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RESEARCH ARTICLE

Inventorisation of Biodiversity of Selected Agroforestry Systems of Central Rajasthan

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Abstract
Agroforestry is a sustainable land use system in which crops, trees and livestock are maintained together on same land to increase total yield and income. The present study was undertaken to assess floral and faunal diversity in different agroforestry systems in Tonk district of Rajasthan. The different land use systems were Agroforestry, Agrosilvipastoral, Monoculture and Barren land. Detailed investigations by different methods of biodiversity assessment revealed that Agri silvipastoral system had the richest biodiversity followed by Agroforestry system. This shows that Agroforestry systems are more suitable for agricultural practices than Monocropping system to enhance and conserve biodiversity.

Keywords: Agroforestry, Agrosilvipastoral System, Biodiversity, Monocroping

Introduction

Agroforestry is a scientific farming practice of ancient times. It is a sustainable land use system in which crops, trees and livestock are maintained together on same land to increase total yield and income. Agroforestry can alter the micro climate of soil under tree canopy. It plays an important role in enhancement of farm productivity, climate change mitigation, carbon sequestration, biodiversity conservation, phytoremediation, water conservation, improvement in quality of soil by addition of plant and animal waste (Nair, 2011).

Traditionally farmers grow tree species like *Acacia nilotica, Terminalia arjuna, Butea monosperma, Dalbergia sissoo, Azadirachta indica, Prosopis cineraria, Eucalyptus, Ficus* species etc on borders of field to meet demand of fodder, fuel, fruits, timber etc.

Trees in agroforestry systems in Rajasthan supports threatened bird species and provide them habitat and forage. Agroforestry system in arid areas of Rajasthan supports diversity of bird species and act as buffer to protected areas (Roy and Tewari, 2012).

The role of agroforestry in conservation of biodiversity involves preservation of germplasm of various sensitive species, it provides natural habitat for several species of flora and fauna, it helps in reduction of natural habitat conversion into commercial farms, it prevents loss of surrounding habitat, provides corridor to connect natural habitats , conservation of area specific species of fauna and flora, provides ecosystem services such as water recharge, control of erosion and thus helps in conservation of biological diversity.

The type of biodiversity and its abundance differs in various agroecosystems. It depends on structure, age, management and diversity. Agricultural biodiversity is divided into following group- (1) Productive biota: it includes crops, trees and animals and has determining role in agroecosystem diversity and complexity.(2) Resource biota: it includes organisms which has contribution in productivity by activities like decomposition, pollination and biological control. (3) Destructive biota: it includes insects, weeds, pests, microbes which are harmful for crops.

Major roles played by agroforestry in conservation of biodiversity are: (1) It helps in preservation of germplasm of sensitive species; (2) It provides habitat to wild species of flora and fauna; (3) It creates corridors between habitat remnants and provides connectivity. This can encourage the protection of fauna and flora sensitive areas and integrity of these remnants; (4) It helps in reduction of rates of conversion of wildlife habitat into agricultural farms by providing sustainable alternative to agricultural

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systems; (5) It also provides other ecosystem services like water recharge and erosion control and helps to conserve biological diversity and prevents degradation and loss of surrounding habitat (Jose, 2009).

Silvipastoral agroforestry can increase the diversity of birds and invertebrates in grassland systems. It can also provide opportunities for increasing the diversity of small mammals, arthropods and birds in agriculture systems. The changes in microclimate and increased number of predators can lead to reduction in number of pests (Burgess, 1999).

Traditional agroforestry system helps in biodiversity conservation through *in situ* conservation of tree species on farms, provide suitable habitat for animal and plant species and reduce pressure on natural forests. By applying adaptive management approaches the relationship may be rendered efficient between trees, agroforests and wild biodiversity. Local knowledge and practice, continuous analysis and tracking can be integrated into the management framework to fed knowledge (McNeely and Scroth, 2006).

In agroecosystems, variety of ecological services are provided by biodiversity like regulation of microclimate, recycling of nutrients, regulation of hydrological processes, detoxification of poisonous chemicals and suppression of undesirable organisms. Biodiversity mediated ecological services and renewal processes are mainly biological and depend on maintenance of diversity and biological integrity in agroecosystems. Crop rotation, intercropping, agroforestry, livestock/ crop mixtures etc. can enhance diversity. Diversification can also be done outside farm like living fences, crop field boundaries with windbreaks, shelter belts which can provide habitat to wildlife and beneficial insects. (Altieri, 1999).

