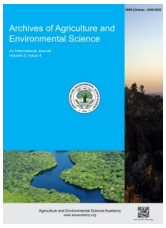
Archives of Agriculture and Environmental Science 10(1): 189-196 (2025)
https://doi.org/10.26832/24566632.2025.1001027

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes



REVIEW ARTICLE

Agroforestry and traditional knowledge: Lessons from indigenous practices in South Asian Countries: A review

Rajesh Prasad Dahal[1*], Samit Kafle[1], Karishma Khanal[2], Sandeep K.C.[1], Manisha Subedi[1], Prakash Ojha[1] and Hammad Ud Din[1]

[1]College of forestry Wildlife and Environment, Auburn University, Alabama - 36849, USA
[2]Department of Crop, Soil and Environment, Auburn University, Alabama - 36849, USA
[*]Corresponding author's E-mail: dahalrajesh11@gmail.com

ARTICLE HISTORY

Received: 10 January 2025
Revised received: 13 March 2025
Accepted: 18 March 2025

Keywords

Agroforestry
Biodiversity conservation
Indigenous knowledge
South Asia
Sustainable development

ABSTRACT

Agroforestry is deeply rooted in South Asian tradition as an important and dynamic land-use system that integrates agriculture and forestry. The review sums up indigenous agroforestry practices in South Asian countries, drawing attention to the multi-dimensional benefits obtained through such practices: food security, biodiversity conservation, and economic resilience. Systems such as multifunctional home gardens, Agri silviculture, silvopasture, and the Taungya system represent the innovative approaches developed in the region to integrate trees, crops, and livestock. The traditional knowledge contributing to such sustainable management is often passed down through generations. These indigenous practices, including home gardens and alley cropping, have ensured continued adaptation to evolving environmental and socioeconomic pressures, and lessons learned contribute to modern-day land management in the face of climate change and urbanization. Active women's involvement secures ecological balance and economic stability, representing the sociocultural dimensions of agroforestry. However, globalization, population pressure, and gaps in policies have confronted these practices, which has marginalized indigenous communities and shifted them towards more market-driven agricultural systems. Countries like Nepal and India have provided a policy impetus to agroforestry yet lack of integration and support remains one of the major obstacles. This review signals the importance of policy reforms that integrate traditional knowledge for sustainable development. Integration of indigenous knowledge with modern techniques of agroforestry could contribute to food security challenges, ecological resilience, and cultural heritage in South Asia. The authors call for increased institutional support and inclusive governance to mainstream agroforestry as a sustainable land-use strategy in the region.

Citation of this article: Dahal, R. P., Kafle, S., Khanal, K., K.C., S., Subedi, M., Ojha, P., & Din, H. U. (2025). Agroforestry and traditional knowledge: Lessons from indigenous practices in South Asian Countries. *Archives of Agriculture and Environmental Science*, *10*(1), 189-196, https://dx.doi.org/10.26832/24566632.2025.1001027

INTRODUCTION

Agroforestry is defined by various experts as a land use system that integrates trees with agricultural crops and/or animals, either simultaneously or in sequence, to enhance productivity, economic returns, and ecological benefits compared to traditional single-crop farming. According to ICRAF (1982), this approach is particularly beneficial for sustaining yields on marginal lands with minimal technological inputs. Lundgren & Raintree (1983) further describe agroforestry as the deliberate use of woody perennials, such as trees, shrubs, and bamboo, alongside crops or animals within the same land unit, arranged in spatial or temporal patterns. Essentially, agroforestry combines trees with crops like food, fruits, vegetables, and fodder on the same land to meet the needs of farmers, foresters, and livestock managers while promoting a balanced, multi-functional land-use

system. It enhances productivity, biodiversity, and sustainability by promoting interactions between agricultural and forestry components. Agroforestry systems have been widely used for their benefits to meet growing demand for forest products and food stuff. It has accomplished dual purposes. Institutional actors in forestry and environmental agencies and the major multilateral donor agencies are forced to promote and preserve agroforestry in many parts of the world. South Asia has a long history of agroforestry, with many farming systems developed over time to provide food, conserve resources, and support rural communities. Traditional practices like home gardens and tree-based farming continue to adapt, helping address challenges like climate change, loss of biodiversity, and land degradation. The various agroforestry systems that have been practiced for centuries in this region have also adapted over time in response to evolving pressures. While these changes highlight the significant potential of agroforestry to address many global challenges, its current level of implementation requires greater support and promotion. The emphasis, therefore, is on sustaining and advancing agroforestry as an enhanced land use strategy amidst competing demands and pressures (Kumar *et al.*, 2012). However, high population pressure (Table 1) has resulted in the over-exploitation of natural resources, including both timber and non-timber forest products. South Asia is home to a multitude of indigenous peoples with various histories, traditions, and ways of life, some of whom are said to have resided there since antiquity. Almost all Indigenous people have different customs and cultures that mostly connect to nature and inculcate relevant values in their way of life. Most of the indigenous peoples in Asia practice some form of shifting agriculture in either lowland, hilly, or even mountainous environments. In some cases, they also integrate shifting agriculture with permanent agriculture, for instance for the cultivation of fruit trees or cash crops. They consider that the shifting cultivation practiced by many forest-based indigenous communities does not harm forest resources in the long run and a highly efficient and sustainable way of using available resources. In contrast, there are clear indications that small-scale shifting cultivation can positively affect forest biodiversity (Persoon *et al.*, 2020). Furthermore, many indigenous communities acquired knowledge or memories about specific natural resources, and they pass to next generations (Tulius, 2020). Indigenous agroforestry systems are sustainable, multifunctional practices that support food security, generate income, and offer medicinal resources while conserving biodiversity. They are deeply woven into indigenous cultural practices, with women playing a critical role in their management, ensuring both family nourishment and economic stability (Gonçalves *et al.*, 2021). Indigenous agroforestry systems have been practiced for centuries, offering invaluable insights into sustainable resource management and biodiversity conservation.

