The landscape of agroforestry in Brazil: a synthesis of research trends, implementation patterns, and policy implications

Agroforestry Systems

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This document presents a concise overview of the different nomenclatures and terminologies used to describe agroforestry systems in studies conducted in Brazil. These practices are structured according to the agrisilvicultural, silvopastoral, and agrosilvopastoral categories established by Nair (1985, 2021). Within this scheme, systems are further classified as simple or biodiverse, reflecting their level of typological complexity. This typology follows the criteria synthesized by Santos et al. (2019), based on the conceptual foundations developed by Schroth et al. (2004), Steenbock and Vezzani (2013), and Miccolis et al. (2016).

1. Agrisilvicultural Systems

1.1 Simple configurations

1.1.1 Alley Cropping

1.1.2 Taungya

Although Alley Cropping and Taungya systems share the core principle of intercropping forest and agricultural species, they differ significantly in design, temporal dynamics, and primary objectives. Alley Cropping consists of integrating rows of trees or shrubs—frequently legumes—with annual crops cultivated in the interspaces (Marin et al. 2007). This configuration prioritizes a stable, long-term joint production of biomass and ecosystem services, such as the preservation of soil physical-chemical conditions and the promotion of deep-soil microbial activity (Marin et al. 2007; Barreto et al. 2012). In this arrangement, periodic pruning of the leguminous components is essential to provide organic residues and minimize competition for sunlight, water, and nutrients (Barreto et al. 2012).

Conversely, the Taungya system involves a temporary consortium where agricultural species are used to offset the initial costs of establishing a forest plantation (Rodrigues et al. 2007). Historically developed for teak (*Tectona grandis* L.f.) cultivation in 19th-century Myanmar, this system has since expanded to include various species combinations (Medeiros et al. 2015; Medeiros et al. 2019). The fundamental distinction between these practices lies in their purpose and operational scale: while Taungya is primarily a silvicultural strategy for large-scale forest establishment where annual crops serve as a secondary financial tool, Alley Cropping is more frequently implemented on family and commercial farms seeking sustained ecosystem resilience and diversified productivity (Cardinael et al. 2020; Nair et al. 2021; Thiesmeier 2024).

1.2 Biodiverse configurations

1.2.1 Cabruca

Cabruca is a traditional method of growing cacao (*Theobroma cacao* L.) in the understory of Atlantic Forest vegetation, occurring mainly in the southern Bahia state. The planting process involves thinning out the lower strata of the forest and opening up the canopy to provide space and allow partial sunlight to enter. Occasionally, farmers include other species of interest among the taller strata, such as additional fruit trees (Sambuichi et al. 2012). Cabrucas form mosaics associated with the primary Atlantic Forest, and due to their complex structure, they enhance ecosystem services and biodiversity conservation in tropical regions (de Assis Bomfim et al. 2013; de Almeida Rocha et al. 2015; Schroth et al. 2015).

1.2.2 Agroforestry System of Tomé-Açu (SAFTA)

The SAFTA is a biodiverse agroforestry system practiced by farmers in Tomé-Açu, northern Brazil. The local agricultural cooperative, Cooperativa Agrícola Mista de Tomé-Açu (CAMTA), was founded by Japanese immigrants and has prospered by selling cocoa, black pepper, and the pulp of various tropical fruits. Examples of these agroforestry systems have shown that the income obtained from 10 to 20 hectares is equivalent to that from pastures of 400 to 1,200 hectares in the region. Additionally, the rural establishments cultivating these agroforestry systems generate more jobs than extensive livestock farming (Yamada and Gholz 2002). According to Piekielek (2010), CAMTA thrived due to its institutional flexibility, as farmers adapted to ecological and economic pressures by innovating, diversifying production, and strengthening cooperative management.

1.2.3 Bracatingal

The name “Bracatingal" refers to the bracatinga (*Mimosa scabrella* Benth.), a pioneer tree species of the Mixed Ombrophylous Forest, which grows in high density during ecological succession processes. The Bracatingal is a traditional system in southern Brazil involving small farmers and land reform settlers. The properties comprise small modules for rotational use, where natural regeneration of each area occurs over seven to nine years, forming a homogeneous pioneer bracatinga forest. The next step involves harvesting the wood for charcoal production and then using fire to break the dormancy of the seed bank (Silva et al. 2016). In the initial years, seasonal crops such as corn and beans are grown. Afterward, the area is left fallow until the next cycle, benefiting bees that forage on the flowers and produce honey. The development of native species from other successional stages occurs synchronously with the bracatinga (Moreira et al. 2011).

The following classification reflects the terminological plurality identified within Brazilian literature. While several systems (notably 1.2.4, 1.2.5, and 1.2.6) exhibit significant structural and functional overlap, they are reported as independent categories to preserve the diversity of regional designations and conceptual frameworks identified during the review, rather than as mutually exclusive biophysical units.

1.2.4 Complex Multi-Stratified Agroforestry Systems

These systems are designed to be structurally and functionally similar to forests. The strata include fruit and timber trees, whose diverse organic matter contributes to the litter layer (Costa et al. 2017).

1.2.5 Successional Agroforestry Systems (SAFS)

1.2.6 Regenerative and Analogous Agroforestry Systems (SAFRA)

These systems are designed to mimic the structure and function of tropical forests. A key technique is leveraging vegetative ecological succession by planning space and time to ensure species diversity supports continuous product harvesting over months and years (Souza and Piñarodrigues 2013). Managing climax or sub-climax plants creates diverse ecological niches, enhancing biodiversity preservation and resource efficiency (Selecky et al. 2017). These dynamic systems also involve pruning to return nutrients to the soil and replacing species that produce biomass for better stratification (Silveira et al. 2007).

