Original Research Article

Identifying the traditional and existing tree –crop combination of agroforestry systemin Southern part of Chhattisgarh

Abstract

Present study was conducted in Bastar district of Chhattisgarhfor identify the traditional and existing agroforestry practices by farmers. The data were collected through field visit and filled out of pre-prepared questionnaires in four blocks of Bastar district, namely Jagdalpur, Bastar, Tokapal and Bakawand. The survey revealed six different types of agroforestry system practices i.e., agrisilvihorticulture, agrisilviculture, silvihorticulture, agrisilvipastoral, silvihortipastoral, and agrisilvihortipastoral while the 67% of farmers were practices agrisilvihorticulture-type agroforestry systems. Farmers of Bastar were found using 29 different tree crops, 17 varieties of horticultural crops, 20 vegetable varieties, and 11 agricultural crops in their fields.

Key words: Agroforestry, Cropping Patterns, Sustainability, Livelihood security, Tree crop interaction, Bastar

Introduction

India contains one sixth of world population is about 1.43billionpeoples[1]. Growing population creates huge pressure on demand of foods, water, and land and also quality of air [2, 3] resulting deteriorates the natural resources. Deforestation due to the construction of roads and buildings, expansion of industries [4]and extensive agriculture are the major causes of disturbing environmental sustainability. On the other hand, the agroforestry system is playing a crucial role in minimizing food shortages through different products and providing livelihood security[5-8].

Agroforestry is a sustainable land use approach that involves consciously combining agri-horticultural output in the lower story alongside a woody component i.e. home garden, hedge, multistoried cropping, windbreak, shelterbelt, border planting, and strip planting[9]. It defined as an agroforestry system is a collective land use where field crops are planted alongside trees and woody perennial plants [10, 11]. It has been multifunctional benefits such as control of soil erosion[12, 13],improve air quality, rich organic matter in soil[14], restore available ground water, shade for beneath growing crops, fodder for livestock, sustain the environment throughconservation of biodiversity[15-18].Adaptation of suitable agroforestry system have been depending upon the various factors i.e. topography of the farm, physiochemical properties of soil [19], agro-climatic features of the regions, availability of labour and irrigation facilities, and size of the farm etc. [20-22]. Different typesof agroforestry systems practiced in the countrynamely agrisilviculture system

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(combination of agricultural field crops + trees), silvipastoral system (livestock production + trees), agrisilvihorticulture system (field crops + horticultural crops + trees), agrisilvipastoral system (agricultural field crops + livestock production + trees), agrisilvihortipastoral system (agricultural field crop+ horticulture crops + animal husbandry + trees), and silvihorticulture system (horticultural crops + trees) [23-25].

This study was conducted in Bastar situated in southern part of Chhattisgarh (India). Bastar is world famous for its traditional tribal culture and handmade art-craft [26]. It covers 403,003 hectare of total geographical area whereas 20.83 % forest land, 17.63% uncultivated land, 10.69% agriculture land and 5.10% wasteland. The tropical moist deciduous type of forest specially dominated by Sal trees (*Shorea robusta*), while other tree species *Bauhiniavariegate, Tectona grandis, Pterocarpus marsupium, Terminalia tomentosa, Anogeissus latifolia, Madhuca indica, Diospyros melanoxylon, Embilica officinalis,Cleistanthuscollinus,Tamirindus indica,Acacia nilotica, Acacia catechu, Mangifera indica, Terminalia arjuna,* and *Dendrocalamus*speciesare present on either bund of the agricultural fields or boundry of the farm. Bastar region mainly covers entisol, inceptisol and alfisol types of soil and nutrient such as nitrogen, phosphorus, potassium were ranged from 188.6-276.64, 7.62-10.72, 121-242.5, kg/ha [27-29]. During monsoon season rice, maize and millets crops are major crops grown in rainfed and irrigated condition while post-monsoon and/or pre-monsoon season wheat, maize, moongbeen, vegetables like cucurbits, papaya, chilli, tomato, brinjal were grown.

Agroforestry system pushed in past three decades to developing nation as a way to raising livelihood income of the growers[5, 30].There is no previously study in the area on which species of tree and crops combination practiced for cultivation, and how much income generated from the forest produces. Hence, this research designs for identification of tree-crop combination practiced as an agroforestry system by the farmers of Bastar.