Furthermore, documenting and integrating indigenous knowledge into contemporary agroforestry practices can help strengthen food security and improve livelihoods for rural communities. This integration not only preserves cultural heritage but also contributes to the conservation of agrobiodiversity, which is critical for maintaining ecosystem health and functionality (Gonçalves *et al.*, 2021). By understanding and valuing these traditional practices, policymakers and agricultural scientists can develop more inclusive and effective agricultural frameworks that respect and incorporate the wisdom of indigenous peoples (Nakashima *et al.*, 2012). Ultimately, this study aims to highlight the significance of agroforestry and traditional knowledge in fostering sustainable development and ecological resilience in South Asia.

METHODOLOGY

Literature collection and selection criteria

This review is based on an extensive analysis of existing literature on agroforestry and indigenous knowledge in South Asia. A structured search strategy was employed to ensure comprehensive coverage of relevant studies.

Sources used: The literature was collected from Google Scholar, ResearchGate, ScienceDirect, Springer, Web of Science, and official government policy documents.

Search keywords: The following keywords were used to identify relevant studies: Agroforestry in South Asia, indigenous agroforestry practices, sustainable land use, traditional knowledge in agroforestry, agroforestry policies in Nepal, India, Bangladesh, Pakistan, Sri Lanka.

Inclusion criteria: Peer-reviewed journal articles, conference papers, and official reports published. Studies focusing on agroforestry practices in Nepal, India, Bangladesh, Bhutan, Pakistan, Sri Lanka, Afghanistan, and the Maldives. Research addressing ecological, economic, and sociocultural aspects of agroforestry. The selected literature was categorized into the following key themes:

Table 1. Summary of land use and population dynamics in South Asian countries. Source (World bank, 2025).

Country	Land (1,000 ha)	Population (2022)	GDP (US $)	Density (per km²)	Forest Area (% of Land Area)
Afghanistan	65,223	41.0 million	1,201	46.5	1.5
Bangladesh	13,017	170.0 million	1,969	1,265	15
Bhutan	3,839	0.8 million	4,506	39.8	72
India	297,317	1.4 billion	2,410	464	24.4
Maldives	30	0.5 million	11,183	1,163	39
Nepal	14,335	30.0 million	1,237	203	40.4
Pakistan	77,088	240.0 million	1,260	265	5
Sri Lanka	6,271	21.5 million	3,588	347	29.7

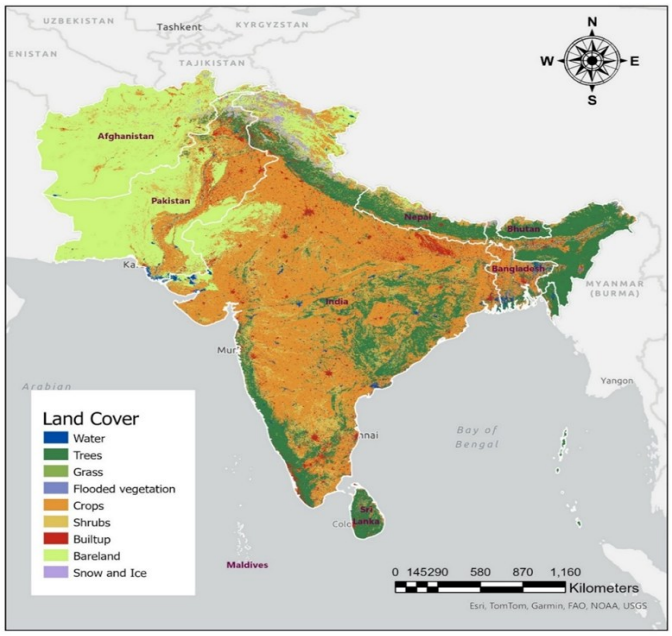


Figure 1. *Land use land cover map of South Asia (Source: Brown et al., 2022).*

Indigenous agroforestry systems: Multifunctional home gardens, Agri-silviculture and silvopasture systems, Taungya and alley cropping practices.

Biodiversity and ecological contributions: Role of agroforestry in biodiversity conservation, Soil fertility improvement and carbon sequestration.

Socioeconomic and cultural aspects: Women's role in agroforestry, Community-based management practices, Traditional knowledge transmission.

Challenges and policy gaps: Effects of globalization and market-driven agricultural shifts, Government policies and institutional support across different South Asian nations, Integration of indigenous knowledge with modern agroforestry techniques.

Data analysis and synthesis

The collected literature was analyzed using a qualitative synthesis approach to identify emerging trends, challenges, and research gaps in agroforestry practices. A comparative analysis was conducted to assess policy frameworks and agroforestry adoption rates across South Asian countries. Case studies highlighting successful indigenous practices and their contributions to food security and ecological resilience were examined. Thematic coding was used to categorize recurring concepts and draw meaningful conclusions from the data.

Limitations of the review

The study relies entirely on secondary data sources, and no primary fieldwork was conducted. Limited documentation of indigenous knowledge in academic literature restricts the scope of analysis. Recent policy changes might not be fully captured due to publication delays in peer-reviewed journals. Despite these limitations, this review offers a comprehensive understanding of agroforestry practices in South Asia and underscores the need for integrating traditional knowledge into modern land-use policies.

Overview of land use, population, and forest coverage in South Asia

The data provides demographic, economic, and environmental statistics for eight South Asian countries, emphasizing their diverse conditions. Afghanistan, with a land area of 65,223 thousand hectares and a GDP per capita of $1,201, has minimal forest cover at 1.5%, reflecting its sparse tree cover. In contrast, Bhutan, despite its small population of 0.8 million, has the highest forest cover at 72%, showcasing its commitment to environmental conservation. India's vast expanse and dense population of 1.4 billion are balanced with a 24.4% forest cover, indicating significant forest resources amidst rapid development.

