Asian Rice Based Farming Systems

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1. Introduction

1.1. Definition for farming system
A farming system is a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate (Food and Agriculture Organization, 1990).

The classification of the farming systems of developing regions has been based on the following criteria: available natural resource base including water and land, grazing areas and forest; climate, of which altitude is one important determinant; landscape, including slope; farm size, tenure and organization.

1.1.1. Rice based farming system

Rice based farming system can be described as mixture of farming practices that comprises of rice as the major crop followed by subsequent cultivation of other crops. Inter-cropping of rice and other compatible crops is also widely practiced in many regions.

1.2. Rice production in Sri Lanka
Rice is the staple food of more than half of the world’s population. It is domesticated in Asia some 8,000 to 10,000 years ago. As a cereal grain, it is the most widely consumed staple food for a large part of the world's human population mainly in Asia. More than 3.5 billion people depend on rice for more than 20% of their daily calories. Rice provided 19% of global human per capita energy and 13% of per capita protein. As an agricultural commodity it was documented as third-highest worldwide production in 2014 (Rice, 741.5 million tons).
In Sri Lanka, paddy is cultivating in all the districts as a wetland crop. Total paddy cultivated land extent in Sri Lanka is about 880,000 hectares at present (2018). Two major cultivation seasons can be identified namely as *Maha* and *Yala* which are coinciding with two monsoons. *Maha* Season falls during “North-east monsoon” from September to March in the following year. *Yala* season is effective during the period from May to end of August.
2. Rice based farming systems in Asia

At present, the majority of all rice produced comes from China, India, Indonesia, Bangladesh, Vietnam, Thailand, Myanmar, Pakistan, Philippines, Korea and Japan. Asian farmers still account for 87% of the world’s total rice production.

Rice continues to remain a political commodity in Asia. Countries in the region are still extremely concerned about rice food security and treat it very differently from other food commodities. Despite the economic boom in the region in the past three decades and the rise in income and prosperity, rice consumption remains strong across countries with some diversification away from rice in a few countries.

Rice production systems in Asia are facing multiple stressors including climate change, land degradation and water scarcity. At the same time, many countries in Asia are recognizing a need to revise and reformulate their rice production strategies, to think beyond simple production targets (FAO 2014). Due to above problems, rice base farming systems are introducing to enhance rice productivity and economic status of farmers.

Rice agro-ecosystems are central to the livelihoods of millions of smallholder farmers, and have the potential to generate multiple benefits for local communities and the public good, at the same time as sustaining rice yields.

Rice based farming system can be described as;

i. Mixture of farming practices that comprises of rice as the major crop followed by subsequent cultivation of other crops.

ii. Inter-cropping of rice and other compatible crops is also widely practiced in many regions.
2.1. Types of rice-based farming system

After the Green Revolution, farmers began to invest considerable time and effort in rice while neglecting other crops. By introducing other crops within the same field and managing them through an ecological approach, farmers are able to lower their dependency on rice both as a crop and in their diet. Throughout the year, farmers are able to harvest vegetables and fish in addition to rice from their fields. They sell and consume these products in varying proportions depending on their needs and their production. The cost of production of these complementary crops produced in the rice field is minimal, and rice production remains the same or possibly increases.

Different types of rice incorporation into farming systems.

I. Mixed varietal cropping of rice
II. Intercropping rice with other crops
III. Relay cropping
IV. Sequential cropping in rice
V. Rice under integrated farming system

2.1.1. Mixed varietal cropping of rice

System of mixing seed of early rice with late maturing deep-water rice is being practiced to avoid total crop loss at the event of flood. The seed of both the types of mixed in 1:1 ratio and has given higher yield than sole cropping of either type. Under normal conditions it has created problems in performing agricultural operations like harvesting, deciding fertilizer doses etc.
2.1.2. Intercropping rice with other crops

It is a common practice under upland conditions to grow rice intercropped with black gram, green gram, sesame, maize, finger millet or other minor millets (Figure 1). The ratio of rice and inter crop is preferred to be 3-4:1

Figure 01: Intercropping with green gram

Different common rice-based cropping patterns

- Rice-rice
- Rice-pulse/green manure
- Rice-pulse/millets
- Rice-other cereals/millets
- Rice-rice-pulse/oil seeds
- Rice-pulse-vegetable
- Rice-rice-fallow and rice-vegetable pattern
Ex: Rice-rice-pulse/oil seeds
In Tamilnadu the first crop starts during June-July and is harvested in October and this crop is known as Kuruvai. Followed by this the second crop usually starts in October-November and is harvested during January-February. The second crop is known as Thaladi. Followed by the second crop, farmers broadcast pulses like black gram, cow pea, horse gram, and oil seeds such as sesame, etc in the paddy lands.

