

# Capturing Traditional Practices of Rice Based Farming Systems and Identifying Interventions for Resource Conservation and Food Security in Tripura, India

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**Abstract** Entire livelihood of farmers in plains of Tripura is dependent on rice based farming systems (RBFS). A good rice crop brings smile to the family and locality and a poor crop brings misery and makes farmers debt ridden. Traditionally, about 5-10% of available farm area is given for water harvesting for life saving irrigation during dry season and most importantly for growing fish and domestic use. The water harvested in ponds is used for lifesaving irrigation of vegetables (15-20% farm area) fruits, etc. grown around rice fields or adjacent to home yards. Lowland rice fields and *lungas* (depressed area in between hills/lowlands) are major ecosystems for indigenous small fish species. The demand and taste of indigenous fish are much better than the improved fishes like Indian major carps, exotic carps etc. Rice ecosystem is also the major habitat for crabs, eels, edible snails, roots etc. that provides nutrition to thousands in northeastern region. Livestock like cattle, buffaloes, poultry etc. are the integral part of the RBFS. The animal component not only contributes to the manure stock and livelihood of small and marginal farmers but also empowers women and children. The fertility of rice fields are maintained over the centuries through efficient residue recycling, livestock penning, application of organic manure and composts etc. The strength of the indigenous RBFS is that there is hardly any case of starvation death or suicide in the state or in the region which is frequent news in other parts of the country. However, there is need for blending improved technologies and high yielding varieties/breeds to the indigenous RBFS for food security of the increasing population in the state similar to other parts of the country.

**Keywords:** rice based farming systems, ecological conservation, livelihood, traditional knowledge, sustainability

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## 1. Introduction

Almost 100 % farmers grow rice in about 80 % of cultivated areas of North East India. Rice culture has been followed by the people of the region by their wisdom from centuries. Agro-climatic condition of the region especially Tripura is very much favorable for rice cultivation. Rice is the main crop of Tripura and cultivated in an area of 0.26 million hectare (91 % of net sown area). The area under rice clearly indicates the importance of rice and rice based farming systems (RBFS) for food security in Tripura. Rice is cultivated in almost all the landforms and ecosystems and they can be grouped into three major ecosystems i.e., *tilla* (uplands including *jhum*), *charra* (medium uplands) and *lunga* (lowlands). Farmers of the region in general and Tripura in particular have been following rice-rice systems from centuries. They have been cultivating rice by

wisdom, tradition and for subsistence. In valley low lands of Tripura, there is three distinct rice growing season i.e., *Aus* (Pre-*kharif*, march/April to July/August), *Aman* (*Kharif/Sali*, July/August to November) and *Boro* (winter, Dec/Jan to April/May). Food security in the State entirely depends on rice as no other cereals are grown by the farmers due to food habits and agro-climatic situations. Self-sufficiency in food grains in Tripura can be achieved only through enhanced productivity of rice and sustaining RBFS. The farmers of the region in general and Tripura in Particular have been following some rich traditional practice in managing rice and RBFS [1]. The locally available resources are used efficiently with minimal dependence on external resources. The RBFS components are location specific and based in the farmer choice and resource available with the farmer. The common components of RFBS in the plains of Tripura are rice, fish, livestock (cow, buffalo, goat), poultry, fruits, vegetables and plantation crops. Soil and water conservation

measures and composting are the integral part of RBFS (Fig 1). There is much to be learned from the indigenous knowledge systems of the people. The traditional agricultural practices evolved by the farmers to meet their needs over centuries and performing well even today without any ecological degradation. The need of the hour is to document such practices for their characterization and possible dissemination with scientific validation, refinement and necessary improvement [1]. Various resource conservation practices such as conservation

agriculture, system of rice intensification, integrated crop management, direct seeding, inclusion of legumes etc. have been recommended for enhancing productivity and sustainability of traditional RBFS [2,3].

The objective of the present study is documentation of the strength, and weakness of existing practices followed by the farmers practices in RBFS and suggest possible measures for sustaining food security and livelihood of farmers.

