which usually falls in the end of September after the long drought called *Nikini* drought (*Nikini idoraya*). Therefore, in minor irrigated areas *Maha* season is initiated between September and October. Irrespective of irrigated or rain-fed systems the *Yala* season is generally started after March 15th and before April 15th, expecting higher yields.

4.4.2 Rainfall Prediction

At present there is a tendency of using a combination of meteorological information and IK by farmers in their seasonal forecasting (Orlove *et al*., 2010; Roudier *et al.,* 2014, Mapfumo *et al*., 2015) while traditional farmers make cultivation decisions based on their prior experiences in empirical observations and IK regarding forecasts (Jiri *et al*., 2016). The findings of the present study revealed that the traditional farmers use various indicators such as tree phenology, animal behaviour, wind circulation, cloud patterns and other social indicators to predict rainfall. These farmers in particular decides the suitable time for their paddy cultivation by observing rainfall prediction signs since most of them cultivate crops under rain-fed systems.

There are ample evidences in literature on the use of vegetation indicators for rainfall prediction in the world. A study conducted in Southern Africa mentioned that fruiting in certain trees, indicates the onset of a good rainfall season or beginning of a poor rainfall season. For instance, in Botswana, Brandy bush/Raisin bush (*Grewia flava*) bears fruits twice a year. Early fruiting (November to early December) indicates low rainfall and late fruiting (February/March) indicates a good season and no fruiting indicates a serious drought (Kolawole *et al.,* 2014). Further, a study conducted in Sri Lanka noted that the distinctively high or low flowering and fruiting in trees such as wood apple (*Limonia acidissima* L.), *Kone* (*Schleichera oleosa*), *Weera* (*Drypetes sepiaria*), *Mora* (*Dimorcarpus longan*) and *Palu* (*Manilkara hexandra*) and appearance of new leaves of certain trees such as *Mee* (*Madhuca longifolia*) indicate either a good or a poor rainfall in the season to follow (Irangani and Shiratake, 2013). The tree phenology indicators used by the respondents in present survey for predicting rainfall in accordance with the past studies in both local and the global contexts of IK (Table 4.4).

Table 4.4: Tree Phenology Indicators of Weather Prediction in IK Practice

Indicator	Area	Weather Prediction
Onset of the Rainfall Emergence of tender leaves and flowers in Mango (*Mangifera indica*) trees	Major Irrigated	Onset of rainy season, Rainfall in near future
Occurrence of the tender leaves in upper parts of Numinan (*Cynometra cauliflora*) trees	Minor Irrigated	Onset of rainy season, Rainfall in near future
Blooming of the *Mee* (*Madhuca longifolia*) flowers	Rain-fed	Sufficient rainfall for cultivation
High yield in Mango (*Mangifera indica*), Rambutan (*Nephelium lappaceum*), Wood apple (*Limonia acidissima*) and Duriyan (*Durio zibethinus*) trees	Irrigated	High rainfall
Abundance of wild fruits in trees such as *Mora* (*Dimocarpus longan*), *Kone* (*Schleichera oleosa*), *Palu (Manilkara hexandra), Weera* (*Drypetes sepiaria*), *Damba* (*Syzygium assimile*), *Daminiya* (*Grewia tiliifolia*) and *Atamba* (*Mangifera zeylanica*)	Irrigated and rain-fed	Season of high rainfall
Flowers of *Daluk* (*Euphorbia antiquorum*) plant turn into upward direction in August	Irrigated and rain-fed	Rainfall within two months
Occurrence of the tender leaves in upper parts of the *Midella* (*Barringtonia racemosa*)tree	Minor Irrigated and Rain-fed	Onset of rainy season
Drought Occurrence of tender leaves in the base of the Numinan (*Cynometra cauliflora*) tree	Minor Irrigated	Season of drought
Occurrence of tender leaves in the base of the *Midella* (*Barringtonia racemosa*)tree	Minor Irrigated	Season of drought
Tree branches droop and trees become weak	Rain-fed	Fall of drought

Source: Authors' own compilation based on field survey (2017)

In the past, traditional farmers mostly used animal behaviour indicators for rainfall predictions. Table 4.5 shows some of the indicators based on birds' behaviour. There are some indicators that are common in both irrigated and rain-fed areas in Sri Lanka. Singing and nesting of certain birds are considered as useful indicators for the onset of rainfall in all farming areas in Sri Lanka. For instance, the study of Irangani and Shiratake, (2013) carried out in Sri Lanka revealed that nest building behaviour of *Wadu kurulla* (Baya weaver), is an indicator of onset of rainfall in Sri Lanka. Further, there is a study that ascertain arrival of migratory birds as an indicator for good rainfall in Zimbabwe, Zambia and Northern parts of South Africa (Orlove *et al.,* 2010). Similarly, farmers in irrigated areas reported that the appearance of migratory birds indicate near rainfall. Further, Table 4.6 shows the animal behaviour indicators that are used by farmers in the present study area for predicting rainfall. The termite appearance and sounds of some animals especially frogs, and buffaloes are considered as good indicators for rainfall prediction in irrigated and rain-fed areas in Sri Lanka. Another example found in past literature has noted that the sounds from certain insects that emerge from overwintering/hibernation tend to signal the start of a new season in Botswana and Zimbabwe (Mapfumo *et al.,* 2015).

Table 4.5: Birds' Behaviour Indicators for Weather Prediction in IK Practice

Indicator	Area	Weather Prediction
Birds		
Nesting of certain birds, e.g. Crows (*Corvus splendens*) and Asian koel/*Kowula* (*Eudynamys scolopacea*)	Irrigated and Rain-fed	Good rainfall
Appearance of migrating birds e.g. Indian pitta / *Avichchiya*(*Pitta brachyura*)	Irrigated	Rainfall in near future
Singing of certain birds e.g. Eagle(*Ictinaetus malayensis*),*AtiKukula*/ Greater coucal (*Centropus sinensis*), Sri Lanka swallow/ *Wahilihiniya* (*Cecropis hyperythra*)	Irrigated and Rain-fed	Rainfall in near future
Cry of the Dove/*Niyan Kobeyya* bird	Minor Irrigated and Rain-fed	No rainfall in near future. Drought persists much longer.
Nesting of Baya weaver/ *Wadu kurulla*/ (*Ploceus philippinus*) and Quail /*Watu kurulla*(*Coturnix coturnix*) e.g. height of the nest building	Irrigated and Rain-fed	If the nests are at a higher level of tree heavy rainfall. If nests are at a lower level of tree lesser rainfall.
Egg laying location of the *Kirala* (*Vanellus indicus*)	Irrigated and Rain-fed	If the egg laying location is close to the tank bund lesser rainfall. If the egg laying location is far away from the tank bund higher rainfall.

Source: Authors' own compilation based on field survey (2017)

Table 4.6: Animal Behaviour Indicators for Weather Prediction in IK Practice

Indicator	Area	Weather Prediction
Other Animals		
Subterranean Termite (*Reticulitermes* spp.) appearance	Irrigated and Rain-fed	Rainfall in near future
Flying large size *Meruwo /Alate /*Subterranean Winged Termite (*Reticulitermes* spp.) (reproductive stage of termites)	Minor Irrigated and Rain-fed	Sufficient rainfall for cultivation
Flying small size *Meruwo/Alate/*Subterranean Winged Termite(reproductive stage of termites)	Minor Irrigated and Rain-fed	Drought season in near future
Appearance of red ants, rapidly increasing size and height of anthills.	Irrigated and Rain-fed	Good rainfall
Frogs are croaking at night	Irrigated and Rain-fed	Good rainfall
Shouting of buffaloes	Irrigated and Rain-fed	Rainfall in near future
Behaviour of monkeys (*Toque macaque* and *Trachypithecus vetulus*),e.g. shouting as a team and shouting of Devil Bird/ *Ulama*(*Bubo nipalensis*)	Minor Irrigated and Rain-fed	Rainfall in near future
Shape of the rice field crab burrows (*Kakkutu gula"*) e.g. upward shape	Minor Irrigated and Rain-fed	Rain in near future

Source: Authors' own compilation based on field survey (2017)

Table 4.7 gives a number of atmospheric indicators of weather prediction in the Sri Lankan traditional agriculture. These indicators vary in irrigated and rain-fed areas. Historical evidences indicate that the natural rainfall patterns are predicted by observing environmental changes such as wind circulation, lightening and humidity in the air (Irangani and Shiratake, 2013). For instance, previous studies have noted that an increase in night-time temperatures, shifts in direction of prevailing winds, particular phases of the moon, the appearance of strong whirlwinds and changes in smell of the environment were considered as indicators for rain in few days. According to Mapfumo *et al.*, (2015), the farmers based on these indicators for farming practices including marketing and trade arrangements for food security.

Table 4.7: Atmospheric Indicators for Weather Prediction in IK Practice

Indicator	Area	Weather Prediction
Appearance of different type of cloud patterns e.g. Seven "*kinihira"*(umbrella shape) type clouds can be seen in the Eastern sky	Major Irrigated	Rainfall will occur within seven hours
Wind blowing patterns	Minor Irrigated and Rain-fed	If wind blowing speed is low less rainfall and if wind blowing speed is high heavy rainfall
Dust comes with the cold wind	Minor Irrigated and Rain-fed	Rainy season in near future
Clear sky and shining stars	Minor Irrigated	Low rainfall
Rains start on new moon day or full moon day	Minor Irrigated and Rain-fed	Good rainfall during the cultivation season
Appearance of a rainbow in east direction of the sky soon after onset of first rainfall	Minor Irrigated and Rain-fed	Rainfall throughout the cultivation season
More lightning and thunder strikes in the sky	Minor Irrigated and Rain-fed	Immediate rainfall

Source: Authors' own compilation based on field survey (2017)

Table 4.8 and 4.9 show social and farmers' experience based weather prediction indicators respectively in IK practice. Orlove *et al.*, (2010), commented on weather forecasting by farmers based on historical patterns, climate observations and signs. Further, past studies in Malawi, Uganda and Botswana revealed that the forecasts tend to be accessible, given by the elders who are predominantly custodians of IK command. The commands are respected in their communities and their stock of personal experience is considered to be valuable (Roncoli *et al*., 2002; Orlove *et al.,* 2010; Briggs and Moyo, 2012; Kolawole *et al.,* 2014).

Table 4.8: Social Indicators for Weather Prediction in IK Practice

Indicator	Area	Weather Prediction
Traditional rainmaking ceremonies	Minor Irrigated and Rain-fed	Huge rainfall the "*Diya kapima*" ceremony
Lunar calendar	Minor Irrigated and Rain-fed	Rainfall in "*Jalawaka*" and "*Thiyawaka*" days
Frequent sweating	Major Irrigated and Rain-fed	Rainfall within short period (1-2 days)

Source: Author's own compilation, 2017

Table 4.9: Farmers' Experience based Weather Prediction in IK Practice

Indicator	Existing Area	District
Less rainfall is expected after May	Minor Irrigated	Badulla
First 15 days in October is considered as drought period		
A short drought period occur in month of December		
Rainy and sunny days are expected in month of April		
Sudden rainfall with shorter durations are expected in months of May and June		
Less rainfall in June, July and August		
Rainy season begins in March	Minor Irrigated	Ratnapura
From December to February *Maha* season rains are occurred. Higher rainfall is expected in month of December and January		Matale
Heavy rain with lightening is experienced in February		Badulla Kegalle
Rainfall is forecasted according to the "*Nakath*" method	Minor Irrigated and Rain-fed	Kurunegala
"*Nanu walawa*" rainfall is expected during the April month after "*Hisa thel gema''* ritual(Hair oiling) of New Year Celebration		Kalutara
In month of May possibility to have rainfall is high when compared to other months		
In month of November rainfall is expected		Kegalle Badulla
The rainfall is expected in the month of January and known locally as "*Hath Duruththa wahinava*"		Badulla
The April rain is an indicator for the initiation of for *Yala* season		Kegalle Matale

Source: Authors' own compilation based on field survey (2017)

4.4.3 Knowledge on Soil Properties

Indigenous farmers practiced IK based technologies for soil management in order to enhance soil fertility in paddy fields. They also knew soil types which are best suited for their cultivation. Therefore, traditional farmers have managed to develop sustainable land use management practices to improve subsistence farming by using their knowledge (Buthelezi, 2010). In soil classification traditional farmers in Sri Lanka mostly use soil fertility indicators such as soil colour, soil texture, stone content, water infiltration, water retention, vegetation, animal behaviour, and environmental factors. For an example, majority of the farmers in minor irrigated areas indicate that the fertile soil is brownish and infertile soil has a light colour. The farmers in irrigated areas perceive reddish coloured soils as the most fertile. Further in all farming areas irrespective of whether irrigated or rain-fed, farmers perceive black soils as the most fertile. Previous studies have shown that the soil colour provides a good measure of inherent soil fertility (Barrios and Trejo, 2003). Consequently, the farmers in minor irrigated and rain-fed areas indicate that gray and black soils are most suited for paddy cultivation. Soil colour and texture are the physical properties of soil predominantly used by farmers in traditional soil classification (Barrera-Bassols and Zinck, 2003). Research findings revealed that the sandy loamy soil is more fertile than sandy soil. However, the farmers in minor irrigated and rain-fed areas in Kurunegala District reported that the sand mixed dry soil is good for some rice varieties such as "*Suduru samba*''.

