Indigenous techniques used in rice cultivation in Sri Lanka: An analysis from an agricultural history perspective

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This study attempted to identify indigenous techniques in rice farming with the aim of understanding the sustainable principles of these techniques that can be adopted to overcome the problems in modern agriculture. The data for the analysis were obtained through interviews with farmers and key informants, focus group discussions, and field observations carried out in a historically important rice-growing area, the Padaviya Irrigation System area, from June to October 2012. The survey of farmers covered 60 farmers scattered throughout the area. The farmers were selected by employing purposive sampling method in order to capture the farmers, who have experience with indigenous techniques. The results indicated that the indigenous techniques in rice farming corresponded to the natural features of the region, including the rainfall patterns, soil conditions, temperature, and humidity. The techniques are entirely dependent on local resources, which are recognized based on the historical experiences of the local population. Cultivation based on rainfall patterns and the lunar calendar and adopted techniques in soil fertility management, seed selection, seed treatment, water management, and pest and disease control techniques provide highly sustainable methods as alternatives to the modern high external input-based techniques. Indeed, decision making based on rainfall patterns and the lunar calendar avoids possible risk in rice farming. These techniques are not harmful to the environment and thus can maintain the long-term production sustainability of rice farming. This study indicates the importance of taking into account the historical experience and knowledge of the local population in the revitalization of the rice sector in Sri Lanka.

Keywords: Agricultural history, Indigenous techniques, Green Revolution, Rice cultivation, Padaviya Irrigation System, Sri Lanka

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Sri Lanka is well known for its hydraulic civilization beginning from the 3rd century BC. For two thousand years, this civilization was based on rice cultivation, which began in 900 BC and has developed in an organized way since 300 BC. The literature in agricultural history extensively explains applied technology in ancient agriculture, particularly irrigation technology, from micro- and macro-perspectives. However, one important contribution of the hydraulic civilization of the country, which is largely neglected in the agricultural history literature, is the wisdom of the indigenous techniques applied in rice cultivation for thousand years. Specifically, until the introduction of the technology package (modern techniques) of the Green Revolution in the mid 1960s, rice grown in Sri Lanka was entirely based on indigenous techniques, which were developed based on the extensive experience and knowledge of local people and tested over thousand years of implementation. Furthermore, these techniques possess scientific rational in terms of agricultural sustainability.

As emphasized in contemporary agricultural history, indigenous techniques in rice cultivation have been replaced by modern techniques introduced in the mid 1960s due to the influence of the Green Revolution, which brought about fundamental changes of the country’s rice sector. The modern techniques comprised modern varieties (high yielding varieties (HYVs)), in association with inorganic fertilizers and other agro-chemicals with pre-scheduled irrigation and new methods of farming. According to history of agriculture, Sri Lanka started improving seeds by using the indigenous rice varieties since 1940s. However, key elements of technology package of the Green Revolution were first introduced
to Sri Lanka in mid 1960s in line with release of a new rice variety—IR8 from the International Rice Research Institute (IRRI)\textsuperscript{5,13,14}. Specifically, the major initiative of technology package of the Green Revolution in Sri Lanka was started with “Food Drive” program of 1967\textsuperscript{13}. According to contemporary agricultural history in the 20\textsuperscript{th} century, the main argument for this technological transformation was the predicted food crisis in the developing countries due to the projected rapidly increasing population.

It is evident that modern techniques undeniably doubled the rice production of the country. However, forty years after the Green Revolution, there was a contentious discussion in the academic literature regarding the adverse effects of neglecting indigenous techniques in technological transformation. Specifically, these studies have cited health, environment, and farm management problems, in addition to problems of the disappearance of indigenous rice varieties (heterogeneous rice varieties), associated with modern technology\textsuperscript{2,9,14,23,28,29}. The cultivation area of indigenous rice varieties declined drastically due to the influence of modern techniques, and, today, indigenous rice accounts for approximately 2\% of the total rice cultivation area of the country. Moreover, the farmers had grown approximately 2,000 indigenous rice varieties by 1950s and there were only less than 100 varieties cultivating by the farmers in 1990s\textsuperscript{22}.

Today, the agricultural and human values of indigenous techniques are increasingly acknowledged worldwide for having enormous potential to contribute to sustainable agricultural production. Many studies have cited that indigenous techniques in agriculture are productive, sustainable, ecologically sound, and turned to the social, economic, and cultural features of farmers\textsuperscript{1,25}. These techniques are the main social assets of the agrarian societies\textsuperscript{24}. However, although indigenous techniques in rice cultivation are an important contribution and micro-aspect of hydraulic civilization of the Sri Lanka, the paucity of empirical research on the indigenous techniques of rice farming has created a knowledge gap, making it difficult to track the problems in the modern rice sector originating from the Green Revolution. Considering the importance of identifying sustainable agricultural and natural resource management techniques undertaken by indigenous rice farmers in Sri Lanka, the present study was undertaken with following two specific objectives.

(i) To identify and document the indigenous knowledge of local farmers with regard to rice farming techniques
(ii) To understand their relevance in tackling the problems facing the farm worker culture in Sri Lanka.