Plant and animal diversity is added to agricultural farms by agroforestry system which otherwise contain only monocultures of agricultural crops. Under changing climate scenario, field shelterbelts and riparian forest buffers are essential for maintaining animal and plant biodiversity. Introduction of species like fruit trees and medicinal plants in home gardens contributes to species biodiversity. The management of land is directly related to its inhabitants. If poor farmers and rural people are provided with opportunity to earn stable and sustainable livelihood then it will help indirectly in conservation of biodiversity of the planet. A balance between biodiversity conservation and production is the basis of concept of ecoagriculture. Agroforestry is best suited to provide eco agriculture solutions (Nair, 2007).

Materials and Methods

Four study sites namely agroforestry, agrosilvipastoral, monoculture and barren land system were observed for floral and faunal diversity in Tonk district (Fig.1).

Fig. 1. Map of Tonk district of Rajasthan

Insects

Insects were collected from four study areas in morning time. Insects were collected by insect trap net and pit fall method (Fig. 2) (Bishnoi and Dang, 2019). Insect net was tied on trees and light lamp was hanged to attract insects. It was kept overnight and insects were collected on next morning. Similarly a pit was dug and bowl full of water was kept to catch creeping insects. Insects were then collected on next morning for identification (Fig. 3).

Fig. 2. Insect Trap Net in Agroforestry System

Birds

Species of birds in study area was observed on a regular basis wherein birds perching on trees and crops were photographed and then identified with the help of an ornithologist.

Plants- The three systems under systematic study: agrosilvipastoral, agroforestry and monocropping system had a fixed organization in terms of floristic composition like in agrosilvipatoral system had trees namely *Saraca asoca, Tectona grandis, Psidium guajava, Punica granatum, Phyllanthus emblica, Annona squamosa, Citrus limon(L), Mangifera indica, Manilkara zapota, Citrus limetta, Plumeria rubra, Delonix regia, Ricinus communis* etc. Fodder for animals like *Medicago sativa* was grown to feed livestock. Crops grown were *Cyamopsis tetragonoloba* in Kharif and *Triticum aestivum* in Rabi season. In Agroforestry system Crops grown were *Brassica nigra, Triticum aestivum*, Trees present on boundary were *Ficus religiosa, Azadirachta indica, Acacia nilotica, Prosopis cineraria.* In Monocropping system, two crops were grown in a year, *Arachis hypogaea* in Kharif and *Brassica nigra* in Rabi season.

In the three cropping systems weeds were removed on a regular basis. In barren land, weeds were found. Weeds were collected and Herbaria was prepared and identified.

Result and Discussion

Insects

Variety of insect species were identified from study area namely agroforestry (Fig. 4) and agrosilvipastoral system (Fig. 5).

Agroforestry System

Several varieties of species of insects were found in agroforestry system like *Vespula vulgaris, Apis dorsata*, cricket gryllus, lace wing, dipteran fly, beetle, red cotton bug, green bottle fly, little honey bee, *Chrotogonus trachypterus* etc.

Agrosilvipastoral System

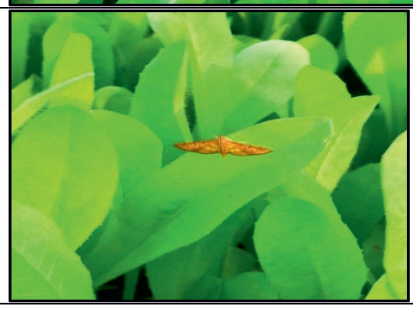
In agrosilvipastoral system, species of insects found were short horned grasshopper, ground beetle, bug, cricket gryllus, *Atractomorpha crenulata*, Damsel fly, mosquito, moth, bug, meat fly, *Chrotogonus trachypterus*, formica, spider, red cotton bug, common moth, shield bug etc (Table 1).