The Maldives, although tiny in land area, demonstrates a high GDP per capita of $11,183 and a notable 39% forest cover, highlighting its economic reliance on tourism and marine resources. Pakistan, with the second largest population in the table, has only 5% forest cover, pointing to challenges in forest conservation. Nepal and Sri Lanka, with forest covers of 45% and 29.7% respectively, illustrate the importance of forest resources in supporting biodiversity and livelihoods. Bangladesh, with its extremely high population density, manages to maintain 15% forest cover, which is crucial for its ecological balance. Each country presents a unique blend of demographic pressures, economic development, and environmental stewardship. Major land use land cover of south Asia region is shown in Figure 1.

AGROFORESTRY SYSTEMS IN SOUTH ASIA

Multifunctional home gardens: These traditional systems integrate a variety of crops, trees, and sometimes livestock within a small area around homes. They promote food security, nutritional diversity, and income generation (Kumar *et al*., 2012).

Agri silviculture systems: This involves the integration of trees with crops. Common examples include the cultivation of poplar (*Populus deltoides)* and eucalyptus (*Eucalyptus spp.*) alongside agricultural crops (Park *et al*., 2022).

Plantation agriculture: This system includes the cultivation of commercial crops like coffee (*Coffea spp.)*, tea (*Camellia sinensis*), cacao (*Theobroma cacao*), and spices (e.g., black pepper, cardamom) in association with shade trees (Kumar *et al*., 2012).

Silvopastoral systems: These systems combine forestry and grazing of domesticated animals on the same land. Trees like carob (*Ceratonia siliqua*) and Euphrates poplar (*Populus euphratica*) are commonly used (Nair *et al*., 2021).

Agrosilvopastoral systems: This is a combination of crops, trees, and livestock. Trees such as mahlab (*Cerasus mahaleb*), sumac (*Rhus coriaria*), and laurel (*Laurus nobilis*) are integrated with agricultural and pastoral activities (Kumar *et al*., 2012).

Fertilizer trees and integrated tree-grass/crop systems: These systems use specific tree species to improve soil fertility and integrate them with crops or grasses. They help in resource conservation and enhance agricultural productivity (Park *et al.*, 2022).

Alley cropping: This system involves planting rows of trees or shrubs at wide spacings with agricultural crops grown in the alleys between the rows. It helps in reducing soil erosion, improving soil fertility, and providing additional income from tree products (Jose, 2009).

Boundary planting: Trees are planted along the boundaries of agricultural fields. This system provides windbreaks, reduces soil erosion, and can yield products like fruits, fodder, and timber without occupying the main cropping area (Brandle *et al.*, 2004).

In South Asia, agroforestry practices vary and are specific to the environmental conditions and cultures of countries, signifying a long tradition of combining agriculture with trees for better productivity and sustainability. Several important systems are used in Afghanistan including agri-silviculture which combines trees and crops to enhance the soil's fertility and crop production, agro-silvopastoral systems which integrate crops, trees, and animals to increase the stability of the agricultural system and natural forest succession which has the aim of allowing the forest to regenerate on its own thus enriching biodiversity and ecosystem services. In Bangladesh, the concept of homestead agro-forestry is widespread where tress, crops and sometimes livestock are kept around the homestead for food, fuel and income purposes by the rural population. Cropland agroforestry involves growing trees within a given agricultural land to improve its soil and crop productivity while multistoried agroforestry entails planting various species of plants at various heights to fully utilize space and resources and make agriculture more diversified. Bhutan has used agri-silvicultural practices where croplands and forestry are integrated so that the optimum land use is achieved and silvo-horticulture system which is integration of fruit trees with other crops to improve both economic and nutritional value. India features such an expressive range of scope of activities and practices in the form of home and backyard agroforestry including home gardens which are small scale, and the region is highly diverse in plant composition within proximity around the household. Details of major agroforestry systems in different countries are shown in Table 2.

Examples of diverse species planted and maintained through traditional methods

Indigenous practitioners and communities have traditionally managed complex agroforestry ecosystems to meet their physical, economic, cultural, and spiritual needs. Despite disruptions to traditional education and natural resource management systems, some communities continue to practice and share their ecological knowledge, although in limited ways. Traditional methods are used to grow and preserve many species. Home gardens are multifunctional systems surrounding households that sustain food security, provide medicinal plants, and maintain biodiversity through traditional knowledge. Contour Bunding entails building small earthen barriers along the contour lines of sloped ground to prevent soil erosion and promote water absorption. Contoured bunding has been found in studies to greatly increase agricultural yields. In southern Mali, millet and sorghum yields increased by 58% and 72%, respectively (Homeshwari-Devi *et al.*, 2024). Incorporating trees and shrubs into agricultural landscapes can improve soil fertility, water retention, and biodiversity. Agroforestry systems have been found to boost crop productivity and resilience to climate change. For example, agroforestry methods in India have resulted in enhanced soil quality and increased agricultural yields (Hamadani *et al.*, 2021). Crop rotation enhances soil structure and nutrient availability, resulting in enhanced crop productivity.

Table 2. Major Agroforestry systems in South Asian countries.

