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Research Article

Sustainable Management and Socio-Ecological Impacts of *Acacia decurrens* Plantations in Northwestern Ethiopia: A Systematic Review

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Abstract

Acacia decurrens, commonly known as green wattle, has emerged as a rapidly expanding plantation species in the highlands of Northwestern Ethiopia. Originally introduced for soil conservation and fuelwood production, its adoption by smallholder farmers has intensified due to economic incentives, policy support, and suitability for degraded lands. Despite numerous studies addressing its socio-economic and environmental impacts, the research remains fragmented, with limited integration across disciplines, locations, and management contexts. This systematic review synthesizes empirical evidence from over 25 studies conducted between 2015 and 2025, examining the socio-economic, environmental, and governance dimensions of A. decurrens plantations in Northwestern Ethiopia. A systematic review was conducted by searching peer-reviewed articles, theses, and reports from 2015-2025 across multiple databases, followed by data extraction and narrative synthesis to integrate socio-economic, environmental, and governance. Findings indicate that the species contributes significantly to rural livelihoods by generating income, employment, and resilience against agricultural shocks, particularly through charcoal production. Environmentally, well-managed plantations enhance soil organic carbon, rehabilitate degraded landscapes, and provide opportunities for climate change mitigation, although intensive monoculture and unsustainable harvesting practices may threaten biodiversity, soil fertility, and land use sustainability. Governance, policy frameworks, and institutional support play critical roles in shaping adoption, management, and equitable benefit-sharing, with gendered disparities noted in access to resources and decision-making. Despite the growing body of literature, knowledge gaps remain regarding long-term ecosystem effects, integration into agroforestry systems, spatially explicit monitoring, and inclusive socio-economic outcomes. The review highlights best practices, including optimized planting density, agroforestry integration, and improved charcoal production, as pathways to balance ecological and socio-economic benefits. These insights inform sustainable management strategies and evidence-based policy interventions, aiming to maximize the long-term socio-ecological contributions of Acacia decurrens plantations in Northwestern Ethiopia.

Keywords

Acacia Decurrens Plantations, Socio-economic Impacts, Environmental Sustainability, Carbon Sequestration, Land Use Change, Smallholder Livelihoods

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1. Introduction

In recent decades, Acacia decurrens (commonly known as green wattle) has emerged as one of the most rapidly expanding plantation species in the highlands of Northwestern Ethiopia, particularly in the Awi Zone. Originally introduced for soil conservation and fuelwood purposes, the species has since evolved into a dominant feature of the farming system, profoundly influencing land use, livelihoods, and environmental processes [1, 2]. The drivers behind the expansion of A. decurrens plantations are diverse. On the one hand, the tree provides multiple economic benefits, including charcoal production, soil fertility improvement, crop integration, fuelwood, and acidic soil amendment, making it highly attractive to smallholder farmers [3-6]. On the other hand, growing market opportunities have further facilitated its adoption at the community level [7, 8]. Plantation management practices, including spacing, density, and rotation length, have also been studied to maximize biomass yield, carbon storage, and energy efficiency [9-11].

At the same time, the rapid proliferation of A. decurrens has generated complex socio-ecological dynamics. Studies indicate that plantation expansion often replaces croplands and grazing areas, leading to significant land use/cover change with mixed livelihood outcomes [12-14]. While many households benefit economically from increased cash income and improved resilience [15-17], concerns have been raised about food security trade-offs, soil acidification, biodiversity loss, and pest and disease outbreaks [18-20]. Moreover, gender-based disparities in access to benefits highlight the uneven social impacts of the plantation boom [21].

Beyond socio-economic implications, *A. decurrens* plays a critical role in carbon dynamics and ecosystem services. Plantation systems contribute significantly to aboveground and belowground biomass carbon storage, improve soil organic carbon under certain management regimes, and offer opportunities for climate change mitigation [9, 10, 22]. Remote sensing and spatial modeling efforts further underscore the rapid expansion and ecological footprint of the species in the Ethiopian highlands [2, 23].

Given these opportunities and challenges, the literature on *A. decurrens* has grown substantially, covering themes ranging from livelihood strategies, land use dynamics, carbon sequestration, soil health, adoption determinants, and gender dimensions to policy and market linkages. However, findings remain fragmented, and a comprehensive synthesis is needed to better understand the multi-dimensional impacts of *A. decurrens* in Northwestern Ethiopia. This systematic review, therefore, aims to consolidate existing evidence on the development, management, and utilization of Acacia decurrens plantations in the Awi Zone and beyond. Specifically, it examines the socio-economic benefits, environmental implications, and governance challenges associated with the species, while identifying best practices and research gaps. By integrating insights from recent empirical studies, this review seeks to inform policy, guide sustainable plantation management, and support balanced livelihood and environmental outcomes.

2. Methodology of the Review

The methodology of this review followed a systematic approach designed to ensure comprehensive coverage of the available literature on Acacia decurrens in Northwestern Ethiopia, with a particular focus on the Awi Zone. A structured literature search strategy was employed to identify peer-reviewed journal articles, doctoral dissertations, book chapters, and institutional reports that address the socio-economic, environmental, and policy dimensions of A. decurrens plantations. Databases including Google Scholar, Scopus, Web of Science, and institutional repositories of Ethiopian universities were searched using a combination of keywords such as “Acacia decurrens,” “Awi Zone,” “Ethiopia,” “plantation,” “livelihood,” “carbon sequestration,” “land use/land cover,” and “charcoal production.” To capture the most recent developments, the search was limited to studies published between 2015 and 2025, though earlier relevant works were also included when they provided critical background information.

