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Traditional farming knowledge on agroecosystem conservation in Northeast coastal Tamil Nadu

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Traditional farming knowledge on agroecosystem management promoted the low cost sustainable development in ecosystems through optimal use of natural resources. It protects and conserves ecological systems, and improving economic efficiency of the farming community. The coastal agroecosystem of Parangipettai (Portonovo) in Northeastern coastal Tamil Nadu is a typical agrisilvicultural zone with an effective traditional farming knowledge. A wider range of indigenous methods like rainwater harvesting, soil and water conservation are in practice now to cultivate annual and perennial crops. These methods are ecofriendly, cost effective and utilization of human knowledge to conserve the local environment, enhancing the use of locally available inputs and are useful to uplift the economic growth of the rural people.

Keywords: Traditional farming, Farm ponds, Mulching, Penning, Tamil Nadu

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Traditional ecological knowledge is vital for sustainability of natural resources and agroecosystems. It comprises of a component of local knowledge of species, environmental phenomenon, beliefs and practice in the way people carry out activities related to resource use with in the ecosystems[1-3]. Interest in traditional ecological knowledge has been growing in recent years, particularly due to recognition that such knowledge can potentially contribute to biodiversity conservation, maintenance of sustainable resources and strategies[4]. Traditional knowledge and practices have their own importance as they have stood the test of time and have proved to be efficacious to the local people and forms the basis for their link with nature, and the varied levels refinement depend on the level at which the society finds itself in the social evolutionary basis[5,6]. Some of the traditional technologies offer promising entry points for developing packages on community based agroecosystem resource management technologies. While these changes in the strategy would result in better implementation of these programmes, the participation of local communities may also lead to greater use of traditional practices. The rediscovery of traditional ecological knowledge as adaptive management and need to apply human ecological and adaptive strategies for natural resource management offers prospects for scientists to address the problems that beset conservation biologists and restoration ecologists[7,8]. Traditional knowledge documentation provides tools for networking, storing, visualizing, and analyzing information, as well as projecting long term trends so that efficient solutions to complex problems can be obtained[9]. It is, therefore, necessary to document such knowledgebase through a properly designed research programme and to analyze their economic, technological and socio-cultural sustainability for optimization of their use.

The agroecosystem of Parangipettai region (historically known as Portonovo) in Cuddalore district of Tamil Nadu covering an area of 160 sq km lies between 11°22′ to 11°32′ N latitude and 79°45′ to 79°48′ E longitude with 6.12 m above Mean Sea Level (Fig. 1). Several major types of ecosystems such as lowland ecosystems, silviagricultural systems, rain fed farming, back water bodies, saline patches, sandy beaches, etc. are evident in this region. The majority of farms in the area are small and medium sized[10]. Around 68% of farmers can be categorized as small holders, with an average land holding is less than 2 ha of which less than one hectare is irrigated

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and the rest areas are practiced rain fed agriculture[10]. From socio-cultural point of view, Parankipettai region (Portonovo) exhibits immense ethnic diversity. Agriculture, animal husbandry and aquaculture are major income sources for the local community.

An agroecosystem is a change from a less manipulated, more or less undisturbed natural system to a carefully managed, controlled and manipulated system designed to maximize food production[11]. Agroecosystems are sustainable to the extant humans make them. Agriculture is the main occupation and about 71% of the total population depends on agriculture for their livelihood. Historically, agricultural development in this region involved two distinct pathways, viz. growing monocultural food crops and establishing tree based crop production systems on arable lands. Sustainable production of these ecosystems depends largely on nutrients input to the soil from biological sources. Rain fed and irrigated rice (*Oryza sativa* L.), maize (*Zea mays* L.), finger millet (*Eleusine coracana* (L.) Gaertn.), sorghum (*Sorghum bicolor* (L.) Moench), cumbu (*Pennisetum glaucum* (L.) R. Br.), black gram (*Vigna mungo* (L.) Hepper.) and greengram (*Vigna radiate* (L.) R. Wilcz.) are the major food crops. Important oil seed crops grown are groundnut (*Arachis hypogeae* L.) and sesame (*Sesamum indicum* L.). Horticultural crops such as watermelon (*Citrullus lanatus* (Thunb.) Matsun & Nakai.), *bhendi* (*Abelmoschus esculentus* L. Moench), chillies (*Capsicum annuum* L.), brinjal (*Solanum melongena* L.), snake gourd (*Trichosanthes cucumerina* L.), bitter gourd (*Momordica charantia* L.), etc. are cultivated in some pockets. *Casuarina equisetifolia* L., *Anacardium occidentale* L. and *Eucalyptus tereticornis* Sm. are the important tree crops (47%) grown in this area. The traditional systems of cultivation practices are well adapted in this region and the traditional knowledge of local communities growing silvicultural and other agricultural crops coupled with conservation practices have enabled them to maintain an ecological balance of this location.

