Agroforestry practices in riparian ecology and its benefits to the farmers of Central Chhattisgarh

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Abstract Agroforestry is a sustainable land use strategy that combines trees and crops for integrated, diverse, and climate-smart farm output. Riverine agroforestry appears to be more diverse, supporting biodiversity, improving microclimate, and increasing cropping intensity. The agroforestry systems along the Lilagar River in Chhattisgarh were researched in this study, and the merits and drawbacks of existing agroforestry systems were evaluated under farm field settings. According to the findings, around 59% of farmers planted border trees of species that regenerate and establish naturally on agricultural grounds. T. arjuna, B. monosperma, A. nilotica, A. indica, and other significant species were found, along with crops such as paddy, pigeon pea, wheat, chickpea, and vegetables. Farmers preserve trees for fuel wood autonomy, lumber, fodder, and food. The biggest barriers to agroforestry adoption identified were concerns with felling and restrictions. Approximately 92% of farmers are dissatisfied with the falling and transit strategy, and 88% are uninterested in agroforestry due to a lack of industry support. As a result, the Agroforestry system can only be promoted by overcoming these limits through supporting legislation, strengthened extension services, research and innovation, and scaling up successful agroforestry efforts.

Keywords: Agroforestry, Forestry, Microclimate, T. arjuna

Introduction

Riverine agroforestry is a land management practice that involves the cultivation of trees, agricultural products, or livestock along riverbanks and floodplains. It is a long-term strategy that capitalises on the ecological benefits of trees while sustaining agricultural output (Overton, 2014). This agroforestry method recognises rivers and their related riparian zones as critical sources of water, nutrients, and habitat for a variety of species (Overton, 2014; Nair, P.K.R. 2011). Riverine agroforestry has received widespread interest due to its ability to address a wide range of environmental, economic, and social issues. This practice promotes biodiversity protection, soil and water conservation, climate change mitigation, and sustainable livelihoods for local populations by planting trees alongside crops or combining them with livestock production (Kumar & Nair, 2004). The ecological, economic, and social worth of Chhattisgarh's Lilagar River is enormous. It is an important water resource, supplying irrigation for agricultural operations and supporting the livelihoods of populations that live along its banks. The Lilagar River also supports a variety of aquatic and terrestrial ecosystems, which contribute to the biodiversity of the region (Das, 2015; http://www.cgwrd.in). The adoption of riverine agroforestry practices along the Lilagar River can help the local ecosystem and communities in a variety of ways. The river's water quality can be improved, erosion reduced, and riverbank stability improved by introducing agroforestry systems. Riverine agroforestry also provides prospects for economic diversification, increased food security, and the preservation of traditional knowledge and cultural legacy (Feyssa, 2011).

The goal of this research is to investigate the prevalence of various agroforestry practices, evaluate the advantages of local communities and stakeholders confront will help to inform evidence-based decision-making and policy creation. As a result, the current study intends to analyse the prevalent agroforestry practices along the Lilagar River, as well as the benefits gained by developing communities and the barriers to adoption of this land use system.

Materials and Methods

A. Study area

The riverine agroforestry practices study was conducted along the Lilagar River (Fig. 1), which originates from the Korba district and terminates into the Sheonath River in the Janjigar-Champa district. The study area is located on the boundary line of the Bilaspur and Janjigar-Champa districts in the state of Chhattisgarh, India. The Lilagar River has a total length of approximately 135 km. The catchment area of the Lilagar River serves as the site for riverine agroforestry practices. Agroforestry systems in the vicinity of the river rely on the water resources and hydrological dynamics of the Lilagar River. Bilaspur (22.1437° N, 82.1278° E) is located in the Plain zone of Chhattisgarh and represents India's Eastern plateau and hills region (Pratap Toppo et al 2016; Chandra, et al. 2018). The climate of this region is monsoonal with three seasons, viz. winter (November to February), summer (April to June), and a rainy season (July to September). As per Koppen-Geiger, it is AW (winter dry season), favorable for paddy cultivation as the area has a fertile plain. The average annual rainfall of this district varies between 1160 to 1259 mm year-1 depending on monsoon conditions (Chandra, et al. 2018).

B. Data collection and analysis

The research was carried out between 2019-2020. To identify existing agroforestry practices along the Lilagar River catchment area, an extensive research effort was undertaken. Grid points were established at intervals of 10 kilometers along the river. At each grid point, the agroforestry practices and tree species present were identified, counted, and recorded in a comprehensive inventory (Abdul Basit et al 2019).
Agroforestry practices prevailing along riverine catchment were identified following various components (Chandra, 2018). The group meeting of farmers was organized in villages to gather information related to tree farming and discuss selected agroforestry practices chosen for study. The objective of the meeting was to collect data for a design and diagnostic survey following the guidelines established by ICRAF (International Centre for Research in Agroforestry) for the global inventory of agroforestry systems. A questionnaire was prepared to ensure the scientific integrity of the survey and to gather accurate and standardized information from the participating farmers (Nair 1989; Chandra 2018; Pratap Toppo et al 2016). The determination of the most important ECs will be based on the outcomes of these interviews and group meetings, considering the collective input from the respondents. This scientifically designed approach provided valuable insights into the prioritization of ECs in the study area. This ranking approach is in line with local knowledge and usefulness (Van-der Wolf et al 2016; Wagner et al. 2019).