Fig. 3. Pit fall method

Fig. 4. Agroforestry system in Tonk District

Fig. 5. Agrosilvipastoral system in Tonk district

Table 1. Insects found in agroforestry and agrosilvipastoral systems in Tonk District

Zoological name	Common name	Order	System	Picture
Vespula vulgaris	Common Wasp	Hymenopterans	Agroforestry	
Dysdercus cingulatus	Red Cotton Bug	Hemiptera	Agroforestry	
Chrotogonus trachypterus	Surface Grasshopper	Orthoptera	Agroforestry	
Zygoptera	Damsel fly	Odonata	Agrosilvipastoral	
Moth	Moth	Lepidoptera	Agrosilvipastoral	

Birds

Several varieties of species of birds were found in study area like *Vanellus indicus* (Red Wattled Lapwing) local name- Titori, *Pycnonotus cafer* (Red Vented Bulbul) local name- Bulbul, *Turdoides striata* (Jungle Babbler) local name- Saat Bhai, *Columba livia* (Rock Pigeon) local name- Kabutar, *Streptopelia decaocto* (Eurasian Collared Dove) local name- Kamedi, *Psittacula krameri* (Rose Ringed Parakeet) local name- Tota, *Pavo cristatus* (Indian Peafowl) local name- Mor, *Corvussplendens*(House Crow) local name- Kauwa, *Passer domesticus* (House Sparrow) local name- Goraiya, *Chaetornis striata* (Bristled Grassbird), *Halcyon smyrnensis* (White-throated Kingfisher) local name- Kilkila, *Francolinus pondicerianus* (Gray Francolins) local name- Titar, *Saxicoloides fulicatus* (Indian Robin) local name- Kali Chidi, *Copsychus fulicatus* (Indian Robin) local name- Kali Chidi, *Prinia sylvatica* (Jungle Prinia), *Merops orientalis* (Green Bee-eater Stock) local name- Hariyal, *Dicrurus macrocercus* (Black Drongo) local name- Jungle Kotwal, *Acridotheres tristis* (Common Myna) local name- Myna, *Centropus sinensis* (Greater Coucal) local name- Mahok, *Ocyceros birostris* (Indian Grey Hornbill) local name- Dhanchidi, *Upupa epops* (Eurasian Hoopoe) local name- Hudhud, *Gracupica contra* (Asian Pied Starling) local name- Ablak Myna, *Sylvia nana* (Asian Desert Warbler), *Turdoides caudata* (Common Babbler) (Table 2).

Plants

Out of the four systems under study, a number of weeds and stray plants were observed in the barren land (Fig. 6). The other systems being under cultivation of specific crops and trees did not show any long standing weed population. Those that appeared naturally were uprooted on regular basis. Weeds that generally found were *Cassia tora* (Famiy- Fabaceae), *Euphorbia hirta* (Family- Euphorbiaceae), *Phyllanthus niruri* (Family- Phyllanthaceae), *Cynodon dactylon* (Family- Poaceae), *Juncus* sp (Family- Juncaceae), *Cenchrus ciliaris* (Family- Poaceae), *Cyperus rotundus* (Family- Cyperaceae), *Digitaria ciliaris* (Family- Poaceae), *Setaria glauca* (Family- Poaceae), *Croton bonplandianum* (Family- Euphorbiaceae).

Phyllanthus niruri

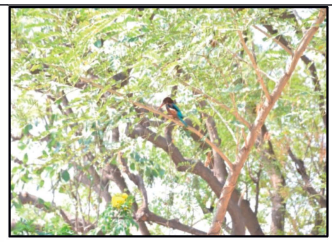
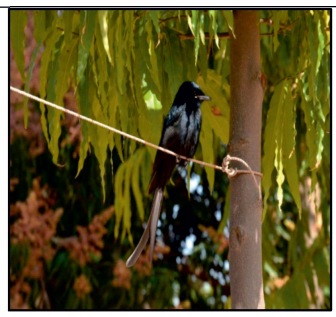
Setaria glauca

Euphorbia hirta

Croton bonplandianum

Fig. 6. Weeds found in Agroforestry and agrosilvipastoral system of Tonk district of Rajasthan

Table 2. Birds found in Agroforestry and agrosilvipastoral system of Tonk district of Rajasthan

Common name	Zoological name	System	Picture
Red Wattled Lapwing	*Vanellus indicus*	Agroforestry	
Eurasian Hoopoe	*Upupa epops*	Agroforestry	
Indian robin	*Saxicoloides fulicatus*	Agrosilvipastoral	
White-throated Kingfisher	*Halcyon smyrnensis*	Agrosilvipastoral	
Asian desert warbler	*Sylvia nana*	Agrosilvipastoral	
Black Drongo	*Dicrurus macrocercus*	Agroforestry	

The species of insects and birds were found in abundance in agroforestry and agrosilvipastoral system as compared to monocropping system. This can be attributed to diversity of plants and trees in this system which provides habitat, food and shelter to variety of fauna in agroecosystems.