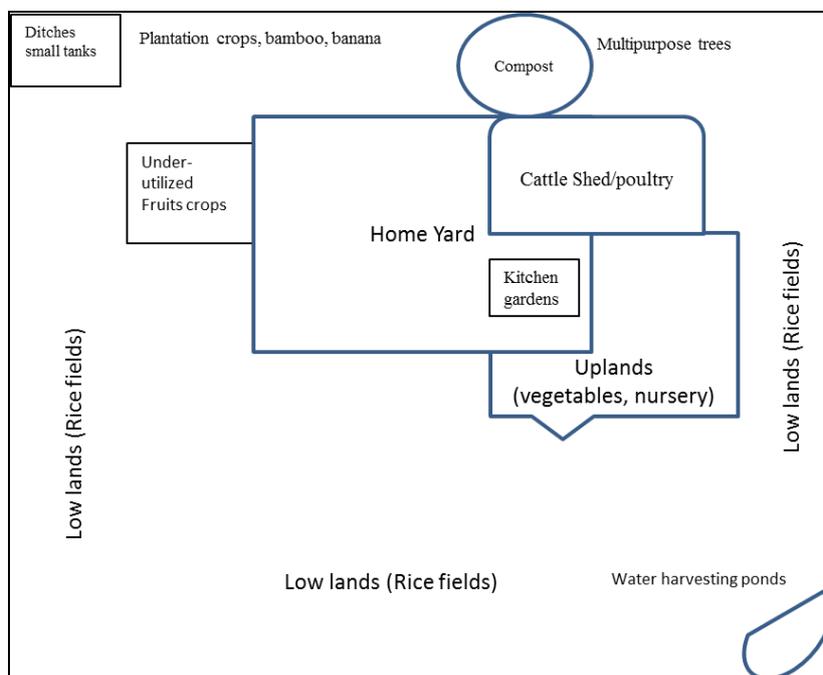


Figure 1. The components of RBFS and their interrelationship in farmers' field

## 2. Methodology

The north-eastern state of Tripura lies between 21.56° and 24.32°N latitude and 91.09° and 92.20°E longitude. Most of soil of the state is acidic to highly acidic in reaction, high in organic matter content, medium in nitrogen, low to medium in available phosphorus and medium to high in available potassium. Soils are red lateritic to sandy clay loam. Average annual rainfall is 2200 mm of which about 65% received during monsoon (June to October). The daily mean maximum and minimum temperature during summer (April to July) are 33°C and 23°C, and that of winter (November to February) are 27°C and 11°C, respectively. The cold weather starts from the end of November when the temperature of both day and night decreases steadily. January is the coldest month when mean daily minimum temperature is about 8.9°C and maximum temperature is 25.2°C. The average rice productivity of the state is 2607 kg/ha which is much higher than the National average and the average rice productivity of North East India [4]. Extensive field visits were made in two Districts of Tripura i.e., Dhalai and North Tripura to collect primary information related to RBFS. Periodic visits were made under National Agricultural Innovation Project (NAIP-3) and Institute programmes to different sites. Simple questionnaire and participatory rural appraisal (PRA) tools were used to

collect the information. Crop cutting methods were used to estimate the crop yield. Photographs of important activities were taken from farmers' field to characterize the systems. Farmers were asked questions on rice cultivation practices, type of crop/livestocks/fish grown, nutrient recycling, water management, integration of components, pest and disease management, strength and weakness of existing farming systems etc. About 300 farmers from 15 villages in two Districts were interacted during 2008-2012 for collecting information related to RBFS. Finally, available literatures were reviewed to fine tune the results and give explanations for the activities of RBFS. Based on the results obtained from the present study and need for enhancing the productivity to feed the burgeoning population a strategy was suggested by blending indigenous knowledge with improved agro-techniques for sustainable RBFS in the region.

## 3. Results and Discussions

### 3.1. Socio Cultural Aspects Of Rice

Rice has been associated in folklore of different ethnic groups in Tripura and rice has interwoven itself into the very fabric of the people. The brown rice is locally called *dhan*, milled rice *chaul* and cooked rice is called *bhat* by the local people. The region has rich tradition of rice culture. The knowledge is just passed onto the next

generations. The people of the state are rich in traditional knowledge and usage of rice for different purposes including food, feed, cosmetics, rituals etc. Various festivals are celebrated in and around the rice season. There are various folk dances, songs, tradition etc. are associated with each practice of rice cultivation such as first day of ploughing, transplanting, first and last day of harvesting, cooking the new rice for the first time etc. *Nabannaya* (harvest festival), *Pous Sankranti*, *Makar Sankranti*, *Laxmi puja*, *Kharchi puja*, *Ambabochi* etc. are few important examples of festivals and rituals related to rice. An account of various festivals, rituals and literatures related to rice and rice seasons have been described by another researcher [5].