Country	Major Agroforestry Systems	References
Afghanistan	Agri silviculture, Agrosilvopastoral systems, Natural regeneration of forests.	Dhyani *et al.* (2021)
Bangladesh	Homestead agroforestry, Cropland agroforestry, Multistory agroforestry	Leuschner *et al.* (1987), Khan & Alam (2015)
Bhutan	Agri silvicultural systems, Silvo horticultural systems, Agroaquaculture	Tornar & Bhatt (2005); Dhital (2009)
India	Home gardens, Alley cropping, Silvopasture systems, Multistrata agroforestry,	Nair *et al.* (2009; Dhyani *et al.* (2021)
Maldives	Coastal agroforestry, Integrated fish and tree farming, Coconut-based agroforestry	Dhyani *et al.* (2021)
Nepal	Agrosilvicultural system, Agrosilvoanimal system, Silvopasture system, Taungya system, SALT.	Aryal & Pyakurel 2007; Joshi, 2015; Amatya *et al.* (2018)
Pakistan	Farm forestry, Agri-silviculture, Shrub-based agroforestry	Khan *et al.* (2017; Hayat *et al.* (2020)
Sri Lanka	Tea agroforestry, Coconut-based agroforestry, multi-tier systems, Taungya	Nelliat *et al.* (1974; Tejwani (1984)

Impact of globalization and urbanization on indigenous agroforestry practices

Our communities, which are based on hopes for advancements in technology and other disciplines, gain from progress in numerous ways, but we must be aware that this development can at times be exploited to violate the rights of others (Emerick *et al.*, 2016). Given the quick pace at which globalization, trade liberalization, and technological advancements, traditional agroforestry systems face many obstacles. Since commercial, market-driven techniques frequently replace traditional, sustainable farming methods, the demands of urbanization and globalization on indigenous practices have a direct impact on agroforestry systems. Due to modernization-driven land use changes, legal restrictions, market system, population dynamics, and financial incentives that prioritize cash crops and monocultures over community-based practices, indigenous agroforestry systems, which have historically been crucial for preserving ecological balance and local food security-face difficulties, even if they always differ in different systems (Islam & Quli, 2016). Indigenous communities face both opportunities and challenges because of modernization, which is fueled by industrialization and globalization. The impacts of modernization and urbanization on indigenous cultures include social, economic, and cultural aspects (Sokk, 2024). Indigenous communities have seen substantial social changes because of modernization, which have affected personal identities, communal ties, and social structures (Higashida *et al.*, 2023). Social cohesion and collective identities that have long supported indigenous economies are being eroded by the expansion of Western ideas and urbanization, which disrupts traditional familial networks and communal rituals (Ford *et al.*, 2020; Patel *et al.*, 2022). Modernization causes intergenerational trauma and poverty cycles through systematic discrimination, displacement, and loss of resources (Morris, 2022). Traditional labor roles and family dynamics change as cash economies replace subsistence systems. This typically challenges gender norms and increases economic inequality by prioritizing market-based wealth over communal resources (Cislaghi & Heise, 2020; Inkeles, 2022). Although modernization has the potential to improve living conditions for individuals, but it also often destroys subsistence economies, undermining the stability of long-standing business partnerships and perhaps disempowering entire communities (MacNeill, 2020). Indigenous communities have been driven by modernization to embrace western development patterns, putting them at risk for resource depletion, cultural decline and displacement. It leaves their rights in threat while making social isolation worse (Gebru *et al.*, 2021; Schapper & Urban, 2021). As a result, numerous communities are fighting for their land, resource rights and traditional knowledge with sustainable economic methods to promote financial independence and cultural resilience (Robinson *et al.*, 2021). Therefore, traditional knowledge of agroforestry is in crisis of becoming extinct asindigenous communities increasingly adopt Western economic models. This would weaken cultural identities and decrease ecological resilience and economic self-reliance, which might exacerbate cycles of poverty and environmental degradation (Gebru *et al.*, 2021; Robinson *et al.*, 2021).

Lack of recognition and support for traditional agroforestry practices

The sustainability, resource conservation, and agrobiodiversity preservation of traditional agroforestry systems are widely recognized (Garrity, 2004). Nevertheless, there is currently insufficient public policy support for these systems (Guillerme *et al.*, 2011). The growing popularity of agroforestry as a practical land management option in South Asia has been inhibited by policies that frequently favor alien species and commercial crops, as well as commodity-centric farming and forest policies (Garrity, 2012). This section presents case studies of South Asian countries that demonstrate the institutional and policy obstacles that agroforestry faces. India's agroforestry industry has issues because of old, contradictory regulations, conflicting interests, and a lack of supportive, integrated policies. Despite the promotion of "modern" agroforestry techniques, adoption rates are still low because agricultural policies often favor market-driven, commodity-centric systems that favor exotic species over native agroforestry techniques (Jara-Rojas *et al.*, 2020). As a result, smallholders have little incentive to adopt agroforestry as a method of land management (Puri & Nair, 2004). Understanding of agroforestry dynamics is limited by the lack of case studies on policy implications. Reform proposals seek to amend antiquated legislation that limits agroforestry's ability (Mohanan, 2002). According to Atreya *et al.* (2021), Nepal's agroforestry sector faces a lack of dedicated programs or human resources within the Department of Forests and Soil Conservation, hindering its development. Agriculture and forestry policies are not integrated, and relevant ministries enforcement of them is weak. To build a comprehensive framework for planning, budgeting, and assessing agroforestry initiatives at all governmental levels, in 2019 Nepal unveiled the National Agroforestry Policy (Government of Nepal, 2019), which aims to establish an interministerial coordination council. However, there are few supporting institutions and unclear institutional limits, which hinder the policy's actual implementation. Although Pakistan's forest policies (1955, 1962, and 1991) recognize the value of farm forestry, socioeconomic and technological obstacles limit its implementation. The environmental benefits of agroforestry and the involvement of small-scale farmers tend to be overlooked by government policies, which prioritize profitable commercial crops (Akbar *et al.*, 2000). As a result, the mainstreaming of agroforestry into national land management techniques has been restricted. These difficulties are made worse by the disagreement between proponents of private or state-controlled ownership and those who support traditional land practices (Paudel *et al.*, 2022).