2.1.3. Relay cropping
Relay cropping is a method of multiple cropping where one crop is seeded into standing second crop well before harvesting of second crop. Relay cropping may solve a number of conflicts such as inefficient use of available resources, controversies in sowing time, fertilizer application, and soil degradation. Relay cropping is a complex suite of different resource-efficient technologies, which possesses the capability to improve soil quality, to increase net return, to increase land equivalent ratio, and to control the weeds and pest infestation.

The seed of succeeding crops like gram, pea, etc. is sown broadcast in maturing rice crop. This will saves time; money (to be spent on land preparation etc.) utilizes residual fertility. This is a common practice in both upland and lowland rice culture.

Some selected short-term pulses are selected for relay intercropping with rice. Among the pulses lentil (Lens culinaris Medikus subsp. Culinaris), grass pea (Lathyrus sativus L) and pea (Pisum sativum L) are the important cool season legume crops grown in Bangladesh under rice-based cropping systems which have significant contribution to food, feed and sustainable development of agriculture. These pulses are mainly grown after the harvest of monsoon-rice in the winter season (October-March) in Bangladesh (Ali and Sarker, 2017).
In Sri Lanka, green gram which is a short-term legume is sown to the rice field just before harvesting of rice. After harvesting the rice green gram gets germinated and grown.

### 2.1.4. Sequential cropping in rice

Sequential cropping refers to the crops grown as preceding or succeeding with rice as shown in the Figure 02.

<table>
<thead>
<tr>
<th>Irrigated conditions</th>
<th>Upland condition</th>
<th>Rice under integrated farming system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice-Rice-Rice</td>
<td>Rice-Chickpea</td>
<td>Rice-Fish-Poultry</td>
</tr>
<tr>
<td>Rice-Rice-Cereal</td>
<td>Rice-Lenil</td>
<td>Rice-Fish-Duckery</td>
</tr>
<tr>
<td>Rice-Rice-Pulses</td>
<td>Rice-Mustard/Linseed</td>
<td></td>
</tr>
<tr>
<td>Rice-Wheat-Pulse</td>
<td>Rice-Barley</td>
<td></td>
</tr>
<tr>
<td>Rice-Toria-Wheat</td>
<td>Rice-Wheat</td>
<td></td>
</tr>
<tr>
<td>Rice-Wheat</td>
<td>Rice-Pea</td>
<td></td>
</tr>
<tr>
<td>Rice-Mustard</td>
<td></td>
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</tr>
</tbody>
</table>

Figure 02: Rice based cropping patterns

### 2.1.5. Rice under integrated farming system

#### a. Rice-Fish integrated farming system

A rice-fish system is an integrated rice field or rice field/pond complex, where fish are grown concurrently or alternately with rice. Fish may be deliberately stocked (fish culture), or may enter fields naturally from surrounding water ways when flooding occurs (rice field fisheries), or a bit of both (Figure 3 and 5). Fish yields can range widely from of 1.5 to 174 kg/ha/season depending on the type of rice fish system, the species present, and the management employed.

Rice-fish systems allow for the production of fish and other aquatic animals, as well as rice, from the same rice field area and generally without causing reductions in rice yields. This source of animal protein may be important for household nutrition and farm income (Figure 04).
The most common indigenous fish [common name (Genus)] found in Asian rice fields include:
**White fish:** (small plant or plankton eating species) such as Danios (Rasbora), Barbs (Puntius) Snakeskin Gourami (Trichogaster) and Half beaks (Xenentodon) (Figure 6).