Along with the agroforestry systems that were selected for particular study, a monocroping system was also studied simultaneously. However in monocroping system, the biodiversity is curtailed in the sense that only the required crop plant is allowed to grow and the weeds are uprooted at very regular intervals. So in that case, the system can only boost off the crop grown and the specific pollinators. Since the biodiversity in such cases is restricted in numbers, so for this particular research paper the monocroping system was excluded.

The biodiversity analysis of the present study showed a number of plant and animal species growing in the uncultivated land. The prominent animal species were insects belonging to order Lepidoptera, Odonata, Orthoptera, Hemiptera and Diptera of class Insecta. The objective was to study plant- pollinator relationship so main focus was on only insects.

The plants were found to be mixture of dicots and monocots typically found in the semi-arid areas of the state of Rajasthan. Monochlamydae was chiefly represented by Euphorbids. A number of grasses and sedges were also reported.

In agroforestry systems, crops that were grown mainly were *Triticum aestivum, Brassica nigra, Pennisetum glaucam, Cyamopsis tetragonoloba*. Tree species that were found in these agroecosystems were *Acacia nilotica, Prosopis cineraria, Azadirachta indica, Phoenix dactylifera, Syzygium cumini*.

The total high rates of bird abundance can be identified within the agroforestry networks allocated to a mix of factors. First, while the agroforestry structures are much less floristically rich and have lower arboreal densities than their equivalents in the forest, they maintain a structurally structured canopy of comparable height to that of forest fragments, thereby offering a variety of perching, nesting and forest fragments and providing conditions that are essential for many tree species. Second, the agricultural practices seem to offer plentiful food resources for fauna and wildlife. Although the agricultural practices are much less floristically complex than woods, many of tree species within the agroforestry systems develop fleshy fruits or nectar that draws birds to the cultivated areas. Insects are often expected to be prevalent in agroforestry systems owing to the systemic and floristic nature of these ecosystems and the fact that insecticides or other inorganic compounds are not included in such systems. Finally, the near proximity of agroforestry systems to forest patches and the extremely heterogeneous existence of the agricultural matrix through which the agroforestry systems are inserted are both likely to lead to high animal diversity by preserving landscape connection and providing a permeable matrix that enables animal movement (Harvey and Villalobos, 2007).

Plant management decisions in the agroforestry systems have enabled the development of vegetation succession processes and the new wild and cultivated plants and hybrids are added, thereby growing the variety of organisms and the genetic diversity of systems. Despite their efficacy in sustaining biological diversity, agroforestry systems have restricted ability to sustain rare native species, possibly because wild structures have a higher number of rare species that occur below 1 per cent. Rare plants are vulnerable to destruction, when crop fields are stripped of ground.

Therefore, conventional agroforestry schemes have strong potential for the protection of biodiversity, but can also be enhanced. Any approaches in this regard direction may aim at (1) Retention of diversity in open spaces inside and throughout the system; (2) establishment of linkages between vegetation corridors and facilitation of animal species movement across residual habitats; (3) Reducing the demand to procure plant resources by maximizing the usage of certain materials, such as fuelwood or aggregating interest, for other non - wood forest; (4)Avoid clearing of natural habitats by enhancing the usage and restoration of cleared areas; (5)Preventing the transition of habitats to intensive farming methods (6) strengthens and even enhances the potential of the environment to maintain biodiversity in terms of species richness and genetic diversity; and (7) enhancing the ability of agroforestry systems to preserve rare and endangered species by undertaking local strategic work (Calles *et al.*, 2010).

Hence Agri silvipastoral system had the richest biodiversity followed by Agroforestry system. This shows that Agroforestry systems are more suitable for agricultural practices than Monocropping system to enhance and conserve biodiversity.

The importance of agroforestry system in biodiversity conservation and other environmental benefits are now being supported for further research and contribution. This study may help in creating awareness for adopting

agroforestry system as farming practice instead of traditional agricultural practices for conservation of biodiversity.

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