Effects of industrial agriculture on traditional agroforestry systems

Intense forestry and agricultural operations have a complex effect on the environment and ecology (Nair *et al.*, 2010). Given the problems of climate change, environmental pollution, biodiversity loss, and soil degradation, the environmental damage caused by industrial agriculture and the potential of agro-

Table 3. Traditional agroforestry species and their cultural and ecological significance.

S. No.	Name	Description
1	*Spathodea campanulata*	This species is kept alive in traditional agroforestry systems by planting it alongside crops to offer shade and promote soil fertility.
2	*Ziziphus mucronata*	This plant is commonly found in traditional medicinal gardens and is utilized for a variety of health purposes. Indigenous knowledge and behaviors contribute to its conservation.
3	*Ficus thonningii*	This species is commonly found in sacred groves and traditional home gardens, and it is protected through cultural activities that emphasize its ecological and spiritual importance
4	*Bombax ceiba*	Used as a pioneer plant in habitat restoration projects by local populations due to its durability and environmental benefits.
5	*Azadirachta indica*	Neem trees have traditionally been placed around homes and temples in India due to its therapeutic powers and capacity to boost soil fertility. The leaves, bark, and seeds are employed in many traditional treatments.
6	*Ficus religiosa*	This sacred tree is commonly found around temples and village commons. It is safeguarded and respected in Hindu and Buddhist traditions, which aids in its preservation

Source : Kandari *et al*., 2014; Patwardhan *et al*., 2021; Ogwu & Osawaru, 2022; Haq *et al*., 2023.

forestry is becoming a more pressing concern (Rosati *et al*., 2020). Traditional mixed farming has mostly been displaced by modern agriculture's emphasis on monoculture for high yield and profit, which has resulted in environmental problems (Nair, 2007). Environmental degradation is the result of modern agriculture's dramatic increase in the use of pesticides, nitrogen, and phosphorus worldwide over the last 50 years (Tilman *et al*., 2002). Greenhouse gases (GHGs) emissions are largely caused by industrial agriculture, which is defined by high-yielding monocrops, heavy reliance on fossil fuels, mechanization, and the use of agrochemicals (Robertson *et al*., 2000). This strategy prompts worries that addressing present demands would compromise the capacity of future generations to survive (Nair, 2007).

Numerous habitats, including the human body, contain detectable levels of pesticides (Niggli *et al*., 2009). Our agricultural systems will also need to adjust to a changing climate in the near future, which is predicted to result in more extreme weather events like droughts and floods as well as a rise in disease and pest outbreaks (Richardson *et al*., 2009). In the developing world, where poverty makes it difficult for people to adjust, the changes will be more severe (Compton & Boone, 2000; Cavigelli & Robertson, 2001). An example of harmful farming techniques combined with a severe drought that had disastrous results is the Dust Bowl of the 1930s (Hall *et al*., 1999). Soil erosion, fertility loss, and reliance on synthetic inputs are all consequences of specialized farming methods that simplify agroecosystems, which eventually jeopardize agricultural sustainability. Significant deforestation has been caused by large-scale commercial agriculture, especially for crops like soybeans and oil palm, in biodiverse areas like the Amazon and Southeast Asian rainforests (DeFries *et al*., 2008) Further deforestation has also been exacerbated by the growth of biofuel production, especially in Africa, Latin America, and Southeast Asia. Mandates for renewable fuels, lax land rules, subsidies, and corporate speculation all encourage this rise (Jr. *et al*., 2011). the introduction of invasive species that disturb hydrology and endanger local biodiversity (Murthy *et al*., 2016). Furthermore, agroecosystem carbon stocks have significantly decreased because of the removal of livestock, manure, trees, and reduced soil organic matter. This has weakened soil fertility, water retention, and permeability, making the area more vulnerable to erosion, drought, water pollution, and carbon emissions (Caon & Vargas, 2017).

Conclusion and recommendations

Agroforestry in South Asia epitomizes a complex mix of traditional knowledge and appropriate methodologies for land use, now facing formidable challenges related to food security, biodiversity loss, and environmental degradation. The different systems, such as the multifunctional home gardens, agrisilviculture, and the silvopastoral approach, show resilience and adaptive characteristics for the indigenous practices. In practice, these are increasingly at risk due to urbanization, globalization, and lack of adequate policy support. Continuity and improvement in agroforestry require an integration of traditional wisdom into modern agricultural frameworks, adding institutional support to indigenous communities for sustaining the role of agroforestry in sustainable development and ecological resilience in this region. Governments would have to integrate agroforestry systems within their respective national land-use policies in tune with agricultural and environmental strategies. Recognition of indigenous peoples' contributions, especially women, may go a long way in the conservation of traditional ecological knowledge and encourage participatory decision-making. Systematic documentation and research are needed, which will bridge the traditional and modern agroforestry practices to enhance their applicability in present times. Capacity-building programs comprising training courses for farmers and policymakers will lead to awareness and adoption of sustainable agroforestry techniques. Such communities practicing agroforestry can be further helped through financial incentives like subsidies and carbon credits, which will encourage the economic viability aspect coupled with environmental conservation. By addressing these gaps and empowering these stakeholders, South Asia can preserve its agroforestry heritage while making strides toward a sustainable and resilient future.

DECLARATIONS

Author contribution statement

Conceptualization: R.D. and.; Methodology: R.D.; Software and validation: S.K., R.D. and K.K.; Formal analysis and investigation: R.D.; Resources: R.D.; Writing—original draft preparation., S.K., K.K.; Writing—review and editing: M.S.; Visualization: R.D.; Su-

pervision: R.D.; Funding acquisition: R.D. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest: The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

Ethics approval: This study did not involve any animal or human participant and thus ethical approval was not applicable.

Consent for publication: All co-authors gave their consent to publish this paper in AAES.

Data availability: The data that support the findings of this study are available on request from the corresponding author.