**Black fish:** (often carnivorous air breathers that can survive low or no oxygen levels) such as Snakehead (Channa), Catfish (Clarias), Climbing Perch (Anabas), Spiny eels Mastacembelus) and Sheatfish (Ompok) (Figure 6).

**Exotic fish species** as; Common Carp (Cyprinus), Tilapia (Oreochromis) and Silver carp (Hypophthalmichthys), other wild aquatic species such as Crabs, shrimp, snails, and insects also introduced (Figure 6).

Figure 05: Practical application of paddy-fish integrated system at real field conditions

**Management of rice field fisheries,**

1. Wild fish can be encouraged to enter rice fields by keeping entrances to fields open, and bunds low
2. They can be attracted by placing branches in the field which provide shelter for the fish or by placing buffalo or cow skins to attract catfish and eels.

3. Wild fish may be harvested from rice fields by netting, hooking, trapping, throwing nets, or by draining the field.

4. As water levels fall, fish may be channeled into adjacent trap pond areas where they can be held alive until required. Black fish from trap ponds are often marketed live in local markets.

**Key features of breeds should have in-order to be selected into rice fish integrated system:**

1. Breeds with fast growth rate
2. Ability to survive in shallow water level
3. Ability to resist high temperature and low oxygen level
4. Not damaging to rice plant
5. Breeds with considerable market demand
6. High availability of the breeds in adequate quantities

**Key advantages of rice fish integrated system**

1. Animal protein also can be gain with the paddy yield
2. Harmful insects, worms, Algae and weeds are eaten by fish
3. Increase soil aeration
4. Excretes of fish add in to the paddy fields as a fertilizer
5. Control of weeds.
6. In the event of a sudden drought, the rainwater harvested in the refuge pond can be used to irrigate the rice and other crops.
b. Rice- Fish- Azolla-Duck Integration system

Although rice fish integration farming system is successful income source for small scale farmers in some situation expected objective may not be fulfilled due to lack of feed for fish in the field and bushy growth of rice plant (high tillering
ability). To avoid this problem *Azolla* aquatic plants and ducks can be introduced into the system with this more rice fish production can be obtained due to high nutrition in the field (Figure 7and 8).

In rice- duck- fish- *Azolla* integration, duck sheds are constructed over the fish pond refuge that is contiguous to the rice field. The floor of the duck house has some spaces to allow manure and the spilled feed to fall directly into the fish pond. The duck manure serves as an organic fertilizer for plankton production for the fish. *Azolla* is an aquatic fern and inexpensive feed for fish. Increase fish production has been demonstrated in integrated rice- fish- *Azolla* production system where azolla served as an in-situ fresh food for the macro- phytophagous fish. Other thing is *Azolla* can fix N2 from air.

![Image](image_url)

**Figure 07**: Rice-fish-Azolla integrated system

**Advantages of rice- fish- *Azolla*-duck integration system:**

1. *Azolla* is an aquatic fern. Farmers disperse these floating *Azolla* in field during transplanting season.
2. Improve the nutrition status of farm
   i. *Azolla* leaves that popularize blue green algae. They fixed N2 from air. These plants die in dry season and nutrients add to the soil for future rice plants.
3. Increase yield and income
4. Provide natural pest control
5. Increase food supply and ensure food security in terms of food availability and accessibility.

c. Rice – duck farming system
A method of rice farming that relies on ducks to eat insects and weeds. The *aigamo* method for growing rice involves releasing aigamo ducklings (Sera) into a rice paddy about one or two weeks after the seedlings have been planted. The *aigamo* is a cross-breed of wild and domestic ducks. Between 15 and 20 of these birds are needed for every 1,000 square meters of farmland. Also necessary is a shelter where the ducklings can rest and take refuge from rain.

