P-ISSN: 2618-0723
E-ISSN: 2618-0731

NAAS Rating: 5.04
www.extensionjournal.com

International Journal of Agriculture Extension and Social Development

Volume 7; Issue 9; September 2024; Page No. 480-484

Received: 24-06-2024
Accepted: 05-08-2024

Indexed Journal
Peer Reviewed Journal

# Structure and composition of agroforestry systems in coastal areas of Uttara Kannada

**[1]Ganesha BH and [2]Jagadish MR**

[1]Ph.D. Forestry Scholar, Department of Silviculture and Agroforestry, College of Forestry, Sirsi, University of Agricultural Sciences, Dharwad, Karnataka, India

[2]Assistant Professor, Department of Silviculture and Agroforestry, College of Forestry, Sirsi, University of Agricultural Sciences, Dharwad, Karnataka, India

**DOI:** https://doi.org/10.33545/26180723.2024.v7.i9g.1104

**Corresponding Author:** Ganesha BH

**Abstract**

The experiment was conducted in coastal areas of Uttara Kannada during 2021-24 to analyse the structure and composition of the agroforestry systems. This study explores the diverse species compositions and stratification layers of various agroforestry systems, highlighting their ecological and economic functions. Agroforestry systems integrate trees and plants into agricultural landscapes, each tailored to specific environmental and productivity goals. Home gardens are characterized by high biodiversity, with a layered structure, tall trees like *Cocos nucifera* (coconut) and *Artocarpus integrifolia* (jackfruit) form the canopy layer, medium-sized fruit and shade trees such as *Anacardium occidentale* (cashew) and *Mangifera indica* (mango) populate the middle layer and smaller trees and shrubs like *Carrica papaya* (papaya) and *Moringa oleifera* (moringa) occupy the intermediate layer. The bottom layer includes vegetables and ornamental flowers, optimizing space for food production and aesthetics. Bund plantations focus on soil conservation and windbreaks, with species like *Glyricidia maculata* species and *Michelia champaca* serving as primary components. Boundary plantations use a mix of large and medium-sized trees, including *Tectona grandis* (teak) and *Dalbergia sissoo* (sissoo), for timber, shade and demarcation purposes. Silvi-horticulture systems combine trees such as *Cocos nucifera* (coconut) and *Tectona grandis* (teak) with horticultural crops, enhancing productivity and biodiversity. Live fences use species like *Glyricidia* and Agave to create barriers that also serve as windbreaks and boundary markers. Aqua forestry systems, planted near water bodies, utilize species like *Glyricidia* and *Casuarina equisetifolia* for soil stabilization and water management. Block plantations focus on high-value timber and economically significant species like *Tectona grandis* (teak) and *Swietenia mahagoni* (mahogany), often including fruit trees. Silvi-pasture systems integrate fodder trees such as *Leucaena leucocephala* with forage crops for livestock. Scattered planting involves distributing valuable trees like *Cocos nucifera* (coconut) and *Mangifera indica* (mango) across landscapes for supplemental income and ecological benefits. Each system demonstrates the adaptability of agroforestry practices to meet specific environmental and economic needs in coastal areas of Uttara Kannada.

**Keywords:** Agroforestry, composition, stratification and home garden

## 1. Introduction

Agroforestry is a sustainable land-use system that integrates trees and shrubs into traditional agricultural landscapes. By combining forestry with agriculture, this practice aims to optimize land productivity while enhancing ecological benefits. Trees and shrubs are strategically planted alongside crops or pastures to create a diverse and multifunctional landscape. One of the primary advantages of agroforestry is its ability to improve soil health. Tree roots help stabilize the soil, reduce erosion, and enhance nutrient cycling, which can lead to more fertile and resilient agricultural land. Additionally, agroforestry promotes biodiversity by providing varied habitats for wildlife, thus supporting a richer and more balanced ecosystem (Wilson and Lovell, 2016) [12].

