

Original Research Article

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

Abstract

Present study was conducted in Bastar district of Chhattisgarh for 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

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Introduction

India contains one sixth of world population is about 1.43 billion peoples [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 agricultural 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 groundwater, shade for beneath growing crops, fodder for livestock, sustain the environment through conservation 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

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and irrigation facilities, and size of the farm etc. [20-22]. Different types of agroforestry systems practiced in the country namely agrisilviculture system (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 *Bauhinia variegata*, *Tectonagrandis*, *Pterocarpus marsupium*, *Terminalia tomentosa*, *Anogeissus latifolia*, *Madhuca indica*, *Diospyros melanoxylon*, *Embilica officinalis*, *Cleistanthus collinus*, *Tamirindus indica*, *Acacia nilotica*, *Acacia catechu*, *Mangifera indica*, *Terminalia arjuna*, and *Dendrocalamus* species are present on either bund of the agricultural fields or boundary 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, moongbean, 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 previous 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 2016-17 in Bastar district (Chhattisgarh), which were situated at 19°10'71" N latitude and 81°95'35" E longitude at an altitude of 850 meter with average annual rainfall and temperature was 1250 mm and 18.9°C - 34.1°C.

The data were collected by pre-prepared questionnaire with regular field visit of the villages [31] and farming system. Twelve villages were randomly selected in each block of Bastar district (Table 1). 25 farmers of each block were randomly selected on the basis of availability farming system with

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different tree-crop combination on the field. The questionnaire was contended different aspect of 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	Jagdapur	Pandripani, Parpa, Pamela, Karkapal, Podaguda, Aasna, Nagrnar, Neeyanar, Ghatpadmur, Sargipal, Lamni, Burungpal
2	Bastar	Marlenga, Chokar, Mahupal, Mongpal, Bastar, Bhirlinga, MohpalBarai, 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 system about 67 % while the 23% agrisilviculture 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 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].

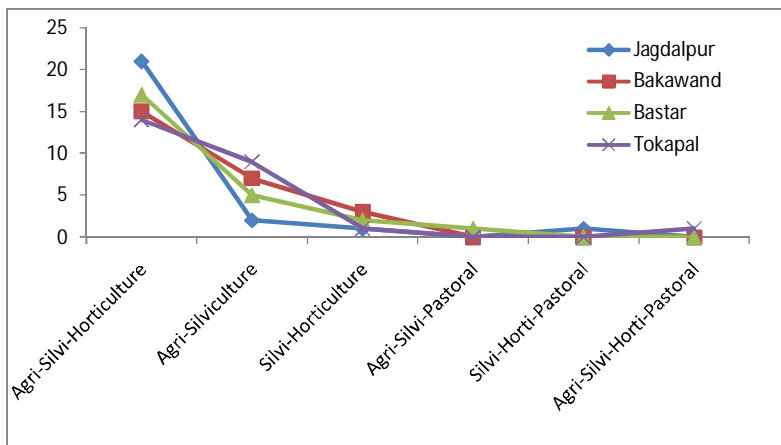


Figure 1. Different agroforestry systems were used by farmers of Bastar.

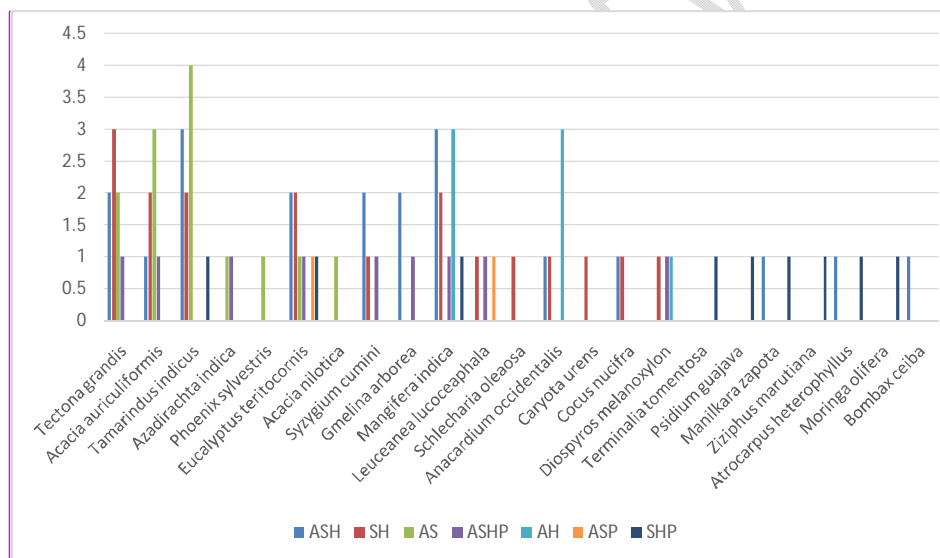


Figure 2 Frequency of tree species occurred in different agroforestry system

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3.2 Tree-crop combination practiced in Agroforestry System