Methodology

The study conducted during 2004-06 was carried out to document the various traditional farming methods practiced by the farming communities in the rural areas of Parangipettai (Portonovo) coastal agroecosystem. Information on traditional farming methods was obtained from interviews using structured questionnaires with the farming communities who have been living in the place for more than 30 yrs. From the study area, six villages were selected randomly and a total of 90 farm households were selected by using a random sampling method. The interviews were conducted individually as well as in groups with the respondents. However, while interviewing in the groups, participant observation method was also employed to observe the farmer's perceptions and recording the knowledge on agroecosystem conservation. Several visits in the rural areas were conducted to collect the information and verification of these practices.

Results and discussion

Traditional soil and water conservation techniques

Soil is one of the most important natural resources that perform many functions essential for maintenance of ecosystem. It serves the substrate that supporting plant growth, acts as a reservoir of many nutrients, as a storage and purification medium for water as it passes through the soil profile, and as a biological reaction completing the cycle of life through decomposition and recycle of organic materials. The soil conservation techniques improved the productivity of crops as well as maintain soil fertility status and protect the agroecosystem environment from degradation[12]. In most of the agricultural fields, soil and water is conserved through traditional methods such as by using crop residue mulching, summer ploughing followed by leaf litter mulching, growing vegetative barriers, crop rotation and relay cropping.

Crop residue mulching

Application of crop residues on field surface is an age old practice followed by most of the farmers (Fig. 2). Farmers left considerable portion of crop parts in field just after harvesting the crops. Left over residue ploughed back into the system which released significant amount of nutrients and ultimately reutilized by the subsequent crops. 34% of the respondents adopted the above practice to conserve moisture. In this practice, after threshing and collecting seeds of sesame crop, the stalks are spread on the soil surface till next crops are grown and the stalks of the rest of the crops such as paddy, groundnut, sorghum and pulses are fed to ruminants as fodder. This act as barriers for reduces runoff, soil loss and conserves soil moisture. It also improves soil structure and fertility status of the soil through decomposition of mulches during the following rainy season without any harmful effects on the succeeding crops. The farmers opined that this practice is cost effective and technically feasible. Maintenance of harvest residue mulching can maintain soil moisture and water use efficiency by increasing water infiltration and cooling the soil surface to a greater degree than tillage[13] and to prevent erosion of fertile topsoil[14].

Summer ploughing followed by leaf litter mulching

Sixty two per cent of the farmers in this region have adopted off-season ploughing followed by leaf litter mulching practices, in order to check the runoff, soil erosion and conserve soil. The farmers practiced summer ploughing after receiving the sufficient rain during summer months by using animal drawn mould bold plough and the entire land is then covered with locally available *Anacardium occidentale* L. and *Casuarina equisetifolia* L. leaf litter. As soon as it rains, the mulch helps to conserve moisture, reduces soil crusting and suppresses the weed growth. Farmers claim that there is no surface runoff is observed from properly mulched fields. Leaf litter mulching helps the farmers to take minimal intercultural operations and the better growth of crops in the field indicates that the crops have the capacity to take up water and nutrients from the soil are increased. The weed suppression could be ascribed to allelopathic interference due to the decaying leaves and litter of the tree which accumulate on the ground and release phytotoxic phenolics[15,16]. The mulched leaves of *Anacardium occidentale* L. form a matrix on the land and release phytotoxins through leaching or decomposition since the leaves and decaying litter may be phytotoxic in nature. Scientists have emphasized that in the agroforestry systems, allelopathy is one of the major determining factors in tree-crop-soil interactions and plays an important role in influencing both the negative effects and the positive benefits in the annual cropping system[17-19]. However, little emphasis has been given to the aspects of allelopathic compounds released by *Anacardium occidentale* L. such as alkaloids and other chemicals helping in weed suppression.