![Figure 08: rice-duck-fish-Azolla integrated system](image)

In order to protect them from dogs, cats, weasels, and crows, the field should be surrounded by an electric fence and protected from above by fishing line. The ducklings help the rice seedlings grow by eating both insects and weeds that get in the way.
Advantages of rice-duck farming system

1. The ducklings' droppings become an important source of natural fertilizer.
2. They stir up the soil in the rice paddy with their feet and bills, a process that increases the oxygen content of the soil, making it more nutritious for the seedlings
3. And when it comes time to harvest the rice in the fall, the ducks have grown fat and can be sold for meat
4. By allowing farmers to grow crops organically and also raise ducks to sell as meat, the aigamo method really does kill two birds with one stone
5. Beneficial from a cost standpoint in that farmers will no longer have to purchase expensive chemical fertilizers or pesticides
6. Extra money can be made when the fully-grown ducks are sold off is another factor that many find appealing

d. Rice-duck-Azolla-loach
Cultivation as an integrated bio system which eliminates the need for fertilizers, herbicides, and pesticides by incorporating duck-raising into organic rice cultivation

Advantages of the loach and duck integrated system
1. The ducklings provide integrated pest management, replacing pesticides and herbicides by naturally controlling predaceous pest populations and digging up or eating competing weeds
2. The loach and duck waste, combined with the nitrate fixing properties of Azolla, increase soil nutrition and maintain productivity levels that are comparable to conventional farming operations without the need for costly synthetic fertilizers
3. The Azolla plants can later be harvested for animal feed
4. A normal organic rice farm would require significant human labor to keep weeds down and maintain soil health, but the ducklings’ natural movement aerates the soil and strengthens rice stalks.

5. The reduction of human effort supported by the process allows farmers to diversify their product base to include organic rice, fish, duck meat and eggs.

6. Reducing their vulnerability to external shocks such as price fluctuations, and potentially creating price premiums from attractive organic food markets.

e. Integration of horticultural crops with paddy cultivation

Vegetables like colocasia, okra, amaranthus, brinjal, cucurbits, etc. are grown adjacent to rice fields during rainy season and potato, sweet gourd, cole crops (broccoli, brussels sprouts, cabbage, cauliflower, collards, kale), leafy vegetables etc. are grown during winter season (about 15-20% of the land) (Figure 9). Bottle gourd, lablab bean, sweet gourd etc. are grown on pond dyke and over the water bodies with support/stakes provided with locally available materials like bamboo, tree branches etc.

Cultivation of leafy vegetables, chili, cucumbers, gourds etc. are common in kitchen gardens and nutrient requirement of kitchen gardens are met from the wastage of kitchen and litters/washings from animal sheds. The watering in kitchen gardens are also done from the household waste water and livestock shed washings.
f. Integration of fruits and plantation crops with paddy cultivation

Most of the farmers maintain few banana clumps (about 5 nos), guava (2-5 plants), coconuts (2-5 plants) and about 25-50 areca-nut plants which provides economic sustenance (Figure 10). All these are grown around the home yard, pond dykes and boundaries. While most of the produces are consumed by the farmers themselves, some quantities are sold to the market by the poor farmers to meet their diversified daily needs. Areca-nut is mostly produced in surplus quantity and farmers earn good amount by selling the nuts.
3. Rice base farming as a viable option for both farmers and consumers in Asia

Rice-based farming will increase farmers’ income and consumers will provide healthier livelihood options. Instead of rice mono-cropping, farmers should also grow other crops, and livestock alongside rice. With the use of existing models like vermiculture, mushroom production, mungbean, corn, garlic, duck, and fish that can be grown and maintained alongside with rice, farmers will have reduced dependence on rice as the main source of income (Figure 11).

This farming system aims to transform a community of farmers into agri-preneurs. Its scope is not limited to crops and livestock but also covers fishes and vermiculture. Its scale is not just for household food security but also covers the national food security as well.

Figure 11: Multiple outputs from the different rice-based farming systems
Everything a farmer places in his farm serves a purpose. With rice as the main crop, vegetables and livestock are also integrated to optimize the overall farm system. Ducks and fish may be integrated for pest control and added income; or azolla may be planted as source of organic inputs. Nothing is wasted in the close-loop method.

With rice-based farming, consumers may also try other staples. *Kamote*, cassava, white corn, brown rice, and parboiled rice are among them. It is also rich with dietary fibers, magnesium, selenium and other vitamins that help reduce the risk of colon cancer.
4. Advantages of rice-based farming systems in Asia

Benefits derived from the rice-based farming systems can be discussed under three main categories as explain below.