Traditional farmers classified the soil fertility depending on the vegetation in the paddy field. Research findings revealed that if *Atawara* (*Panicum repens*) and Guinea grasses (*Megathyrsus maximus*) grow well in the paddy field then the soil is fertile. The farmers in all farming areas indicate that the soil is rich in Nitrogen if there are Shameplant / *Nidikumba* (*Mimosa pudica*) on the ground. According to farmers in major irrigated and rain-fed areas, the soil is more fertile if *Batadalla* (*Isachne globosa*) plants grow intensively. Majority of the farmers in major irrigated areas reported that the paddy fields with *Adanahiriya* (*Crotalaria retusa*), *Wal Kochchi* (*Capsicum spp.*), *Wara* (*Calotropis gigantea*) and Lantana /*Poddisinnomaran* (*Lantana camara*) are fertile. Further the farmers in minor irrigated and rain-fed areas indicate that the paddy fields with *Pila* (*Tephrosia purpurea*), *Diyahabarala* (*Monochoria vaginalis*) and *Ikiri* (*Acanthus ilicifolius*) are fertile while the farmers in minor irrigated areas reported that the soil is not fertile if Undupiyaliya (*Desmodium triflorum*) is grown in the field. Further, the farmers in major irrigated areas mentioned that the soil has more moisture holding capacity if mushrooms are grown.

Previous studies have also provided evidence on the traditional knowledge of rural people to understand the salinity status of soil by observing the plants that grow in an area. For instance, *Wood apple/diwul (Limonia acidissima L), Keeriya (Acacia chundra), Indi (Phoenix zeylanica), Ikiriya (Hygrophila spinosa), Pothu-pan (Scleria poaeformis), Wetakeiya (Pandanus kaida), Illuk (Imperata cylindrica)* are grown in saline soils (Dharmasena, 2010). However, high salinity of the soil is not suitable for the rice cultivation as indicated by some farmers in minor irrigated and rain-fed areas. Conversely, the farmers in Moneragala District indicate that some of the traditional rice varieties such as *Pokkali, Wedha heenati* and *Batapolal* are suitable for cultivate in saline soils. Past studies have also noted that there are many traditional rice varieties tolerant to saline conditions of the soil, including *Pachchaperumal*, *Wanni dahanala*, *Rathdel*, *Dahanala*, *Kuruluthuda* and *Madathawalu* (Dharmasena, 2007). Further, the farmers in all farming areas indicate that well drainage soil is more suitable for the cultivation since traditional varieties grow taller and are susceptible to water logging.

Moreover, the farmers in all farming areas indicated that if there are more earthworms/ Ati panuwan /Gadawillan in soil (*Ambi pas*), the soil is more fertile and farmers in minor irrigated and rain-fed areas reported that the paddy fields with rice field crab burrows ("*Kakkutu gula*") are not fertile. All these findings indicate the farmers traditionally knew the soil organisms that are able to enhance the soil fertility in rice fields.

4.4.4 Selection of Paddy Varieties and Preparation of Seed

4.4.4.1 Selection of Paddy Varieties

The seed varieties are selected based on the suitability to the farming area, predictions of the weather conditions in the next season, rainfall patterns and other environmental factors. Moreover, research findings reveal that the farmers in all farming areas select long term rice varieties for *Maha* season and short term rice varieties for *Yala* season. Past studies also noted that when farmers predict a drought season, they select short term rice varieties such as *Hatada wee, Kuru wee* and *Pachchaperumal* that are more drought tolerant. In contrast when a rainy season is predicted; farmers select long term rice varieties such as *Dik wee, Madatawalu* and *Hondara walu* (Irangani and Shiratake, 2013).

Further, the farmers have reported that the selection of rice varieties, either long term (4 – 4 ½ months) or short term (3 months) is based on the rainfall pattern and the cultivation season. For instance, in the *Maha* season sowing

is carried out before the onset of the North East Monsoon rains before 15th of October. Normally in Sri Lanka, North East Monsoon rains (*maha wesi*) occur in the late October and continue up to late December. The farmers perceived that the monsoon rain provides essential nutrients to the soils in the paddy fields hence they can get a higher yield. Past literature has also provided evidence on the importance of the monsoon in the rice cultivation (Irangani and Shiratake, 2013).

The farmers in Moneragala District indicated that some of the traditional rice varieties such as *Pokkali, Wedha heenati* and *Batapolal* are suitable for the saline soils since they traditionally knew that these rice varieties can be grown in saline soils. Moreover, research studies conducted in India also reported that the farmers use IK to select suitable rice varieties according to soil conditions of the paddy fields (Das and Das, 2005; Singh and Sureja, 2008).

Seed preparation follows after selecting the suitable rice variety for cultivation. Majority of the farmers reported that the most successful paddy varieties from the previous cultivation are selected for the preceding cultivation. These farmers prepare seed paddy by themselves and borrow seeds from neighbouring farmers if their own seed stock is not enough for their cultivation. The farmers in minor irrigated and rain-fed areas use six months old seeds preserved from the last season as seed paddy. At the threshing floor, non-mixed and unbroken paddy seeds are separated for the next year cultivation. Further, the farmers in major irrigated areas in Moneragala District reported on a process called *Garawa Kiranawa*, which is done to remove debris from the seed paddy. Moreover, research studies conducted worldwide reports that the traditional farmers use similar type of IK practices for seed selection. Olatokun and Ayanbode (2010) observed that Nigerian women cull the seeds and preserve them for the next planting season. According to Belemie and Singh (2012) the farmers in Ethiopia select healthy crops in terms of maturity period, height, colour, and size. The panicles or the spikes of the selected varieties are separately harvested, dried, carefully threshed, and save grains for replanting.

In order to separate viable seeds for germination, farmers apply several techniques and treatments using locally available resources. For instance, the farmers cultivating minor irrigated and rain-fed systems in the Kegalle District carry out a pretest on a sample of seed paddy to separate viable seeds for germination. At pre testing stage the farmers check the germination percentage of the seed paddy sample and based on the germination success they select the suitable seed paddy for their cultivation. The farmers in the Ratnapura District use habarala (*Alocasia* spp.) stalk as

substrate to pretest seed germination. They divide the stalk into two pieces and place paddy seeds and ties with a rope to observe germination percentage after four days. These observations clearly suggest that farmers have IK on the separation of viable seeds for their rice cultivation with the intention of establishing a healthy paddy field, which is resistant to pest and disease attacks and capable of giving a substantial yield. Historical evidences also prove the importance of the treatments on seed paddy as means of obtaining high yields from the paddy cultivation (Irangani and Shiratake, 2013).

4.4.4.2 Seed Preparation

In general, the seed paddy bed (*yahan kereema*) is prepared by laying paddy seeds, soaked in water for about 24 hours and kept on the floor covered with green leaves of banana (*Musa* spp.) or arecanut (*Areca catechu)* or habarala (*Alocasia* spp.) and placing a mat ("*magala*") woven by using leaves of coconut palm (*Cocos nucifera)* or Wetakeiya *(Pandanus tectorius)* over it with a heavy weight for about two to five days. The thickness of the seed paddy bed (*maluwa*) is about three to four inches. After several days seeds begin to germinate *(kanu kapenawa)* and becomes ready for sowing. Further, the farmers reported that these germinated seeds are kept for one day covered with habarala (*Alocasia* spp.) leaves and planted in the nursery a week before transplanting in the field. However, according to research findings the soaking period vary 12 hours to 48 hours and during this time infertile seeds (*bol wee*) are removed by the farmer. As reported, traditional paddy farmers decide the soaking period based on the rice variety and thickness of the seed coat. For instance, the farmers in Polonnaruwa and Kalutara Districts reported that the traditional rice should be soaked in water for about one and half days (36 hours) before laying on the ground because the seed coat is thick in these varieties. The farmers in Matale and Kalutara Districts mentioned that if the seeds used are old they soak in water for about 48 hours. The farmers in Moneragala, Badulla and Jaffna Districts mentioned that when *balawee* (short age rice varieties) is used the soaking time in water is about 12 hours. Moreover, the farmers in Ratnapura District place paddy seeds (about 2 *karthu*) in sacks and soak in water for 24 hours, then taken off and kept it on the floor. These sacks are covered with habarala *(Alocasia* spp.) leaves with weight on top and kept for about three days and seeds soaked in water again for one to two hours. This process is known as "*pawan diya dameema"*. Once the soaking is over they lay seeds on floor covered with habarala (*Alocasia* spp.) leaves and when seed paddy reaches germination or "*kanu kapenawa"* stage, and separate seeds which adhere together by gently rubbing with the palm "*kata kadanawa*". A day before sowing they apply cow dung (*ela goma*) with water. These farmers

traditionally knew locally available resources that can be applied to enhance the seed germination percentage and suitable environmental factors such as moisture content and temperature for successful seed paddy germination.

At seed preparation stage traditional farmers have followed some *kems* and rituals to protect crops from pest and disease attacks as well as from spiritual evils and envious. For instance, the farmers in Kalutara District chants "*Uthum Shrimaha Buddha Bogan*" before seeds are soaked in water. In some cases, a small portion of seed paddy is taken at an auspicious time and *pirith* is chanted and mixes with the whole seed lot. The traditional farmers believed astrology and *kem* methods can minimize the problems related to cultivation. *Kem* methods mostly depend on the religious basis of the farming community. Praying and chanting to Gods, Goddesses and Buddha are very common in *kem* methods which are mostly practiced. The religion base of *kems* practiced, helped to sustain those for over centuries in the rural farming community as part of the IK. These indigenous practices were also cited in past literature (Endagama, 1998; Helvetas, 2001).

Traditional farmers knew indigenous practices that are applied before sowing in order to minimize possible risks, especially pest and disease attacks. Prior to sowing or nursing, majority of farmers practice indigenous treatments on germinated seeds with expectations of obtaining a higher rice yield by reducing pest and disease attacks. According to the survey, it was revealed that the traditional farmers apply locally available materials for seed treatments. The farmers in all farming areas mentioned that they use cow dung (*ela goma*). Further, other planting materials that the farmers used varied among districts. For instance, the farmers in Hambanthota District apply the mixture of "*dubul*", cowdung, *gata thumba* (*Leucas zeylanica)*, *abul bomi*, and belathana (*Pennisetum triflorum*) when seeds are soaked in water while the farmers in Moneragala District reported that they use a mixture of *mee pothu* (*Madhuca longifolia*), wax gourd "*alu puhul"* (*Benincasa hispida)* leaves, belathana (*Pennisetum triflorum*) roots and cowdung to spray over germinated seeds when placing on the seed paddy bed (*seed maluwa*). Moreover, the farmers in Ratnapura District mentioned that they apply a mixture of belathana (*Pennisetum triflorum*), wal koththamalli (*Scoparia dulcis*), neem/kohomba leaves (*Azadirachta indica*) and karanda leaves (*Pongamia pinnata*) on germinated seeds prior to sowing. Existing literature provides significant insight to the use of the indigenous practices in seed preparation and the importance of the locally available materials in seed treatments (Helvetas, 2001; Irangani and Shiratake, 2013).

4.4.5 Land Preparation

The traditional farmers determine the suitable time for land preparation based on the rainfall pattern in the area, astrology and by their farming experience. They also look for specific days and auspicious times for commencing the land preparation. For instance, the farmers in minor irrigated areas in the Matale District begin land preparation either on Tuesday, Thursday or Sunday while the traditional farmers in the rain-fed areas in the Ratnapura District decide on the day by avoiding inauspicious time (*raahu kālaya*) and initiate land preparation in *guru* or *budha horawa.* Traditional farmers also follow certain rituals when commencing the land preparation. According to the survey, it was revealed that farmers in Matale District at the beginning of first ploughing, the owner of the buffaloes place the stalk (*kevita*) on the plough (*Nagula*) and worship three times, with the expectation of a good harvest. According to Endagama (1998), some traditional farmers commence land preparation in a lucky hour (*suba horawa*) getting from the *nekath rala* and by a cultivator who has the credit of being fortunate.

Further, it is reported that the farmers in major irrigated areas and rain-fed areas begin land preparation in late July and finishes in September in the *Maha* season. It is noteworthy that the farmers in Polonnaruwa District believe that the soil organisms which are favourable to paddy cultivation actively contributes for soil improvement in the paddy fields during this time of the year. The past literature also provide evidence on the use of indigenous practices in land preparation. According to the study conducted by Irangani and Shiratake (2013), the land preparation begins at the end of the July and early August and the traditional farmers follow the Lunar calendar for land preparation practices beginning their work after the new moon day believing that the soil organisms enhancing the soil fertility are active during this period.

Majority of farmers in all farming areas complete land clearing / *wanath kapeema* before first ploughing. When clearing the land, the farmers cut the small trees and remove the weeds and incorporate debris into the paddy field. Consequently, these debris gradually decompose and release essential nutrients into the soil. Generally, in the past, at the beginning of the cultivation (*Mada govithena*), first ploughing was conducted after *wanath kapeema* and thereafter the ridges /*niyara* are constructed. The first ploughing (*Palamu heeya*) was performed with the onset of *Ak* rain (*Ak wessa*) which is usually received at the end of September after the long drought called *Nikini* drought (*Nikini idoraya*). The farmers who cultivate under minor irrigated and rain-fed systems in the Kalutara District never

constructs ridges (Niyara) forming a cross (*Hathara man handi*) and instead they construct to take the shape of an elephant back. The farmers in Moneragala District, during the preparation of *niyara* an additional amount of mud (*Wakkata*/*Mada kata*) is stored at some places of the *niyara* for the purpose of reconstructing *niyara* (*Niyara bandeema*) once. Then the water is introduced through the openings (*wakkadawal*) by repairing and sloping the ridges with mud. The farmers soak the paddy field for 15 days before the second ploughing (*deheeya*) allowing an interval for weeds to sprout so that they can suppress all the weeds sprouted in their paddy fields. After second ploughing they apply cattle manure, straw and green manure to the field for providing essential nutrients into the soil. Then the third ploughing follows after a week. It appears that these indigenous practices firmly address the major challenge in paddy cultivation, declining of soil fertility due to prolong cultivation. Majority of the farmers do *Porugama* at the third ploughing with a large board (*poruwa*) dragged on its edge by buffaloes, and smaller boards (*atporu*) dragged by themselves. *Katu poruwa* was used for dragging the turfs. After ploughing and prior to sowing they store water in the paddy field and this process is known as *diya saaththu kireema*.