**Methodology**

**Selection of the study area**

The study was conducted in a historically important rice growing area, Padaviya Irrigation System area, in Sri Lanka. The area is located in Anuradhapura district in North Central Province (Fig. 1), which is the dry zone of the country. The irrigation system is centered on the Padaviya reservoir, which was built by King Moggallana in the 6\textsuperscript{th} century AD\textsuperscript{21} with the aim of storing rain from the North-East Monsoon. The reservoir has a gross water capacity of 85,000 acre feet and is the second largest reservoir in the Anuradhapura district. The study area experiences a climatic condition similar to other areas in the dry zone of the country. The annual mean rainfall in the area is 1,270 mm and 60\% of annual rainfall occurs from October to January (Maha season). The average annual temperature is 27°C. At present, 6,206 families are living in the area and their

![Fig. 1—Location map of the study area](image-url)
main economic activity is agriculture. The main crop grown in the area is rice and today, 17,000 acres are cultivated. According to recent survey of Department of Census and Statistics, 34% of total population in the area is poor.

In the 1950s, the area was rehabilitated under a government colonization scheme, and approximately 3,000 farmers in the Anuradhapura district currently practice indigenous techniques in rice farming at different scales. The density of the indigenous rice farmers in the Padaviya area is relatively higher than that of other areas of the district because there are 10 well-organized indigenous rice farmer organizations in the area. These farmer organizations have been mobilized by a local organization named the “Movement for the Protection of Indigenous Seeds (MPIS)”. This local organization was established by farmers and activists in the 1970s when the destructive effects of the Green Revolution introduced in the 1960s became clear and widespread. Moreover, the majority of the farmers in the area are farmers who settled in the 1950s. As these farmers have knowledge about indigenous and modern techniques in rice farming, this region is a good choice of a study area for this research.

Data sources
The study mainly involved primary data collected using different methods, such as interviews with farmers and key informants, focus group discussion, and field observations. The focused farmer group included those farmers experienced in rice farming since the 1950s. This criterion was adopted for the data collection as this group represents the last generation of rice farmers who have experience with indigenous techniques, and these farmers can easily understand the relevance of indigenous techniques in tackling the modern problems in the rice-production sector. The survey also covered historical evidence of the indigenous techniques, including diary records, ancient equipment, photos of indigenous techniques, and records in palm leaf books. The farmer survey covered 60 farmers scattered throughout the area. Since this is more qualitative study, the farmers were selected by employing purposive sampling method in order to capture the farmers, who have experience with indigenous techniques. 

Results and discussion
Indigenous rice farming techniques applied by the farmers in the survey area

Land preparation and soil fertility management techniques—before planting
The indigenous farmers determine the appropriate time for land preparation based on the rainfall pattern in the area and the lunar calendar using such auspicious times as Nekath, Karna, Hora, and Yoga (Tables 1 & 2).

The farmers generally begin their land preparation activities with Ak rain (Ak wessa), which is usually received at end of September after the long drought called Nikini drought (Nikini idoraya, usually beginning in early July). First, the farmers cut the field to incorporate the debris into paddy field; this debris gradually decomposes and provides nutrients to the soil. The first plowing is performed with the Ak rain after which the farmers wait for two weeks to plow a second time. The expectation of this interval is to provide adequate time for the seeds of weeds to sprout in the rice field. The farmers reported that the two-week waiting period should be during the waning half of the lunar calendar (Table 1). It is called “commencement of the field preparation after new moon day” (Amavakata pasu weda allima). The reason for the selection of the moon waning period is that the farmers traditionally know that the soil organisms, which are very favorable to crops and contribute to improving soil fertility, area active during the waning
Table 1—Relationship of indigenous techniques with the lunar calendar

<table>
<thead>
<tr>
<th>Position</th>
<th>Period of lunar month</th>
<th>Applicable techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waxing crescent moon</td>
<td>Continuing field preparation</td>
<td></td>
</tr>
<tr>
<td>First quarter of half moon</td>
<td>Weed sprouting period after the first plowing</td>
<td></td>
</tr>
<tr>
<td>Waxing gibbous moon</td>
<td>Continuing field preparation and seed germination activities</td>
<td></td>
</tr>
<tr>
<td>Full moon</td>
<td>Seed sprouting and plant growth</td>
<td></td>
</tr>
<tr>
<td>Waning gibbous moon</td>
<td>Beginning field preparation,</td>
<td></td>
</tr>
<tr>
<td>Last quarter of half moon</td>
<td>Watering, fertilizing, controlling pests and weeds, tillering, pruning, and harvesting</td>
<td></td>
</tr>
<tr>
<td>Waning crescent moon</td>
<td>Controlling pest and weeds, Pruning and harvesting</td>
<td></td>
</tr>
<tr>
<td>New moon</td>
<td>Not practicing any field work on New moon day</td>
<td></td>
</tr>
</tbody>
</table>

Source: Field survey, 2012

Table 2—Relationship of indigenous techniques with the rainfall pattern in the area