Growing vegetative barriers

Value of traditional agroecosystems in supporting the plant diversity is colossal and the vegetation diversity in these ecosystems is often the product of interaction of local and formal knowledge[20]. Growing vegetative barriers around farmlands is one of the important traditional technologies in this coastal agroecosystem. This consists of a group of trees and shrubs, which are very closely planted, and they work as a protective mechanism against wind and sand movement during summer season. This indigenous traditional practice is followed by most categories of farmers, who grow *Borassus flabellifer* L., *Commiphora caudata* (Wight & Arn.) Engl., *Casuarina equisetifolia* L., *Delonix elata* (L.) Gamble, *Glyricidia sepium* (Jacq.) Walp., *Jatropha curcus* L., *Lannea coromandelica* (Houtt.) Merril, *Leucaena leucocephala* (Lam.) de Wit., *Thespesia populnea* (L.) Soland. ex Correa and *Vitex negundo* L. on their farm bunds and around the farm ponds at very closer spacing. The selection criteria of the above species considerably vary and mostly based on its popularity, stress tolerant capacity, capable of coppice, and meet their fuel and fodder requirements especially during the off seasons. The farmers opined that this practice highly reduced the movement of sand particles from one place to another, reduce surface runoff, increase infiltration and reduce siltation in farm ponds. The green leaves of *Gliricidia sepium* (Jacq.) Walp., *Leucaena leucocephala* (Lam.) de Wit. and *Thespesia populnea* (L.) Soland. ex Correa are used as fodder for animals and green leaf manure to fertilize their fields. It is well-known that improvements in soil structure occur when tree biomass is incorporated into the soil. Closely spaced trees also reduce soil erosion by acting as a multi-layer defense mechanism against the impact of falling rain drops/protection against wind erosion, and increasing the infiltration capacity[21]. Such systems often promote the landscape heterogeneity through augmented growth of crops, trees and other vegetation, which in turn supports the biodiversity. Stability of agroecosystems can be optimized through the implementation of appropriate habitat management[22].

Crop rotation and relay cropping

The use of crop rotation helps to increase soil fertility, reduce erosion and bring biological diversity back to the soil. The rotation of different crops such as cereals, millets, oil seeds, pulses and woody perennials, with their ability to addition of organic matter, nitrogen fixation and optimizes the network of root channels in the soil leading to increased water penetration to deeper soil depths. Sowing of black gram and green gram seeds on clay and clay loam soils at about one week prior to harvest of irrigated or lowland paddy is common traditional practice to utilize moisture and shade to achieve better germination and growth of succeeding crop. The above practice (relay cropping) of sowing pulse seeds reduce the cost and time for field preparation, effectively used the residual moisture in the paddy field and the prevailing microclimate of the standing paddy crop helps the successful germination of pulse seeds. Manual harvesting of paddy crop do not affect the germinated crop seeds. In India, local practice of vegetation management perhaps emanate from the basic ecological concepts of local communities reflected in ecosystem like concepts in traditional societies[23]. The better use of crop rotations providing nutrients, disease and weed break for the subsequent crop is an important agronomic management tool for crop management[24]. Broad crop rotations within farmland maintain greater species diversity, soil macrofauna and soil microfauna leads to sustainable ecological balance of the ecosystem[25].

Growing trees on field bunds

The agroforestry systems are characterized by high levels of on-site nutrient conservation. Growing of trees such as *Azardirachta indica* A. Juss., *Lannea coromandalica* (Houtt.) Merr., *Leucaena leucocephala* (Lam.) de Wit and *Thespesia populnea* (L.) Soland. ex Correa on field bunds is a regular practice in this region (Fig. 9). This practice helps to optimize the supply of green leaf manure thereby improving the nutrient availability, providing stress resistance against soil moisture, reduced the intensity of soil born diseases particularly wilt caused by *Fusarium oxysporum* Schlecht. emend. Snyd. & Hans in vegetables and root rot caused by *Macrophomina phaseolina* (Tassi) Goid. in rice fallow pulses and improvement in rhizosphere environment favorable for plant growth. Trees on field bunds act as a habitat for birds and honeybees. The birds involved in biological control of insects and honeybees act as natural pollinator and improved the seed set of cultivated crops. The return of considerable quantities of organic matter and nutrients in to the agroecosystem soils either naturally through litterfall and root turnover, or deliberately through pruning[26]. For instance, the deep-reaching tree roots mobilize nutrients from zones far below the ground level for use by the field crops growing in association (nutrient pumping). In certain cases, the proximity of trees to one another increases subsoil-nutrient recovery and horizontal transfer/sharing of nutrient ions between the rhizospheres of the neighbouring plants are probable through release, leaching, and/or exudation of mineral and organic materials[27]. Therefore, this practice is considered a key component to achieve sustainable crop production and has an important role to play for biodiversity conservation and sustainability.