Majority of the farmers mentioned that in the past, the ploughing was done by using buffaloes and iron plough (*Sinhala nagula*). The farmers traditionally knew that the weeds can be suppressed by ploughing with *nagula* and water holding capacity of the soil can be improved by deep cattle foot marks in the paddy field. Unlike in the past, now the farmers use tractors for land preparation but still some of the traditional land preparation practices exist in some rural areas. For instance, farmers in rain-fed areas mostly use mammoty (*udalla)* for land preparation instead of plough (*Nagula*) since the paddy fields in these low country areas are usually swampy. The first mudding in the paddy fields, dug up by men with *udalla* is known as *puran ketima.* The farmers in the Kalutara District names this as *paluman gaheema.* Farmers in the Ratnapura District mentioned that once they dug up the field with *udali* repeat again after a month, which they call as *deketuma*. Whichever way the paddy fields are dug up by farmers with *udali* they level the field by using *atporu*.

The farmers in Anuradhapura and Polonnaruwa District mentioned that they have practiced *kekelum govithena* in the past, the term they referred for dry sowing of paddy seeds early in the season. In this method the field is ploughed twice with the iron plough to suppress the weeds in the paddy field and to obtain a dispersed soil for sowing. After sowing, the field was ploughed again to properly mix the seeds with the soil.

The farmers in the Hambantota District mentioned of a practice known as first mudding (*puran ketima*), which they do as the first step of the land preparation two weeks before constructing the ridges (*niyaras*). A few days prior to manuring, they themselves trample the field crushing the larger clods *(keta paganava)* and level the field by *atporu.* All these practices exemplify the traditional knowledge of farmers for appropriate land preparation in a sustainable way by improving the soil fertility as well as eliminating weeds in their paddy fields.

4.4.6 Seed Sowing and Transplanting

Majority of the farmers in all areas followed sowing method instead of transplanting irrespective of rain-fed or irrigated farming. The farmers mentioned that even though the yields are high when paddy is transplanted compared to broadcasting, transplanting is costlier and requires more labour. Therefore, most of them preferred the broadcasting method. Generally, in traditional paddy farming the sowing date is decided by the farmers based on factors such as panicle initiation time, vulnerability to pest and disease attacks, weather conditions, Lunar calendar and astrology. For instance, the farmers in major irrigated areas carry out in mid-October in the *Maha* season, because by tradition they knew that when sowing is done during this time of the year the crop loss is minimum in rice fields. Further when planting during in *Maha* season, they cultivate long aged varieties expecting panicle initiation in January to February. As stated in past literature, low temperature and high humidity are favourable for paddy pests and diseases (Singh and Sureja, 2008) and therefore, farmers in rain-fed areas especially those in Kalutara District do sowing in *mul kaluwara* (waxing gibbous moon - the time period after new moon and prior to full moon) or *binara karuwala* prior to *wap pura* (full moon poya day in October) to get a high yield. Historical evidences also reported that the main reason for the selection of sowing date with the basis of Lunar calendar and moon patterns are to avoid the panicle initiation during the dry months. Further past literature also reveals that when panicle initiation occurred during waning half of the Lunar month, the rice could be stored over a long time after harvesting (Irangani and Shiratake, 2013).

Traditional farmers seek for an auspicious time for seed sowing or transplanting of seedlings and also it is a ritual when beginning cultivation according to astrology. The existing literature states that the traditional farmers believed an auspicious time is good for attracting energy from other planets and hence the rays and energy that comes from those have a positive effect on the plant growth and the harvest (Helvetas, 2001). Farmers mentioned that they look for auspicious *Nekath* and *Karanaya*

especially *divi karanaya* or *sinha karanaya* for carrying out seed sowing. The farmers in minor irrigated and rain-fed areas decide auspicious days as Wednesday, Thursday, Friday or Saturday for sowing by avoiding the inauspicious time (*raahu kālaya)*. Further, farmers in the Kalutara District mentioned that they do not sow in the evening. In conclusion it can be said that the traditional farmers have been aware of most suitable days and times for seed sowing in order to ensure higher yield with favourable environmental conditions, and avoid possible damages due to pest and diseases.

A number of practices and beliefs associated with paddy sowing in different farming communities came out during the study. The most noteworthy of those are as follows.

Farmers who cultivate in both under minor irrigated and rain-fed areas in the Kalutara District develop and level the paddy field before sowing and prior to sowing that they plant a habarala plant (*Alocasia* spp. known to be a termite repellent) or an inflorescence of arecanut/ *Areca catechu* (symbol of prosperity) in the center of the paddy field. Majority of the farmers in all farming areas preferred to choose a farmer who is known to be a person with the credit of being fortunate and having good experience in seed broadcasting for sowing while farmers in the Badulla District treasured when this person followed traditional and religious rituals for seven days (*sath dinakpeweema*) before sowing.

Farmers in rain-fed areas especially in the Kegalle District collects a handful of paddy seeds at an auspicious time and chant *pirith* before sowing. The *pirith* chanted paddy seeds are first broadcasted in the field by a well experienced farmer and after that the sowing is completed by other farmers. Further, the farmers who cultivate in minor irrigated and rain-fed lands in the Matale District place seeds in three corners marked in the paddy field and commence sowing from these three corners at an auspicious time.

Seeding rate (seeds/ac) varied with the cultivation season and fertility of the soil. It is generally low in the *Maha* season and high in the *Yala* season. Farmers in major and minor irrigated areas, especially those in Hambantota and Ratnapura Districts maintain a high seed rate in infertile areas than fertile areas in the paddy field.
Farmers who cultivate under minor irrigated and rain-fed areas in the Kalutara District sow at relatively a high seed rate, 3 seeds for an area equivalent to a foot step of a dog ("*Balu adiyata wee ata thunai*") in the *yala* season compared to the rate they sow in the *Maha* season, 3 seeds for an area equivalent to a foot step of an elephant (“*ath adiyata wee ata thunai*”).

Table 4.10 gives an account of some unique indigenous practices followed by paddy farmers with respect to seed sowing in irrigated and rain-fed areas. The farmers continued to follow these seed sowing traditions for generations because they believed that these indigenous practices and rituals will help them to minimize their problems during the cultivation and ensure a good harvest at the end.

Table 4.10: Some Unique Indigenous Practices of Seed Sowing Followed by Rice Farmers in Irrigated and Rain-fed Areas

Indigenous Practice	Area
Maintains a seed rate, 2-2.5 "Busals" of seed paddy per acre.	Major Irrigated
Extensive amount is sown to cover natural loses.	Major Irrigated
Sowing seeds October in the *Maha* season to minimize pest damages.	Major Irrigated
Plant few *wara(Calotropis procer)* branches at the four corners of the farm yard after seed sowing to prevent Swamphen / *seru* (*Poliocephalus spp.*) damage.	Minor irrigated
Plant a branch of Jack – kos (*Artocarpus heterophyllus*) in the upper water inlet / wakkada (nawatha) before sowing.	Minor irrigated
Placing branches of Naththasooriya (*Tithonia diversifolia*) and Karanda (*Pongamia pinnata*) in the paddy field as an offering to the God.	Minor irrigated
Seeds sown in *mul kaluwara* (period after new moon day and prior to full moon day).	Rain-fed
Sowing seeds in an auspicious day following Puja (expression of honour, worship and devotion to God).	Rain-fed
Sowing at a seed rate, three seeds per area equivalent to a hens foot step ("*kukul andata wee ata thunai* ") in the *Maha* season.	Rain-fed
Sowing at a seed rate, two seeds per area equivalent to a hens foot step ("*kukul andata wee ata dekai*") in the Yala season.	Rain-fed

Source: Authors' own compilation based on field survey (2017)

4.4.6.1 Transplanting

Table 4.11 gives an account of some unique indigenous practices followed by paddy farmers with respect to transplanting in major irrigated and rain-fed areas.

Table 4.11: Unique Indigenous Practices Followed by Farmers when Transplanting Paddy in Major Irrigated and Rain-fed Areas

Indigenous Practice	Area
When transplanting, upper part of the paddy seedling is cut to make it a bush type plant.	Major irrigated
Transplanting is done after two weeks from nursery establishment.	Major irrigated
When transplanting a 4" distance is kept apart from one to another seedling.	Major irrigated
In *Maha* season transplanting is done in December.	Major irrigated
Sabba pappassa gathawa is chanted during transplanting.	Major irrigated
Niyagala (*Gloriosa superba*) sprouting is an indication of the time for transplanting.	Rain-fed

Source: Authors' own compilation based on field survey (2017)

Mostly experienced farmers are occupied in transplanting activities. Further, the farmers in Kurunegala, Anuradhapura and Matale Districts reported that women involvement could be seen much in the transplanting process and they worked according to the *Aththam* method while the farmers in Moneragala District mentioned that transplanting is mostly practiced in *Maha* season. Moreover, the farmers in Kurunegala District mentioned that quarter acre nursery is required for transplanting of one-acre paddy field. The farmers in minor irrigated and rain-fed areas reported that they have planted three plants in one hole and maintained 7-8 inches space between two holes during the transplanting. However, in present also the farmers in some areas conduct transplanting due to advantages such as less seed requirement and less weed rivalry.

4.4.7 Water Management

Sri Lanka is an island nation well known for its hydraulic civilization and for more than two thousand years this civilization was based on paddy cultivation (Mahawansa, 1912; Deraniyagala, 1992). Rice is known as a high water consuming crop. Consequently, water management techniques in rice cultivation have been linked together with the rainfall pattern, Agro Climatic Zone and the type of irrigation. According to literature traditional farmers carry out various water management methods, specific to paddy cultivation. Even though the main purpose of the water management is to increase the sprouting rate of sown seeds and enhance the rice plant growth, traditional farmers apply water management techniques to control weeds and pests as well (Irangani and Shiratake, 2013). Findings of this research also reveal that traditional farmers in all areas made use of water management techniques to suppress weed growth.

As revealed by farmers, the water management is made on decisions taken at the *kanna* meeting (pre-seasonal meeting of farmers) especially on matters related to repair and maintenance of the tank bund. In the ancient times the water management was done according to the orders of *vel vidanes*. Both in major and minor irrigated areas the source of irrigation is tanks. During the seasons of poor rainfall, the limited tank water is efficiently distributed to traditional farmers through well planned water management procedures. Keeping a close check on the tank's water level *vel vidane* or the farmer organization decides the allocation of water for neighbouring plots. Mostly land is divided into equal portions or in some occasions based on land ownership for distribution of water. This system was known as the *bethma* cultivation practice, adopted by the farmers when water is not adequate due to poor rainfall to cultivate the entire paddy tract (*vel yaya*) using the limited water in the tank (Dharmasena, 2010).

As mentioned by farmers in all farming areas, they divide the maintenance works such as tank bund clearing, bund repair and canal clearing among them before the commencement of cultivation. This reduces the cost of maintenance and shares responsibility among farmers. If any farmer fails to fulfill the allotted task he will be punished by *vel vidane*. Accordingly, proper and regular maintenance of tanks and canals ensure efficient water management in rice cultivation. In *Yala* season, tanks and bund clearing starts March while in *Maha* season it commences towards end of September.

In paddy lands, a canal known as *kiul ela* is constructed near the *niyara* as a common drainage system to prevent water logging conditions. There are evidences in previous studies also mentioning the vital role of *kiul ela,* removing salts and iron polluted water while facilitating the drainage condition in the paddy tract (*vel yaya*) (Dharmasena, 2010). They also construct a canal known as *bada ela* for proper water drainage within the paddy field. They also construct channels for the purpose of irrigation in paddy fields. Farmers construct furrows with various designs for efficient water management. For instance, farmers in minor irrigated and rain-fed areas in the Kalutara District establish furrows in the paddy field similar to the shape of the rising sun. There are historical evidences that in ancient times, the traditional farmers have constructed furrows in paddy fields in various other shapes as well, *viz.*, fan, umbrella, rising sun, tunnel, and bose (Lewis,1920). Further, it has been informed that the farmers in all areas followed water declination when water is introduced through the inlets (*wakkadawal*) in the *niyara* to the paddy field.

Normally three days after sowing water is filled to a certain height (*Isnam badinawa*) and allow it to dry to provide better environment for sown seeds. This process is repeated three times (*Isnam mura thunak badeema*) and it contributes to eliminate weeds in the rice field. Depending on the rainfall and soil water condition, first water release is done within three to seven days after sowing. For instance, farmers in minor irrigated and rain-fed areas do the first release of water six days after sowing allow water to store for nine days after sowing within the paddy field before draining out. Generally, when the seedling height reaches 2-3 inches, water is stored within the paddy field while farmers in major irrigated areas do water storing after a month of planting and drain off one week before harvesting. In minor irrigated and rain-fed areas, water is kept in the paddy field until the completion of the formation of rice pod. The farmers in Badulla and Kegalle Districts store water in the paddy field until it reach the thickness of betel leaf. However, according to farmers in major irrigated areas, water is not kept within the paddy field during high rainfall.