Supplementary data: No supplementary data is available for the paper.

Funding statement: No external funding is available for this study.

Additional information: No additional information is available for this paper.

REFERENCES

Akbar, G., Baig, M., & Asif, M. (2000). Social aspects in launching successful agroforestry projects in developing countries. *Science Vision*, *5*, 52-58.

Amatya, S. M., Cedamon, E., & Nuberg, I. (2018). *Agroforestry systems and practices in Nepal*.

Aryal, A., & Pyakurel, A. (2007). Ecological impact of Agroforestry System in Nepal. In: M. Sc. Forest Ecology and management, ALU.

Atreya, K., Subedi, B. P., Ghimire, P. L., Khanal, S. C., Charmakar, S., & Adhikari, R. (2021). Agroforestry for mountain development: Prospects, challenges and ways forward in Nepal. *Archives of Agriculture and Environmental Science*, *6*(1). https://doi.org/10.26832/24566632.2021.0601012

World bank, T. w. (2025). *South Asia Overview: Forest Area and Economic Indicators*. https://datahelpdesk.worldbank.org/knowledgebase/articles/906522-data-updates-and-errata

Brandle, J. R., Hodges, L., & Zhou, X. H. (2004). Windbreaks in North American agricultural systems. In P. K. R. Nair, M. R. Rao, & L. E. Buck (Eds.), *New Vistas in Agroforestry: A Compendium for 1st World Congress of Agroforestry, 2004* (pp. 65-78). Springer Netherlands. https://doi.org/10.1007/978-94-017-2424-1_5

Caon, L., & Vargas, R. (2017). Threats to soils: global trends and perspectives. *Global Soil Partnership Food and Agriculture Organization of the United Nations, Brajendra (Eds.) A contribution from the intergovernmental technical panel on soils. Global land outlook working paper*.

Cavigelli, M. A., & Robertson, G. P. (2001). Role of denitrifier diversity in rates of nitrous oxide consumption in a terrestrial ecosystem. *Soil Biology and Biochemistry*, *33*(3). https://doi.org/10.1016/S0038-0717(00)00141-3

Cislaghi, B., & Heise, L. (2020). Gender norms and social norms: differences, similarities and why they matter in prevention science. *Sociology of Health & Illness*, *42*(2). https://doi.org/10.1111/1467-9566.13008

Compton, J. E., & Boone, R. D. (2000). Long-term impacts of agriculture on soil carbon and nitrogen in new england forests. *Ecology*, *81*(8). https://doi.org/10.1890/0012-9658(2000)081

DeFries, R., Morton, D., Van Der Werf, G., Giglio, L., Collatz, G., Randerson, J., Houghton, R., Kasibhatla, P., & Shimabukuro, Y. (2008). Fire-related carbon emissions from land use transitions in southern Amazonia. *Geophysical Research Letters*, *35*(22).

Dhital, D. B. (2009). Bhutan forestry outlook study. *Bangkok (Thailand): Food and Agriculture Orgazination of the United Nations Regional Office for Asia and the Pacific*.

Dhyani, S., Murthy, I. K., Kadaverugu, R., Dasgupta, R., Kumar, M., Gadpayle, K. A., Dhyani, S., Murthy, I. K., Kadaverugu, R., Dasgupta, R., Kumar, M., & Adesh Gadpayle, K. (2021). Agroforestry to Achieve Global Climate Adaptation and Mitigation Targets: Are South Asian Countries Sufficiently Prepared? *Forests 2021, Vol. 12, Page 303*, *12*(3). https://doi.org/10.3390/f12030303

Emerick, K., de Janvry, A., Sadoulet, E., & Dar, M. (2016). Technological Innovations, Downside Risk, and the Modernization of Agriculture. *American Economic Review*, *106*, 1537-1561. https://doi.org/10.1257/aer.20150474

Ford, J. D., King, N., Galappaththi, E. K., Pearce, T., McDowell, G., & Harper, S. L. (2020). The Resilience of Indigenous Peoples to Environmental Change. *One Earth*, *2*(6). https://doi.org/10.1016/j.oneear.2020.05.014

Garrity, D. (2012). Agroforestry and the Future of Global Land Use. *Agroforestry - The Future of Global Land Use*. https://doi.org/10.1007/978-94-007-4676-3_6

Garrity, D. P. (2004). Agroforestry and the achievement of the Millennium Development Goals. *Agroforestry Systems*, *61*(1). https://doi.org/10.1023/B:AGFO.0000028986.37502.7c

Gebru, K. M., Rammelt, C., Leung, M., Zoomers, A., & Westen, G. v. (2021). The commodification of social relationships in agriculture: Evidence from northern Ethiopia. *Geoforum*, *126*. https://doi.org/10.1016/j.geoforum.2021.07.026

Gonçalves, C. d. B. Q., Schlindwein, M. M., Martinelli, G. d. C., Gonçalves, C. d. B. Q., Schlindwein, M. M., & Martinelli, G. d. C. (2021). Agroforestry Systems: A Systematic Review Focusing on Traditional Indigenous Practices, Food and Nutrition Security, Economic Viability, and the Role of Women. *Sustainability 2021, Vol. 13, Page 11397*, *13*(20). https://doi.org/10.3390/su132011397

Government of Nepal, M. o. A. a. L. D. (2019). *National Agroforestry Policy*. Government of Nepal, Ministry of Agriculture and Livestock Development Retrieved from https://moald.gov.np/wp-content/uploads/2022/04/National-Agroforestry-Policy-2019.pdf

Guillerme, S., Kumar, B. M., Menon, A., Hinnewinkel, C., Maire, E., Santhoshkumar, A. V., Guillerme, S., Kumar, B. M., Menon, A., Hinnewinkel, C., Maire, E., & Santhoshkumar, A. V. (2011). Impacts of Public Policies and Farmer Preferences on Agroforestry Practices in Kerala, India. *Environmental Management 2011 48:2*, *48*(2). https://doi.org/10.1007/s00267-011-9628-1