Growing cover crops and green manuring

In *situ* growing of legumes such as *Sesbania rostrata* Bremek. & Oberm., *Sesbania aculeata* L. *Crotalaria juncea* L. and *Theprosia purpurea* (L.) Pers. MOSS. conserve the soil and improved fertility status of the soil through fixation of atmospheric nitrogen with the help of associated microorganisms like *Rhizobium*. Incorporation of these species before flowering (50–60 days after sowing) provide a substantial amount of green leaf material and can decompose easily in the soil. Growing cover crops during off seasons tends to conserve soil even if some minerals are carried away in the removal of crops[28]. Applying green leaf manures 15-20 days before planting of paddy is another traditional method for improving the fertility status of the soil. Under this practice, green leaves and twigs are collected from the near by areas and incorporated into the soil to enrich soil fertility.

Animal penning

Penning is an important traditional practice and more than 57% of farmers follow the practice at least once in 2 yrs. This practice involves camping of cattle, sheep, duck, etc. in the crop fields over night or days of nights after the crop harvest. The farmers prioritize the use of penning with in the land patches with their production potential (Fig. 8). The paddy, groundnut and vegetables get priority for manuring as they assure food supply and enhancing farm household income. For penning, the shepherds pool their animals into a flock that numbers about 250-1,000 sheep or 500–750 ducks. Farmers who want to fertilize their lands make arrangements with the shepherds to pen the flock overnight on their land. During day time, the animals are carried to surrounding fields for grazing. The location of the penning is changed every day. This practice helps to uniform distribution of manures and prevent from disease infestation. Normally, penning is performed for 7–15 days depending on the number of animals and when excreta deposition on the fields is considered adequate, then the camp shift to other places. In general 3,500 to 4,000 sheep's per ha are utilized to fertilize the lands. This traditional practice still provides a valuable source of manure for maintaining the fertility status of soil and reduced the cost of production of cultivated crops.

Sheep night penning combined with grazing is often used for weed control. Large increases in soil fertility from the addition of sheep excreta led to the removal of the weed population, in accordance with the ecological theory of disturbance and evolution[29]. Penning for eight consecutive nights was shown to be most efficient for elimination of natural vegetation and succeeding pasture establishment in the rainy season[30]. After penning nights, the ground was completely covered with sheep excreta and the native herbaceous weed species were completely removed. A high concentration of nitrogen in fresh sheep excreta could have been a major contributor to the vegetation change. The concentrations of ammonium N and nitrite N in the soil were high enough to be toxic to plant roots during and after sheep night penning. The loss of nitrogen occurred immediately following urine application to soil, this pulse of denitrification being attributed to the large increase in soil water soluble carbon levels and decreased O_2 status that were not conducive, and sometimes even toxic to plants[31]. The accumulation of nitrite N in soil is toxic to plants, even if the accumulation is short-term[32,33]. Inorganic nitrogen in sheep urine and dung hydrolyzed into ammonium N quickly on rainy days. Hence the high soil N levels apparently did not affect the establishment of succeeding crops. The nutrient loss is reduced through improving livestock systems with corralling and controlled grazing in favorable conditions that allow direct recycling of manure[34].

Traditional water harvesting systems

Revival of local rainwater harvesting globally could provide considerable amounts of water for nature and society (Fig. 6). Over many decades societies have developed a diversity of local water harvesting and management regimes that still continue to survive[35]. Such systems are often integrated with agricultural and agroforestry practices[36].

Farm ponds

The farm ponds are traditionally the backbone of agricultural production in coastal agroecosystem of Parangipettai region (Fig. 3). Throughout the area, ponds have been the mainstay of rural communities for centuries. This region has around 426 structures with an irrigation potential of 500-750 ha. Each and every farmer had dig saucer shaped pond to a depth of 3-5 m based on its water yield potential and either the low lying area or in their middle of the field and collect run off water with only nominal maintenance expenses (Fig. 4). Water availability from ponds would range from two months to a year after the rains. One such pond is sufficient to irrigate 1-2 acres of crop fields (groundnut, brinjal, jasmine and *Casuarina*) and they meet more than 75% of the water needs of the crop cultivation in that locality and are an important source of water for livestock during off-season. Based on farmer's opinion, an appreciable amount of water collects over a period of time reduces the salinity level of ground water. In most cases, farmers did the desilting and deepening their pond bed process every year before the onset of monsoon and silt is used to fertilize their fields (Fig. 7). Rainwater harvesting have been found to be scientific and useful for rain fed areas[37]. The small water storage ponds make far more sense as they are less expensive and can be controlled by the local people[38].