Agroforestry also contributes to climate resilience. Trees sequester carbon dioxide, mitigating greenhouse gas emissions and helping to combat climate change. They offer shade and windbreaks, which can moderate temperature extremes and protect crops and livestock from harsh weather conditions. Economically, agroforestry offers opportunities for diversification. Farmers can generate additional income from tree products such as fruits, nuts, or timber, complementing their primary agricultural activities. This diversification can enhance overall farm profitability and stability (Brown *et al.*, 2016) [1].

Agroforestry systems are characterized by their diverse structures and compositions, which can vary based on regional conditions, land use, and specific goals. The fundamental structure of agroforestry typically includes a combination of trees, shrubs, and agricultural crops or livestock, arra in various configurations to maximize ecological and economic benefits. In a typical agroforestry system, the composition usually involves three main components: trees, crops, and/or livestock. Trees are strategically planted to provide benefits such as windbreaks, shade, and soil stabilization. They can be arranged in rows, scattered throughout fields, or planted in dedicated groves

depending on the design and purpose of the system. These trees may include fruit-bearing species, timber trees, or nitrogen-fixing species that enhance soil fertility (Nair, 1991) [8].

Crops are grown in the spaces between trees or in combination with them. The choice of crops depends on the specific agroforestry model and local conditions. For example, in alley cropping systems, rows of trees are interspersed with rows of crops, allowing for efficient use of land while benefiting from the trees' contributions to soil health and microclimate regulation. Livestock may also be integrated into agroforestry systems, grazing on pastures that are maintained alongside or beneath tree canopies. This integration can help in nutrient cycling and pest management, as animals can contribute to the maintenance of healthy soils and reduce the need for chemical inputs (Shi *et al.*, 2018) [10]

The documentation of such traditional agroforestry systems will help in building the knowledge treasure of the science of agroforestry (Devaranavadgi *et al.*, 2010) [4]. Traditional agroforestry systems, practiced by indigenous communities for generations, offer valuable insights into sustainable land management and biodiversity conservation. These systems can be tailored to local environmental conditions, making them highly adaptable and effective in different regions. It will be helpful in implementing some of the most promising agroforestry models directly on the farmer's fields. By documenting and analysing traditional agroforestry practices, researchers can identify best practices that can be scaled up and adapted to modern agricultural challenges (Dagar and Tewari, 2017) [3]. Besides, it will also help for future planning of agroforestry research. Integrating traditional knowledge with scientific research can enhance the resilience and productivity of agroforestry systems, ensuring long-term sustainability and food security.

Overall, the structure and composition of agroforestry systems are designed to create a balanced and functional ecosystem that supports biodiversity, enhances soil health and provides economic benefits through diversified production.

## 2. Materials and Methods

Experiment study was carried out 3 coastal taluks of Uttara Kannada namely Ankola, Kumta and Bhatkal. Uttara Kannada District is a major coastal district of Karnataka, with the largest coastal length (142 Km). Major part (Karwar, Ankola, Kumta, Honnavar and Bhatkal taluks) of Uttara Kannada district falls under Coastal Agro-climatic zones (zone-10) of Karnataka and districts falls under West Coast plains and hills of Agro-climatic zones of India (zone-12).

Species composition reflects the relative dominance of species on site and species structure and composition helps to know the richness of species in the study area. Species in the farm was recorded as whole numbers and species composition. The species were recorded from each agroforestry systems. The total number of each tree species in all sample farms was tabulated. The number of farms, where the particular tree was found out was counted. In each agroforestry system managed by farmers, species were stratified into top, middle and lower strata. These stratifications were carefully recorded and subsequently analysed to understand their distribution and interactions within the system. This methodical approach allowed for comprehensive data collection and detailed analysis of the agroforestry structures.