<table>
<thead>
<tr>
<th>Climatic pattern</th>
<th>Period</th>
<th>Related activities and stage of rice cultivation</th>
</tr>
</thead>
</table>
| Nikini drought (Nlikini idoraya)  | July to the end of October      | • Release cattle into the harvested rice field  
• Mid-season cropping practices  
• Commencement of primary land preparation  
• First plowing (Palamu heeya)  
• Second plowing (Deveni heeya)  
Applying re-cycled straw, cattle manure, and nitrogen-rich green manure, such as Makulata [Gliricidia sepium (Jacq.) Walp.], Karanda (Carissa carandas L.) leaves, Walsuriya (Helianthus annuus L.), Girapala (Commelina diffusa Burm.f.), and Kappetiya (Crotalaria retusa L.  
• A third plowing is performed at one week after the second plowing  
• Immersion of citron family fruits in the mud  
• Sowing  
• Homemade nitrogen liquid is applied to the field at one week after sowing  
• Water management for weed control  
• Trailing of a plantain trunk on the field for weeding and to facilitate for multiplying  
• Soil fertility improvement techniques (organic manure application, hormone treatments)  
• Weed, pest, and disease control using traditional techniques  
• Panicle initiation  
| Nikini paluwa or Wal ata wessa—a slight rain | Around the end of July to early August |                                                                                                           |
| Ak rain (AK wessa)—a slight rain      | End of September to early October |                                                                                                           |
| Transitional period (no rain)        | Early October to mid October     |                                                                                                           |
| North-East Monsoon rain (Maha wesi)  | Late October to late December    |                                                                                                           |
| Duruthu (low temperature or cool period) | January to February             |                                                                                                           |
| February to March (dry period)       |                                  |                                                                                                           |

Source: Field survey, 2012

period. In the second plowing, the farmers expect to eliminate all the weeds that sprouted and thus wait for a week before the last plowing (Theveni heeya or Poru heeya). Between the second and third plowings, the farmers apply cattle manure, re-cycled straw, and green manure, such as Makulata [Gliricidia sepium (Jacq.) Walp.], Karanda leaves (Pongamia pinnata (L.) Pierre), Wathupaliwel [Mikania scandens (L.) Wild.], and Walsuriya (Helianthus annuus L.), in to the rice field. According to the existing knowledge, these materials are related to improvements in the soil fertility condition of rice fields. Thus, techniques address one of main concerns of sustainable agriculture declining soil fertility. In addition, organic manure improves the soil structure and water retention capacity of the soil.
Specifically, cattle manure and other organic manure has been applied since ancient times in Sri Lanka and was first recorded in the 13th century AD. Thus, farmers traditionally know the locally available important plants that can be applied to improve soil fertility in rice fields.

For further soil fertility management, some techniques that involve the previous season are applied. The farmers reported two types of traditional approaches: intercropping and mid-season cropping system techniques and releasing cattle into the rice field. The technique of intercropping is applied by cultivating crops on the ridges or selected sites within the field. The technique of mid-season cropping involves the scattering of the seeds of pulses, legumes, and large seeded cereals a week prior to the rice harvest. The purpose of adopting these two cropping systems is to provide nutrients to the soil and to generate additional income and contribute to household food security during the lean period. The historical and archeological evidence shows that the farmers in the 4th century AD practiced mid-season (made hasa) cropping. In particular, the legumes plants improve the nitrogen condition of the soil and can grow under low moisture conditions. The indigenous farmers reported that there is a favorable ecological condition in the rice fields for such crops at the time of rice harvesting, thus the intercrops do not require additional resources. The farmers who do not practice mid-season cropping system release their cattle into the rice land or allow neighboring cattle farmers to release their cattle just after harvesting. The farmers indicated five purposes of adopting this technique: to provide the opportunity for the cattle to feed and breed; to provide required nutrients to the paddy fields from cattle urine and dung; to control the weeds; to improve the water-holding capacity of the soil due to the deep cattle foot marks in the field; and to improve the biodiversity. Previous studies have proved that cattle urine and dung provide essential nutrition to the soil. Additionally, the technique improves water-holding capacity. The farmers particularly noted that this technique increases the bird populations, including crane, mynah, crow, swift swallow, and common babbler, in rice-growing areas, resulting in an improved biodiversity condition in the fields.