Hall, S. J., Matson, P. A., Hall, S. J., & Matson, P. A. (1999). Nitrogen oxide emissions after nitrogen additions in tropical forests. *Nature 1999 400:6740*, *400* (6740). https://doi.org/10.1038/22094

Hamadani, H., Rashid, S. M., Parrah, J. D., Khan, A. A., Dar, K. A., Ganie, A. A., Gazal, A., Dar, R. A., & Ali, A. (2021). Traditional Farming Practices and Its Consequences. *Microbiota and Biofertilizers, Vol 2*. https://doi.org/10.1007/978-3-030-61010-4_6

Haq, S. M., Pieroni, A., Bussmann, R. W., Abd-ElGawad, A. M., El-Ansary, H. O., Haq, S. M., Pieroni, A., Bussmann, R. W., Abd-ElGawad, A. M., & El-Ansary, H. O. (2023). Integrating traditional ecological knowledge into habitat restoration: implications for meeting forest restoration challenges. *Journal of Ethnobiology and Ethnomedicine*, *19*(1). https://doi.org/10.1186/s13002-023-00606-3

Hayat, M., Zha, T., Nizami, S. M., Gulzar, S., Khan, A., Iqbal, S., & Khan, M. S. (2020). Productive role of agroforestry system in context of ecosystem services in district dir lower, Pakistan. *Pakistan Journal of Botany*, *52*(4), 1411-1419.

Higashida, M., Matsuo, K., & Gohori, J. (2023). Integrating Indigenous Perspectives into International Social Work Edu. *Springer Series in International Social Work*. https://doi.org/10.1007/978-3-031-37712-9_9

Homeshwari-Devi, M., Haokip, I. C., & Kalidas-Singh, S. (2024). Impact of traditional land management practices on soil fertility. https://doi.org/10.1007/978-981-97-5223-2_11

Inkeles, A. (2022). Industrialization, modernization and the quality of life. In *Ecology, World Resources and the Quality of Social Life* (pp. 51-79). Routledge.

Islam, M., & Quli, S. (2016). Motivation strategy for agroforestry intensification among small holders. *Advances in Life Sciences*, *5*(10), 3878-3883.

Jara-Rojas, R., Russy, S., Roco, L., Fleming-Muñoz, D., & Engler, A. (2020). Factors Affecting the Adoption of Agroforestry Practices: Insights from Silvopastoral Systems of Colombia. *Forests*, *11*(6), 648. https://www.mdpi.com/1999-4907/11/6/648

Jose, S. (2009). *Agroforestry for ecosystem services and environmental benefits: an overview*. Springer.

Joshi, T. (2015). Technological advancement in Agroforestry systems: strategy for climate smart agriculture technologies in Nepal. In (pp. 203-232): SAARC Agriculture Centre Bangladesh.

Jr., S. M. B., Hall, R., Scoones, I., White, B., & Wolford, W. (2011). Towards a better understanding of global land grabbing: an editorial introduction. *The Journal of Peasant Studies*, *38*(2). https://doi.org/10.1080/03066150.2011.559005

Kandari, L. S., Bisht, V. K., Bhardwaj, M., Thakur, A. K., Kandari, L. S., Bisht, V. K., Bhardwaj, M., & Thakur, A. K. (2014). Conservation and management of sacred groves, myths and beliefs of tribal communities: a case study from north-India. *Environmental Systems Research*, *3*(1). https://doi.org/10.1186/s40068-014-0016-8

Khan, A., & Alam, M. (2015). Technological advancement in agro-forestry systems: strategy for climate smart agricultural technologies in Bangladesh.

Khan, M., Mahmood, H. Z., Abbas, G., Damalas, C. A., Khan, M., Mahmood, H. Z., Abbas, G., & Damalas, C. A. (2017). Agroforestry Systems as Alternative Land-Use Options in the Arid Zone of Thal, Pakistan. *Small-scale Forestry*, *16*(4). https://doi.org/10.1007/s11842-017-9372-3

Kumar, B. M., Singh, A. K., & Dhyani, S. (2012). South Asian agroforestry: traditions, transformations, and prospects. *Agroforestry-The future of global land use*, 359-389.

Leuschner, W. A., Khaleque, K., Leuschner, W. A., & Khaleque, K. (1987). Homestead agroforestry in Bangladesh. *Agroforestry Systems*, *5*(2). https://doi.org/10.1007/BF00047518

Lundgren, B. & raintree, J.B. 1983, Sustained agroforestry In B. Nestel, ed. Agricultural research for development: potentials and challenges in Asia. The Hague, ISNAR.

MacNeill, T. (2020). Indigenous Cultures and Sustainable Development in Latin America. https://doi.org/10.1007/978-3-030-37023-7

Mohanan, C. (2002). Policy and legal issues in cultivation & utilization of bamboo, rattan, and forest trees in private & community lands. National Workshop on Policy and Legal Issues in Cultivation and Utilization of Bamboo, Rattan, and Forest Trees in Private and Community Lands (2001: Kerala Forest Research Institute),

Morris, A. (2022). Alternative View of Modernity: The Subaltern Speaks. *American Sociological Review*, *87*(1). https://doi.org/10.1177/00031224211065719

Murthy, I. K., Dutta, S., Varghese, V., Joshi, P. P., & Kumar, P. (2016). Impact of agroforestry systems on ecological and socio-economic systems: a review. *Global Journal of Science Frontier Research: H Environ Earth Science*, *16*(5), 15-27.