Materials and Methods

The study was carried during the period of 2016-17in Bastar district (Chhattisgarh), which were situated at 19º10´71” N latitude and 81º95´35” E longitude at an altitude of 850 meter with average annual rainfall and temperature was 1250 mm and 18.9ºC - 34.1ºC.

The data were collected bypre-prepared questionnaire with regular field visit of thevillages [31]and farming system. Twelve villages wererandomly selected in each blocks of Bastar district (Table 1). 25 farmers of each block were randomly selected on the basis of availability farming system with different tree-crop combination on the field. The questionnaire was contended different aspect of

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agroforestry system such as available tree species in the farm, crops grown, mixed cropping techniques, utilization of tree products,income from tree produces etc.

Table 1 Blocks and villages were selected for surveyed during the study.

Sl. No.	Blocks	Villages
1	Jagdalpur	Pandripani, Parpa, Pamela, Karkapal, Podaguda, Aasna, Nagrnar, Neeyanar, Ghatpadmur, Sargipal, Lamni, Burungpal
2	Bastar	Marlenga, Chokar, Mahupal, Mongpal, Bastar, Bhirlinga, Mohpal Barai, Kawadgaon, Kudkanar, Ghatlohanga, Kaviashana, Parchanpal
3	Bakawand	Bakawand, Sivnagudam, Karpawand, Devbeejaguda, Chhotedevda, Banras, Dongrepal, Sonpur, Kodawand, NarawandMatiguda, Kosmi
4	Tokapal	Tekameta, Bademorthpal, Parakuriyaguda, Bhaluguda, Kuranga, Karanji, Aavarabhata, Kodipara, Kalepal, Telimarenga, Matigudapara, Karanji, Chhotemorathpal

Results and Discussion

The result was revealed in agroforestry system practiced by the farmers of different blocks. The maximum number of farmer practiced agrisilvihorticulture systemabout 67 % while the 23% aagrisilviculture system, 7% silvihorticulture system, 1% agrisilvipastoral, 1% silvihortipastoral, 1% agrisilvihortipastoral system were recorded (Fig. 1).Adaptation of suitable agroforestry system have been depending upon the various factors i.e. topography of the farm, physiochemical properties of soil, agro-climatic features of the regions, availability of labour and irrigation facilities, and size of the farm etc [20]. The dependency of farmers on agrisilvihorticulture system was highest due to the their diversified produces such as tree provides wood for their house construction and making agriculture implements, crops provided food grains, and horticulture system provides fruits, flowers, vegetables etc for selling [32]. The Bastar area employs a wide range of agro - forestry approaches. The selection of tree species varies from based on site to site, need of the farmer, and their socioeconomic considerations [23, 33].This gives several examples of where farmers in the area have successfully used traditional agro - forestry techniques and indigenous techniques and agroforestry systems plays crucial role in ensuring the sustainability in resources for livelihood[34].

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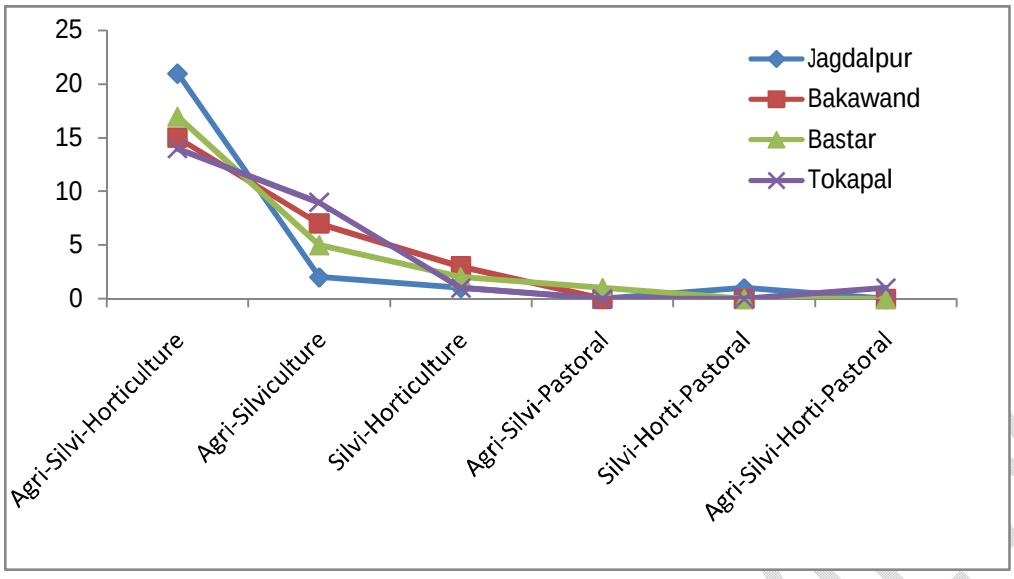