**Seed selection and pre-planting techniques—including seed treatment**

The seed varieties are selected based on the prediction of the weather conditions in the next season and the water level in the reservoir. The natural rainfall patterns for next season are predicted by assessing environmental changes, which is performed by the community. Some of the facts considered in the assessment include the following: the behavior of certain birds, such as Wadu kurulla (Baya weaver), with regard to their nest building; abnormally high or low flowering and fruiting in certain trees, such as Divul (Limonia acidissima L.), Kone [Schlechteria oleosa (Lour.) Merr.], Weera [Drynques sepia (Wight & Arn.) Pax & K.Hoffm.], Mora (Dimocarpus longan Lour.), and Palu [Manilkara hexandra (Roxb.) Dubard]; wind speed and direction; the appearance of new leaves of certain trees, such as Mee [Madhuca longifolia (J.König ex L.) J.F.Macbr.]; lightening; and humidity in the air. For instance, if the farmers determined a possible drought in the cultivation season under consideration, they select short term rice varieties that are more tolerant to drought, such as Hatada vee, Heenati, Dahanala, Kokkali, Siwandel, Pachchaperumal, Kanni murunga, Kuru vee, Rathdel, and Rath tambiliya. Conversely, a possible flood or heavy rainy season is predicted, the farmers select long term rice varieties, such as Maha ma vee, Bata ma vee, Dik vee, Hata paduru vee, Madal, Deva raddari, Madatawalu, Murungakayam, Wella illangaliya, Hondaru walu, Gangala, Beru wel, Masuran, Sulai, and Handiran. Reliability of consideration of environmental indicators in predicting rainfall and weather conditions have been confirmed by many communities in the world, though those indicators vary from region to region. Moreover, there are some historical and archeological evidences that indigenous farmers had decided the rice variety considering different factors of the field including location—distance to the reservoir, soil type, etc. Local soil knowledge adaptation in rice variety selection for cultivation and crop yield enhancement has also been reported by some studies, particularly in India. Moreover, the farmers reported that the selection of rice varieties (either 4-month or 3-month rice varieties) is also determined based on the lunar calendar and natural rainfall patterns (Tables 1 & 2). The sowing period usually occurs before the onset of the North-East (NE) Monsoon (Maha wes) of the country. The farmers strongly believe that NE monsoon provides adequate nutrients to the paddy fields; therefore, they expect vigorous growth of the rice (Oryza sativa L.) plants with the monsoon.
In terms of the separation of viable seeds for germination, increasing the seed germination rate, and improving the resistance of the germinated seeds to possible diseases after the planting, the farmers apply several techniques and treatments using locally available resources. They traditionally know that selection of the strongest seeds is important for a high germination rate, for the maintenance of a healthy rice field, and to obtain a high yield. This indicates that indigenous techniques in rice variety selection could address main challenges of sustainable agriculture such as agrochemical usage in the rice field, and improve rice plant resistance to pest and diseases and drought conditions. The importance of these techniques for yield stability and other desired traits like tolerance to physiological and ecological stress and resistance to pest and diseases has also been cited in the literature.

The majority of the farmers reported using a pre-test method on a sample of seed to separate the viable seeds for germination. In addition, seeds are traditionally added to salt water, and the floating seeds are discarded. Some farmers apply salt-mixed water technique with follow of ‘egg method’, which facilitates the removal of both semi- and fully infertile seeds. The seeds selected for germination are immersed in water for 28 hrs.

Some farmers apply a mixture that is prepared by mixing raw dung from local cow and water to the separated viable seeds: 1 kg of indigenous raw cow dung with 1 bushel of seeds (1 bushel = 21 kg). This technique is applied to increase the seed germination rate. Next, the seeds are laid on a floor prepared with plantain [Musa × paradisiaca L.] or Habarala [Alocasia macrorrhizos (L.) G.Don.] leaves and covered with the same leaves for two nights for germination. The farmers reported that this technique helps to maintain the required temperature during seed germination.

Before sowing, the farmers practice some treatments on the germinated seeds. The intention of these treatments is to eliminate the adverse fungi that may later cause diseases, to increase disease resistance during the growth period, to increase the rice yield, and to reduce pest attacks during sprouting. Therefore, they minimize possible future risks by applying several techniques before sowing, and the farmers reported two treatment methods. First, some farmers spread a liquid on the germinated seeds, which is prepared by mixing indigenous cow milk and urine, using 1 L of indigenous cow milk with 0.5 L of indigenous urine for a bushel of germinated seeds. The farmers also reported that this treatment results helps to prevent the disease called “Angamaraya” (rice blight). Second, some farmers spread Ati kesel (Musa × paradisiaca L.) liquid on germinated seeds prior to sowing or nursing the germinated seeds.

**Water management techniques**

Water management techniques are also linked with an understanding of the particular agro-climatic conditions of the region, particularly the rainfall pattern, and the position of the lunar calendar (Tables 1 & 2). Although rice is known to be a high water-consuming crop, the indigenous farmers use water management techniques for several specific purposes in the rice field: to increase the sprouting rate of the sown seeds; to control weeds; to enhance the rice plant growth; and to control pests. For instance, 3 days after sowing, the first release of water (Snam themeema) to the field is performed in an effort to create a better environment for the sown seeds. Next, at 12 days after sowing, water is again released into the rice field to control weeds, with the water level being similar to the height of the rice plants during the first two days. Subsequently, the water level is reduced twice a day by approximately two inches. When water level reaches its minimum in the field, a plantain trunk is trailed to remove the rotten weeds and adjust the rice plants for necessary multiplying.

Moreover, determining the sowing period by taking into account the panicle initiation time in January also is associated with water management techniques. In Sri Lanka, the conditions during January are relatively cool, and the ensuing maturity period coincides with the dry period. The farmers use upper water inlet to diffuse some liquid prepared for rice plant growth, such as Jeevanmrutha diyara. The farmers reported that this liquid can also be applied with water management techniques during land preparation, two weeks after sowing and at panicle initiation. Pests are also controlled in the field by maintaining wet and dry environments using the water management techniques. The farmers are traditionally aware of the possible pest attacks at each stage of rice development. For instance, when farmers notice the pest Keedawa (Nilaparvata lugens) during the maturity period, they institute dry conditions in the field. In contrast, when they notice a worm problem in
the field at the early stage of rice growth, they supply more water into the field, forcing the worms to move out of the plants; the technique encourages worm consumption by birds.