Nair, P. K. R., Kumar, B. M., & Nair, V. D. (2009). Agroforestry as a strategy for carbon sequestration. *Journal of Plant Nutrition and Soil Science*, *172*(1). https://doi.org/10.1002/jpln.200800030

Nair, P. R. (2007). The coming of age of agroforestry. *Journal of the Science of Food and Agriculture*, *87*(9). https://doi.org/10.1002/jsfa.2897

Nair, P. R., Kumar, B. M., Nair, V. D., Nair, P. R., Kumar, B. M., & Nair, V. D. (2021). Silvopastoral Systems (SPS) in the Tropics and Subtropics. *An Introduction to Agroforestry: Four Decades of Scientific Developments*, 169-193.

Nair, P. R., Nair, V. D., Kumar, B. M., & Showalter, J. M. (2010). Carbon sequestration in agroforestry systems. *Advances in agronomy*, *108*, 237-307.

Nakashima, D., Galloway McLean, K., Thulstrup, H., Ramos Castillo, A., Rubis, J., & Traditional Knowledge Initiative. (2012). Weathering uncertainty: traditional knowledge for climate change assessment and adaptation; 2012.

Nelliat, E. V., K.V.A., B., & P.K.R., N. (1974). Multistoreyed cropping- a new direction in multiple cropping for coconut.

Niggli, U., Fließbach, A., Hepperly, P., & Scialabba, N. (2009). Low greenhouse gas agriculture: mitigation and adaptation potential of sustainable farming systems. In (Vol. 141, pp. 32-33): Food and Agriculture Organization of the United Nations, Rome.

Ogwu, M. C., & Osawaru, M. E. (2022). Traditional Methods of Plant Conservation for Sustainable Utilization. *Sustainable Development and Biodiversity*. https://doi.org/10.1007/978-981-19-3326-4_17

Park, M. S., Baral, H., & Shin, S. (2022). Systematic approach to agroforestry policies and practices in Asia. In (Vol. 13, pp. 635): MDPI.

Patel, J., Durey, A., Naoum, S., Kruger, E., & Slack-Smith, L. (2022). Oral health education and prevention strategies among remote Aboriginal communities: a qualitative study. *Australian Dental Journal*, *67*(1). https://doi.org/10.1111/adj.12890

Patwardhan, A., Ghate, P., Mhaskar, M., Bansude, A., Patwardhan, A., Ghate, P., Mhaskar, M., & Bansude, A. (2021). Cultural dimensions of sacred forests in the Western Ghats Biodiversity Hot Spot, Southern India and its implications for biodiversity protection. *International Journal of Anthropology and Ethnology*, *5*(1). https://doi.org/10.1186/s41257-021-00053-6

Paudel, S., Baral, H., Rojario, A., Bhatta, K. P., Artati, Y., Paudel, S., Baral, H., Rojario, A., Bhatta, K. P., & Artati, Y. (2022). Agroforestry: Opportunities and Challenges in Timor-Leste. *Forests*, *13*(1), 41. https://doi.org/10.3390/f13010041

Persoon, G. A., Minter, T., Persoon, G. A., & Minter, T. (2020). Knowledge and Practices of indigenous peoples in the context of resource management in relation to climate change in southeast Asia. *Sustainability*, *12*(19), *7983*. https://doi.org/10.3390/su12197983

Puri, S., & Nair, P. K. R. (2004). Agroforestry research for development in India: 25 years of experiences of a national program. *Agroforestry Systems*, *61*(1). https://doi.org/10.1023/B:AGFO.0000029014.66729.e0

Richardson, D., Felgate, H., Watmough, N., Thomson, A., & Baggs, E. (2009). Mitigating release of the potent greenhouse gas N_2O from the nitrogen cycle – could enzymic regulation hold the key? *Trends in Biotechnology*, *27*(7). https://doi.org/10.1016/j.tibtech.2009.03.009

Robertson, G. P., Paul, E. A., & Harwood, R. R. (2000). Greenhouse Gases in Intensive Agriculture: Contributions of Individual Gases to the Radiative Forcing of the Atmosphere. *Science*, *289*, 5486. https://doi.org/10.1126/science.289.5486.1922

Robinson, M. J., Gellie, N., MacCarthy, D., G., J. M., O'Donnell, K., & Redvers, N. (2021). Traditional ecological knowledge in restoration ecology: a call to listen deeply, to engage with, and respect Indigenous voices. *Restoration Ecology*, *29*(4). https://doi.org/10.1111/rec.13381

Rosati, A., Borek, R., Canali, S., Rosati, A., Borek, R., & Canali, S. (2020). Agroforestry and organic agriculture. *Agroforestry Systems*, *95*(5). https://doi.org/10.1007/s10457-020-00559-6

Schapper, A., & Urban, F. (2021). Large dams, norms and Indigenous Peoples. *Development Policy Review*, *39*(S1). https://doi.org/10.1111/dpr.12467

Sokk, V. (2024). Tradition in Transition Investigating the Impact of Modernization on Indigenous Cultures. *Journal Social Humanity Perspective*, *2*(1), 15-23.

Tejwani, K. (1984). *Agroforestry in Asia-Pacific*.

Tilman, D., Cassman, K. G., Matson, P. A., Naylor, R., Polasky, S., Tilman, D., Cassman, K. G., Matson, P. A., Naylor, R., & Polasky, S. (2002). Agricultural sustainability and intensive production practices. *Nature*, *418*(6898). https://doi.org/10.1038/nature01014

Tornar, J., & Bhatt, B. (2005). Studies on agroaquaculture agroforestry system in north eastern Himalayas, India. *Indian J Hill Farming*, *18*, 21-27.

Tulius, J. (2020). Lesson from the past, knowledge for the future: roles of human memories in earthquake and tsunami narratives in Mentawai, Indonesia. *Paradigma: Jurnal Kajian Budaya*, *10*(2). https://doi.org/10.17510/paradigma.v10i2.396