## 3. Results

### 3.1 Composition Species documented in different agroforestry systems

The agroforestry systems outlined represent various ways in which trees and plants are integrated into agricultural landscapes, each serving specific ecological and economic functions (Table 1). Home gardens are rich in biodiversity, featuring a mix of fruit trees such as *Mangifera indica* (mango), *Anacardium occidentale* (cashew) and *Psydium guajava* (guava), alongside other useful plants like *Cocos nucifera* (coconut) and *Moringa oleifera*. They also include ornamental flowers and spices such as *Myristica fragrans* (nutmeg) and *Murraya koenigii* (curry leaf). This system supports diverse needs from food and medicinal uses to aesthetics. Bund plantations focus on soil conservation and windbreaks, incorporating species like *Glyricidia* species and *Michelia champaca*. These plants are chosen for their ability to stabilize soil and provide shade. Boundary plantations involve tree species selected for their timber, shade and ecological benefits. Species such as *Tectona grandis* (teak), *Dalbergia sissoo* (sissoo) and *Casuarina equisetifolia* (casuarina) are common, reflecting a focus on timber production and boundary demarcation.

Silvi-horticulture systems integrate trees and horticultural crops, with species like *Cocus nucifera* (coconut) and *Tectona grandis* (teak) used to complement the growth of other crops, enhancing productivity and biodiversity. Live fences use trees and plants like Glyricidia species and Agave species to create barriers that can serve as windbreaks, livestock deterrents and boundary markers. Aqua forestry systems, which involve planting near water bodies, utilize species like *Glyricidia* and *Casuarina equisetifolia*. These species are chosen for their adaptability to wet conditions and their ability to stabilize soil along water edges.

Block plantations are more intensive, focusing on high-value timber and other economically important species such as *Tectona grandis* (teak), *Swietenia mahagoni* (mahogany), and Sandal wood. These plantations often aim for commercial production and include a mix of fruit and timber trees. Silvi-pasture systems integrate fodder production with tree cultivation, using species like *Leucaena leucocephala* and *Glyricidia maculata* to provide forage for livestock while also enhancing soil quality. Scattered planting involves the distribution of economically valuable or useful trees like *Cocus nucifera* (coconut), *Mangifera indica* (mango) and Bamboo across the landscape, often for supplementary income and ecological benefits. Each agroforestry system is tailored to its specific environmental and economic goals, demonstrating the versatility and adaptability of agroforestry practices.

### 3.2 Stratification of layer in different agroforestry systems

The data on agroforestry systems describes various layers of plant species within each system, illustrating how different types of plants are arranged to achieve specific ecological

and agricultural goals.

In home Gardens, the top layer occupied by tall or large trees like *Cocus nucifera* (coconut) and *Artocarpus integrefolia* (jack fruit), providing canopy and shade. Middle layer consists of medium-sized trees and shrubs such as *Anacardium occidentale* (cashew), *Sapindus emerginatus* (soapberry) and *Mangifera indica* (mango), offering fruit, shade and structural support. The intermediate layer consists of smaller trees and shrubs including *Carrica papaya* (papaya), *Moringa oleifera* (moringa) and *Citrus species* (citrus), which contribute fruits, spices and medicinal plants. The bottom layer comprises vegetables, agricultural crops and ornamental flowers, making use of the space for food production and aesthetics. Bund plantations consist of trees like *Glyricidia species*, *Michelia champaca*, *Casuarina equisetifolia* and *Cocus nucifera* (coconut), focusing on soil stabilization and windbreaks. Boundary plantations comprises of mix of large and medium-sized trees such as *Tectona grandis* (teak), *Leucaena leucocephala*, *Casuarina equisetifolia* and *Dalbergia sissoo* (sissoo), chosen for their timber, shade, and boundary demarcation roles.

Silvi-Horticulture systems consists of trees like *Cocus nucifera* (coconut), *Tectona grandis* (teak), and *Anacardium occidentale* (cashew) are integrated with horticultural crops. Live fence composed of species like *Glyricidia species*, *Agave species*, and *Grevelia robusta*, which are used to create protective barriers. Aqua forestry consists of species like *Glyricidia* and *Casuarina equisetifolia*, which thrive in or near aquatic environments and help in soil stabilization and water management. Block plantations consists of high-value timber and economic species including *Tectona grandis* (teak), *Swietenia mahagoni* (mahogany), *Bamboo*, *Red sander*, *Agar wood*, and *Sandal wood*. It also includes fruit trees like *Anacardium occidentale* (cashew) and *Mangifera indica* (mango).