**Date and method of rice planting**

The majority of the farmers reported that they generally use a sowing method. The sowing date is determined by accounting for the panicle initiation time and lunar calendar. In particular, the panicle initiation time would be the waning half of lunar month, January to February in terms of the Maha season (Table 1). Based on this technique, the farmers expect a high productivity by creating a favorable environment, particularly with regard to temperature, for pollination and reducing pest attacks and diseases. According to documented evidence in the literature, the local farmers believe that low temperature and high humidity caused for development of insect and pest\(^2\). The critical reason for basing the sowing date on the lunar calendar is to avoid panicle initiation during the dry months. The farmers also noted that the most suitable storage time for harvested rice was when panicle initiation occurred during a waning half of the lunar month; they also determined that Nekath and Karana were the most favorable times for sowing to ensure success and avoid damage from pests, diseases, and birds and other wildlife.

**Soil fertility management—after planting**

Soil fertility management during rice growing is also largely associated with local resources. The farmers reported that they prepare a liquid called Jeewanmrrutha diyara and apply it to the field to achieve vigorous plant growth. According to researchers at MPIS, the scientific rationale behind this technique is that the liquid mixture has specific characteristics for promoting beneficial bacteria in the root system of the plants. The technical procedure of the preparation of liquid per acre is as follows. First, 10 L of indigenous cow urine and 10 kg of raw cow dung are mixed together with 100 L of water. Second, properly mixed Kithul (Caryota urens L.) jaggery (2 kg) and 2 kg of cereal (legumes crop) powder, such as green gram, black gram, Undu, is mixed with the above mixture. Soil, which was collected from the ridge of the rice field, is then applied to above mixture. After preparing the mixture in the barrel, it is covered from a gunny sack and blended (Jaadi kireema) 3 times a day toward the right side using a wooden stick. The prepared mixture can be applied after 48 hrs, and the farmers reported that the mixture should be used within seven days. The farmers also reported that the prepared liquid can be applied during the period of land preparation, at two weeks after sowing, and at panicle initiation.

The farmers also apply charred rice husk, re-cycled rice straw, and cow dung to the field. The cultivation of legumes on the ridges or selected areas in the field is also adopted.

Moreover, the farmers reported two soil fertility improvement methods that were introduced by the local organizations. These methods can be considered a type of innovation of the indigenous technology. First, the farmers reported treatments for improving the nitrogen condition of the soil and breeding earthworms. According to key informant interviews, this technique is applied to restore soil conditions worsened due to the long term application of agrochemicals and improve the slow-worm population in the soil. The farmers strongly believe that a high density of slow-worms in the soil of rice fields is an essential condition for plant growth. The technical procedure of this technique is as follows. First, the farmers place selected materials into a barrel that has a tap at the bottom. Materials, such as chopped bricks, small sized gravel, loam, creamy raw cow dung, chaff, earthworms, and dry cow dung, should be arranged in the barrel as layers from the bottom up. As these materials should be kept wet, a watering can with small hole is suspended over the barrel to supply a continuous drip of water. Usually, the materials, such as cow dung, rice straw, and leaves, are removed for three days while adding new materials; the farmers thereby obtain a nitrogen-rich liquid from the tap at the bottom of the barrel. The farmers spray this liquid into the rice field by mixing one bottle of liquid with two bottles of water when the rice plants are 7 days old and at the panicle initiation period. The treatment should be performed in the evening.

Second, the farmers reported utilizing a growth treatment, which is prepared with five types of materials received from indigenous cows: cow dung, ghee (Elangithel), cow milk, cow urine, and curd. The treatment is prepared as follows. First, 5 kg of raw cow dung is mixed with 1 L of ghee and kept covered. After three days, 3 liters of cow milk and 4 L of cow urine are added to the above mixture, and it is kept covered. Two liters of curd are added after another
three days, and the mixture is kept covered for another three days. Finally, they open the mixture. After a total of 20 days, the mixture is applied to the field using an upper water inlet or by spraying. The farmers reported that they can expect vigorous plant growth and high yield by applying this hormone treatment three times prior to panicle initiation.

**Weed control techniques**

The farmers apply weed control methods at several steps. The first step is to apply land preparation techniques of appropriate time duration. For example, the farmers start to apply land a preparation technique with the Ak rain received after a long drought. After first plowing, they wait two weeks for the second plowing, allowing sufficient time for sprouting of all the weeds. Moreover, one of main expectations of plowing three times within roughly three to four weeks is to eliminate all types of weeds in the rice field. A study conducted in Madhya Pradesh, Central India also reports similar techniques in land preparation and water control in rice farming in order to eliminate weeds. After the second plowing, the farmers apply only materials free of weed seeds, such as cow dung and rice straw. The second step is to control the weeds that can spread with the rice seeds during sowing. For this purpose, the seeds of weeds are removed by such traditional techniques as winnowing fan or riddle (sieve) prior to rice seed germination. The third step is to apply water control techniques at the early stage of the rice plants. At three days after sowing, the first release of water (Snam theemeema) is undertaken, and the rice field is then allowed to dry. Thus, there is sufficient time for any remaining weeds to sprout between the first and second water release. As explained in the previous sections, the farmers apply weed control techniques with the second release of water when the rice plants are 12 days old. Some farmers reported that they apply salt to the field with the intention of weed control, and they cultivate legumes to control weeds in the ridges. In addition, the farmers manually remove the weeds, utilizing women for this labor.