I. Economic Benefits
II. Social Benefits
III. Environmental benefits

4.1. Economic benefits

a. Cost of production rice reduced
   – Use waste material of one component at the least cost. Thus, reduction of cost of production and form the linkage of utilization of waste material, elimination of middleman interference in most input used. Working out net profit benefit cost ratio is increased.

b. Increase economic yield per unit area
   – Rice base farming system provides an opportunity to increase economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises.

c. Regular income and year-round employment
   – Due to interaction of enterprises with rice, eggs, meat, fish Provides continuous flow of money to the farmer throughout the year.

d. Minimize the risk of failure in productivity
   – Land productivity was improved by accelerating natural nutrient cycling process, natural pest and weed control process, and maintain proper soil microbial conditions etc. Therefore, possibility to reduce
the expected yield is very much law. And also, as farmer’s income will depend on several sources (mainly from rice, additional income sources; fish source, duck meat, eggs, and other value-added products) therefore if there is a reduction in rice yield farmer can survive with the income gain from other various sources.

e. Efficient utilization of family labour
   - Available labor source can be used for different farming activities of different integrated farming methods. Therefore, Available labour sources will be utilized in an efficient way without an wasting.

f. Reduction in animal feeding requirement
   - In rice- livestock farming system, forage requirement will be mainly fulfilled by the crop residues and natural vegetation under cut and carry system. On the other hand, animals can allow to free graze in the paddy land during non-cultivation period.

g. Enhance employment generation
   - Combing crop with livestock enterprises would increase the labour requirement significantly and would help in reducing the problems of under employment to a great extent rice base farming system provide enough scope to employ family labour round the year.

4.2. Ecological benefits

a. Reduction in use of agricultural chemicals
   - Generally, in rice-based farming systems necessity to apply chemical fertilizer, weedicides and pesticide is very poor. Because due to facilitation of proper ecological conditions for both above ground and below ground components, natural process make nutrient more
available to the consumption of the plant. Therefore, requirement to apply chemical fertilizer is minimum.

b. Improvements in soil fertility and soil health
   – Properly managed rice-based farming system also behave similar to the natural ecosystem. Negative impacts from external sources are very limited. Through facilitation proper micro climatic conditions and strengthening the natural nutrient cycling process, enhancing soil microbial population, improving soil fertility and organic matter content will leads to improvement of soil biological, chemical properties.

c. Recycling of agricultural wastes
   – Waste materials are effectively recycled of in rice base farming system.

d. Conservation of natural resources
   – Due to efficient use of available resources reduces the over usage of natural resources.

e. Minimization in pollution hazards
   – In rice base farming system, waste materials are effectively recycled by linking appropriate components, thus minimize environment pollution.

f. Saving Energy
   – Identify an alternative source to reduce dependence on fossil energy source within short time. Effective recycling technique the organic wastes available in the system can be utilized to generate biogas. Energy crisis can be postponed to the later period.
4.3. Social benefits

a. Improves the status and livelihood of the farmer.
   – Provide continuous income throughout the year from different components. Reduce the risk associated with crop loss due to bad weather conditions, pest attack or diseases.

b. Provides balance nutritious food for the farmers.
   – Rice base farming system is linked components of varied nature enabling to produce different sources of nutrition.

c. Potentiality/ Sustainability
   Organic supplementation through effective utilization of by-products of linked component is practiced thus providing an opportunity to sustain the potentiality of production base for much longer periods.
5. Limitation of rice-based farming system in Asia

Rice based farming system was identified as more successful farming system which provides multiple opportunities for both farmer and consumer in environmentally friendly manner through efficient utilization of limited natural resources. However, few limitations are identified as which can reduce the real potential of the rice-based farming system.

a. Lack of Awareness about sustainable farming system.
b. Unavailability of varied farming system models.
c. Lack of credit facilities at easy and reasonable interest rate.
d. Non-availability of ensured marketing facilities specially for perishable commodities.
e. Lack of knowledge among farming community specially of rural youth.
6. Future strategies improvement of rice-based farming systems in Asia

Intensification of crops in rice-based production systems by increasing the number of crops grown on the same land each year following the main rice crop is one of the strategies for enhance the performance of the rice-based farming systems. Crop intensification may be achieved by using shorter season varieties, improving on-farm water and soil fertility management (e.g. water-harvesting practices, minimum tillage, supplementary irrigation), and introducing rotation crops.