Silvi-Pasture system includes species like *Leucaena leucocephala* and *Glyricidia maculata*, which provide shade and fodder and bottom layer consists of forage crops such as Super Napier, Guinea, Fodder Sorghum, and African Tall Maize, providing food for livestock. Scattered planting comprises of trees like *Cocus nucifera* (coconut), *Mangifera indica* (mango) and *Bamboo*, scattered across the landscape for supplemental production.

## 4. Discussion

### 4.1 Species found in the different agroforestry systems

Coastal areas often experience a range of environmental conditions such as high humidity, salinity and occasional extreme weather events (Table 1). Home gardens, with their rich biodiversity and mix of fruit trees, spices and medicinal plants, are studied to understand how these systems can enhance resilience to these conditions. By integrating species like *Mangifera indica*, *Annacardium occidentale and Psidium gujava* and these diverse plantings contribute to soil health, microclimate regulation and local food security.

The study is in line with the study conducted by Dagar (2014) [2] who reported that *Cocus nucifere and Artocarpus integrifolia* are most common species found in Coastal areas and Andaman and Nicobar Islands. Nair (1993) [7] reported that in home gardens generally consists of *Mangifera indica*, *Annacardium occidentale species.* Gebauer (2005) [6] also reported the variety of species in home gardens of Central Sudan. Bund plantations are critical in coastal regions for their role in soil conservation and windbreak functions. Coastal soils are often prone to erosion due to wind and water, and plants like *Glyricidia* species and *Michelia champaca* are studied for their effectiveness in stabilizing soil, reducing erosion, and mitigating wind damage. Research focuses on how these species enhance soil structure, prevent nutrient loss and contribute to overall land stability, which is crucial for sustainable agriculture in coastal settings. Study is line with the study conducted by Varadaranganatha and Madiwalar (2010) [11] who found presence of *Glyricidia* species growing extensively on bunds in coastal areas of Uttara Kannada.

Boundary plantations in coastal areas helps to demarcate property lines and provide timber resources while addressing ecological concerns. Species such as *Tectona grandis*, *Dalbergia sissoo* and *Casuarina equisetifolia.* These plantations also serve as a model for integrating commercial forestry with environmental stewardship, offering insights into sustainable land use practices in coastal regions. Similar study was conducted by Varadaranganatha and Madiwalar (2010) [11] who found growing of *Casuarina equisetifolia* and *Tectona grandis* on boundary of the farm land in coastal areas of Uttara Kannada.

Silvi-horticulture systems combine tree cultivation with horticultural crops, addressing the need for increased productivity and biodiversity in coastal areas. Coastal soils can benefit from the combination of species like coconut and teak with other crops, which can improve soil fertility, enhance water retention, and increase crop yields. Studying these systems helps understand how tree-crop interactions can optimize land use, improve resource efficiency, and support sustainable agriculture in coastal environments.

Live fences, made from trees and plants like *Glyricidia maculata* species and Agave, are particularly relevant in coastal areas for their role in windbreaks and livestock deterrence. Aqua forestry systems are designed to address the unique challenges of planting near water bodies in coastal areas. Species like *Glyricidia maculata* and *Casuarina equisetifolia* are studied for their adaptability to wet conditions and their role in stabilizing soil along water edges. Research focuses on how these species can prevent erosion, improve water quality, and support aquatic ecosystems, providing valuable insights into managing coastal areas where land and water interact.

Block plantations in coastal areas focus on high-value timber and other economically important species. By studying species like teak, mahogany, and sandalwood, researchers explore their growth dynamics, timber quality, and economic viability. This research helps in understanding how intensive timber production can be managed sustainably in coastal environments, balancing economic benefits with ecological impacts.