**Pest and disease control techniques**

A unique feature of the farmers with regard to pest and disease control is that they are very aware of both pre- and post-control techniques. According to the surveyed farmers, they perform seed treatment at the seed germination stage with the intention of reducing pest and disease risk during rice growth. These techniques are explained under the section of seed selection and pre-planting techniques. Moreover, during the third plowing in the land preparation stage, the farmers immerse citrus fruits, such as Ambul dodam (Citrus aurantium L.), Sidaran (Citrus medica L.), and Heen naran (Citrus reticulata Blanco), in each plot of the field to prevent pest attacks in the early stage of rice growth. It is reported that the citrus peels have insect repellent properties (Table 3).

Most of the farmers who had experience with regard to both indigenous and modern rice farming techniques reported much fewer pest attacks in the indigenous rice fields compared to the modern rice fields. According to their knowledge, the main reasons for the reduction are the specific characteristics of the indigenous rice varieties, including a relatively smaller sugar content in the plant and the roughness of the rice stem and leaves. Some studies in India have also confirmed the specific characteristics of indigenous rice varieties such as tolerance against the insect infections and resistance against diseases.

However, the farmers are aware of many treatments for pest attacks that occur during the early growth stage. For example, to avoid such pest attacks as Kudiththa or Pala makka (aphids or planthoppers), Puruk Panawa (Tryporyza incertulas), Kola makka (leaf hoppers), Kanda massa (Atherigona oryzae), and Gok massa (Orseolia oryzae), the farmers spray a liquid to the rice field prepared using tobacco stalks. They prepare this liquid (per acre) by immersing 3 kg of tobacco stalks in a water barrel for three weeks; this liquid is mixed with water at a rate of 1:5 and then sprayed onto the rice field. The farmers also minimize worm attacks by sprinkling wood ash on dewy rice plants at dawn, a technique that has much success because the treatment prevents a favorable environment for worms and insects on the plants. The studies have reported that wood ash acts as a detergent and thus chewing and sucking type of insects, find it difficult to chew plant parts due to deposition of ash.

Moreover, the farmers reported that they use spiritual powers, such as the water of chanted piritth (Pirith pan) to eliminate pest attacks. Some of them offer foods to the gods, particularly milk rice and oil cake and sweet-smelling fruits with a ghee lamp in the center of the rice field in the morning, with the aim of receiving relief from pest and disease attacks.
Table 3—Types of local plants used in pest and disease control in rice farming and their method of use

<table>
<thead>
<tr>
<th>Local name</th>
<th>Scientific name</th>
<th>Related pest and diseases</th>
<th>Method of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ati Kesel</td>
<td>Musa × paradisiaca L.</td>
<td>Bacterial infectious diseases, rice blight</td>
<td>Blended Ati Kehel liquid mixture with germinated seeds.</td>
</tr>
<tr>
<td>Kala wel</td>
<td>Diospyros affinis Thwaites</td>
<td>Gok massa (Orseolia oryzae) and Kanda massa (Atherigona oryzae)</td>
<td>Leaves and creepers are chopped and placed at the upper water inlets of the field.</td>
</tr>
<tr>
<td>Tithia wel</td>
<td>Anamirta cocculus (L.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Daluk</td>
<td>Euphorbia antiquorum L.</td>
<td>Paruk panuva (Tryporyza incertulas), Gayam massa (paddy fly)</td>
<td>Immersion of the rope in Daluk latex and trailing, contacting the rice plants.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stems are chopped into pieces and applied to the upper water inlets.</td>
</tr>
<tr>
<td>Keppetiya,</td>
<td>Croton retusa L. Geiseler</td>
<td>Rice insects</td>
<td>Leaves are applied to the soil during land preparation.</td>
</tr>
<tr>
<td>Wel keppetiya</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sera</td>
<td>Cymbopogon citrates Stapf</td>
<td>Gayam massa (paddy fly)</td>
<td>Leaves of Sera are hung with sticks in the field, or Sera bushes are grown on the ridges in the field.</td>
</tr>
<tr>
<td>Walsurtya</td>
<td>Helianthes annuus L.</td>
<td>Paruk Panuva (Tryporyza incertulas)</td>
<td>These plants are grown on the ridges and boundaries.</td>
</tr>
<tr>
<td>Makulata</td>
<td>Gliricidia sepium (Jacq.) Walp.</td>
<td>Bacterial attack, Kadittha (aphid)</td>
<td>Makalata leaves, cow dung and cow urine for retting are placed in a hole in the field near the upper water inlets. After one week, the mixture is release into the field.</td>
</tr>
<tr>
<td>Madu</td>
<td>Cycas cirinalis L.</td>
<td>Paddy fly and insects</td>
<td>Madu flowers are hung with sticks in the field.</td>
</tr>
<tr>
<td>Kohombha (Neem)</td>
<td>Azadirachta indica A.Juss.</td>
<td>Kola hakulana dalambuwa (leaf roller - Cnaphalocrocis medinalis), Kadittha (aphid), Gundhi bug (Leptocoris acuta)</td>
<td>The seeds and leaves of the Kohombha tree are blended with cow dung and urine, and the mixture is sprayed onto the rice field.</td>
</tr>
<tr>
<td>Anoda (Custard apple)</td>
<td>Annona squamosa L.</td>
<td>Kola hakulana dalambuwa (leaf roller - Cnaphalocrocis medinalis), Keedawa (Nilaparvata lugens) and leaf hoppers</td>
<td>The seeds and leaves of Anoda are blended with water, and the prepared liquid is applied to the field.</td>
</tr>
<tr>
<td>Heerassa</td>
<td>Cissus quadrangularis L.</td>
<td>Paruk Panuva (Tryporyza incertulas)</td>
<td>Pieces are randomly planted in the field.</td>
</tr>
<tr>
<td>Mee</td>
<td>Madhuca longifolia J.König ex L. J.F.Macbr.</td>
<td>Insect larva and pupae, Kola hakulana dalambuwa (leaf roller - Cnaphalocrocis medinalis)</td>
<td>The roots of the Mee tree are buried in the each plot, or chopped roots are placed in the upper water inlet. Mee oil is sprayed to control the rice leaf roller.</td>
</tr>
<tr>
<td>Leimba</td>
<td>_</td>
<td>Paruk Panuva (Tryporyza incertulas)</td>
<td>Leimba fruits are buried in the paddy field.</td>
</tr>
<tr>
<td>Kithul</td>
<td>Caryota urens L.</td>
<td>Rice caseworm (Nymphula depunctalis)</td>
<td>Kitul seeds are chopped and placed the upper water inlets of the field.</td>
</tr>
<tr>
<td>Pawatta</td>
<td>Justicia adhatoda L.</td>
<td>Rice caseworm (Nymphula depunctalis)</td>
<td>Pawatta leaves are blended with water, and the prepared liquid is sprayed onto the rice plants.</td>
</tr>
<tr>
<td>Kalu alakola</td>
<td>Colocasia Schott</td>
<td>Rice caseworm (Nymphula depunctalis)</td>
<td>All parts of this plant are chopped and put to the upper water inlets of the field with row indigenous cow dung. Chops the raw fruit of Gaslabu in to pieces and placed into each plot. The latex of the pieces injury the rats’ gums, wounding the mouth.</td>
</tr>
<tr>
<td>Gaslabu (Papol)</td>
<td>Carica papaya L.</td>
<td>Rice rat</td>
<td></td>
</tr>
</tbody>
</table>