Boosting yields by improving the efficiency of water and nutrient use is another strategy. The entry point for yield enhancement is to improve the crop water-use efficiency of both irrigated and dryland components of rice-based systems. Water productivity gains will need to be underpinned by sustainable soil fertility. This will necessitate targeted research to develop site-specific nutrient management systems, including more efficient use of fertilizers, soil ameliorants, green and animal manures, and residues. Tailoring agronomic practices (e.g. weed management, planting methods) to local conditions will further enhance water and nutrient efficiency.

Improving livestock production by integrating animals more effectively with rice-based cropping systems is another strategy. Livestock production is highly dependent upon feed sourced from crops – grains and tubers, stover, green forage, and processing by-products – together with weeds within and beside crops. The transformation of poor farmers from livestock keepers to active market-oriented producers will require improvements in livestock reproduction and nutrition coupled with better access to markets.
Strengthening policy settings by improving understanding of the linkages with, and impacts on, food security can be taken as another strategy. Food security is affected by the mix of policy settings at local to international scales. Achieving more productive and sustainable rice-based cropping systems will necessitate better understanding of and integration across formal and informal policies, especially in the arenas of agricultural industry and trade, land and water resources management, agricultural extension systems, and marketing systems for rice and related products.

Build capacity of individuals and institutions by establishing effective collaborative relationships and facilitating knowledge sharing is another effective way for improving rice-based farming systems. Effective and lasting results for food security will depend upon developing strong in country capacity for framing. This capacity extends from individual researchers to the broader institutional arrangements.

To sustain rice-based farming systems, there is urgent need for scientific nutrient cycling, appropriate integration of various enterprises and adoption of improved varieties/breeds of crops and livestock. The need of the hour is judicious blending of traditional knowledge with modern scientific tools and technologies for sustaining the fragile ecosystem of the region and to conserve the rich traditional knowledge base in agriculture.
7. Diverse practices in Asian rice-based farming systems in Asia

7.1. Water harvesting and fish culture in India

Art of water harvesting is the key to the success of indigenous rice-based farming systems in the eastern and north eastern region of India. This provides some amount of resilience to the system in the event of drought like situation. It is almost a common view during dry season (February to March/April) that one will see such as drying ponds, cracks in the fields, poor health of animals etc. About 5-10% of available land area is given for water harvesting for life saving irrigation during dry season and most importantly for growing fish and domestic use. About 82% of the farmers are marginal (<1 ha land holding) with average land holding of 0.34 ha. The fish productivity in such ponds is in the range of 0.75 to 1.2 t/ha based on the management practices followed by the farmers.

Farmers grow local fishes along with common carps, mrigal, katla etc. to some extent. Low land rice fields are major ecosystem for growth of indigenous fish and it is an accepted fact that the demand and taste of indigenous fish are much better than the Indian major carps and exotic carps.

7.2. Residue management

It is a common practice to leave at least 30 to 50 % crop residues/standing stubbles in the field. The field is ploughed two to three times mostly with bullock drawn indigenous plough and the straw is incorporated before rice is transplanted. During following season, the field is ploughed immediately after receiving first rain during April-May incorporating all the residues and manures into the soil. The final ploughing is done about 20 days after first ploughing to ensure decomposition of the entire weed and crop biomass along with organic manure. In this way, the problem of weeds also reduces to a great extent especially
during initial growth period of rice. Farmers also disposed-off residues of crops/weeds/threshing floor wastages etc. in rice field which is incorporated into the soil during ploughing. Off late, at least 50% farmers have started using power tiller for ploughing the field. However, leveling and planking are still done using bullock drafts.