Water management practices

Water management is the most important factor permits the successful crop production and ecosystem development. Irrigation practices in agriculture provide suitable moisture environment to the crops to obtain optimum and sustained crop yields with maximum economy in the use of water as input[39]. Due to the sandy nature of the soil the water holding capacity is poor therefore the irrigation practices begins at the time of land preparation to the harvest of the crop.

Monitoring soil moisture for rain fed crop cultivation

In the rain fed agro-ecosystem, rainfall is the only source to replenish the soil moisture. The effective rainwater harvesting is enough available to produce a good crop, if the water is used effectively. The most farmers will have to make an estimation of soil water content based on the feel and appearance of their soil. The farmers find out how much available soil water is present before sowing the crop. This can help in making a wise decision about which crop to plant. If the monsoon seemed to be not promising at the sowing time, farmers would plant high quality drought tolerant crops, usually finger millet or sorghum or sesame, under pond irrigation. If the season looked good, they would go far paddy and groundnut cultivation. During the monsoon deficit years the crops that needed more water were discouraged and replaced with perennial trees and or local drought resistant short duration crops like cumbu, ragi, sorghum and sesame.

Pond fed irrigation system

Traditionally, the small farmers carry water in pots during summer to irrigate their perennial tree crops and horticultural crops. The farm owners fix schedule of irrigation depending upon the nature of crops, season and availability of water. The shallow ponds are dugout near by cropped area and are used for irrigating their crop fields. The depth of the pond depends on the water table and when the water availability is considered to be inadequate a new pond is dugout at nearby another area. In this system, water is carried out with the help of narrow mouth mud pots with the capacity of 10-15 L. One pot of water is enough to irrigate 1.5-3.0 sq m area or 5-7 plants. *Casuarina* nurseries and vegetable crops are irrigated with the help of pond fed irrigation system (Fig. 5). This shows irrigation experience of farmers develops a wealth of knowledge about irrigation requirements for local soils and crops.

Nursery techniques for rising tree seedlings and tree planting

In Swamyarpet village of Parangipettai region, 81% farmers commercially produced casuarina seedlings and supplied to the other areas throughout the year. Raised and sunken bed methods are used to raising *Casuraina equisetifolia* L. seedlings. Nursery bed preparation depends upon the choice of the nursery owner and the climatic condition of the locality. The farmer wish to raise seedlings during rainy season raised bed is followed to avoid water stagnation and during summer sunken bed is followed to facilitate the maintenance of moisture for longer period. For the formation of raised beds, farmers raise the ground level to 15-20 cm height by filling with the mixture of sand, rhizosphere soil of *Casuarina* and pond silt in 1:1:1 ratio with the width of 1 m and convenient length. The sunken beds are prepared by deepening ground level to the depth of 10-25 cm and refill the bed with nursery mixture to a level of 5-10 cm. The farmers do not use farmyard manure or chemical fertilizers in nursery preparation to prevent the weed infestation and protect the seedlings from scorching effect. The pond silt is used to fertilize the nursery; this method was observed to use above 92% of the respondents. The farm pond silt contains high amount of organic matter and nutrients and is enough to supply the nutrients for the growth of young seedlings. The seeds @ 750 gm bed^{-1} (10 sq m) were broadcast on the bed. A thin layer of sand is spread over the seed to avoid exposure of seeds and spread a layer of casuarina needles or locally available similar materials on the top of the bed up to 10 days to avoid displacement of seeds while watering and also to provide shade. Life saving pot watering is given to the seedlings in the morning and evening daily for the initial 30-40 days afterwards watering was done every morning. The seedlings are ready for transplanting in 120 days and naked seedlings (seedlings without root ball) are used for planting in main field.