Source: Field survey, 2012
These rituals attract beneficial birds, such as common babbler, swifts, mynah, parrots, and crows, to the rice field that feed on the worms and insects. The farmers also prepare some botanical pesticides with tree leaves, stem bark, roots, seeds, and fruits. Most of the farmers place the chopped creepers, leaves, and flowers of some specific plants, such as *Kalawel* (*Diospyros affinis* Thwaites), *Tiththa wel* (*Anamirta cocculus* (L.) Wight & Arn.), *Daluk* (*Euphorbia antiquorum* L.), *Keppetiya* (*Croton laccifer* L.), *Sera* (*Cymbopogon citrates* Stapf), and *Walsuriya* (*Helianthus annuus* L.), at the upper water inlet of each plot. The farmers also spread the crushed seeds of *Kithul* (*Caryota urens* L.) through the upper water inlets to repel pests. Some farmers reported that they immerse a rope in the milk of *Daluk* (*Euphorbia antiquorum* L.) and then trail the rope properly, touching the upper part of the rice plants. The latex of *Daluk* is very harmful to worms, particularly *Purak panuwa*, such fly species as *Kanda massa* and *Gok massa* and, swarming caterpillars (*Spodoptera antiquorum* L.). Moreover, a preparation of indigenous cow urine, cow dung, and *Makulata* (*Gloricidia sepium* (Jacq.) Walp.) leaves is placed into a hole close to the upper water inlets. After one week, the mixture is released into the field through the upper water inlets as a strategy to repel pests in the field. Specifically, these materials contain Nitrogen which helps to revive the damage caused by rice hispa. Some studies in India have reported that management of insect pests though cow urine + *Vitex negundo* L. (*Nirgundi*) + *Ferula asa-foetida* L. (*Hing*)

Moreover, the farmers grow some flowering plants that generate repelling aromatics, such as *Walsuriya* (*Helianthus annuus* L.), *Madu* (*Cycas circinalis* L.), and *Dhas pethiya* (*Calendula arvensis* (Vaill.) L.), in the ridges to reduce the pest population in the field.

If the farmers observe any other diseases, they usually apply liquid that is prepared using the seeds and leaves of *Kohombha* (*Azadirachta indica* A.Juss.) and the leaves of *Pawatta* (*Justicia adhatoda* L.). It has been scientifically proved that *Azadirachtin* present in the *Kohombha* seeds and leaves act as antifeedant and growth retardant to insect. Some farmer spray a juice prepared using *Kohombha* seeds and the leaves and seeds of *Anoda* (*Annona squamosa* L.). For *Kolapulli* disease (brown leaf spot disease), they apply a liquid prepared using indigenous cow urine and cow dung. Specifically, water in the rice field mixed with cow dung can control rice case worm (*Nymphula depunctalis*) due to oxygen deficiency.

**Traditional significance of study to the farmers and some constructive recommendations**

This study provides some important facts regarding farmers in Sri Lanka, and innovative ideas for future researchers engaged in present, controversial discussions of forty years of experiences of the Green Revolution in the country. Today, the farmers in the main rice growing areas of the country, including the survey area, face a dilemma when rice farming with modern farming techniques; recent reports by the WHO and various findings of other scholars ascertained that the chronic kidney, cancer, and diabetes issues in these rice growing area are the results of long term use of agrochemicals by the farmers. It is reported that approximately 15% of the population in the North Central province, where the survey area is located, are suffering from and in danger of these health issues caused by Green Revolution. Indeed, these trends place extremely severe economic burdens on farming households. In this context, the present study provides important information concerning an alternative sustainable farming system to modern rice farming system.