Silvi-pasture systems integrate tree cultivation with fodder production, which is particularly useful in coastal regions with diverse vegetation. Species like *Leucaena leucocephala* and *Glyricidia maculata* helps in providing forage, improving soil quality and supporting livestock. Research in this area focuses on optimizing the balance

between tree and pasture management to enhance productivity and sustainability in coastal agricultural systems.

Scattered planting involves distributing valuable or useful trees across the landscape, which can be particularly beneficial in coastal areas for supplementary income and ecological benefits. By studying species like coconut, mango and bamboo, researchers assess their role in providing economic benefits, enhancing biodiversity and contributing to ecological stability. This approach helps understand how scattered tree planting can support sustainable land use and resilience in coastal environments.

It provide a comprehensive understanding of how different agroforestry practices can be adapted and optimized for the specific conditions of coastal areas, contributing to sustainable land management and environmental resilience.

### 4.2 Stratification of layer in different agroforestry systems

The stratification different agroforestry systems shows varied species (Table 2). In home gardens, the arrangement of plants in different layers maximizes productivity and functionality. The top layer, featuring tall or large trees such as *Cocus nucifera* (coconut) and *Artocarpus integrafolia* (jackfruit), provides essential canopy and shade. This shading helps in creating a microclimate that benefits the plants in the lower layers by reducing direct sunlight and maintaining soil moisture. The middle layer, consisting of medium-sized trees and shrubs like *Anacardium occidentale* (cashew), *Sapindus emerginatus* (soapberry) and *Mangifera indica* (mango), contributes fruits and additional shade, while also offering structural support to the garden's ecosystem. The intermediate layer is populated with smaller trees and shrubs, including *Carica papaya* (papaya), *Moringa oleifera* (moringa) and Citrus species, which add variety by providing fruits, spices, and medicinal plants. The bottom layer is dedicated to vegetables, agricultural crops, and ornamental flowers, ensuring efficient use of space for both food production and aesthetic appeal.

The study is in line with the study conducted by Dagar (2014) [2] who reported that *Cocus nucifere and Artocarpus integrifolia* occupied the higher strata and receive maximum sun light in Coastal areas and Andaman and Nicobar Islands. Nair (1993) [7] reported that in home gardens generally have 3-4 vertical layers. Horticulture crops occupy middle layer and leafy vegetables and agriculture crops occupy bottom layer.

Bund plantations utilize trees such as *Glyricidia maculata* species, *Michelia champaca*, *Casuarina equisetifolia*, and *Cocus nucifera* (coconut) primarily for soil stabilization and creating windbreaks. These species are chosen for their ability to enhance soil structure and prevent erosion, while also mitigating wind impacts that can affect crop yields. The bunds act as barriers to wind and water runoff, protecting the soil and improving the overall health of the land. Boundary plantations often include a mix of large and medium-sized trees like *Tectona grandis* (teak), *Leucaena leucocephala*, *Casuarina equisetifolia* and *Dalbergia sissoo* (sissoo). These trees are strategically planted along property boundaries to provide timber, shade, and delineate land ownership. They also contribute to the aesthetics of the landscape and can serve as natural barriers to livestock and human encroachment. Ranganatha (2008) [9] reported that *Casuarina equisetifolia* is generally planted at farm boundary in Coastal areas of Uttara Kannada.

In silvi-horticulture systems, trees such as *Cocus nucifera* (coconut), *Tectona grandis* (teak), and *Anacardium occidentale* (cashew) are integrated with horticultural crops. This integration allows for the simultaneous cultivation of high-value timber and fruit crops, enhancing the economic viability of the land. The system supports diverse production, combining the benefits of tree cover with the productivity of horticultural plants. Live fences, created using species like *Glyricidia* species, *Agave* species and *Grevillea robusta*, are employed to establish protective barriers around agricultural lands. These fences provide multiple functions including boundary demarcation, livestock management, and protection against wind and soil erosion. They also offer additional benefits such as fodder, fuel, and ornamental value. Aqua forestry practices involve species like *Glyricidia* and *Casuarina equisetifolia* that thrive in or near aquatic environments. These trees play a crucial role in soil stabilization, water management, and preventing erosion along water bodies. They help in maintaining the integrity of riparian zones and contribute to the overall health of aquatic ecosystems.