During *Casuarina* tree planting the pit size of 30 cm^3 were made with the help of spade and backfilled with mixture of 200 gm locally prepared vermicompost with castings (without sieved), crushed root nodules of *Casuarina* and dugout soil. No other manuring was done during planting. This practice substantially improved the growth and establishment of the seedlings. The eggs present in the vermicastings enhanced the population of earthworms in the rhizosphere soil and facilitates good aeration to the roots. Further *Frankia* in root nodules easily multiplied in the rhizosphere and involved in nitrogen fixation. Sustainable production of land depends largely on nitrogen input to the soil from biological sources. Improving *Casuarina* species for wood and biomass production as well as high capability for nitrogen fixation can be achieved by *Frankia* inoculation[40,41]. *Casuarina* can input a huge amount of nitrogen to the ecosystem through symbiotic nitrogen fixation process with filamentous soil bacteria (*Frankia*) and is comparable to that fixed by legumes[42].

Agroecosystem intensification

Most of the farmers follow mixed farming to minimize risk against total crop failure, in which animal husbandry is an important component. The farmers raise a small number of animals in their houses and allowed to graze on their farm. Buffalo and cattle are vitally important for their household consumption, manure, ploughing fields and sold when the family needs additional income. Crop animal systems in this region, where 75% of ruminants are found in the mixed farming systems are famous for agroecosystem intensification. In animals, the farmers prefer local breeds because they are well adapted to the local environment, highly resistant to diseases,

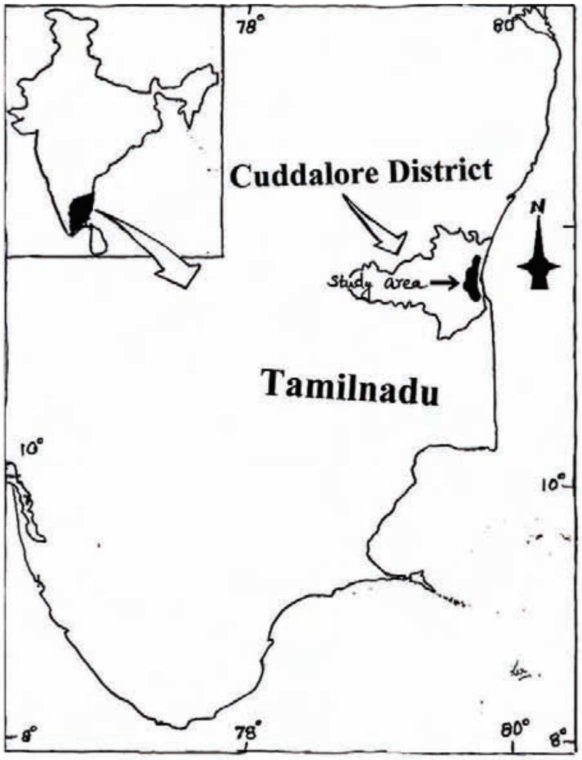

Fig.1 Map showing study area

Fig.2 Crop residue mulching

Fig.3 A farm pond in Parangipettai coastal agroecosystems

Fig.4 Pond bed deepening process

Fig.5 *Casuarina* seedling production

Fig.6 A pond used for potable water

Fig.7 Importance of pond silt

Fig.8 Sheep penning

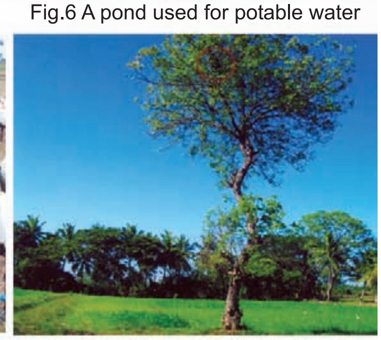

Fig.9 *A. indica* A. Juss. on field bund act as habitat for honey bees

cope with low quality feed and to the farmers management practices when compared to cross breeds. Crop animal systems are projected to see growth and remain the dominant system in India. Biodiversity in such mixed farming systems are vital for food production[43]. Increased productivity from livestock will be necessary in these systems to meet the increased demand for animal products, to alleviate poverty and to improve the livelihoods of resource poor farmers[44]. Integration of various systems enables better recycling and there by further utilization of available resources and provides short and medium term relief to poor and small land holders[45].