### 3.2. Rice Biodiversity

There is wide diversity of rice such as sticky, aromatic, glutinous, scented, colored, short, long etc. and each one is having a particular use. The genetic diversity and associated population structure of 6,984 rice accessions (conserved in National Bureau of Plant Genetic Resources, New Delhi, India), originating from North Eastern region of India including 226 from Tripura were assessed [6]. The northeastern state of Tripura has immense wealth of aromatic rice. About 10 cultivars were found to possess aroma in Tripura. Most of the rice germplasm of the region are rich in protein, ash [7], carbohydrate and fat [8] content. Some of the important local rice varieties of Tripura are *kalikhasa*, *khassa*, *harinarayan*, *binni* [9]. There are some local rice cultivars tall in habit, having more biomass production ability and used as fodder for cattle by the farmers. Local rice cultivars (*Aman*, *Binni*, *Halpani* etc.) and improve cultivars (Swarna masuri, Ranjit, Naveen, Gomati, Pooja etc.) are grown by the farmers.

### 3.3. Multiple Uses of Rice and Rice Ecosystems

Rice is the major staple food of the people of eastern and north eastern part of India. Almost all social and cultural activities are directly or indirectly related to rice, rice landscapes and rice season. Entire livelihood is dependent on RBFS and there are strong inter linkages of various components (Fig 1). A good rice crop brings smile to the family and locality and a poor crop brings misery and makes farmers debt ridden. Each and every part of rice plant is having economic and social significance. Rice has many uses medicinal, food, feed, cosmetics, rituals etc. [8]. Grain is the staple food for human, husk, and bran as livestock feeds, straw is used in thatching the rural huts, bedding materials for livestock and mainly as fodder for cattle during dry season. Straw is also used as fuel in cooking and as binding materials for mud plastering of houses and so on. Practically rice and rice products are the main food items during breakfast, lunch as well as dinner. Needless to say that majority of the population takes three meals of rice a day. Pooped rice (*Khoi*), puffed rice (*Muri*), flattened rice (*Chira*), dry fried uncooked rice (*koroi*) etc. are the major life supporting food items of the people. The leftover cooked rice of previous night is mixed with normal water and kept as such overnight for fermenting (locally called *pantha bhat*). The next day morning, rice (*bhat*) is removed from water and mixed with lemon and

sugar and taken by the farmers in the early dawn before proceeding for ploughing/other activities in the field. *Panta* means "soaked in water" and *bhat* means 'boiled rice'. This dish is also served with salt, onion and chili. It is especially popular in rural areas [10,11] served as a breakfast. A similar dish consumed in Orissa and Chattisgarh is known as *Pakhal*, *Pakhala* or *Pakhal Bhat*. In Assam, it is called *Poitabhat*, offering *Dudh Panta* (milk with stale water-soaked rice) is a part of the marital rituals [12]. This rice is rich in food values especially protein, iron and zinc [13]. Rice beer and delicious rice products (locally called *pitha*) during New Year and *Makar Shankranti* are other significant use of rice in the region. Rice ecosystem is also the major habitat for edible snails, eels, crabs, root crops, other water loving crops (lotus, colocasia, aloccasia) etc. that sustains the lives of thousands in the region including Tripura. Woman buy daily food items (pooped rice, parched rice, fermented fish, other edibles), domestic items (utensils, cloths), toys for children, etc. in exchange of rice grain from vendors.

### 3.4. Water Harvesting and Fish Culture

Art of water harvesting is the key to the success of indigenous RBFS 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. The pond (*pukur*), ditches (*khal*), trenches (*nala*) etc. may be in one corner, in one side or even in the middle of rice field. The dimension of water harvesting structures in rice field varies with the resources available with the farmers, the area to be irrigated etc. In rice field the area of pond may be as small as 25 m<sup>2</sup> to as big as 500 m<sup>2</sup>. It is again a common practice to have one or two ponds either at the front or any side of the home yard. These ponds are on an average 500 m<sup>2</sup> area. The pond depth ranges from 1.25 to 2 m with average depth of 1.5 m. The water harvested in ponds are used for life saving irrigation of fruits, vegetables etc. grown around rice fields or adjacent to home yards. A meal of 'rice with fish' is the most cherished food of the people of the region. 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. People of the state from their forefathers' days have been following some innovative fish catching techniques from rice fields (Plate 1) and small rivulets mostly passing through the rice fields. The running water is obstructed with bamboo and other locally available materials and some local made traps (*hufa/jhuti* etc.) are used and such practices are locally called *khati/rani*. The fish ponds are the farmers' bank, whenever they need cash for emergency, they sell them in the market and earn livelihood.