Figure 1.Different agroforestry systems were used by farmers of Bastar.

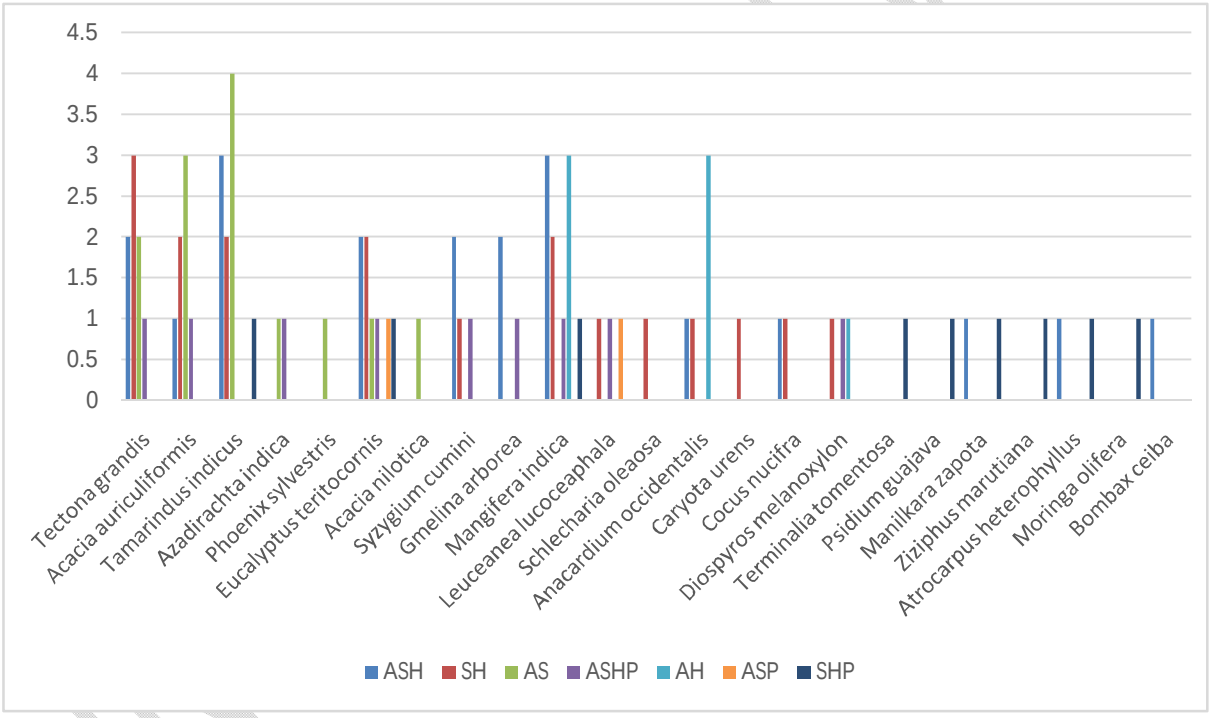

Figure 2 Frequency of tree species occurred in different agroforestry system

3.2 Tree-crop combination practiced in Agroforestry System

The study was revealed the six type of agroforestry system practiced by the farmers in Bastar such as agrisilvihorticulture, agrisilviculture, silvihorticulture, agrisilvipastoral, silvihortipastoral, and agrisilvihortipastoral. The maximum variation in species of agroforestry system was recorded in agrisilvihorticulture. Whereas 29 tree species, 17 horticultural crops, 20 vegetables crop species and 11 agricultural cropswereused in tree-crop combination system. *Mangifera indica* and *Eucalyptus*