7.3. Livestock component and composting

livestock contributes to the organic manure stock of the farmers. The livestock component provide farmers the much needed cash whenever they need for emergency (medicine, admission of children, festivals etc.). The significant aspect is that the small livestock (goat/sheep) and poultry/ducks/pigeon etc. are exclusively managed by women and children and the earnings from such livestock go to women/children. Hence, animal component empowers the women and children and improves their nutrition and livelihood. Farmers mostly feed their livestock with on-farm resources and hardly any concentrates other than salts. Kitchen wastes, broken grains, rice bran etc. are used for feeding backyard poultry and ducks. Grasses in and around home yards, field bunds etc. and rice straw is used for feeding cattle.

Rice straw is stored in a low cost shed made of bamboo with roof made of rice straw. It is also very common to pile well dried rice straw around a single bamboo pole in an artistic manner. Grazing in wasteland, fallow land and road sides are most common practice. All most all the households maintain an earthen compost pits in the corner of the home yards where the animal dungs, along with bedding materials, litters, kitchen wastes etc. are deposited and composted. Such composts are mostly used for cultivating vegetables to get higher return.
7.4. **Nutrient cycling in traditional rice farming**

It is reported that recycling of straw in the field (about 5 t/ha dry matter/ rice season) contributes about 31.5 kg N, 9.5 kg P$_2$O$_5$ and 69 kg K$_2$O/ha considering N: P$_2$O$_5$: K$_2$O content of rice straw at 0.63, 0.19 and 1.38%, respectively. Similarly, from recycling of weed biomass (about 3 t/ha dry matter/rice season) may supply about 45 kg N, 6 kg P$_2$O$_5$ and 37 kg K$_2$O/ha considering N: P$_2$O$_5$: K$_2$O content of weed biomass 1.50, 0.19 and 1.22%, respectively. Thus, in a rice growing season of about 130 days, it is possible to recycle about 75 kg N, 15 kg P$_2$O$_5$ and 105 kg K$_2$O/ha. High nutrient recycling potential of rice and rice-based cropping systems has been reported.

It is a common practice to let leave livestock viz., cows, buffaloes, goats and sheep in the paddy field during dry season where a good amount of dung is deposited in the field and contributes to soil fertility. The amount of N, P and K added through animal grazing is about 30-35 kg/ha. Thus, the amount of nutrient available in rice field is almost sufficient for a good rice crop.
8. Indigenous technical practices in a rice-based farming systems in Asia

8.1. Indigenous soil health care practices

Indigenous soil health care practices are those practices evolved, adopted, and modified by farmers based on their own informal experiments with an objective to maintaining the fertility and productivity of the soil.

**Crop rotation** is a practice in which farmers grow different types of crops in various seasons. Crop rotation also implies that at least one legume crop should be incorporated in the cropping pattern in a year.

**Fallowing** is an indigenous soil health care practice in which farmers let cultivated land rest for a certain period of time before using it again.

**Application of farm yard manure.** Farm yard manure is a mixture of cow dung, cow urine, and paddy straw. Farmers apply farm yard manure especially to cereal crops such as rice, finger millets, and oilseeds such as groundnuts. Farm yard manure regulates the supply of nitrogen. Farm yard manure changes the color of the soil which is essential for absorbing sunlight. Farmers refer to this process as mann matram in Tamil.

**Casuarina leaves:** Farmers harvest Casuarina equisetifolia, a fuelwood tree, collecting the leaves and applying them to problem soils to counteract soil alkalinity.

**Riverbed sand:** Farmers apply sand that is collected from river beds if the problem of soil alkalinity is severe. There are some experienced farmers in the villages who can identify the severity of the soil alkalinity problem. Farmers facing
alkalinity problems contact the experienced farmers for advise to correcting this problem.

**Plowing Daincha (Sesbania bispinosa) in situ:** Daincha is a root nodule shrub. Farmers with clayey soils, before planting rice, sow the Daincha seeds and plow the plants in situ when the plants become 45 days old. Mulching consists of leaving crop residues in the field, or bringing in other materials such as foliage from elsewhere.

### 8.2. Indigenous rice seed selection and processing techniques

**Removing rogue (destructive) plants:** Rogues are different varieties of the same crop. Identifying and removing the rogue plants is a skillful technique. Farmers remove rogue plants at least 25 days before harvesting in order to avoid admixtures and also to maintain the genetic purity of a particular variety of a rice crop. Farmers claim that rogue plants mature first.