**Plate 1.** A typical rice landscape with livestock, trees, dry fodder etc. practiced by farmers of North Tripura Tripura

### 3.5. 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.



**Plate 2.** Rice + fish + duck farming followed by farmers of Tripura (Dhalai)

### 3.6. Livestock Component and Composting

It is an added advantage that all the farmers' rear livestock (Plate 2 & Plate 3) like local breeds of cows (2-3 Nos), goats (3-4 Nos.) and ducks (5-8 Nos). Some farmers keep buffalo (1-2 nos), poultry (4-5 nos), ducks (4-5 Nos), pigeon etc. All these 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.), they sell them in the market and earn livelihood. 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 maintains an earthen compost pits in the corner of the home yards where the animal dung, along with bedding materials, litters, kitchen wastes etc. are deposited and composted. Such composts are mostly used for cultivating vegetables to get higher return.



**Plate 3.** Rice + pond+ fruits (mango) + arecanut

### 3.7. Vegetables- Integral part of RBFS

Vegetables like colocasia, okra, amaranthus, brinjal, cucurbits, etc. are grown in *charra lands* (medium upland) adjacent to rice fields during rainy season and potato, sweet gourd, cole crops, leafy vegetables etc. are grown during winter season (about 15- 20 % of the land). Bottle gourd, lablab bean, sweet gourd etc. are grown on pond dyke (*pukur par*) and over the water bodies with support/stakes provided with locally available materials

like bamboo, tree branches (*Chang, Palo*) etc. On the other hand some farmers grow ash gourd, lablab bean, pumpkin, etc. near the main house, allow the vines to climb and spread over the roof (*chal*) of the house. 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.



**Plate 4.** A typical rice based farming system (rice + pond+ banana + areca-nut)

### 3.8. Fruits and Plantation Crops

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 (Plate 4). 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 (Rs.100/kg). Beside these major fruit/plantation crops, a number of indigenous life supporting fruit plants like ber (*Ziziphus mauritiana*), jamun (*Syzygium cumini*), golden apple (*Aegle marmelos*), amla (*Phyllanthus emblica*), amra (*Spondias dulcis*) and many other local minor fruits are grown around the home yard which provides nutrition to the farm families.

### 3.9. Nutrient Cycling in Traditional Rice Farming

The recycling of straw in the field (about 5 t/ha dry matter/ rice season) contributes about 31.5 kg N, 9.5 kg P<sub>2</sub>O<sub>5</sub> and 69 kg K<sub>2</sub>O/ha considering N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>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<sub>2</sub>O<sub>5</sub> and 37 kg K<sub>2</sub>O/ha considering N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>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<sub>2</sub>O<sub>5</sub> and 105 kg K<sub>2</sub>O/ha. High nutrient recycling potential of rice and rice based cropping systems has been reported [14]. Besides, it is a common practice to let leave livestock viz., cows, buffaloes, goats and sheeps 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 animal excreta may vary from 1 to 5 t/ha (average 2 t/ha) depending upon the location, type of animal grazed in the field and duration for which animal is allowed grazing in the field. The amount of N, P and K added through such 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. The urine of animals is collected in-situ in the field, which is very rich in nitrogen (0.40%) and potassium (1.35%) [15]. In present study the crop residue and weed biomass contribution from winter season (grazing period) is not considered. Thus, contribution from penning of cattle etc. is included in nutrient source estimation. The biological activities in natural soils are much higher than that of conventionally fertilized plots [14]. Again, depending upon the availability of organic manure, the framers traditionally apply FYM/Composts @ 5-10 t/ha (average 2.0 t/ha/annum) at least once in three years (Table 1). The average nutrient content in FYM/composts is about 0.75, 0.25 and 0.78%, N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O, respectively. Higher biological activities including beneficial bacteria, earthworms etc. are reported from soil managed through in-situ residue management compared to inorganically managed plots which helps in enhancing mineralization and nutrient availability to plants [14,16]. Interaction with the farmers revealed that local cultivars require less input and better adapted to the

specific agro-ecosystem, less prone to pest and diseases and therefore, provides some amount of resilience against changing climate.