Results

A. Existing agroforestry practices and tree crop structure along the Lilagar River

Various agroforestry practices were discovered in the study among farmers in the studied locations to meet their unique needs. Boundary plantations were the most common practice observed, accounting for 59% of all riverine practices. *T. arjuna, B. monosperma, A. nilotica, A. indica, B. ceiba, D. sissoo, G. arborea, A. procera, T. tomentosa, D. melanoxylon, F. racemosa, A. lebeck, and F. religiosa* were among the tree species discovered in this practice. Fruiting trees included *T. indica, M. indica, S. cumini, Z. mauritiana, M. longifolia, A. marmelos, and S. pinnata.* It is worth noting that 97% of the tree species employed in agroforestry grew naturally, but just 3% of species such as *M. indica, T. grandis,* and *G. arborea* were planted for wood and fruit production. *T. arjuna, A. nilotica,* and *B. monosperma* were the most prevalent tree species found in this practice. Furthermore, 8% of farmers had commercialized horti-silviculture practices. *T. arjuna, A. nilotica, A. procera, A. lebeck, G. arborea, M. indica, P. guajava,* and *M. longifolia* were among the tree species involved in this practice. These trees were grown with rice and vegetables. The silv-pastoral system, which was used by 5% of farmers, comprised tree species such as *B. monosperma, A. excelsa, T. arjuna, T. grandis, A. nilotica, A. indica,* and *S. pinnata,* as well as various fruit trees. This practice also included grasses such as *Cynodon dactylon, Cyperus rotundus,* and *Sacharum species.* Furthermore, 3% of resource-rich farmers have developed block plantations of *T. grandis* and other selected tree species. It should be emphasised that there was no planned placement of trees on bunds. Farmers, on the other hand, started tending operations to reduce the impacts of shade on crops and to produce larger timber sizes for higher economic returns.

B. Agroforestry Benefits and Constraints for non-adopters

A questionnaire sent to determine the important ecosystem services (ECs) for tree species owners in the study region, as well as independent individuals living near the grid points. Respondents will be able to rank the services based on their perceived relevance using the questionnaire. The list will be divided into four categories: “most important” (I), “important” (II), “less important” (III), and “not important” (IV). Furthermore, information on the barriers to the adoption of tree species in crop fields was gathered. With a total sample size of 100 participants, this information was acquired through interviews and/or group sessions. Interactions with tree owner farmers were done during the field project, and group meetings were held at each grid point. Figures 2 and 3 show the findings of the farmers’ perceptions of the positive and negative features of agroforestry, respectively. Figure 2 shows that fuel wood is a key requirement in rural India, and agroforestry plays a critical role in meeting domestic demand for fuel wood and lumber, particularly in non-forest areas where the value of trees is higher than in forested areas. Approximately 82% of farmers rely on agroforestry trees primarily for fuel wood, while 68% prioritize trees for wood production. Similarly, 15% of farmers plant trees primarily for money, whereas just 5% practice agroforestry using fruit-bearing tree species.

Overall, all participating farmers believed that trees are critical to supporting their families’ diverse requirements and boosting agriculture. However, a tiny minority of farmers (5% to 18%) do not recognize the benefits of trees grown in agricultural fields. In terms of agroforestry restrictions, Figure 3 shows that 92% of respondents viewed permission for felling and transit as a serious issue. Furthermore, 88% of farmers identified a lack of industry support as the area’s second most critical limitation. Due to the presence of trees, only 11% of farmers expressed concern about cultural operations in agricultural lands.

Discussion

The study’s findings show that varied agroforestry practices are common among farmers in the surveyed locations, with boundary plantations being the most common. This practice entails planting a wide variety of tree species along the borders of agricultural areas (Chandra, 2018). The existence of tree species such as *B. monosperma, B. retusa, T. grandis, T. arjuna, A. indica,* and others suggests that agroforestry systems can use both native and commercially planted trees. *B. monosperma* is used for lac production, therefore farmers in AF keep a sufficient number of plants (Toppo et al. 2016, Chandra, 2018). The dominance of naturally growing tree species in agroforestry practices (97%) implies reliance on locally accessible resources, emphasizing the importance of incorporating indigenous species into agroforestry systems (Jose, 2009; Altieri, 2017). Commercial planting of certain tree species for wood and fruit production, on the other hand, highlights the economic concerns involved in agroforestry decision-making. The agro-silviculture system, integrated approach showcases the potential for combining trees and crops to enhance overall farm productivity and sustainability (Gupta et al., 2014). The adoption of horti-silviculture practices by a subset of farmers further demonstrates the diversification of agroforestry systems, with the inclusion of fruit-yielding tree species alongside paddy crops and vegetables. This practice can provide additional income streams and nutritional benefits to farmers (Tiwari, 2014). Although practiced by a lower percentage of farmers, the silvi-pastoral system involves the integration of tree species such as *B. monosperma, A. excelsa* and *A. indica* with grazing grasses. This system demonstrates the possibility of merging cattle production with agroforestry, encouraging ecological balance and offering diverse outputs from the same land area (Cubbage, et al. 2012). It’s worth noting that the lack of a planned arrangement of trees on bunds suggests a more unstructured approach to tree planting, with farmers using tending operations to regulate shade effects on crops and maximise timber production. This method to adaptive management represents farmers’ strategies for the highest advantages of trees in agroforestry systems. The research findings regarding the positive and negative attributes of agroforestry in riverine areas provide valuable insights into the perceptions of farmers and the challenges they face.