4.4.8 Fertilizer Application

Soil fertility, defined as the capacity of the soil to support the plant growth (Watson *et al.,* 2002) is an essential component in sustainable agriculture towards achieving food security. It is evident form past literature that traditional farmers in Sri Lanka as well as in world were aware of this and practiced several indigenous approaches to improve soil fertility in their paddy fields.

The farmers who participated in the present survey revealed many noteworthy practices in the Sri Lankan context and most noteworthy of those is herein summarized.

Farmers apply fertilizer in several stages of paddy cultivation; *wanath kapima* is the first stage followed by farmers all over the country where they bury plant debris in the paddy field to gradually decompose and release nutrients into the soil. The farmers in major irrigated areas prepare land in the *Maha* season around end of July to end of September because they knew this time period is favourable for soil organisms become active and contribute to improve the soil fertility.

During land preparation the traditional farmers apply straw, cattle manure, goat manure, poultry manure and green manure into paddy fields between second and third ploughing. Farmers in the Kurunegala District preferred cow dung while those in the Moneragala District like straw and paddy husk and in the Jaffna District goat manure is the choice for application when

preparing lands for paddy cultivation. The farmers in the Moneragala District apply cuttings of Albisia (*Albizia amara*), Wal sooriyakantha (*Tithonia diversifolia*), Erabadu (*Erythrina variegata*), Ipil Ipil (*Leucaena glauca* L.) and Gansooriya (*Thespesia populnea*) into their paddy fields before ploughing those in Jaffna District apply Gliricidia (*Gliricidia sepium*) and Gandapana (*Lantana camara*) into their fields as fertilizer. Moreover, farmers in minor irrigated and rain-fed areas use branches and leaves of Kappetiya (*Crotalaria retusa* L.), Mee (*Madhuca longifolia*), Karanda (*Pongamia pinnata*), Pila (*Tephrosia purpurea*), Lunu midella (*Melia azedarach*), Sapu (*Michelia champaca*), *Bu kenda (Mallotus tetracoccus)* and *Wel kaduru* (*Cerbera manghas*) as a green manure to improve fertility in their paddy fields.

The past literature also provides a significant insight on the use of cattle manure and other organic materials for enhancing soil fertility in paddy lands. According to Siriweera (1993), there are evidence since 13th century AD that Sri Lankan traditional farmers used cattle manure and other organic materials as fertilizers in paddy cultivation. Generally, organic manure plays a vital role in enhancing soil fertility by improving soil structure and its water retention capacity (Singh and Sureja, 2008). It is evident from the past literature that traditional farmers knew the potential of local plant varieties as organic manures for enhancing soil fertility in paddy fields.

In paddy cultivation, soil fertility management is mostly related with locally available materials for use as fertilizer. According to Irangani and Shiratake, (2013), geri katu pohora (crushed bones of cattle) was applied into paddy fields by farmers in all farming areas in the past and is being still practiced farmers in Hambantota and Moneragala Districts. Farmers who cultivate under minor irrigated and rain-fed systems in the Kurunegala District applied ash and plant debris coming with the water flow as fertilizer in their paddy fields. Traditional farmers in minor irrigated and rain-fed areas applied Thora (*Senna tora*) and Nidikumba (*Mimosa pudica*), which grew in the paddy field as a fertilizer after the plowing. Further, Jaffna farmers cultivated some plants like Sun hemp (*Crotalaria juncea*) on the ridges in the paddy field with an expectation of supply nutrients especially Nitrogen (N) sources into the soil. Farmers in minor irrigated and rain-fed areas often used rain water as a good N source when irrigating their fields. In addition, mostly in minor irrigated and rain-fed areas in the Kalutara District farmers grew trees such as, Mee (*Madhuca longifolia*) and Attikka (*Ficus racemosa*) in the paddy fields to host bats to collect fecal matter to use as fertilizer.

In addition to previously mentioned traditional methods it has also been evident that farmers joining with neighbouring farmers as a community in

irrigated and rain-fed areas release cattle into the paddy field during the fallowing period. As revealed by the current study the traditional farmers knew that cow dung and cow urine provide nutrients to the soil, which are necessary for paddy cultivation.

The past literature also provided significant evidence on the importance of traditional methods used in soil fertility management. As noted by Irangani and Shiratake (2013), farmers release cattle into their paddy fields with following objectives; to provide opportunity for the cattle to feed and breed, to provide essential nutrients to the soil in paddy fields by means of dung and urine, to control weeds in the paddy field, to improve the bio diversity and to improve water holding capacity. According to the existing literature, past studies have provided adequate evidence to prove the potential of cattle urine and dung as a provider of nutrients to the soil (Singh and Sureja, 2008; Dey and Sakar, 2011).

Moreover, the findings revealed that some of the farmers in major irrigated areas have used liquid fertilizers that are prepared by themselves. Farmers in the Polonnaruwa District mentioned that they prepare a liquid fertilizer by mixing cow urine, cow dung and Watahiriya (*Gliricidia sepium*) leaves together and leaving for 21 days to ferment for use as a liquid fertilizer in paddy fields. Further, they have also mentioned about another liquid fertilizer prepared by mixing 10 Kg of cow dung, 1 Kg of jaggery / *Sakkara*, and cow urine and diluting with water at ratio of 1:10 ratio for spraying over the farm yard.

4.4.9 Pest Management

4.4.9.1 Weed Management

Farmers in irrigated and rain-fed areas practice various types of weed control techniques at several stages of paddy cultivation. During land preparation, at the very beginning they remove weeds by mammoty and two weeks after the first ploughing (*puran heeya*), the second ploughing (*deheeya*) is done, which in rain-fed areas is called as *Deketum Keteema* and another ploughing if needed by allowing sufficient time for sprouting of all the weeds with the intention of eliminating all types of weeds from the paddy field. After the second ploughing, mulching was done by farmers in some areas using weed free materials. For instance, farmers in Jaffna District mentioned that they lay Cadjan leaves (woven coconut palm leaves) to suppress weed growth. Mulching apart from preventing weed growth helps in improving infiltration and conserving moisture.

A past study reported that farmers in India too practice similar techniques during land preparation and water management in traditional farming to control weeds in paddy fields (Singh and Sureja, 2008). In the Sri Lankan Traditional Agriculture, water management techniques are mostly used by farmers in all paddy cultivating areas to eliminate weeds from their fields. As mentioned by farmers, at three days after sowing water is filled to a certain height (*Isnambadinawa*) and allow it to dry and repeat the process for three times to control the weeds. Farmers in Hambantota District it is reported that growth of weeds such as *Gojarawalu/ Gomathana/ Kudu Kedu* (*Ischaemum rugosum*) and *Kudamatta* (*Fimbristylis miliacea*) can be suppressed by filling water and allowing to dry.

Further it is reported that to control *Kudamatta* plant (*Fimbristylis miliacea*), *keselkota saaththuwa* was mostly used by traditional paddy farmers in Sri Lanka. In this *kem* method they keep water within the farm yard and drags part of a banana stem tied with two ropes to the ends over the plants. Then they allow rice field to dry. Three days after performing the *kem*, they release water to the field giving a sufficient time for weeds to sprout and with the second water release weed plants will be destroyed. According to farmers, this *kem* is applied when paddy plants are 14 days old.

According to the findings, some farmers in Ratnapura District reported that they apply weedicide prepared by themselves. This weedicide is prepared by mixing cow urine with lime juice and stored for 22 days. Farmers who have cultivated under minor irrigated and rain-fed systems in Moneragala and Ratnapura Districts mentioned that when paddy plants are growing well, automatically weeds are suppressed. Consequently, in major irrigated areas, high density seed sowing was done with the expectation of eliminating weeds in their paddy fields. In addition to above mentioned techniques, weeds are removed by manually using female labourers in all farming areas irrespective of the irrigation method.

4.4.9.2 Insect Pest Management

A growing interest was seen among traditional farmers in the study area of the present on indigenous pest management practices for protecting their crops and harvest from pest damages. These traditional methods are mainly, astrological practices, *kems*, and biological, mechanical and botanical pest control methods. These farmers follow indigenous pest management practices at various stages in paddy cultivation *viz*., initiation of the cultivation, prior to sowing and after sowing. Further, they do seed treatments during seed preparation with the intention of avoiding pest attacks which occur during the vegetative phase of rice plants. These

traditional farmers were well aware of both pre and post pest management practices in paddy farming.

Astrological Practices

Astrology plays a vital role in traditional agriculture, especially in Sri Lankan paddy cultivation because farmers believe that certain days and *karana* are good for commencing the cultivation. Usually, the farming practices begin on an auspicious day and at an auspicious time. The farmers who cultivate under major irrigated schemes and rain-fed systems in the Moneragala District mentioned that they begin their farm practices at the *Sinha karanaya* to prevent the damages from rice pests, especially elephants since they have witnessed this practice is very effective for protecting the crop from wild elephants. The farmers in rain-fed areas commence farm practices on a Friday with *Sikuru horawa* and *Divi karanaya*. This ritual is commonly practiced to avoid animals' attacks from elephant (*Elephas maximus)*, wild boar (*Sus scrofa*), peafowl (*Pavo cristatus*) and others.

Kems and Rituals

Even today *kems* are practiced by farmers in certain rural areas of Sri Lanka. It is a kind of practice, a ritual, a technique, or a custom that people follow to obtain some relief from a problem. *Kems* in general use specific plants or herbs, *manthras* and astrological practices while there are some *kems,* which are based on careful observation of nature and natural phenomena. These traditional practices have survived because of their effectiveness witnessed by people otherwise if these indigenous practices had not shown any real effect, they would have disappeared a long time ago (Senanayake, 2006). Table 4.12 gives some of the *kem* methods that are used by farmers in the study area responded to the present survey.

Table 4.12: Existing *Kem* Methods in Sri Lanka

Indigenous *Kem* Practice	Related Pest/s	Area
Chanting "*Seema Bandanaya*"- a mantra while burying four rocks at the four corners of the rice field.	Wild boar	Major Irrigated
Placing inflorescences of coconut palm (*Cocos nucifera*) / Pol Mal at four corners of the rice field.	Rice Pests e.g. wild animals	Major Irrigated
Catching a paddy bug and throwing out to a faraway place from the rice field.	Paddy bug (*Leptocorisa acuta*)	Major Irrigated
Collecting soil from a place underneath a *Kaduru* (*Cerbera manghas*) tree, chanting a special *manthra* and applying to the rice field.	Rats	Major Irrigated
Chanting a manthra on king coconut water and spraying to the paddy field.	Rice insects	Minor Irrigated
Selecting Mee(*Madhuca longifolia*) plants from an area from the north of the paddy field, removing seven rings of the bark and placing in the upper water inlet "*Nawatha*" wakkada.	Rats	Minor Irrigated
Placing a stalk in the rice field hanging a *Goda kaduru* (*Strychnos nux vomica*) fruit on each and surrounding rice field by immature coconut leaves *'Gokkola'.*	Worms	Minor Irrigated
Chanting a manthra on immature coconut (tender nut) added with crushed Black fennel seeds/kaluduru (*Nigella sativa*), cotton/kapok (*Gossypium herbaceum*) seeds and mustard (*Brassica juncea*) and spraying to the rice field.	Godawella (*Spodoptera mauritia*)	Rain-fed
Dragging a *Dik kekuna*(*Canarium zeylanicum*) or Bamboo (*Bambusa vulgaris*) stick, applied with *kekuna iti/*wax along the paddy field (*Boku gaama*)	Paddy bug (*Leptocorisa acuta*)	Rain-fed
The rope which is dipped in Neem(*Azardirachta indica*) leaf extraction, dragged through the rice field.	Paddy bug (*Leptocorisa acuta*)	Rain-fed

Selecting a *Mee* (*Madhuca longifolia*) plant, remove three rings from the bark facing east of the *Mee* plant and cut into small pieces, mix the pieces with sand collected from an area free of foot prints and spraying to the paddy field by chanting a *manthra* 108 times.	Rats	Rain-fed
Placing branches of Palol (*Stereospermum suaveolens*), Neem (*Azardirachta indica*) and Mango (*Mangifera indica*) in the paddy field, early in the morning.	Rice Pests	Rain-fed
Spreading sea sand enchanted with *pirith* (*Jalanandana piritha* or *Sabba papassa akaranam*) to the paddy field.	Rice Insects	Rain-fed

Source: Authors' own compilation based on field survey (2017)

Surveyed farmers have used various types of *kems* in their paddy fields in order to eliminate pest attacks. For instance, against paddy bug the traditional farmers in the Anuradhapura District practiced a *kem* known as "*Sivuru Wati Damima*". In this method they make torches (*pandam*) soaked in coconut oil, using wicks made of old robes "*Sivuru*" collected from a temple nearby and lights in the middle of the farm yard in the evening as the sun fades off. In the Badulla District they catch a paddy bug, place on a chili pod and hang on the roof near to the cooker. The farmers believe that the paddy bug population can be minimized by practicing this *kem*.

It is also reported that farmers in minor irrigated and rain-fed areas spread wood ash into paddy fields in the morning to control worms. As stated by Senanayake (2006) *Alu Saaththuwa* (broadcasting of wood ash to the paddy field) is a practice among traditional farmers for controlling leaf eating caterpillars in paddy fields. The paddy farmers in the Jaffna District sprinkle wood ash and charcoal on dewy rice plants at dawn to minimize the worm's infestation. There are historical evidences to substantiate that wood ash treatment as a successful pest control method because it prevents a favourable condition and a suitable environment for worms and other insects that invade paddy plants (Irangani and Shiratake, 2013). Further a study conducted by Lal and Verma (2006) reported that wood ash act as a detergent posing a problem for chewing and sucking type insects who feed on plant parts due to deposition of wood ash.