This study provides necessary information to the farmers by encouraging continuing rice farming with traditional practices, without depending on expensive and harmful modern inputs. The indigenous techniques used in rice farming are entirely dependent on local resources which are not destructive to human health and the environment, and they are economically favorable and accessible to all farmers, rainfall patterns, lunar calendar, and agricultural rituals practiced throughout Sri Lanka’s history. Recognition of such possibilities for improving the economic status of farmers, by using indigenous techniques, was also one particularly significant contribution of this study. One of the main concerns of indigenous farmers was the relatively low yield. It is evident that modern science-based rice farming techniques have mainly focused the yield (productivity) by applying different combinations and types of chemical inputs, establishing a rice monoculture system in the main growing regions.

In contrast, this study confirmed the potential benefits of indigenous rice farming rather than
modern rice farming techniques, demonstrating that they can record relatively high yields and maintain heterogeneous rice fields. The traditional focus of indigenous techniques was not only on the yield, but also on including different types of naturally-grown vegetables, ridge cultivation, and mid-season farming in the rice lands, while contributing to soil fertility and enhancing biodiversity. These practices have traditionally played an important role in terms of income, food security, and the availability of healthy and nutrient-rich foods. Moreover, indigenous techniques use locally available resources and thereby avoid requiring farmers to purchase high-cost external inputs. In this regard, this study provides a range of technical yet highly practical information discovered through field work. Specifically, indigenous techniques, which are recognized as social assets of the farmers, make the farmers self-reliant due to non-dependency on market oriented inputs. Moreover, environmental friendliness of these techniques also provides alternative solutions to problems of ground water pollution, worsening of natural soil fertility, and loss of biodiversity in these areas. They are the main economic and environmental concerns of modern rice farming techniques.

There are also several social and cultural values of indigenous techniques, including the exchange of technological knowledge, labor, and inputs among the farmers that develop interrelationships among them, which cannot be seen in the practices of modern farming techniques. In addition to the farmers, this study provides a base for researchers on how to tackle the current problems of agriculture in Sri Lanka by using similar techniques. Specifically, the study provides some innovative ideas—for example, the use of the rainy season calendar and lunar cycle for yield-enhancing cultivation, and the use of botanical materials for soil fertilization, germination, and pest and disease control. Therefore, researchers can further improve upon these methods and ascertain best practices through additional social and natural science work.

The study makes following constructive recommendations based on field observations. First, it is important to establish an indigenous knowledge bank in the country with the support of the country’s higher education systems, relevant research institutions, and volunteer organization. This is because there are very limited farmers who have adequate knowledge of the indigenous techniques, because of the huge influence the Green Revolution has had over the past forty years. Second, agricultural subsidies—the fertilizer subsidies in particular—discourage farmers from using the indigenous techniques, and should, therefore, be withdrawn. Third, the establishment of a segmented market for indigenous rice is very important. There is no segmented market for indigenous rice, because there is no wholesale market for indigenous rice in the area or even the country at large. Here, experts can use specific information about indigenous techniques, health and food safety, and the historical importance of reestablishing these techniques. Fourth, a support system to the farmers should be established so that they can access indigenous seeds, further knowledge, and market information. These recommendations will eventually support the dissemination of indigenous knowledge on rice farming techniques among all the farmers in the country. This will contribute to the elimination of the environmental problems associated with agrochemical usage on the rice farms, it will ensure food safety and the security of the country’s people, and it will eliminate the health risks of the rice producers and consumers.

**Conclusion**

Over the last forty years, modern rice farming techniques have weakened the sustainability of rice farming in the main rice growing regions. The factors that weakened the sustainability of rice farming were: agrochemical usage; modern rice varieties (HYVs); lost of biodiversity due to agrochemical usage and rice monoculture system, change of cropping patterns which are not adaptable to the natural features of the regions; labor saving agricultural mechanization; and neglect of indigenous knowledge or techniques which is the social assets of the agrarian societies of the country among other factors. This study attempted to identify indigenous techniques in rice farming applied by farmers at each stage of cultivation, with the aim of identifying the sustainable principles of those techniques. The study demonstrated that indigenous techniques in rice farming correspond with the natural features of the region, including the rainfall patterns, soil conditions, temperature, and humidity, and are dependent on the local resources. Cultivation based on rainfall patterns and the lunar calendar and the adopted techniques of soil fertility management, seed selection, seed treatment, water management, and pest and disease control provide highly sustainable
alternatives to the modern high external input-based techniques. However, the main argument against indigenous techniques is the relatively low yield, which is eventually associated with the country’s food security. The relatively low yield is making rice farmers, particularly the new generation, reluctant to apply indigenous techniques, even though the production costs are significantly lower in comparison to modern techniques. Thus, further research should be conducted on the unique conditions of and the technology adopted by progressive farmers who record high yield to identify yield-enhancing techniques in different regions. Indeed, these indigenous techniques are not harmful to the environment and thus can help to maintain the long-term production sustainability of rice farming. This study suggests that the strategies designed to tackle the problems of modern rice farming should take into account the characteristics of the indigenous rice farming techniques in Sri Lanka.

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