A. Positive Attributes of Agroforestry:

The high proportion of farmers (82%) who rely primarily on agroforestry trees for fuel wood (figure 2) demonstrates the importance of agroforestry in meeting rural communities’ fundamental energy demands. This finding is consistent with prior research that emphasizes the role of agroforestry in providing renewable energy sources, such as fuel wood, in rural regions (Kumar et al., 2010). Furthermore, the fact that the majority of farmers (88%) (figure 2) prioritize trees for wood production underlines the economic benefit associated with timber from agroforestry systems. Agroforestry has been recognized as a sustainable method of timber production, with benefits such as reduced strain on natural forests and higher income creation for farmers (Sears et al., 2014). The discovery that 15% of farmers plant trees primarily for money...
underlines agroforestry's economic potential. Agroforestry systems, with their many tree species and products, can give farmers various revenue streams, resulting in enhanced lives (Reyes et al., 2005). Furthermore, while only 5% of farmers practice agroforestry with fruit-bearing tree species, this practice has the potential to increase farm income while also providing nutritional benefits through the growth of fruit trees. Agroforestry systems with fruit trees have been found to increase agricultural production, revenue, and food security (Leakey et al., 2005). These favorable agroforestry features are consistent with the general literature on agroforestry benefits, such as its role in delivering ecosystem services, diversifying agricultural outputs, increasing resilience, and encouraging sustainable land management (Jose, 2009; Nair, 2011).

B. Constraints of Agroforestry adoption

The demand for clearance for felling and transit (92%) and a lack of industrial support (88%) are the key restrictions mentioned by farmers (Figure 3). These findings emphasize administrative and market-related hurdles that agroforestry growers encounter. Permissions and rules for tree removal and transportation might impede tree management and utilization in agroforestry systems. Complex bureaucratic processes and insufficient help for farmers in managing these restrictions can stymie agroforestry's full potential (Poudyal, 2011).

The lack of industrial support shows that agroforestry products have limited market linkages and value chains, which might impair the profitability and viability of agroforestry systems. Efforts to build strong market ties and generate value-added products from agroforestry produce are critical to improving farmers' economic prospects (Jose, 2009). It is worth noting that only a small percentage of farmers (11%) (Figures 2 & 3) reported cultural operation concerns caused by trees in agricultural fields. This shows that, in general, farmers believe the benefits of agroforestry outweigh the challenges of incorporating trees into agricultural practices. However, further research is needed to investigate specific cultural management practices that can effectively address these challenges. The restrictions found in this study are consistent with current literature on agroforestry problems, such as governmental and institutional hurdles, market restraints, and the need for supportive extension services (Kiptot et al., 2018). The talks on the benefits and drawbacks of agroforestry in riverine settings emphasize the relevance of agroforestry in fulfilling energy needs, creating money, and improving farmer livelihoods. Administrative barriers, a lack of industry backing, and cultural operational concerns, on the other hand, offer challenges to fully realizing the potential benefits of agroforestry. To address these obstacles, legislative interventions, institutional assistance, and the creation of strong market links for agroforestry goods are required.

Conclusion

Finally, the research on riverine agroforestry practices indicated a wide range of practices used by farmers in the researched areas. The most common practice was boundary plantations in conjunction with agri-silviculture practices. Indigenous species contributed 93% of total tree diversity compared to introduced species. The species are chosen purely for their benefits, which include fuel, wood income, and others such as fruit, NTFP, and so on. Farmers have adopted trees that demand less care and cost and grow quickly. Farmers like these multipurpose plants along riverside agroforestry because indigenous trees are more acclimatized than foreign trees. The key barriers to agroforestry adoption identified were issues with felling and transit, a lack of industry support, and a lack of price strategy. If these barriers are overcome, agroforestry will spread widely in the area's farming communities. agroforestry.

References


Figure 1: Map of India depicting Chhattisgarh State, Bilaspur with Lilagar river, (Source: Google Earth).

Figure 2: Percent of farmers responded on benefits parameters (Functions) of tree species used in riverine agroforestry along Lilagar river.

Figure 3: Percent farmer’s response on different constraint parameters identified during the meeting with farmers (n = 100).