Spraying of charming sand and water has been common indigenous practices in Sri Lankan traditional rice cultivation. The farmers in all farming areas mentioned that they spray enchanted sand, oil and water into paddy

fields to protect crops from pest attacks. According to literature this charming has to be done by a devout person who leads a religious and righteous life (Kumari, 2016). In ancient times many traditional farmers in rural areas obtain the services of such persons to protect their crops against pests and diseases. However, at present these types of indigenous practices mostly not attended by farmers due to dearth of persons of such caliber with proper knowledge and credentials for chanting.

Since ancient times *Pirith* and *Manthra* has been trusted and mostly used by traditional farmers in their rice cultivation. For instance, the farmers cultivating under minor irrigated and rain-fed areas in the Badulla District reported that the palmyrah (*Borassus flabellifer*) leaf was taken by chanting some *pirith* or *manthra* and wrote relevant *pirith* or *manthra* on that leaf. Then eight of these taken and placed in eight corners and middle of the field by hanging in *Kaduru* (*Cerbera manghas*) stalks. This practice has to done early in the morning without talking anyone as a rule for successfully preventing invasion of pests in paddy fields. Further, they also mentioned another practice they follow, burying a small bottle filled with enchanted white soil and clay in the paddy field on the day of sowing. According to traditional farmers, people in past, followed *manthra* practices to prevent damage from elephants and buffaloes (*Bubalus bubalis*) and the past literature says that there were specific *manthras* for different animals such as elephants, wild boar and rats (IUCN, 2016).

When the farmers find their own strategies are not adequately effective to overcome issues arising in the paddy field, they look for the help of Gods and spirits. Therefore, combination of spiritual practices, astrology and eco-friendly practices has become a custom in traditional agriculture. For instance, the traditional paddy farmers cultivating under minor irrigated and rain-fed areas in Kegalle and Matale Districts mentioned that they perform a ceremony in the paddy field before cultivating with the help of a *kapu rāla* in a Wednesday or a Saturday for an auspicious beginning. At the end of the ritual the *kapu rāla* himself hangs aricanut (*Arica catechu*) flowers in the field. Further the traditional farmers in Kalutara District reported that the ceremony called *gara wespanawa* was performed in ancient times to ensure the crop protection from the evil eye and evil mouth (*eswaha katawaha*). This ceremony was mostly done before the blossom has set in the rice plants in the field. The ritual is a dance along with some religious practices performed by a person called devil dancer (*kattadiya*) wearing a mask, which drag over the rice plants in the field at the end of the act. Some of these spiritual practices still exist in rural areas of Sri Lanka but the real meaning of these spiritual practices is not fully understood by the younger generation of farmers Dharmasena (2010).

Biological Pest Control Methods

Biological control, mostly followed by traditional farmers in their paddy fields, is literally defined as an effective and environmental friendly approach of pest control (Kumari, 2016). In these methods paddy pests are destroyed or controlled by using predators. As stated in existing literature, birds are the major biological agents which traditional farmers use for pest control. For instance, swifts (*wehi lihiniya*) is a beneficial bird, because it feeds on *Nilaparvata lugens* (*Keedawa*) which is a serious pest in paddy (Ulluwishewa, 1992). Similarly, it was revealed in the study that farmers cultivating in major and minor irrigated areas of the Polonnaruwa District mentioned that when "*Godawella*" damage is severe in the rice field, they place portions of milk rice in the paddy field to attract beneficial birds to field who feed on worms in the field. Further, the farmers in Moneragala and Kurunegala Districts mentioned that they place coconut mid ribs (*Pol pithi*) with coconut husks placed on fronds in the paddy fields for birds like owls who picks on rats to rest upon. Farmers mentioned that this structure also looked like owls. Even today the farmers practice indigenous methods to control paddy pests in their fields because they believe that these methods are effective in pest controlling. Table 4.13 summarizes some of the biological control methods practiced in traditional Sri Lankan agriculture.

Table 4.13: Biological Control Methods Practiced in Traditional Sri Lankan Agriculture

Indigenous Practice	Significance	Existing Area
Placing rice and dry fish curry in evenings in rice field.	Attracts Owls who acts as a natural predators of rats.	Major irrigated
Growing Sun hemp (*Crotalaria juncea*) and maize (*Zea mays*) plants on ridges / *Niyara* of the paddy field.	Attract honey bees (*Apis dorsata*) who acts as a natural predators of paddy bug.	Major irrigated
Hanging tender coconut leaves and red coloured flowers on the bark of the Wallapatta *(Gyrinops walla*) plant and placed in the rice field.	Attract beneficial birds who feed on worms.	Minor irrigated

Source: Authors' own compilation based on field survey (2017)

Mechanical Control

The traditional farmers use physical elements and mechanical methods to control rice pests in the fields. The farmers in the Kurunegala District mentioned that they use sticky substances to glue paddy pests in their fields. For instance, a rope, dipped in sticky substances is dragged over the paddy plants by holding its two ends across the farm yard. There are also some *kems*, associated with mechanical methods and botanicals. It has been reported that the farmers in minor irrigated and rain-fed areas use light traps such as fire torches (*pandama*) and bonfires in the field to protect crop against paddy bug. The farmers in the Kalutara District mentioned that they use *paspangiri* (five *Citrus* species) ash to repel insect pests in the paddy field by collecting burned ash of five *Citrus* species, broadcasting over the field early in the morning. It is evident that the *pangiri (Citrus* species) plants have insect repellent properties. Further, they have reported use of chanted *pasthel*, which is a mixture of oils extracted from five species of plants *viz*., Kohomba (*Azardirachta indica*), Gingelly *(Sesamum indicum)*, Mustard (*Brassica juncea*), Coconut (*Cocos nucifera*) and Castor oil (*Ricinus communis*) for controlling paddy pests by firing four torches (*pandams*) soaked in charmed *pasthel*. These torches they erect for lighting in the four corners of the paddy field during night. In this method, it was essential to erect fire torch above the level of paddy plants.

There are also various types of oil lamps used by traditional farmers for controlling paddy pests. The farmers in minor irrigated and rain-fed areas mentioned the use of Mee (*Madhuca longifolia*) oil lamps, lighted in the field to protect crops from paddy insects, especially paddy bugs. Further, farmers in the Anuradhapura District reported that Mee oil were enchanted by a *manthra* and lamps were lighted at the farm yard using enchanted Mee oil with a robe of a monk. The farmers in some rural areas in the Polonnaruwa District reported use of lighted clay lamps using *dummala*/ resins and coconut oil and similarly use of Kohomba /Neem (*Azardirachta indica*) oil lamps lighted on coconut husks placing at the several places in the farm by farmers in the Kurunegala District. In conclusion it can be stated that farmers experienced many traditional practices, which they learnt from ancestors for repelling and controlling insect pests in paddy fields by using locally available raw material.

Water Management Methods

Water management is also a successful pest control method which has been in practice in paddy cultivation in many areas in Sri Lanka. When farmers notice thrips (*Stenchaetothrips biformis)* attack in their fields they supply

more water in to the field in the evening and release in the following morning. The water forces the worms to move out of the paddy plants and gets exposed to prey birds inhabiting paddy growing areas. It has been mentioned by the farmers in the Kalutara District that they practice water method to control Rice Caseworm (*Paraponyx stagnalis stagnalis*)/ *Kokkanawo* in rice cultivations. There are also historical evidences on carrying out water management by traditional farmers to control worms in paddy fields as a successful method of controlling pests and harmful organisms before seeding (Irangani and Shiratake, 2013; Kumari, 2016).

Botanical Pest Control Methods

In ancient times as well as in present, traditional farmers use plants, leaves and plant extracts to control pests in the paddy field. Further, they have identified a wide range of plant species which can be used to pest control. According to the farmers, there are some plants species produce substances which repel or poison the insects. Therefore, farmers use different products such as leaves, fruits, bark and seeds of these plants in various ways to control pests. For instance, the farmers in major irrigated areas reported that the leaves of Gliricidia (*Gliricidia sepium*), Kohomba/Neem (*Azardirachta indica*) and Naththasuriya (*Tithonia diversifolia*) are applied to the soil during land preparation. Thus, rice insects affected due to the pungency of those leaves. The farmers in Moneragala District have practiced indigenous pest control methods in their cultivations. They have mentioned that the Daluk (*Euphorbia antiquorum* L.), Kala wal (*Diospyros affinis*) and Madu bark (*Cycus circinalis* L.) are crushed and placed at the upper water inlets (*Nawathawakkada*) of the paddy field to control pests such as paddy bug, thrips and worms. Further, the farmers indicate that the *Mahapatta* (*Leea macrophylla roxb.ex*) is crushed and placed in main upper water inlet to control paddy insects. Once *Mahapatta* extract mixed with water its bad smell affects insects. To control worms in the rice field they have applied the juice of Kappara walliya (*Plectranthus amboinicus*) to the field. Moreover, the farmers in Polonnaruwa District indicate that the Red Kala Wal (*Diospyros affinis*) are crushed and put into the farm yard or spread over the farm yard to prevent the Keedawa (*Nilaparvata lugens*) damage. Majority of the farmers traditionally know the plants that generate repellent aromatics. For examples the farmers in Moneragala District have applied Neem/*Kohomba* leaves while the farmers in Ratnapura District have placed Kelaniya (*Languas chinensis*) branches with twisted top in paddy field to control paddy bugs. As the aroma of the Kelaniya (*Languas chinensis*) trees act as repellent for paddy bugs.

There were several traditional methods to control rats in the paddy fields. In present day also some of these methods are practiced by traditional farmers in rural areas. For instance, the farmers in Kurunegala District indicate that the Watakeiya (*Pandanus kaida*) leaves are spread over the farm yard, farmers in minor irrigated and rain-fed areas cut the raw fruit of papaya (*Carica papaya*) in to pieces and spread over the farm yard to prevent the rat damages. The past literature also provided the evidences to the use of papaya for controlling rat damages and it was revealed that the latex of the papaya pieces injury the rats' gums, wounding the mouth (Irangani and Shiratake, 2013). Further, they have reported that the Albisia (*Albizia amara*) flowers are spread to the rice field to control rats.

In minor irrigated and rain-fed areas of Sri Lanka, there are various types of traditional methods to control worm damages in the paddy field. For instance, the farmers in Kurunegala District reported that they have used Daluk (*Euphorbia antiquorum* L.) plant to control worms in their paddy fields. In this method, Daluk plants are cut into pieces and spread over the farm yard to prevent worm damage. Past literature also proved that the latex of Daluk plant is very harmful to the worms especially Paddy Stem Borer/*Puruk panuwa* (*Scirpophaga incertulas*) (Irangani and Shiratake, 2013). Further, the farmers in Anuradhapura District reported that the Pathok (*Euphorbia neriifolia*) trees are cut in to pieces and spread across the farm yard to control the worm damages. The farmers in Moneragala and Badulla Districts plant Madu (*Cycus circinalis* L.) branches in the paddy field to control worms while the farmers in Matale and Anuradhapura Districts reported that the *Madu* flowers were applied to the field to prevent insect damages. According to existing literature *Madu* leaves have opposite repulsive smell to insect, therefore the farmers grew *Madu* tree for keep the insects away from the paddy fields (Kumari, 2016). The farmers in Kegalle District control worm attack by using Kappetiya (*Crotalaria retusa* L.) plants. They reported that the Kappetiya branch was placed in paddy field or leaves were spread over the field during the land preparation to control the worms in their paddy fields. Moreover, Table 4.14 shows some of the botanical pest control methods that are practiced by traditional farmers in study area.

Table 4.14: Botanical Pest Control Methods

Indigenous Method	Related Pest	Area
The seeds of Neem (*Azardirachta indica*) and Tobacco (*Nicotiana tabacum*) stems are blended with water and the mixture is spread onto the paddy field.	Rice insect pests	Major Irrigated
Neem (*Azardirachta indica*) leaves and bark are left to rot and applied onto the paddy field.	*Kolahakulana dalambuwa (Cnaphalocrocis medinalis)*	Major Irrigated
Daluk (*Euphorbia antiquorum*) branches are hung on some places of the paddy field.	Puruk Panuva (*Tryporyza incertulas*)	Major Irrigated
The bunches of the Maduruthala (*Ocimum tenuiflorum*) plant are placed in paddy field.	Paddy Bug	Major Irrigated
The leaves of the Ranawara (*Senna auriculata*) plants are boiled with water and the mixture is sprayed over the paddy field.	Worms	Minor Irrigated
Walkochchi and Maduruthala (*Ocimum tenuiflorum*) plants are boiled with water and sprayed over the paddy field.	Rice insects	Minor Irrigated
A Masan (*Ziziphus mauritiana*) branch is dragged over the rice field.	Worms	Minor Irrigated
The seeds of the Mee (*Madhuca longifolia*) plant are chopped and sprayed to the rice field.	Paddy bug	Rain-fed
Leaves and creepers of *Thiththa wal* (*Anamirta cocculus* L.) are chopped and placed at the upper water inlet of the rice field.	Paddy bug	Rain-fed

Source: Authors' own compilation based on field survey (2017)

4.4.9.3 Disease Management

The farmers who have cultivated both traditional and modern rice varieties in study area reported much fewer pest attacks in the traditional rice fields compared to the modern paddy fields. As revealed by Irangani and Shiratake, (2013) the main reasons for the minimal pest attacks in traditional rice varieties are relatively smaller sugar content in the rice plant and the roughness of the paddy stem and leaves.

The farmers in major irrigated and rain-fed areas reported that the traditional rice varieties have resistance against diseases. Past literature also provided the significant evidences on the specific characteristics of traditional rice varieties such as tolerance against the insect infections and resistance against the diseases (Singh and Sureja, 2008).