Conclusion

The farmers of Parangipettai agroecosystem have practiced different farming systems such as agroforestry, crop and animal husbandry, soil and water conservation strategies, etc. Crop production absolutely depends upon the input of locally available organic manure derived through penning and crop residues. The social acceptance of such technologies is highly positive but the ecological recognition has constraints sometimes due to the eradication of natural vegetation during penning and allelopathic effect of crop reside mulching. Management of traditional water resources are considered important in conservation and utilization of natural resources. Traditional knowledge systems and technologies have been found to contribute sustainability in diverse fields such as maintenance of ecosystems services viz., supply of food, fodder and fuel, ecological and biocultural restoration, sustainable water and fertility management, genetic resource conservation and management of other natural resources. Wide ranges of indigenous practices enhance the use of locally available inputs and support the economic growth of the rural people. Sharing of traditional knowledge may be helpful to protect the environment from degradation, sustained crop production, promote landscape heterogeneity and generate employment opportunities.

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References

1 Agrawal A, Indigenous and scientific knowledge: some critical comments, *Indigenous Know Dev Moni*, 3 (3) (1995) 3-6.

2 Brodt SB, A systems perspective on the conservation and erosion of indigenous agricultural knowledge in central India, *Human Ecol*, 29 (2001) 99-120.

3 Cavalcanti C, Economic thinking, traditional ecological knowledge and ethnoeconomics, *Curr Socio*, 50 (2002) 39-55.

4 Girigan G, Anil Kumar N & Arivudai Nambi V, *Vayals*: A traditional classification of agricultural landscapes, *Low Ext Input Sus Agri*, 6 (4) (2004) 27-28.

5 Ramakrishnan PS, Linking natural resource management with sustainable development of traditional mountain societies, *Trop Ecol*, 44 (1) (2003) 54.

6 Colding J, Folke C & Elmqvist T, Social institution in ecosystem management and biodiversity conservation, *Trop Ecol*, 44 (1) (2003) 41.

7 Berkes F, Colding J & Folke C, Rediscovery of traditional ecological knowledge as adaptive management, *Ecol Appl*, 10 (2000) 1251-1262.

8 Bates DG, *Human Adaptive Strategies: Ecology, Culture, and Politics*, (Allyn & Bacon), 2000, 238.

9 Pandey DN, Cultural resources for conservation science, *Conserv Biol*, 16 (2002) 912-914.

10 Anonymous, *Details of Hamlets*, Parangipettai Block, (Govt of Tamil Nadu, India), 2005.

11 Eswaran H, Beinroth F & Reich, Global land resources and population supporting capacity, *Am J Alternative Agric*, 14 (1999) 129-136.

12 Hazra CR, Soil and water conservation for natural resource regeneration in agroforestry, *Range Manage Agrofor*, 15 (1994) 239.

13 Hatfield JL, Sauer TJ & Krueger JH, Managing soils to achieve greater water use efficiency: A review, *Agron J*, 93 (2001) 271-280.

14 Schlecht E, Buerkert A, Tielkes E & Bationo A, A critical analysis of challenges and opportunities for soil fertility restoration in Sudano-Sahelian West Africa, *Nut Cycl Agroecosys*, 76 (2006) 109-136.

15 Gonzalez L, Souto XC & Reigosa MJ, Allelopathic effects of *Acacia melanoxylon* R. Br. phyllodes during their decomposition, *For Ecol Mgmt*, 77 (1995) 53-63.

16 Kogel I & Zech W, The phenolic acid content of cashew leaves (*Anacardium occidentale* L.) and of the associated humus layer, Senegal, *Geoderma*, 35 (1985) 119-121.

17 Rao MR, Nair PKR & Ong CK, Biophysical interactions in tropical agroforestry systems, *Agrofor Syst*, 38 (1998) 3-50.

18 Singh HP, Batish DR & Kohli RK, Allelopathic effect of *Leucaena leucocephala* on *Zea mays*, *J Trop For Sci*, 11 (1999) 801-808.

19 Bhatt B P & Todaria N P, Studies on allelopathic effects of some tree crops of Garhwal Himalayas, *Agrofor Syst*, 12 (1990) 251-255.

20 Shastri CM, Bhat DM, Nagaraja BC, Murali KS & Ravindranath NH, Tree species diversity in a village ecosystem in Uttara Kannada district in Western Ghats, Karnataka, *Cur Sci*, 82 (2002) 1080-1084.

21 Kumar BM, Agroforestry: the new old paradigm for Asian food security, *J Trop Agric*, 44 (1-2) (2006) 1-14,

22 Altieri MA, Ponti L & Nicholls C, Enhanced pest management through soil health: toward a belowground habitat management strategy, *Biodynamics*, 18 (2005) 33-40.