Block plantations are dedicated to high-value timber and economic species such as *Tectona grandis* (teak), *Swietenia mahagoni* (mahogany), bamboo, red sandalwood, agarwood, and sandalwood. These plantations are managed for their commercial value, including timber and non-timber products. Additionally, fruit trees like *Anacardium occidentale* (cashew) and *Mangifera indica* (mango) are included to provide supplemental income and diversify production. The silvi-pasture system incorporates species like *Leucaena leucocephala* and *Glyricidia maculata* to provide shade and fodder. The bottom layer is occupied by forage crops such as Super Napier, Guinea grass, Fodder Sorghum, and African Tall Maize, which are crucial for livestock feed. This system supports sustainable livestock production by combining tree cover with nutrient-rich forage. Scattered planting involves the distribution of trees like *Cocus nucifera* (coconut), *Mangifera indica* (mango) and bamboo across the landscape. This approach allows for supplementary production of fruits and other products while maintaining an open, accessible land layout. The scattered trees provide benefits such as shade, fruits, and additional income while minimizing competition for space. The study is in line with study conducted by Dobriyal *et al.* (2019) [5] who reported that agri-silviculture, agri horticulture, agri-silvi-horticulture, horti-silviculture, horti-pasture and home garden systems (vegetables + mango + teak) and agri-silvi-horticulture (sapota + grass + teak) were the most common practices of the region. Boundary plantation of *Tectona grandis*, were commonly found in most of the districts of south Gujarat.

Each agroforestry practice is tailored to specific land uses and environmental conditions, aiming to maximize the benefits of biodiversity, productivity, and sustainability. Hence, agroforestry integrates the land in sustainable manner and boost the productivity of the systems.

**Table 1:** Species found in different agroforestry systems in the experimental study area

| Systems | Common species found in different agroforestry systems |
|---|---|
| Home garden | *Bamboo, Sapindus emerginatus, Anacardium occidentale, Mangifera indica, Artocarpus integrefolia, Acrus zapota, Psydium guajava, Citrus species, Cocus nucifera, Garcinia species, Myristica fragrans, Ramapathre, Dalchinni, Theobroma cocoae, Murraya koenigii, Vitex alticima, Musa paradesica, caryota urens, Moringa oleifera, ornamental flowers, Carrica papaya, Areca catechu*<br>Climber: Pepper, Beetle vine |
| Bund plantations | *Glyricidia maculata, Michelia champaca, Casuarina equisetifolia* |
| Boundary plantations | *Tectona grandis, Leucaena leucocephala, Casuarina equisetifolia, Dalbergia sissoo,* Garcinia species, *Gmelina arborea, Terminalia sp., Pongamia pinnata, Grevelia robusta, Canophyllum inophyllum, Ailanthus malabarica* |
| Silvi-horticulture systems | *Cocus nucifera, Tectona grandis* |
| Live fence | Glyricidia species, Agave species, *Grevelia robusta* |
| Aqua forestry | *Glyricidia, Casuarina equisetifolia* |
| Block plantation | *Tectona grandis, Swietenia. mahagoni,* Bamboo, *Pterocarpus santalinus, Aquileria agalocha, Santalum album, Anacardium occidentale, Mangifera indica, Cocus nucifera,* |
| Silvi-pasture system | *Leucaena leucocephala,* Glyricidia, Super Napier, Guinea, Fodder Sorghum, African Tall Maize, BNH-10 |
| Scattered planting | *Cocus nucifera, Mangifera indica,* Bamboo |