Majority of the farmers traditionally know the disease management techniques and further they are aware of both pre and post control techniques. For instance, to avoid the diseases in the cultivation farmers practiced "*Kal Yal Bala Govithana*" (cultivation at right season, right time) and started cultivation practices at an auspicious time. The farmers in Hambantota and Matale Districts reported that the land preparation is done at suitable time in order to prevent the yellowing of paddy plants. In ancient times as well as in present some customs and religious practices are practiced by traditional farmers in order to achieve disease free cultivation. Generally, most of the farmers visit the temple and make offerings before they start cultivation. Further, the farmers in Kurunegala District reported that they have prepared an almsgiving using panicle initiation stage paddy plants and visit the temple with an expectation of disease free cultivation.

Moreover, the farmers in minor irrigated and rain-fed areas especially farmers in Anuradhapura and Moneragala Districts reported that the positive conditions around the paddy field affected to successful rice cultivation. Thus, according to them disease management methods were not needed at the past. Further, the farmers in Kalutara District mentioned that water and fertilizer are provided only at necessary levels to obtain disease free cultivation. Moreover, the farmers in Jaffna District control diseases in their rice cultivations by sprinkling charcoal and wood ash to dewy rice plants.

In the past traditional rice farmers have conducted several *kems* in order to achieve disease free cultivation. Table 4.15 shows some of the *kems* and other methods that are used by farmers in their cultivation. For instance, the farmers in Ratnapura District reported that they have performed *kem* method using Kappetiya (*Crotalaria retusa* L.) branch. In this method the branch of Kappetiya (*Crotalaria retusa* L.) plant is placed in the starting point of the paddy field at Sunday. After a week, first branch is taken off and placed in middle of the field and placed new branch at starting point. Then after week again taken off middle one and placed in end point, second branch placed in middle, third (new) branch placed in starting point, fourth week first branch removed from the field and rotation is continued. Further, they have mentioned that this process should be done without talking.

The farmers traditionally know the plants and other locally available resources that can be applied to the paddy field in order to protect crops from diseases. The farmers in Moneragala District indicate that the Wal sooriyakantha (*Tithonia diversifolia*.) has fungicide effects. They have reported that the Karanda (*Pongamia pinnata*), Erabadu (*Erythrina variegata*) and Murunga (*Moringa oleifera*) branches are cut and applied to the rice field to control diseases. Further, they have sprayed the mixture of Dubul oil, Neem oil, Kapuru oil (*Chrysanthemum spp*.) and Mee oil to the paddy field. As mentioned by farmers these oils are not dissolved in the water then oil layer is created. Thus, this is helped to control the diseases in the paddy field.

Table 4.15: Indigenous Practices for Disease Management

Indigenous Practice	Area
The oil lamp is lightened in the rice field.	Minor irrigated
Niyagala(*Gloriosa superba*) creeper is taken, made rounds and placed it in the field.	Minor irrigated
Neem/ *Kohomba* (*Azardirachta indica*) leaves, *Katumana* branch and *Higuru wal* (*Acacia caesia*)are dragged through the rice field to avoid leaf curl disease.	Minor irrigated
The mixture of cow dung, coffee seed cover, paddy husk and Calcium Oxide (Alu hunu) is applied to the paddy field to control the brown leaf spot disease.	Minor irrigated
Citronella oil extraction left overs is burned and ash is applied to the field.	Rain-fed
Holy water (*Pirith pan*) is sprayed to the rice field.	Rain-fed
"*Ala kola handigaama*" – *Ala* (*Alocasia* spp.) leaves are cooked in the paddy field and spread over the paddy field.	Rain-fed
The Puja is made in the Koovil.	Rain-fed

Source: Authors' own compilation based on field survey (2017)

4.4.10 Labour and Equipment

4.4.10.1 Labour Management

Farmers used various types of labour management practices such as *Aththam*, *Muththettu*, both the family members and hired labourers participate as labor force irrespective of irrigation method variation. In past most of the farmers in paddy cultivation used *Aththam* practice to fulfill their labour requirement. '*Aththam*' is a traditional arrangement which operates normally among the rural farming communities, providing labour assistance by pooling the labour of a group of cultivators or farmers (Daskon, 2015). According to the past records, even in the absence of

machinery and equipment some of the labour intensive farming practices such as land preparation, planting, weeding and harvesting have been successfully performed by rural farmers in Sri Lanka through practice of informal mutual help group systems: *Aththam* (Endagama, 1998).

"*Muththettu*" is another practice that was used in paddy cultivation. In this method food is provided for the workers but not essential to go their farm works. In past, family members were mostly engaged in farming activities however in present family members of farming families are mostly engaged in other occupations. Consequently, farmers have to depend on hired labourers but today finding labourers for farming activities is also a major issue. Absence of mutual help in the communities today has reflected in labour scarcity, which is a menace in the whole agricultural sector (Endagama, 1998).

4.4.10.2 Farm Equipment

Various types of farm equipment were used by traditional paddy farmers in irrigated areas as well as rain-fed areas in their farming activities. There were different types of farming equipment that were specified to each cultivation stage based on functions.

The *Sinhala Nagula* is held with great significance in traditional agriculture and it was widely used by traditional paddy farmers in Sri Lanka. A *Nagula* or plough is a wooden tool used in paddy farming to prepare paddy field for cultivation. The *Nagula* is basically used to turn and loosen soil before sowing seeds or planting seedlings in the paddy field.

Mammoty is a special type of garden hoe. In Sinhalese language mammoty is usually known as *Udalla.* In rain-fed areas farmers mostly used *udali* to land preparation instead of using *Nagula*. In first mudding if the paddy fields are dug up by men with *udali this* process is known as *puran ketima*. If the *nagula* and use of buffaloes is not possible, it is recommended that farmers to use *udali* or two-wheel tractor with a rotary to plough paddy fields. Unlike past, in present most of the farmers use two-wheel tractor in land preparation. However, the results revealed that the traditional farmers in rain-fed areas especially in Kalutara and Ratnapura Districts use *udali* for land preparation in their field.

Poruwa is also used in land preparation. As the final stage of land preparation the mud is levelled with a large board (*poruwa*) dragged on its edge by buffaloes, and by smaller boards (*atporu*) worked by men.

In some areas *Govi lalla* is used to levelling the paddy field at the final stage of the land preparation. *Govi lalla* is a large board with wooden stick, that stick is attached to the center of the board. At the threshing floor this *Govi lalla* is normally known as *Poru goyiyawa* and this is used to collect paddy (*rahi karanawa*) into the heap which is ready to be measured.

When the land preparation is finished, seed sowing is taken place. In seed sowing time paddy is stored in a container called as *Mul awilla*. In some areas seed sowing box is used to store seeds.

Sickle (*Daakaththa*) is one of the most ancient agricultural tools which used in the harvesting stage of rice cultivation. And also it is a hand-held agricultural tool designed with variously curved blades and typically used for harvesting, or reaping grain crops such as millets, sorghum etc.

After cleaning the threshing floor as the first step of threshing (*Kola madeema*) the stem of a strong tree such as Mee (*Madhuca longifolia*) or Kumbuk (*Terminalia arjuna*) is fixed at the center of the threshing floor (*kamatha*). This stem is usually known as *Vee Gaha* and six buffaloes are made to rotate around it during threshing/*kola madeema*.

The *Kulla* or winnowing basket is mostly used in the household as well as in agriculture in rural areas of Sri Lanka. In the households *kulla* is used to separate chaff from rice. In the *kamatha* it is used to remove chaff from the paddy seeds.

Unsophisticated tools are used by farmers in traditional agriculture. There are various types of tools used in threshing floor such as *Ukunu Detta* (Pitch fork) to remove paddy stems, *Katumana atta* to heap paddy seeds on to the sides of the *Kamatha* and broom*/Bolatta* to remove straw from the threshing floor. Flail*/Deti-goyiya* is commonly used in threshing floor. Within a short time, the unthreshed paddy on the borders of the threshing-floor is tossed onto the center heap with the *deti-goyiya* and the straw *(cata-kedu-meduvan)* thrown outside the *kamatha.* In the threshing floor various types of measuring equipment are used by traditional farmers. '*Karthuwa', 'Laha'* and '*Kuruniya'* were used in the past to measure the threshed paddy/*Betha*.

4.4.11 Harvesting and Post-Harvest Methods

Table 4.16: Decision on Harvesting Time

Indigenous Practice	Area
After 90% maturing of panicle stage, harvesting is done	Major irrigated
Harvesting is not practiced in full moon days.	Major irrigated
Harvesting is done at new moon days.	Major irrigated
When touching panicle, if the last seed is removed easily then suitable for harvesting.	Rain-fed
Seeds are matured near to full moon day.	Rain-fed
Before pod is fallen down harvesting is done.	Rain-fed

Source: Authors' own compilation based on field survey (2017)

Farmers traditionally know by their experience when the crop is ready for harvesting. Majority of the farmers in study area decide the harvesting time according to the age of rice varieties while the farmers in Badulla District indicate that they have decided the harvesting time based on the colour of the panicle. Further, they have mentioned that if the paddy panicle can be seen in golden colour the paddy field is ready for harvesting. However, in ancient times the harvesting time was decided after having a discussion with *Vel Vidane*. The farmers who have cultivated under minor irrigated and rain-fed systems in Anuradhapura District also practiced this indigenous practice in the past. Further, according to the study findings it was revealed that all farmers in entire paddy tract (*vel yaya*) initiated cultivation at the same time then they discussed and decided the dates of harvesting. For instance, the farmers in Moneragala District reported that this practice was mostly practiced in the past. However, in present day also these indigenous methods exist in some rural areas in Sri Lanka.

Majority of the farmers decide the harvesting time by avoiding rainy season. The farmers in irrigated and rain-fed areas mentioned that they have conducted harvesting during the dry period with an expectation of giving most suitable storage time for their harvest. For instance, the farmers in study area reported that the harvesting is mostly done in February in the *Maha* season while in the *Yala* season the harvesting is done in August or early September. Moreover, the farmers in Kalutara District reported that the harvesting is done before the 15th of August at *Yala* season and harvesting is done in February at *Maha* season. The past literature also proved that the harvesting is done during the February to March (dry period). As noted by Irangani and Shiratake, (2013) the harvest have most suitable storage time when the panicle initiation occurred during waning half of the Lunar month and harvesting is done during dry period. Similarly, the farmers in major irrigated areas reported that the harvesting is not practiced in full moon days and the harvesting is practiced in new moon day.

Further, they have mentioned that if harvesting is practiced in full moon day weight of the harvest will be high and storage time will be reduced due to the high moisture content in the surrounding environment.

4.4.11.1 Harvesting

Majority of the farmers reported that the harvesting is done at an auspicious time and specific days. For an example the farmers in minor irrigated and rain-fed areas reported that the harvesting is done on Wednesdays, Thursdays or Sundays. The past literature also provided the significant evidences on the use of astrology in harvesting. As noted by Endegama (1998), traditional farmers reap corn on good days at specific *nekaths* like *Kethi, Ada, Pusha, Sa, Denata, Puwaputupa, Anura, Ma* and *Siyawasa*. Further, majority of the farmers in study areas reported that the harvesting is done using *Athulath Nekath*. Especially, the farmers in the Kurunegala District mentioned that before starting the harvesting an almsgiving (*Bandi poojawa*) was offered to the temple using specially harvested rice pods. By doing these indigenous practices farmers expect the protection for their harvest in the field.

Normally harvesting is carried out in the early morning as far as possible, before the sun is very hot and it is done with the sickle. According to the findings the farmers in rain-fed areas especially in Ratnapura District indicate that when kingfishers sound is heard in the early morning, farmers went to the paddy field with large shells, shaped like a flower-bud/*Hakbella* which is inserted with salt, turmeric and chili. Then it is placed on the paddy field and initiated the harvesting at an auspicious time. The farmers in Kalutara and Badulla Districts mentioned that bunch of harvested paddy hanged in the field for birds.

The farmers in major irrigated areas reported that the high involvement of women can be seen in harvesting while the farmers in minor irrigated and rain-fed areas reported that both male and female participate in harvesting. After harvesting was done harvest was kept in the farm yard before carrying to the threshing floor (*kamatha*). This was known as "*Watamalu Gasima*". Further, the findings revealed that the harvested paddy was carried to the threshing floor (*Goyam goda adeema*) was specially done by women in minor irrigated and rain-fed areas. As noted by Endagama (1998), the paddy was carried to the threshing floor by women, but the first sheaf must be carried by a man. However, in generally threshing activities were not done by women in all farming areas.

4.4.11.2 Threshing

The threshing activities are done at an auspicious time and good days. For instance, the farmers in minor irrigated and rain-fed areas reported that they have selected Tuesdays, Thursdays or Fridays to initiate threshing activities in their rice fields. Especially, the farmers in Anuradhapura District reported that Tuesdays and Fridays were known as paddy born days (*wee upan dawas*) and these days were suitable for threshing activities.