1.2.7 Syntropic Agriculture

The term "syntropic agriculture" has been used primarily since 2013, with limited published scientific literature despite its growing prominence in Brazil over the past decade. Pasini (2017, p. 6) defines it as "a particular type of successional agriculture or agroforestry system, but with the peculiarity of being based on natural fertility-building processes, guided by the logic of syntropy." Its creator, Ernst Götsch, a pioneering and renowned professor of agroforestry systems in Brazil, emphasizes that syntropic agriculture aims to create agroecosystems that resemble local natural ecosystems, considering both structure and functionality. The ethical goal is for farmers to become "agents for optimizing natural processes, reconciling the satisfaction of their material needs with the maintenance and recovery of natural environments" (Andrade 2019, p. 81). According to this concept, in nature, "cooperation plays a greater role than competition" (Andrade et al. 2020, p. 3). In a 1994 case study, Ernst Götsch managed a “Forest Garden,” a term of Mexican origin (Schulz et al. 1994). Some of the management techniques and principles characterizing the forest garden are similar to what was later defined as syntropic agriculture.

1.2.8 Capoeira (Fallow Land)

Capoeira refers to land areas generally composed of herbaceous and woody shrubs at various stages of natural regeneration. The type of prior disturbance influences the speed of recovery and plant composition (Costa et al. 2016). Enriching fallow areas with nitrogen-fixing species and slow-growing fruit trees also positively impacts ecological functionality and revenue generation (Joslin et al. 2011; Joslin et al. 2019).

Unlike the preceding categories derived from specific literature nomenclature, this classification (1.2.9) is a deliberate thematic grouping proposed in this study. It consolidates various forms of anthropogenic forest intervention into a unified category characterized by active cultivation within established secondary forest structures.

1.2.9 Management of Species in Secondary Forest

Agroforestry cultivation in secondary forests involves enriching the tree strata with economically valuable species in advanced stages of regeneration. This approach prioritizes maintaining the standing forest and allowing the extraction of non-timber products. In the Atlantic Forest of the Southeast Region, plantations of the juçara palm (*Euterpe edulis* Mart.) have shifted from harvesting the palm heart to collecting the fruits for a nutritious pulp (de Souza et al. 2016). Similarly, in the Amazon Forest, açaizais are dominated by açaí (*Euterpe oleracea* Mart.) (Steward 2013). Another important activity in the Amazon Forest is the management of traditional rubber trees (*Hevea brasiliensis* (Willd. ex A.Juss.) Müll.Arg.) in secondary forests. Besides sustainable rubber collection, farmers also cultivate other tree species in the same area, such as Brazil nut (*Bertholletia excelsa* Bonpl.), cupuaçu (*Theobroma grandiflorum* (Willd. ex Spreng.) K.Schum.), and andiroba (*Carapa guianensis* Aubl.) (Schroth and da Mota 2013).

2. Silvopastoral Systems

2.1 Biodiverse configurations

2.1.1 Faxinal

2.1.2 Caíva

Two cultivation systems exclusive to the south of Brazil, Faxinal and Caíva, are located in the Mixed Ombrophylous Forest, also referred to as the Araucaria Forest (*Araucaria angustifolia* (Bertol.) Kuntze), a phytophysiognomy of the Atlantic Forest. Properties under these systems typically form a gradient. This gradient includes minimally modified native forests, fragmented secondary woodlands, and pastures closer to residences. In addition to animal husbandry and the cultivation of annual species for subsistence, it is common to harvest the araucaria pine nut and yerba mate (*Ilex paraguariensis* A.St.-Hil.). The Faxinais are Special Areas of Regulated Use (ARESUR) (Antoneli et al. 2019), and the organization of land allows for shared use among families. In Caívas, by contrast, the properties are privately owned and preserve a high diversity of tree species, contributing to forest conservation (Hanisch et al. 2019; Hanisch et al. 2022). These systems originated with Portuguese and Spanish colonization in the 17th and 18th centuries and were continued by Polish and Ukrainian immigrants (Antoneli et al. 2018).

3. Agrosilvopastoral Systems

3.1 Simple configurations

3.1.1 Integrated Crop-Livestock-Forestry System (ICLFS)

The Integrated Crop-Livestock-Forestry System (ICLFS) is a production strategy that integrates annual crops, timber or fruit tree species, and livestock. These arrangements can involve either consortia or crop rotation. ICLFS is typically implemented on a medium or large scale because the most commonly used species, such as soy, corn, eucalyptus, and beef cattle, have well-established technologies in conventional agriculture. In the scientific and technical literature, ICLFS is also referred to as the Integrated Farming Production System (SIPA) (Carvalho et al. 2014). The ICLFS encompasses three other combinations: Crop-Livestock Integration (ICL), Crop-Forest Integration (ICF), and Livestock-Forest Integration (ILF). The term 'agrosilvopastoral' is often used synonymously with ICLFS. However, the literature also documents agrosilvopastoral systems with dozens of species (Slinger 2000). The main goals of ICLFS are to optimize the use of space and inputs, generate environmental benefits along with profits, and promote mitigation and adaptation to climate change (Salton et al. 2014; Embrapa 2020).

3.2 Biodiverse configurations

3.2.1 Homegarden Agroforestry

Widely used in Brazil and other tropical regions, especially in family farming, these systems provide food security for subsistence, socioeconomic benefits from product sales, and family well-being (Almeida and Gama 2014). Homegardens are considered extensions of homes and feature various floristic structures. Herbaceous and shrub species of culinary and medicinal importance are planted adjacent to homes, while surrounding areas contain orchards and native trees for multiple uses (Steward 2013). With a complex structure, homegarden agroforestry systems typically have multi-stratified vegetation (Albuquerque et al. 2005).

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