23 Berkes F, Kislalioglu M, Folke C & Gadgil M, Exploring the basic ecological unit: Ecosystem-like concepts in traditional societies, *Ecosystems,* 1 (1998) 409-415.

24 Turner C Neil, Agronomic options for improving rainfall use efficiency of crops in dryland farming systems, *J Exp Bot*, 55 (407) (2004) 2413-2425.

25 Gabriel D, Roschewitz I, Tscharntke T & Thies C, Beta diversity at different spatial scales: Plant communities in

organic and conventional agriculture, *Ecol Appl*, 16 (5) (2006) 2011-2021.

26 Jamaludheen V, & Kumar BM, Litter of nine multipurpose trees in Kerala, India: Variations in the amount, quality, decay rates and release of nutrients, *For Ecol Mgmt*, 115 (1999) 1-11.

27 Kumar SS, Kumar BM, Wahid PA, Kamalam NV & Fisher RF, Root competition for phosphorus between coconut, multipurpose trees and *kacholam* (*Kaempferia galanga*) in Kerala, India, *Agrofor Sys*, 46 (1999) 131-146.

28 Chinnamani S, Soil and water conservation in the hills of Western Ghats, *Soil Conserv Dig*, 5 (1977) 33.

29 Wang G, Wu MQ & Jiang WL, The study of weed ecology for sown pasture, the relationship between weed invasion and grazing intensity, *Acta Prataculturial Sinica*, 4 (1995) 23-25.

30 Jiang WL, Wa QR & Liu GY, Study on the effects of improving natural grassland with sheep night penning: Sheep night time, intensity and herbage mixture, *Acta Prataculturial Sinica*, 5 (1996) 17-25.

31 Monaghan RM & Barraclough D, Nitrous oxide and dinitrogen emissions from urine affected soil under controlled conditions, *Plant Soil*, 151 (1993) 127-128.

32 Lee RB, The effect of nitrite on root growth of barley and maize, *New Phyto*, 83 (1979) 615-622.

33 Schmitt MA, Sawyer JE & Hoeft RG, Incubation of injected liquid beef manures effect of time and manure rate, *Agron J*, 84 (1992) 224-228.

34 Shepherd M, Philipps L & Bhogal A, Manure management on organic farms: to compost or not to compost? The world grows organic, *Proc 13th IFOAM Sci Conf, Basel, Switzerland,* 2000, 50-53.

35 Agarwal A & Narain S, Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems, (Centre for Science and Environment, New Delhi), 1997.

36 Wagachchi HR & Wiersum KF, Water management in agroforestry systems: integrated buffalo ponds and forest gardens in Badulla district, Sri Lanka, *Agrofor Sys*, 35 (1997) 291-302.

37 Li F, Cook S, Geballe GT & Burch J WR, Rainwater harvesting agriculture: an integrated system for water management on rain fed land in China's semiarid areas, *Ambio*, 29 (2000) 477-483.

38 Maya S, Temple tanks–the ancient water harvesting system of Kerala and their multifarious roles, *Indian J Traditional Knowledge*, 2 (3) (2003) 224-229.

39 Anonymous, *Cashew based cropping system*, Annual Report All India Coordinated Res Project Cashew, (NRC Cashew, Puttur), 4-6 June, 2004.

40 Reddell P, Increasing productivity in planting of *Casuarina* by inoculation with *Frankia,* In: Advances in *Casuarina* Research and Utilization, edited by El-Lakany MH, Turnbull JW & Brewbaker JL, *Proc Second Inter-Casuarina Workshop,* (Desert Development Center, American University, Cairo, Egypt), 1990, 133-140.

41 Mansour SR, Zaied A & Dewedar A, Performance of two *Casuarina* species inoculated with pure culture of *Frankia* under field conditions, *Egypt J Microbiol,* 31 (2) (1996) 287-302.

42 Mansour SR, Improving wood and biomass production of some *Casuarina* species through symbiotic association in Egypt, *Nit Fix Tree News*, 6 (1) (2003) 1-7.

43 Devendra C, Crop-animal systems in Asia: future perspectives, *Agril Syst*, 71 (2002) 179-186.

44 Devendra C & Thomas D, Crop-animal systems in Asia: Importance of livestock and characterisation of agro-ecological zones, *Agric Syst*, 71 (2002) 5-15.

45 Singh C, Fisheries based integrated farming system, *Fishing chimes*, 22 (1) (2002) 146.