Traditional farmers dedicated their paddy crop to Lord Buddha since paddy was respectfully known as 'Buddhas' Crop (Buddha *Bogaya*) and the *kamatha* was a sacred place where the Buddhas' Crop was stored temporarily. Thus, indigenous farming rituals were very common in the threshing floor (*kamatha*) in the past. For an example, majority of the farmers in study areas reported that the ash treatment (*Aluhanwadeema*) was conducted to protect paddy from devils (*yaksayo*) after harvesting and expecting prosperity in the next seasons. In this ritual as the first, threshing floor was cleaned and arecanut pole was erected in the middle of the threshing floor. Then three circles and traditional equipment used in the paddy field were drawn using ash. This drawing in the threshing floor was known as *Yanthra*. At an auspicious time, the harvested paddy was bundled (*kola badeema*) and carried by the leader farmer. One or three bundles were taken by him and kept on his head and walked three times around the *kamatha* by chanting phrases as "*Sabba Papassa Akaranam*" which express religious values. In the end of chanting, leader farmer placed that bundle on a small circle around the arecanut pole. This was done by facing East direction. Then he crushed seed pods with his hands and worshiped to the paddy. Then the rest of the farmers also followed the leader farmer. Finally, as a result of this process harvested paddy being made into heap for threshing.

Further, before made the *yanthra* certain protective offerings were buried in the hole/*arakwala* in the threshing floor. Then the stone was placed on it and this stone was named as *arak mutta* or *arak gala*. For instance, the farmers in Badulla District mentioned that before made *yanthra*, they have dug a hole in *kamatha* and placed elephant jaw, *hakbella* and medicinal plants such as *Sawandara (Chrysopogon zizanioides)* and *Araththa (Alpinia calcarata)* on it while the farmers in Kurunegala, Pollonnaruwa and Badulla Districts reported that the *Arakwala* was made at the center of the *Kamatha*. A *Kohomba Lalla*, *Hiressa wela (Ciccus quadrangularis L.)*, *Tholambo leaf* (*Crinum asiaticum*) and *Hakbella* were placed in this "*Arakwala*". Past literature also provided the evidences on the use of similar types of indigenous methods. As stated by Endagama (1998) in the past, the farmers in Uva province have placed different planting materials in the hole

or *arakwala*. These planting materials were two stalks of *iluk*grass (*Imperata arundinacea*), two leaves of *tolambo* (*Crinum asiaticum*), seven *bo* leaves (*Ficus religiosa*), a piece of *rambuk* (*Saccharum arundinaceum*) stalk, a piece of the creeper *maduwela* (*Ipomoea obscura*) and five stalks of paddy with the ears. After conducting above mentioned rituals threshing and winnowing had taken place. Moreover, the findings revealed that, in the present majority of the farmers didn't conduct these indigenous methods in the threshing floor due to the use of modern agricultural equipment.

According to the findings, threshing (*kola madeema*) was conducted by using buffaloes in most areas while in some areas this was conducted by manually using bare foot. Threshing was done during morning or evening hours. In some areas this process was conducted at night as the afternoon sunset create the harsh conditions for the buffaloes work in the threshing floor. Threshing was done to separate paddy seeds from the panicle and threshing activities were carried out facing East or North direction. For this process as first the arecanut pole (*vee gaha*) was erected at the center of the *kamatha* then the trimmed rice pods were placed around it. Five or six buffaloes were made to rotate around it during threshing. The majority of the farmers mentioned that the buffaloes were carried to the clock wise direction in threshing floor while the farmers in Badulla District mentioned that the number of buffaloes are decided based on the size of the paddy heap (*Goyam kolaya*). Within a short time, the unrushed paddy on the borders of the threshing-floor was tossed onto the center heap with the *deti-goyiya.* This process was known as *wata kadanawa*. Then the straw *(cata-kedu-meduvan)* was thrown outside the *kamatha* and this process was known as *maduwan banawa*. When buffaloes were ready to defecate, a farmer hold a mat woven using paddy stems, underneath to collect the cow dung (*gompas*) in it. This was ensured that the cow dung did not mix with the paddy in the threshing floor. Finally, the separated paddy was collected to a large mat called the *magala* which was spread on the *kamatha*. This process was known as *rahi kirima*. The findings revealed that only men were in *athulath kamatha* and conducted threshing activities while women were not allowed to enter the *athulath kamatha*. When the threshing was completed winnowing taken place. *Mandaya* (the standing structure) was made at the *kamatha* to carryout winnowing*/ batha hulan kirima*. The threshed paddy was winnowed to remove debris and this process was known as *Batha pahima*. This was done by using winnowing basket (*kulla*). *Pita kamatha* was used for winnowing process and this was mostly done by women. Further, winnowed paddy was measured (*yallanawa*) by the owner in the threshing floor.

The farmers in rain-fed areas reported that the threshing was done by the men at night with moon light. The findings revealed that this method was conducted mostly in Ratnapura and Hambanthota Districts. According to the farmers, threshing floor (*kamatha*) was cleaned as first and *boalaththa* was used for remove straw and debris from the *kamatha*. For instance, the farmers in Hambanthota District reported that the mixture of burnt lemon, coconut milk and turmeric (*handun kiri pan*) was spread over the *kamatha* to clean the area. Before start the threshing activities farmers worshiped Lord Buddha and Gods with an expectation of protecting their harvest in the threshing floor. This was a common ritual in the threshing floor.

If threshing was done by manually (*minissungen paganawa*) *a katira* was erected. This construction consisted of four poles, placed so as to form two crutches, across which another pole *(pavara leeya or akleeya)* was laid horizontally, which was about chest height of the farmer. The farmers in Ratnapura District reported that the plants having latex/*kiri leeyak* such as Burulla (*Leea indica*), Godapara (*Dillenia retusa*), Rukaththana (*Alstonia scholaris*) or Kaduru (*Cerbera manghas*) was used for make threshing supporter when threshing was done using bare foot. Then the mats (*magal*) were spread on the threshing floor beneath the cross pole. The farmers in Ratnapura District reported that before threshing the sickle, *kaduru* leeyak, *Niyagala (Gloriosa superba) wela* and bunch of paddy were placed beneath the *magala*. Further, the farmers in rain-fed areas reported that the owner of the paddy field went to the field early in the morning and first threshing was done by him for three times (*pawara pagima*). Then six farmers were threshed the paddy under a *Pandalama.* When the entire paddy had been threshed the mats were taken up and covered the threshed paddy with straw to protect from rain. Finally, the threshed paddy was winnowed (*hulan karanawa*) and dried thoroughly before storage.

Moreover, the farmers in Hambanthota District mentioned that they have conducted the special custom in the threshing floor which was called as *goigate*. This was the tying of the cultivator's knot. A few stalks with the ears of corn attached were taken and tie a knot and buried it in the heap. Then threshed paddy was covered with straw. Further, *goigate* was left beneath the paddy heap until all the sheaves have been threshed, winnowed and measured. According to the farmers the main objective of this ceremony was to protect their harvest from devils in the threshing floor. According to the past literature similar type of indigenous methods were practiced in the past in Southern province (Endagama, 1998).

After threshing, traditional farmers made offerings from the first fruits of harvest to the Gods as well as to Buddhist priests. Majority of the farmers indicate that the first portion of the new harvest was offered to Gods and it

was named as *akkiyal*. Further, almsgiving to Buddhist priests (*agasdanaya*) was preceded and followed the New Rice Feast (*Aluth Sahal Mangalya*). For instance, the farmers in Kalutara District reported that the special milk rice was prepared from newly harvested paddy and it was offered to the God in the temple and also by keeping them in the paddy field in cones made out of banana leaves (*dangotuwa*). Farmers believed that the worshipping, God *Kataragama* was helped to protect the cultivation as well as the village. Further they have mentioned that the milk rice was prepared in the threshing floor and keeping them in the paddy field in traditionally prepared altars (*malpale*). This was done by farmers to pay gratitude to earth (*boomi devathawa*), sun and Gods.

4.4.11.3 Post-harvest Methods

Table 4.17: Post Harvest Methods

Indigenous Practice	Area
Harvest was stored in the " *veebissa*" at an auspicious time.	Major irrigated
Paddy was stored by using "*Ritimalla*": sack made from the "Riti plant" (*Lepurandra saccidora*).(Opening place of the sack was small)	Major irrigated
Burutha (*Chloroxylon swietenia*) leaves were used for prevent insect damages.	Minor irrigated
"*Batha waru*" were used to store paddy temporarily in the threshing floor. It was made by using hay.	Minor irrigated
In the past roofs of houses were covered by coconut fronds, Illuk (*Imperata cylindrica*) and clay tiles so it made good effect for harvest when it was placed in attic /*Atuwa*.	Rain-fed
First portion of threshed paddy was placed in the paddy box by pregnant mothers on "*Budha''* or *''Guru*" *Horawa.*	Rain-fed

Source: Authors' own compilation based on field survey (2017)

In ancient times traditional paddy farmers have practiced various post-harvest methods in their cultivation. These indigenous post-harvest methods have been developed and practiced over the years. According to traditional farmers' indigenous storage methods were designed to protect paddy seeds from rice pests, rodents, fungus and other microorganisms. The results revealed that the farmers in study areas have used various storage methods and applied some organic materials to protect seeds from rice pests. Majority of the farmers in the study area mentioned that the *Attic* or *Bissa* were used to store harvest in order to eliminate pest attacks.

The findings revealed that the harvest is dried well under the sunlight for two or three days before storing. The farmers in Moneragala and Badulla Districts

mentioned that the leaves of Kappetiya (*Crotalaria retusa*), Pinna (*Clerodendrum infortunatum*) and Kohomba/Neem (*Azardirachta indica*) plants are used for prevent the insect attacks while some of the farmers in Moneragala District mentioned that the leaves of the lime (*Citrus medica*) and *Karapincha*/curry leave (*Murraya koenigii*) trees are mixed with paddy in order to prevent insect damages. Further, the farmers in Kalutara District reported that the coconut mid rib (polpithi) and lemon leaves was burnt and those ashes mixed with paddy before storing.

The traditional farmers mentioned that the *vee bissa* was a special household granary or a bin for storing harvest. The structure of *vee bissa* was made using split bamboo panels (*Batapathuru*) and small poles. This structure was filled and covered with using the mixture of cow dung and clay. The roof of *bissa* was made using straw. According to the findings majority of the farmers reported that, before harvest was stored in the *bissa*, they have applied *Kohomba*/Neem (*Azardirachta indica*) leaves to protect the harvest from rice insects especially *ipio* (*Sitatroga cerealella* (*Olivier*)). Past literature has proved that the seed paddy could be stored for three or four years after adding *Kohomba* leaves (Helevetas, 2001). For instance, the findings revealed that the use of *vee bissa* still exists in rural areas of Kurunegala District.

The farmers in Hambanthota District reported that they have used the attic (*Atuwa*) to store seed paddy in the past. As mentioned by them the attic was the uppermost story in the traditional house and it was placed within the roof and the *dummessa*. Inside the attic, box was made using split bamboo panels and plastered using clay and cowdung mixture. Then the sun dried seed paddy was stored in this box by traditional farmers. Further, the farmers in Kurunegala District reported that the *atuwa* was used to store seed paddy in the past and the *atuwa* was made using wood and clay and they have mentioned that this *atuwa* was like a household granary. Seed paddy was stored in the *atuwa* after adding dried *Kohomba*/Neem (*Azardirachta indica*) leaves.

The farmers who have cultivated under minor irrigated and rain-fed areas in Ratnapura, Batticaloa, Kegalle and Matale Districts reported that the harvest was stored in a wooden box and this was known as paddy box/*vee pettiya*. In this method the paddy box was kept in the dry place to ensure that it did not get wet.

Moreover, the farmers in Ratnapura District reported that the *dummessa* was used to store seed paddy in the past. As mentioned by farmers the *dummessa* was a platform made between the roof and fire place in the traditional kitchen and the smoke of the fire place passed through the *dummessa*. Further, they have mentioned that the sun dried seed paddy was

filled in gunny bags and stored on *dummessa*. Even though there were various storage methods, in the present most of the farmers stored seed paddy in the gunny bags.

There is a vast amount of IK still exist with the paddy farmers in all climatic zones irrespective of the irrigation variation. However, the practice of those methods are limited due to various constrains and farmer perception on IK. The proceeding chapter: Chapter 5 provides the insight to those limitations and the economic valuation on traditional paddy cultivation.

CHAPTER FIVE

Indigenous Knowledge Status in Sri Lankan Paddy Cultivation

This chapter presents the barriers and constraints related to IK practices, cost structure and the economic valuation of the traditional paddy cultivation.

5.1 Barriers and Constraints Related to Indigenous Knowledge (IK) Practices

According to the survey 28 per cent of the respondents have issues related to agricultural inputs and inherent characteristics of traditional rice varieties. Comparatively low yield per land area, and long age of traditional rice varieties are the major drawbacks observed by traditional rice farmers, which needs to be addressed through research and development. The input related problems include lack of good quality seeds when needed, lack of labour, lack of knowledge among young generation on traditional methods of farming, difficulties in finding animal power to perform traditional practices such as ploughing by buffaloes, very few farmers engaging in traditional paddy cultivation since it is difficult to perform some traditional paddy farming activities such as *yaya* (paddy tract) cultivation and no or lack of plant based materials that are used in traditional cultivating methods.

The distribution of water for agricultural and the other purposes such as power generation and drinking, is the responsibility of the Irrigation Department and other relevant government institutions. However, it has been observed that the water distribution does not suffice the agricultural water requirements mainly because water distributing plans are made without consulting the farmer organizations. Since, the water management techniques used to control weeds are not effectively performed in most of the areas surveyed due to lack of water when needed for the operations, the farmers have to resort for intensive use of weedicides. The other institutional related problems are; traditional farmers who cultivating in large scale not getting the benefit of fertilizer subsidy, lack of infrastructure development such as irrigation channels, clearing etc., and lack of storage facilities for storing the harvest. The other perceived constraints are climate change and lack of recognition for farmers.