tree species wasreported almost all type of agroforestry system while the other trees such as *Phoenix sylvestris,Acacia nilotica, Schlechariaoleaosa, Caryotaurens, Cocusnucifra, Terminalia tomentosa, Psidium guajava, Ziziphus marutiana,Moringa olifera*, and *Bombax ceiba*practiced in scattered form or on the bundsin an agroforestry system. Frequency of tree species present in an agroforestry system were also recorded (Fig. 2). This study was reported the combination of agriculture crops, horticulture crops and tree species practiced on the field of farmers in Bastar region as shown in Table 2and Fig. 3. Agroforestry system provide wide range of benefits to the farmers such as food for life, woods for furniture and construction home, fruits for nutrition, etc. Similarly investigation were reported on the hortsilviculture based agroforestry models whereas horticulture species includes*Emblica officinalis, Psidium guajava, Punica granautum, Aegle marmelos, Z. mauritiana*combination with trees species includes *T. grandis, G. arborea, A. lebbeck, T. arjuna* and *A. nilotica* on the field [34]. Studied inBastar region on different aspect of agroforestry system and reposted the agrisilvihorticulture system were highly practiced with the combination of tree species like *Acacia auriculiformis Psidium guava, Tectona grandis, Cocos nucifera,* with the horticultural fruits crops like *Punica granatum, Anacardium occidentale, Emblica officinalis, Manilkara achras, Mangifera indica, Psidium guava, Terminalia Arjuna, Tamarindus indica, Terminalia belerica, Litchi chinensis*[23]. The agroforestry systems have used to intensify in the farming system by maximizing of resources. The agroforestry system was a very promising method for Mediterranean areas with intercropping, such as growing olives with grain crops like barley and mixes of barley and leguminous plants [35]. Landscapes for agriculture have always included windbreaks as a vital component. Among its many functions are crop protections from wind, conserving habitats for biodiversity, safeguarding against soil erosion, and creating microclimates that mitigate the impact of adverse weather conditions [36, 37].

Table 2Tree- crop combination practiced by the farmers of Bastar in various Agroforestry systems.

Sl. No.	Agroforestry System	Combination of trees, horticultural crops, agricultural crops and fodder crops on the same piece of land in same time
1	Agrisilviculture system	*Tectona grandis + Oryza sativa / Zea mays*
		Tamarindus indicus + Eucalyptus tereticornis + Manihot esculenta
		Phoenix sylvestris + Oryza sativa
		Acacia nilotica + Oryza sativa
		Eucalyptus tereticornis + Oryza sativa

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		Azadirachta indica, + Tamarindus indica + Saccharum officinarum
		Acacia auriculiformis +Zea mays / Oryza sativa/ Saccharum officinarum
		Tamarindus indica + Zea mays / Zingiber officinales
2	Silvihorticulture system	*Tectona grandis + Mangifera indica / Capsicum annum*
		Syzygium cuminii + Capsicum annum
		Eucalyptus tereticornis + Momordica charantia + Abelmoscus esculentus
		Acacia auriculiformis + Abelmoscus esculentus
		Anacardium occidentalis + Abelmoscus esculentus
		Gmelina arborea + Abelmoscus esculentus / Capsicum annum
		Caryotaurens + Cocus nucifera + Vigna anguiculata
		Tectona grandis + Tamarindus indicus + Leucaena luecocephala +Schleichera oleosa + Semecarpus anacardium + Litchi chinensis + Manilkara zapota + Mangofera indica + Syzygiumcuminii + Psidium guajava + Carissa carandus + Capsicum annum + Abelmoscus esculentus
		Mangifera indica + Abelmoscus esculentus + Polianthes tuberose *Eucalyptus tereticornis + Acacia auriculformis + Caryotaurens + Tamarindus indicus + Diospyrosmelonoxylon + Mangifera indica + Anacardium occidentalis*
3	Agrisilvipastoral System	*Eucalyptus tereticornis + Leucaena leucocephala +Oryza sativa / Zea mays + Ipomoea batatas* + Nepiar grass
4	Silvihortipastoral system	*Eucalyptus tereticornis / Tamarindus indicus + Terminalia tomentosa + Mangifera indica + Manilkara zapota + Psidium guajava + Cynadondactylon /*Nepiar grass