**Spreading notchi (Vitex negundo) leaves over the rice seeds:** Once rice seeds are processed and stored, farmers spread notchi leaves over the rice seeds to prevent infestation by stored pests.

**Sieving rice seeds:** Before sowing, farmers sieve rice seeds in order to separate the seeds of weeds. Since most of the weed seeds are bigger than rice seeds, they are filtered out in the sieves.

**Manual threshing of rice seeds:** By threshing rice seeds manually, farmers claim that the plumule area of rice seeds are protected. Man, farmers are of the opinion that tractor threshed rice seeds are of poor germination potential.

**Selecting healthy plots:** Farmers by physical observation demarcate a small plot for seed purposes. This is usually done one month prior to harvesting. Healthy
plots that are free from pests or diseases attack are selected. Farmers also hold certain beliefs while selecting the rice seed plots. During the samba season, they select a plot from the north east corner of the field. This is locally termed as *sani moolai*. During the *Navarai* season, they select a plot from the southwest corner of the field, locally termed as *pillayar moolai*.

**Farmer-to-farmer seed exchange**: Farmers practice their own system of obtaining quality seeds. They form an informal network wherein they visit each other’s fields before harvest. They judge the quality of the seeds by observation. If they are satisfied, they buy from each other. There are some large-scale farmers in the village who raise one to two-acre seed farms every season. Many small-scale and marginal farmers reported that these seed grower are more reliable than the public seed distribution system.

### 8.3. Indigenous crop nutrient management practices

Indigenous crop nutrient management practices are those manuring and fertilizing practices developed by farmers through judicious mixing of organic manures and chemical fertilizers.

**Sheep manure**: Some marginal farmers rear sheep especially for their manure value. According to them, five to six sheep are sufficient to cater to the manure needs of one acre of rice. Sheep manure is usually applied once in a year. Farmers who apply sheep manure usually skip the basal application of chemical fertilizers. Sheep manure is powdered and mixed with urea for top dressing. Sheep manure releases the nitrogen quickly when compared to farm yard manure.

**Farm yard manure**: Farm yard manure is a mixture of straw, cow dung, urine, and other plant materials. Pure cow dung is not good for the rice crop. According to farmers, the farm yard manure has certain specific advantages:
a. Farm yard manure increases yield by at least two bags (1 bag=75 kgs.);
b. Farm yard manure increases the grain weight of rice
c. Robust seedlings can be obtained by the application of farm yard manure
d. Top dressing of nitrogen can be reduced if farm yard manure is applied basally
e. Farm yard manure adds roughness to the crop surface thus minimizing pest incidence.

8.4. Indigenous rice transplanting techniques

**Row planting:** Planting in rows significantly increases the production of tillers in rice variety *ponni*. This practice also enables the farmers to undertake intercultural operations such as application of fertilizers and pesticides.

**Pinch planting:** During *navarai* season, farmers ask the laborers to plant only 2-3 seedling per hill. This is locally referred to as *killi poduthal* (pinch planting).

**Clump planting:** During samba season, farmers ask laborers to plant 45 seedlings per hill. This practice is locally referred to as *pudichi poduthal* (clump planting).

8.5. Indigenous rice pest management strategies

**Pest monitoring:** Most of the farmers apply pesticides after a thorough pest monitoring. Farmers look for pest symptoms in rice tillers. For each rice pest, farmers have their own economic injury levels. They apply pesticides only if the infestation crosses economic injury levels. Only for ear head bug, do they apply pesticide immediately even if only one bug is seen.

**Proper aeration to manage the attack of brown plant hopper:** In order to minimize the attack of the brown plant hopper, farmers fold the rice crop once in
eight feet. This practice not only provides aeration for the rice tillers but also exposes the culms of the rice crop where the brown plant hopper is usually found.

**Local rat traps:** Farmers invented these rat traps to kill rats in the rice fields. Rats are one of the major non-insect pests and contribute to 35% of grain loss. The damage is severe during the milky stage and grain formation stage. Farmers install these traps along the bunds to kill the rats during night times. The infestation is severe only during the night times. These traps are effective than chemical rodenticides. Moreover, rodenticides are known for polluting the environment as well as groundwater.
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