**Table 2:** Stratification of layer in different agroforestry systems

| Systems | Number of layer |
|---|---|
| Home garden | Top layer: *Cocus nucifera, Artocarpus integrefolia*<br>Middle layer: *Anacardium occidentale, Sapindus emerginatus,* Bamboo, *Mangifera indica, caryota urens, Areca catechu, Terminalia catappa*<br>Intermediate layer: *Carrica papaya, Moringa oleifera, Dalchinni, Citrus species, Murraya koenigii, Acrus zapota, Garcinia species, Myristica fragrans, Ramapathre, Theobroma cocoae, Vitex alticima, Musa paradesica*<br>Bottom layer: Vegetables, Agricultural crops, ornamental flowers |
| Bund plantations | *Glyricidia species, Michelia champaca, Casuarina equisetifolia, Cocus nucifera* |
| Boundary plantations | *Tectona grandis, Leucaena leucocephala, Casuarina equisetifolia, Dalbergia sissoo, Melia dubia,* Garcinia species, *Gmelina arborea, Terminalia sp., Pongamia pinnata, Grevelia robusta, Canophyllum inophyllum, Acacia species.* |
| Silvi-horticulture systems | *Cocus nucifera, Tectona grandis, Anacrium occidentale* |
| Live fence | *Glyricidia maculata, Agave species, Grevelia robusta* |
| Aqua forestry | *Glyricidia maculata, Casuarina equisetifolia,* |
| Block plantation | *Tectona grandis, Swietenia. mahagoni,* Bamboo, *Pterocarpus santalinus, Aquileria agalocha, Santalum album, Anacardium occidentale, Mangifera indica, Artocarpus integrefolia Cocus nucifera, Tamarindus indicus* |
| Silvi-pasture system | Top layer: *Leucaena leucocephala, Glyricidia maculata*<br>Bottom layer: Super Napier, Guinea, Fodder Sorghum, African Tall Maize, BNH-10 |
| Scattered planting | *Cocus nucifera, Mangifera indica,* Bamboo |

## References


1. Brown S, Miller D, Ordonez P, Baylis K. Evidence for the impacts of agroforestry on agricultural productivity, ecosystem services, and human well-being in high-income countries: a systematic map protocol. Environ Evid. 2018;7:1-16.
2. Dagar JC, Pandey CB, Chaturvedi CS. Agroforestry: a way forward for sustaining fragile coastal and island agro-ecosystems. In: Agroforestry systems in India: livelihood security and ecosystem services; c2014. p. 185-232.
3. Dagar J, Tewari V. Evolution of Agroforestry as a Modern Science; c2017. p. 13-90.
4. Devaranavadgi SB, Wali SY, Patil SB, Jambagi MB, Kambrekar DN. Survey of traditional agroforestry systems practiced in northern dry tract of Karnataka. Karnataka J Agric Sci. 2010;23(2):277-281.
5. Dobriyal MJ, Husain M, Prajapati VM, Devanand J. Agroforestry Models of South Gujarat. Flora Fauna. 2019;25(2):137-139.
6. Gebauer J. Plant species diversity of home gardens in El Obeid, Central Sudan. J Agric Rural Dev Trop Subtrop. 2005;106(2):97-103.
7. Nair PKR. An Introduction to Agroforestry. Klgwer Academic Publishers. Dordrecht, Netherlands; c1993.
8. Nair P. State-of-the-art of agroforestry systems. For Ecol Manage. 1991;45:5-29.
9. Ranganatha Varada GH. Studies on Agroforestry Systems in Uttara Kannada District to prioritize tree/shrub species. M.Sc. Thesis. University of Agricultural Sciences, Dharwad; c2008.
10. Shi L, Feng W, Xu J, Kuzyakov Y. Agroforestry systems: Meta-analysis of soil carbon stocks, sequestration processes, and future potentials. Land Degrad Dev. 2018;29(1):3886-3897.
11. Varadaranganatha GH, Madiwalar SL. Studies on species richness, diversity and density of tree/shrub species in agroforestry systems. Karnataka J Agric Sci. 2010;23(3):452-456.
12. Wilson M, Lovell S. Agroforestry: The Next Step in Sustainable and Resilient Agriculture. Sustainability. 2016;8:574.