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5	Agrisilvihortipastoral system	*Azadirachta indica* + *Eucalyptus tereticornis* / *Diospyros melonoxylon* + *Leucaena leucocephala*(Fodder) + *Ziziphus mauritiana* + *Atrocarpus heterophyllus* / *Syzygiumcumini* + *Allium cepa* + *Abelmoscus esculentus* / *Phaseolus species* + *Oryza sativa* / *Zea mays* + *Saccharum officunarum* / *Cynadondactylon* (Fodder
		Tectona grandis / *Gmelina arborea* + *Acacia auriculiformis*+ *Mangifera indica* + *Moringa oleifera* + *Cocus nucifera* / *Vigna anguilata* + *Oryza sativa* /*Zea mays* + *Cynadondactylon* / *Pennisetum glaucum*
6	Agrisilvihorticulture system	*Tamarindus indicus* + *Capsicum annum* + *Zea mays* + *Helianthus annus*
		Tamarindus indicus + *Eucalyptus tereticornis* + *Acacia auriculiformis* + *Manngifera indica* + *Atrocarpus heterophyllus* + *Syzygiumcuminii* + *Zea mays*
		Tamarindus indicus + *Gmelina arborea* / *Tectona grandis* + *Cocus nucifera* +*Atrocarpus heterophyllus* + *Mangifera indica* + *Manilkara zapota* + *Oryza sativa*/ *Zea mays*
		Gmelina arborea + *Tectona grandis* + *Eucalyptus tereticornis* + *Bombax ceiba* + *Mangifera indica* + *Anacardium occidentalis* + *SyzygiumCuminii* + *Oryza sativa*

***Tectona grandis* with *Abelmoscus esculentus* in Neeyanar**

***Mangifera indica* with *Tagest species* in Pandripani**

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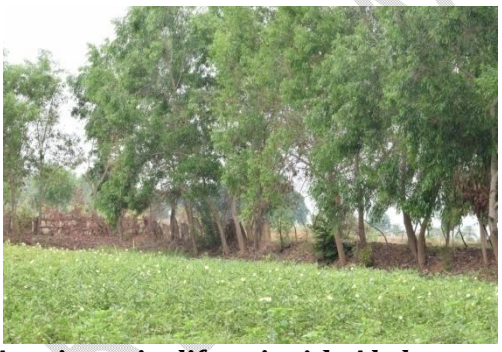
***Acacia auriculiformis*with *Zea mays* in Tekameta**

***Tamarindus indicus* with *Capsicum annum* in Aashana**

***Eucalyptus teretocornis*with Bitter gourd in Ghatpadmur**



***Acacia auriculiformis*with *Abelmoscus esculentus* in Karanji**

***Acacia auriculiformis*with *Oryza sativa* in Tekameta**

***Mangifera indica* with *Cymbopogon flexuosus*in Kodipara**

***Mangifera indica* with *Solanum melongina*in Pandripani**

***Tectona grandis* with *Capsicum annum* in Bastar**

***Anacardium occidentalis* with *Cymbopogon flexuosus*in Kodipara**

Tamarindus indica with Zingiber officinalis in Kodipara

***Tectona grandis* with *Mangifera indica* in Mohpal Barai**

***Mangifera indica* with *Zea mays* in Bastar**

***Mangifera indica* with *Curcuma longa* in Sargipal**

***Syzygium cuminii* with *Capsicum annum* in Pandripani**

Figure 3 Agroforestry system existed in field of Bastar farmers.