**Table 1. Nutrient recycling in rice fields under Indigenous farming systems**

Particulars	Dry biomass recycled (t/ha)	N (kg/ha)	P <sub>2</sub> O <sub>5</sub> (kg/ha)	K <sub>2</sub> O/ha (kg/ha)
Rice straw	5±1.26	31.5±7.93	9.5±2.4	69±19.2
Weed biomass	3±0.62	45±9.3	5.7±1.2	36.6±7.6
Livestock penning	2±0.75	15±0.56	5±1.9	15±5.6
FYM/Compost	2±0.90	15±6.75	5±2.3	15.6±6.7

### 3.10. Productivity and Income of RBFS

The farmers in plains of Tripura harvest rice about 4.0 t/ha with minimal external inputs [1]. The fish productivity of about 750 to 1200 kg/ha is obtained with traditional practice. About 90% farmers have kitchen garden with average size of 75±25 m<sup>2</sup>. About 100 to 150 kg vegetables are harvested from kitchen gardens that includes leafy vegetables, cucurbits, beans etc. The role of kitchen garden as a component of farming system in providing nutrition and livelihood especially to the women has been reported [17]. Farmers harvest 5 to 7 banana bunches (50 - 75 kg) and 50 to 75 kg dry arecanut. The local cow gives about 1 to 3 litres of milk/day, some even go for goat's milk (poor man's cow) for their daily requirement. About Rs.30000 to 40,000/ha is obtained annually by the small and marginal farmers as gross income most of which is considered as net income as family labour is mostly used and very meager external inputs are procured. The important aspect of RBFS is the empowerment of children and women, where returns from small livestock and kitchen garden etc. goes mostly to women hand. The productivity of most of the vegetables are very good and on an average farmers harvest 10-12 t/ha fresh vegetables. The vegetables such as cabbage, cauliflower, lablab bean, potato, brinjal, colocasis, ridge gourd, bootle gourd, sweet gourd etc. provide much higher income than that of rice (data not presented). Due to favourable climatic conditions, good soil quality and rich knowledge base in managing RBFS, the farmers of the state and region are sustaining their livelihood on agriculture for centuries with almost negligible case of suicide or famine death which is almost a frequent news from some of the other states of the country and thus, showcasing the strength of the traditional farming systems.

### 3.11. Employment

The special feature of RBFS is the year round employment and engagement of farmer's family members in diversified farming activities. While up to 80% activities in rice fields are performed by men, women dose 70-80% activities in kitchen gardens, poultry farming etc. On an average 350 to 450 man-days are generated from each hectare of RBFS in terms of investment of family labor. Family absorption of 470 man-days [18] and 373 man-days [19] has been reported from different kinds of farming systems. Thus, RBFS provides opportunity and sustainable development of livelihood for the farmers.

### 3.12. Issues to be Addressed

With the increase in population pressure and decrease in per capita land holding (< 0.15 ha/capita), the pressure on land is increasing seriously [1]. In plains the farmers started applying fertilizer and chemicals and using high yielding varieties for enhancing productivity. The irony is that still the region is in deficit of about 1.40 million ton of rice, in spite of its rich natural resource base and potential in improving the productivity substantially. There is degradation of natural resources especially soil

and biodiversity due to intensive cultivation and less time left for developing soil resilience [20]. Climate change especially frequent drought is the major threat to the rice farmers. Less income from rice compared to other business avenues and involvement of more energy in terms of drudgery are the other areas of challenges. Though the local rice varieties requires less inputs with better adaptation to the specific agro-ecosystem but its yield are low. Thus, there is threat of sustaining the age old practice of sustaining RBFS in the state of Tripura in particular and region in general.