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

tree species was reported almost all type of agroforestry system while the other trees such as *Phoenix sylvestris*, *Acacia nilotica*, *Schleicharia oleosa*, *Caryotaurens*, *Cocus nucifera*, *Terminalia tomentosa*, *Psidium guajava*, *Ziziphus marutiana*, *Moringa olifera*, and *Bombax ceiba* practiced in scattered form or on the bunds in 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 2 and 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 *Embllica officinalis*, *Psidium guajava*, *Punicagranatum*, *Aegle marmelos*, *Z. mauritiana* combination with trees species includes *T. grandis*, *G. arborea*, *A. lebeck*, *T. arjuna* and *A. nilotica* on the field [34]. Studied in Bastar region on different aspect of agroforestry system and reported the agrisilviculture 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*, *Embllica 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 2 Tree- 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	<i>Tectona grandis</i> + <i>Oryza sativa</i> / <i>Zea mays</i>
		<i>Tamarindus indica</i> + <i>Eucalyptus tereticornis</i> + <i>Manihot esculenta</i>
		<i>Phoenix sylvestris</i> + <i>Oryza sativa</i>
		<i>Acacia nilotica</i> + <i>Oryza sativa</i>
		<i>Eucalyptus tereticornis</i> + <i>Oryza sativa</i>

		<i>Azadirachta indica</i> , + <i>Tamarindus indica</i> + <i>Saccharumofficinarum</i>
		<i>Acaciaauriculiformis</i> + <i>Zea mays</i> / <i>Oryza sativa</i> /
		<i>Saccharumofficinarum</i>
		<i>Tamarindusindica</i> + <i>Zea mays</i> / <i>Zingiberofficinales</i>
2	Silvihorticulture system	<i>Tectonagrandis</i> + <i>Mangifera indica</i> / <i>Capsicumannum</i>
		<i>Syzygiumcumini</i> + <i>Capsicum annum</i>
		<i>Eucalyptustereticornis</i> + <i>Momordicacharantia</i> + <i>Abelmoscusesculentus</i>
		<i>Acaciaauriculiformis</i> + <i>Abelmoscusesculentus</i>
		<i>Anacardium occidentale</i> + <i>Abelmoscusesculentus</i>
		<i>Gmelinaarborea</i> + <i>Abelmoscusesculentus</i> / <i>Capsicumannum</i>
		<i>Caryotaurens</i> + <i>Cocus nucifera</i> + <i>Vignaanguiculata</i>
		<i>Tectonagrandis</i> + <i>Tamarindusindicus</i> + <i>Leucaenaleucocephala</i> + <i>Schleichera oleosa</i> + <i>Semecarpusanacardium</i> + <i>Litchichinensis</i> + <i>Manilkarazapota</i> + <i>Mangifera indica</i> + <i>Syzygiumcumini</i> + <i>Psidiumguajava</i> + <i>Carissa carandus</i> + <i>Capsicumannum</i> + <i>Abelmoscusesculentus</i>
		<i>Mangifera indica</i> + <i>Abelmoscusesculentus</i> + <i>Polianthestuberose</i> <i>Eucalyptustereticornis</i> + <i>Acaciaauriculiformis</i> + <i>Caryotaurens</i> + <i>Tamarindusindicus</i> + <i>Diospyromelonoxydon</i> + <i>Mangifera indica</i> + <i>Anacardiumoccidentalis</i>
3	Agrisilvipastoral System	<i>Eucalyptustereticornis</i> + <i>Leucaenaleucocephala</i> + <i>Oryza sativa</i> / <i>Zeamays</i> + <i>Ipomoea batatas</i> + <i>Nepiargrass</i>
4	Silvihortipastoral system	<i>Eucalyptustereticornis</i> / <i>Tamarindusindicus</i> + <i>Terminalia tomentosa</i> + <i>Mangifera indica</i> + <i>Manilkarazapota</i> + <i>Psidiumguajava</i> + <i>Cynadondactylon</i> / <i>Nepiargrass</i>

5	Agrisilvihortipastoral system	<i>Azadirachtaindica</i> + <i>Eucalyptus tereticornis</i> / <i>Diospyros melonoxylon</i> + <i>Leucaena leucocephala</i> (Fodder) + <i>Ziziphus mauritiana</i> + <i>Atrocarpus heterophyllus</i> / <i>Syzygium cumini</i> + <i>Allium cepa</i> + <i>Abelmoschus esculentus</i> / <i>Phaseolus species</i> + <i>Oryza sativa</i> / <i>Zea mays</i> + <i>Saccharum officinarum</i> / <i>Cynadondactylon</i> (Fodder)
		<i>Tectona grandis</i> / <i>Gmelina arborea</i> + <i>Acacia auriculiformis</i> + <i>Mangifera indica</i> + <i>Moringa oleifera</i> + <i>Cocos nucifera</i> / <i>Vigna anguilata</i> + <i>Oryza sativa</i> / <i>Zea mays</i> + <i>Cynadondactylon</i> / <i>Pennisetum glaucum</i>
6	Agrisilvihorticulture system	<i>Tamarindus indicus</i> + <i>Capsicum annum</i> + <i>Zea mays</i> + <i>Helianthus annuus</i>
		<i>Tamarindus indicus</i> + <i>Eucalyptus tereticornis</i> + <i>Acacia auriculiformis</i> + <i>Mangifera indica</i> + <i>Atrocarpus heterophyllus</i> + <i>Syzygium cumini</i> + <i>Zea mays</i>
		<i>Tamarindus indicus</i> + <i>Gmelina arborea</i> / <i>Tectona grandis</i> + <i>Cocos nucifera</i> + <i>Atrocarpus heterophyllus</i> + <i>Mangifera indica</i> + <i>Manilkara zapota</i> + <i>Oryza sativa</i> / <i>Zea mays</i>
		<i>Gmelina arborea</i> + <i>Tectona grandis</i> + <i>Eucalyptus tereticornis</i> + <i>Bombax ceiba</i> + <i>Mangifera indica</i> + <i>Anacardium occidentale</i> + <i>Syzygium cumini</i> + <i>Oryza sativa</i>