Benefits from tree in an agroforestry system

This study found that varied uses of trees occurred on agricultural farms, whether they were naturally occurring or planted (Table 3). Farmers receive benefits from agroforestry strategies in combination with a variety of produce.During the study, it was found that most of the farmers in Bastar district expressed their desire to plant various types of tree species in their fields as per their needs and utility namely *Tamarindus indica,Mangifera indica,Atrocarpus heterophyllus,*

*Anacardium occidentalis,Caryotaurens,Madhuca indica*and *Diospyros melonoxylon.* As estimated by CAFRI, Jhansi, there are 1,023 million ha of agroforestry globally, and 13.75 million ha of agroforestry are found in India. It indicates that hardly 10% of the country's agricultural areas are covered with agroforestry [38].An agroforestry system produces high-quality fruits, vegetables, and lumber [39]. It is believed to be able to interact with ecosystem functions and contribute to sustainable agriculture [40].Silvopasture is a viable agroforestry farming substitute that combines the benefits of trees (timber production) with the production from livestock, including meat and dairy [41].Similary, agrisilviculture models provide a higher quality of both agriculture grain and timber production, resulting in farmers receiving a higher profit per unit of land [42]. Because of the wide range of items produced, it also offers nutritional security. The normative return from cultivating vegetables is greater than that of ordinary field crops [43].

Table 3 Farmers of Bastar used of tree species for different purposes.

Tree species	**Common name**	**Uses**	**Marketable value (In INR)***
Mangifera indica	Mango	Fuel wood, fruit	80-100/ kg
Leucaena leucocephala	Subabul	Fodder, fuel wood	-
Syzygium Cuminii	Jamun	Fruit	Dried seeds- 42/ kg
Bombax ceiba	Semul	Timber, fibre	-
Acacia auriculiformis	Australian babul	Timber, fuel wood	-
Diospyros melonoxylon	Tendu	Fruit, timber, fuel wood, tendu patta	4000/standard bag
Azadirachta indica	Neem	Timber, medicinal value, Seeds	Seeds- 27/ kg
Ziziphus mauritiana	Ber	Timber, fruit, fodder	40-80/ kg
Terminalia tomentosa	Saja (Aasan)	Timber, silk rearing, fuel wood	Silk rearing- 400/ 100 pieces
Tectona grandis	Teak	Timber	-
Gmelina arborea	Khamhar	Timber, fodder	-
Eucalyptus tereticornis	Nilgiri	Timber, oil extraction	-
Cocus nucifera	Coconut	Fruit	50/ piece

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Moringa oleifera	Drum stick	Fruit	50-80/ kg
Atrocarpus heterophyllus	Jack fruit	Fruit, fuel wood	50-60/ kg
Tamarindus indicus	Imli	Fruit pulp, fuel wood, seeds, flower	Seeds- 36/ kg Flower- 63/ kg Pulp- 35-40/ kg
Psidium guajava	Guava	Fruit	50-80/ kg
Schleichera oleosa	Kusum	NWFP, Lac production	Lac- 300-400/ kg
Semecarpus anacardium	Bhelva	Fuelwood, fruit	9/ kg
Manilkara zapota	Sapota	Fruit	80-100/ kg
Litchi chinensis	Litchi	Fruit	80-100/ kg
Phoenix sylvestris	Chhind or silver date palm	Fruit, beverage	Beverage- 40.00/ litre
Madhucaindia	Mahua	Seeds, Flower, beverage	Seeds -29/ kg Flower-30/ kg Beverage – 60/ litre
Caryotaurens	Sulfi	Beverage	80-10/ litre
Shorea robusta	Sal	Seeds	20/ kg

*Source of marketable value – local market and Chhattisgarh minor forest produce limited [44].

Conclusion

Agroforestry is a dynamic and sustainable land management system that involves deliberately growing of woody perennials along with agricultural crops on farmlands to secure both direct and indirect benefits for farmers. This study reported the identification and documentation of patterns of tree-crop combinations used in the agroforestry system by the farmers of Bastar District. The agrisilvihorticulture agroforestry system was mostly practiced throughout the Bastar district, and *Tectona grandis, Shorea robusta, Eucalyptus tereticornis, Phenix sylvestris, Mangifera indica, Syzygiumcuminii, Gmelina arborea, Pongamia pinnata, Tamarindus indica, Bambosabambos, Ancardium occidentalis, Teminalia arjuna, Terminalia balerica, Madhuca indica, Acacia auriculiformis,* and *Acacia nilotica*tree species were grown by the farmers on their field.

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