**Table 2. Practices followed in indigenous farming systems and suggested practices for sustainability**

Particulars	Indigenous practice	Suggested improved practice
Tillage practice	3 to 4 ploughing followed by leveling and planking mostly by bullock drawn ploughs.	1 or 2 primary tillage followed by leveling and planking is sufficient for a good crop of rice. Use of power tiller is a tested technology in the state for enhancing efficiency in rice cultivation.
Varieties/Breeds of crops/livestocks/fish	Low yielding local varieties/breeds of crops and livestock. Some farmers do grow high yielding varieties but seed replacement rate is negligible.	At least 50% of the farm should be brought under high yielding varieties/breeds for higher productivity and income. Seeds should be replaced once in every 3-year.
Nutrient management	Mostly cultivated under low level of fertilizer particularly N (urea) at 40-50 kg/ha. FYM applied once in 3-4 years. About 30% rice residues are recycled within the field. Fertilizer urea is sometime broadcasted even in the standing or running water condition in the field. The use of phosphate and potassium fertilizer is negligible.	Application of balance NPK at least 50% of crops requirement from chemical fertilizers+ FYM/Compost 5 t/ha every year is required for a good crop and sustaining soil health. Composting, green manuring etc. should be part of the farming system. Along with rice residue recycling, residues of other crops, vegetables and weeds should be recycled into the field. The water should be drained off before applying fertilizer for better results. Where ever possible legume should be included in the cropping system.
Water management	Rice is cultivated as rain-fed during <i>kharif</i> season. During <i>rabi</i> season irrigation is provided from harvested water or from the tube well. Continuous flooding is the prevalent practice.	Recently system of rice intensification (SRI) and integrated crop management (ICM) are getting momentum in the state and about 20% cultivated area is already under the practice. SRI, Direct seed rice and aerobic rice can save water and enhance productivity [3]. SRI and ICM require much less water and other inputs and gives 10-20% higher yields [2 Das et al., 2014]. Thus, these practices should be popularized among other farmers to save natural resources and increase food security.
Weed management	Only hand weeding (HW) is practiced	One HW + one/two cono-weeding is recommended for higher productivity and income. Herbicides may be used in places where labor is problem. Integrated weed management is the best option for rational management of weeds without deteriorating ecosystems.
Pest/Disease management	Indigenous technical knowledge (ITK) like use of Eupatorium/Sal branches, ash etc. are commonly practiced. Use of pesticide is only limited to few advance pockets and as a last measure.	Along with ITKs, pesticides like neem oil, neem cakes, entomopathogenic fungus and other biological means should be used. Need based use of synthetic pesticides is required to get optimum productivity and income. Integrated pest and disease management is recommended for higher productivity and income.
Cropping systems	Rice mono-cropping or rice-rice system is prevalent in lowlands.	Rice should be rotated with pulses/oilseeds especially leguminous crops to break pest/disease cycles and build soil fertility wherever possible. Lentil, pea and rapeseed are the potential crops for rice fallow in the region [22].
Livestock/fish management	Only local breeds/species are cultivated. Local grasses, household waste etc. are provided as feed and hence low productivity and income.	High yielding breeds of livestock/fishes along with good quality fodder, concentrates etc. should be used for feeding. Composite fish culture utilizes water column effectively, hence recommended for higher productivity and income. Liming, FYM application should be part of fish farming for higher pond productivity [23]. At least 5% of farm area may be given for fodder production like oats, congo-signals, stylosanthes, guinea etc.
Integration	Although almost all crop/livestock components are managed by the farmers, there is very limited integration among components. E.g. livestock shed is generally within home-yard instead of pond dykes. The liquid portion of the animal excreta is not utilized.	There should be effective recycling of resources and waste of one unit should serve as input for other enterprise to harness the complementarities of crop-livestock-fish-tree interactions. Pond silt is rich in essential nutrients and must be recycled in crop fields once in every 2-3 years to improve soil quality. Livestocks shed should be established beside the pond dykes instead of home-yard to utilize the liquid portion of the animal excreta (24).

### 3.13. Strategies for Sustainability of RBFS for Food Security and Livelihood

To sustain RBFS 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 (Table 2). Considering such needs, large scale farmers participatory technology demonstrations have to be undertaken improving RBFS with the intervention of appropriate new technologies in all the northeastern states for improving livelihood of the farmers. An account of traditional and improved farming systems in the context of agro-climatic conditions of Tripura have been described [21].

## 4. Conclusions

The RBFS of Tripura is a time tested farming practice for resource conservation, optimum productivity and sustainable income. Almost all components of farming like crops, vegetables, fruits, livestock, fish etc. are practiced by the farmers in a mixed manner keeping rice cultivation as the central activity. There is year round employment due to diversified farming activities. However, due to cultivation of low yielding local varieties/breeds there is low productivity and income which use to be sustainable when the population pressure was low and farmers had sufficient land. With the increase in population and reduction in land holding, there is need for enhancing the productivity of traditional RBFS. Adoption of high yielding varieties/breeds of crops/livestocks along with efficient use of on-farm resources and integrated resource management are the needs of the hours to sustain the productivity, soil health and enhance the carrying capacity of the ecosystem.

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