***Tectona grandis* with *Abelmoschus esculentus* in Neeyanar**



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



Acacia auriculiformis with *Zea mays* in Tekameta



Tamarindus indicus with *Capsicum annum* in Aashana



Eucalyptus tereticornis with Bitter gourd in Ghatpadmur



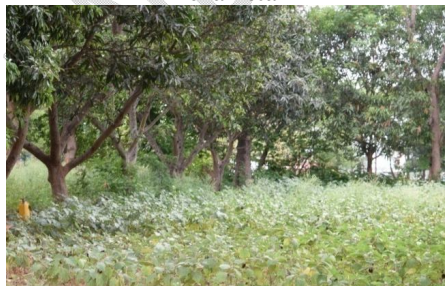
Acacia auriculiformis with *Abelmoscuseculentus* in Karanji



Acacia auriculiformis with *Oryza sativa* in Tekameta



Mangifera indica with *Cymbopogonflexuosus* in Kodipara



Mangifera indica with *Solanum melonginain* in Pandripani



Tectona grandis with *Capsicum annum* in Bastar



Anacardium occidentale 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 cumini 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*,

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Anacardium occidentale, *Caryota urens*, *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]. Similarly, 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)*
<i>Mangifera indica</i>	Mango	Fuel wood, fruit	80-100/ kg
<i>Leucaena leucocephala</i>	Subabul	Fodder, fuel wood	-
<i>Syzygium cumini</i>	Jamun	Fruit	Dried seeds- 42/ kg
<i>Bombax ceiba</i>	Semul	Timber, fibre	-
<i>Acacia auriculiformis</i>	Australian babul	Timber, fuel wood	-
<i>Diospyros melonoxylon</i>	Tendu	Fruit, timber, fuel wood, tendupatta	4000/standard bag
<i>Azadirachta indica</i>	Neem	Timber, medicinal value, Seeds	Seeds- 27/ kg
<i>Ziziphus mauritiana</i>	Ber	Timber, fruit, fodder	40-80/ kg
<i>Terminalia tomentosa</i>	Saja (Aasan)	Timber, silk rearing, fuel wood	Silk rearing- 400/ 100 pieces
<i>Tectona grandis</i>	Teak	Timber	-
<i>Gmelina arborea</i>	Khamhar	Timber, fodder	-
<i>Eucalyptus tereticornis</i>	Nilgiri	Timber, oil extraction	-
<i>Cocos nucifera</i>	Coconut	Fruit	50/ piece
<i>Moringa oleifera</i>	Drum stick	Fruit	50-80/ kg

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<i>Atrocarpusheterophyllus</i>	Jack fruit	Fruit, fuel wood	50-60/ kg
<i>Tamarindus indicus</i>	Imli	Fruit pulp, fuel wood, seeds, flower	Seeds- 36/ kg Flower- 63/ kg Pulp- 35-40/ kg
<i>Psidium guajava</i>	Guava	Fruit	50-80/ kg
<i>Schleicheraoleosa</i>	Kusum	NWFP, Lac production	Lac- 300-400/ kg
<i>Semecarpusanacardium</i>	Bhelva	Fuelwood, fruit	9/ kg
<i>Manilkara zapota</i>	Sapota	Fruit	80-100/ kg
<i>Litchi chinensis</i>	Litchi	Fruit	80-100/ kg
<i>Phoenix sylvestris</i>	Chhind or silver date palm	Fruit, beverage	Beverage- 40.00/ litre
<i>Madhucaindia</i>	Mahua	Seeds, Flower, beverage	Seeds -29/ kg Flower-30/ kg Beverage – 60/ litre
<i>Caryotaurens</i>	Sulfi	Beverage	80-10/ litre
<i>Shorearobusta</i>	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 agrisilviculture agroforestry system was mostly practiced throughout the Bastar district, and *Tectonagrandis*, *Shorearobusta*, *Eucalyptus tereticornis*, *Phenix sylvestris*, *Mangiferaindica*, *Syzygiumcumini*, *Gmelinaarborea*, *Pongamiapinnata*, *Tamarindusindica*, *Bambosabambos*, *Ancardiumoccidentalis*, *Teminaliaarjuna*, *Terminalia balerica*, *Madhucaindica*, *Acacia auriculiformis*, and *Acacia niloticatree* species were grown by the farmers on their field.

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