5.2 Economic Impact of Indigenous Knowledge (IK) Practices in Paddy Cultivation

The field data collected from 03.09.2017 to 26.12.2017 during this study were used for calculating the cost of cultivation for paddy using IK practices in the *Maha* season. The general cost of cultivation for paddy was obtained from Cost of Cultivation of Agricultural Crops 2015-16 *Maha* published by Department of Agriculture, 2017. The survey data indicates that 76.7 per cent of the farmers who engage in paddy cultivation by using IK practices use new improved varieties for cultivation and only 20 per cent use traditional rice varieties. Majority (83.3%) of the farmers who use IK practices cultivate in the *Maha* season while only 16.7 per cent cultivate in the *Yala* season. Amongst all 70 per cent of the farmers engage in rice cultivation under rain-fed conditions.

5.2.1 Cost Structure

In the present analysis the total cost was divided into three main components, namely labour, machinery and inputs. The percent share of labor cost in total cost for paddy cultivation using IK accounted for 66.7 per cent while all island paddy cultivation labour cost share in total cost accounted for 46.7 per cent. The labour cost difference between traditional paddy cultivation and the general paddy cultivation is LKR 4,346.00. When calculating the input cost, it was considered that the paddy cultivation using IK have an insignificant use of inorganic pesticides and weedicides. Majority (93.00%) of the farmers stated that there was no cost for weedicide application and 86.7 per cent stated the same for pesticide application. Therefore, the input cost for paddy cultivation using IK included only the costs for seed and fertilizer.

Table 5.1: Cost of Cultivation per Acre (LKR/acre) in IK based Paddy Cultivation vs. General Paddy Cultivation under Rain-fed Conditions in the Entire Country

Description	Labour	Machinery	Input	Total
General land preparation	4,742.00 2,076.00*	-	-	4,742.00 2,076.00*
1st 2nd and 3rd plough with 4wt	300.00*	5,242.00*	-	5,542.00*
(1st 2nd and 3rd plough with 2wt)	-	(7706.00)*	-	-
1st 2nd and 3rd plough	3,715.00	-	-	3715.00
Plastering bunds	4,308.00*	-	-	4,308.00*
Levelling and broadcasting	2,829.00 2,604.00*	-	4,704.00 3,520.00*	7,533.00 6,124.00*
Fertilizer application	1,429.00 4,800.00*	-	513.87 833.00*	1942.87 5633.00*
Weed control	576.00 720.00*	-	- 1,877.00*	576.00 2,597.00*
Pest and disease control	487.00 670.00*	-	- 1,677.00*	487.00 2,347.00*
Water management	506.00	-	-	506.00
Harvesting and processing	1,320.00*	5,546.00*	-	6,866.00*
(manually)	4,367.00 12,960.00*	-	-	4,367.00
(Threshing and winnowing with engine powered paddy thresher)	2280.00*	(3533.00)*	-	-
Threshing and winnowing	2,025.00	-	-	2,025.00
Total including imputed cost	20,952.00 16,606.00*	- 10,788.00*	10,435.74 7,907.00*	31,387.74 35,493.00*
Total excluding imputed cost	10,143.00 10,822.00*	- 10,242.00*	10435.74 7,200.00*	20,578.74 28,234.00*

Note: * general paddy cultivation: cost
Source: Authors own calculation and cost of cultivation of agricultural crops 2015/16 Maha, Department of agriculture (2017)

5.2.2 Quantity and Price of Inputs

Total man days used in paddy cultivation using IK practices was observed as 18/acre whereas it is estimated as 14/acre in general paddy cultivation. The

percentage use of hired labour and family labour is 50 per cent in paddy cultivation using IK. The man days used in paddy cultivation using IK practices were comparatively high as the IK practices are more labour intensive. According to Table 5.2 the total fertilizer use was 119.00 Kg in general paddy cultivation in rain-fed areas and it was 73.41.00 Kg for paddy cultivation using IK practices. The seed cost of paddy cultivation using IK practices is comparatively high (the LKR 98.00) and the requirement is 48 Kg/acre.

Table 5.2: Quantity and Price of Inputs in IK based Paddy Cultivation vs. General Paddy Cultivation under Rain-fed Conditions in the Entire Country

Description	Unit	Quantity	Unit price (LKR)
SEED			
Seed	Kg	48.00	98.00
		55.00*	64.00
LABOUR			
Hired	md	9.00	1,191.00*
		9.00*	
Family	md	9.00	
		05.00*	
Total	md	18.00	
		14.00*	
FERTILIZER			
TSP/Urea/MOP	Kg	73.41	7*
		119.00*	

Note: *general paddy cultivation: cost.
Source: Authors own calculation and cost of cultivation of agricultural crops 2015/16 Maha, Department of agriculture (2017)

5.2.3 Yield and Returns

Table 5.3 shows the yield and return estimations for the paddy cultivation using IK practices and general paddy cultivation. According to the estimation the average yield of the traditional rice varieties is comparatively low when compared to the new improved rice varieties.

Table 5.3: Yield and Return in IK based Paddy Cultivation vs. General Paddy Cultivation under Rain-fed Conditions in the Entire Country

Yield & Returns	Per ac	Per Ha
Average Yield(Kg)	1,177.46	2,908.33
	1,320.00*	3,262.00*
Price of produce (LKR/Kg)	124.00	-
	32.90*	-
Gross income(LKR)	146,005.04	360,632.45
	43,428.00*	107,311.00*
Profit including imputed cost (LKR)	114,617.30	283,104.73
	7,935.00*	19,607.00*
Profit excluding imputed cost (LKR)	125,427.04	309,804.78
	15,164.00*	37,471.00*
Unit cost (including imputed cost LKR./Kg)	26.65	-
	26.89*	
Unit cost (excluding imputed cost LKR./Kg)	17.46	-
	21.41*	

Note: * general paddy cultivation: cost

Source: Authors own calculation and cost of cultivation of agricultural crops 2015/16 Maha, Department of agriculture (2017)

However, the farm gate price of the traditional rice varieties is four-fold high when compared to new improved rice varieties. This high price at the farm gate have significantly contributed to high returns for the traditional paddy farmers. The estimates revealed that the paddy cultivation using IK practices have an economic value of 110,263.04 LKR when compared to the general paddy cultivation. The main contributor for this comparatively high economic value is the price gain at the farm gate. This is due to the high market demand and comparatively low supply of traditional rice varieties in the open market.

CHAPTER SIX

Conclusion and Recommendations

6.1 Conclusion

The present study mainly focused on identifying the importance of indigenous techniques in paddy cultivation and it was revealed that farmers engage in indigenous practices in all stages of paddy cultivation. The traditional farmers determine the suitable time for land preparation by rainfall patterns, astrology and their farming experiences. The rainfall patterns are predicted using various indicators such as tree phenology, animal behaviour, wind circulation, cloud patterns and other social indicators, which differ from region to region.

Further, there is a growing interest to use traditional pest management practices in paddy cultivation. The use of land preparation techniques and water management techniques are very common practices in weed management. The ingredients used in indigenous pest and disease control methods mainly consists of locally available resources and botanicals which are environmental friendly. Hence, these indigenous practices provide a sustainable alternative to rice cultivation. However, the water distribution mechanism currently controlled by the state in major and minor irrigated areas does not suffice the agricultural water requirements of traditional rice cultivation. It is also noted that the officials responsible for water distribution do not consult farmer organizations when water distribution plans are made. Thus the water management for weed controlling has not been practiced in most of the areas surveyed.

IK practices still exist in some rural communities in Sri Lanka. The adaptation to these techniques by new generation is low despite the significantly low cost with IK practices. The main reasons for this low adaptation rate are the comparatively less yield per land area in traditional rice varieties, long age of traditional rice varieties, inadequate supply of good quality seeds when needed, high labour requirement, limited knowledge among young generation on traditional rice farming practices, difficulties in finding animal power and plant based materials that are used in traditional rice farming practices. Therefore, research and development on traditional rice varieties and effective knowledge dissemination on traditional paddy cultivation methods is essential for popularizing traditional rice cultivation techniques. According to the economic estimation the per cent share of labour cost in total cost for paddy cultivation using IK accounted for 66.7 per cent. Paddy

cultivation using IK have an insignificant requirement for inorganic pesticides and weedicide as inputs. However, the average yield of traditional rice varieties is comparatively low but the farm gate price is four-fold high when compared to the new improved rice varieties. The economic value estimation revealed that the paddy cultivation using IK practices have an economic value of LKR 110,263.04. The main contributor for this comparatively high economic value is the price gain at farm gate. This is due to the high market demand and comparatively low supply of traditional rice varieties in the open market.

6.2 Recommendations

- Research and Development (R&D) for popularizing IK in order to establish a sustainable method of paddy cultivation.
- Regulate water distribution mechanisms in state controlled major and minor irrigated systems as a means of promoting traditional rice cultivation.
- IK is a precious gift of knowledge that has evolved through accumulation of knowledge over generations. However, these IK practices still existing in some rural communities in Sri Lanka has a low level of adaptation by new generations. Therefore, further research on IK practices and dissemination of such through R&D recommended as a necessity for developing a sustainable rice cultivating tradition in the country.

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ANNEXES

Appendix 1: Traditional Paddy Varieties

Paddy Varieties	Age (months)	Cultivation Season
Hondarawalu	4-5	Maha
Ma wee	5-6	Maha
Kuru ma wee	5-6	Maha
Baala ma wee	5-6	Maha
Kaluheenati	3-3 ½	Yala
Suduheenati	3 ½	Yala
Rathuheenati	3-3 ½	Yala
Suwadal	3 ½	Yala
Pachchaperumal	3-3 ½	Yala
Murungakayan	3 ½ - 4	Yala
Kuruluthuda	3	Yala
Polayal	3	Yala
Ilankaayan	3 ½	Yala
Dik wee	3 ½ - 4	Yala
Suwadha Samba	3	Yala
Rath mada al	3 ½	Yala
Mada al	3 ½	Yala
Danahalaa	3 ½	Yala
Kalukada	3 ½	Yala
Hatada wee	3	Yala
Madathawalu	3 ½	Yala
Suduru samba	3	Yala
Gonabaru	3 ½ -4	Yala

GLOSSARY

Agasdanaya	Almsgiving to Buddhist priests
Ak wessa	The rain which is usually received at the end of September after the long drought called *Nikini* Drought (*Nikini idoraya*)
Akkiyal	First portion of the new harvest was offered to Gods
Alu Saaththuwa	Broadcasting of wood ash to the paddy field
Aluth Sahal Mangalya	New Rice Feast
Arak mutta or *arak gala*	The stone was placed on the arakwala
Arakwala	The hole in the threshing floor and different planting materials were placed in that hole
Atuwa	Attic is used to store paddy and it was placed within the roof and the *dummessa*
Baalawee	Short age rice varieties
Batha pahima	The process of removing debris by winnowing
Batha waru	It was used to store paddy temporally in the threshing floor and made by using hay
Binora Maha Konaya	The time period between September 15th to October 15th
Buddha *Bogaya*	Buddha's Crop
Dangotuwa	Cones made out of banana leaves containing rice for spirit
Dangotuwa	Cones made out of banana leaves containing rice for spirit
Deheeya	Second ploughing
Deti-goyiya	Flail
Dummessa	Platform made between the roof and fire place in the traditional kitchen
Eswaha katawaha	Evil eye and evil mouth
Garawa Kiranawa	The process which is done to remove the debris from seed paddy
Goigate gaseema	The special custom in the threshing floor
Govi lalla	Is a large board with wooden stick, that stick is attached to the center of the board
Hisa thel gema ritual	Ritual of Hair oiling
Hulan karanawa	Winnowing the threshed paddy
Isnambadinawa	At three days after sowing water is admitted to a certain height
Kalyal balaa govithena	Cultivation at right season, right time
Kamatha	Threshing floor

Kanna	Season
Kanu kapenawa	The stage of seeds begin to germinate
Karthuwa, Laha , *Busal* and *Kuruni*	Traditional measures
Kata kadanawa	Germinated paddy seeds which adhere together are finally separated from each other by gently rubbing between the palms
Kekulam govithena	Dry sowing of paddy seeds early in the season
Kem	Kind of practice, ritual, technique or custom that is followed in order to obtain some favourable effect from a problem
Keta paganava	The paddy fields were trampled by men to crush the larger clods
Kevita	Stalk
Kinihira	Umbrella shape
Kola madeema	Threshing
Kulla	Winnowing basket
Maha	Big, also refers to a cultivation season with high rainfall
Maha wesi	North East Monsoon rains
Magala	Large mat
Malpale	Traditionally prepared altars
Mandaya	The standing structure
Manthra	Magical Chant
Maluwa	Seed paddy bed
Mul awilla	In seed sowing time paddy is stored in a container called as *mul awilla*
Mul kaluwara	The time period after new moon day and prior to full moon day
Nagula	Plough
Nawatha wakkada	Upper water inlet
Niyara	Ridge
Palamu heeya	First ploughing
Pandama	Torches
Puja	Expressions of honour, worship and devotional attention to God
Raahu kaalaya	Inauspicious time
Rahi karanawa	Collect paddy into the heap
Salaris	It was given by the farmers to *Vel vidane* for appreciate his work and that was corresponding to half a bushel of paddy per acre

Sivuru	Monk robes
Udalla	Mammoty
Ukunu Detta	Pitch fork
Vee bissa	A special household granary or a bin for storing harvest
Vee upan dawas	Paddy born days
Vel Vidane	Irrigation Headman
Vel yaya	Paddy tract
Wakkadawal	A point at which water enters a paddy field
Wanath kapeema	Land clearing
Wap	October month
Yaksayo	Devils
Yala	Season with reduced or low rainfall
Yallanawa	The process of measuring the winnowed paddy by the owner in the threshing floor
Yanthra	Magical drawing