The inclusion criteria for the review were defined to ensure relevance and quality of the studies. Only empirical studies, reviews, and theses that explicitly focused on Acacia decurrens plantations in Ethiopia were considered. Works had to provide insights into one or more aspects of plantation development, such as land use dynamics, carbon storage, socio-economic contributions, adoption determinants, or policy frameworks. Studies that focused on other tree species without clear linkage to *A. decurrens*, as well as publications lacking empirical evidence, were excluded. Duplicated entries from multiple sources were carefully screened to avoid redundancy.

Following the identification and selection of relevant literature, a process of data extraction and synthesis was undertaken. Key information such as study location, methodology, major findings, and thematic focus was recorded for each reference. The extracted data were then categorized into thematic areas including socio-economic benefits, environmental impacts, carbon dynamics, and governance issues. A narrative synthesis approach was applied, which allowed the integration of findings from both quantitative and qualitative studies. This approach facilitated the identification of patterns, contradictions, and knowledge gaps across the literature. By combining multiple lines of evidence, the review provides a holistic understanding of the opportunities and challenges associated with Acacia decurrens plantations in the Ethiopian highlands.

3. Results and Discussion

3.1. Characteristics of Studies

A substantial body of research has investigated *Acacia decurrens* plantations in the highlands of Northwestern Ethiopia over the past decade (Figure 1). Studies have focused on multiple dimensions, including plantation development and management, socio-economic impacts, environmental implications, and spatial dynamics. For instance, research by [1, 15], and [24], emphasized smallholder adoption practices, livelihood contributions, and best management practices. In total, over ten studies have examined socio-economic outcomes, highlighting that *A. decurrens* provides income, employment, and resilience benefits to rural households. Gender and equity considerations have been addressed in a smaller but growing number of studies, such as [21] and [16], which show disparities in access to plantation benefits and underscore the importance of inclusive policies.

Environmental studies form another significant portion of the literature. More than eight studies, including [10, 18], and [22], examined soil fertility, organic carbon, biomass accumulation, and plantation density effects. These studies indicate that *A. decurrens* can enhance soil carbon and rehabilitate degraded lands, but monoculture practices and intensive harvesting may negatively affect biodiversity and soil nutrients. Land use and land cover changes have been widely investigated in at least six studies, such as [2, 12, 14], using remote sensing and GIS tools to map spatial expansion and identify drivers of plantation growth, including market demand, energy needs, and policy incentives.

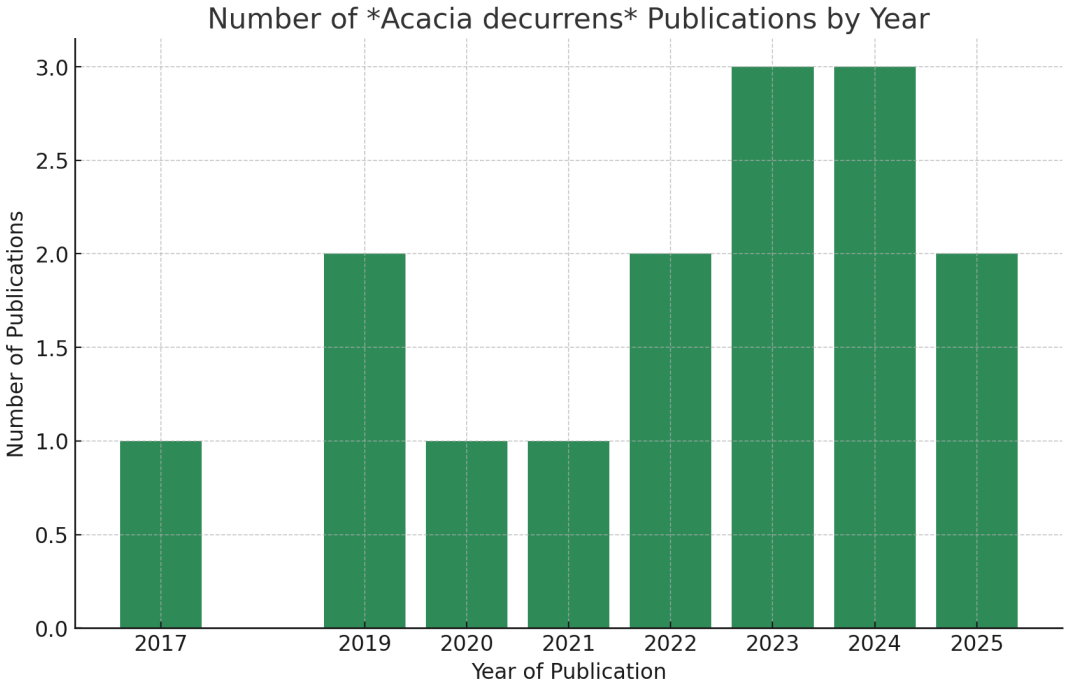

Figure 1. *number of publications by year.*

Research on carbon sequestration and climate mitigation potential has also gained attention, [9, 11], and [23] quantifying aboveground and belowground biomass carbon stocks, soil carbon improvements, and the potential for climate-smart practices. Studies on value chains, energy efficiency, and charcoal production have highlighted the dual socio-economic and environmental roles of *A. decurrens*, though they also point to trade-offs with food security and land access [3, 4]. Overall, more than 25 studies collectively demonstrate that *Acacia decurrens* plantations are critical for rural livelihoods, ecosystem rehabilitation, and climate mitigation in the Ethiopian highlands. While the literature is robust in socio-economic and environmental dimensions, gaps remain in long-term ecosystem effects, gendered impacts, integration into mixed land-use systems, and spatially explicit monitoring using advanced remote sensing technologies. These gaps highlight avenues for future research to optimize the sustainability and equitable benefits of *A. decurrens* plantations.

3.2. Historical Context and Expansion of Acacia Decurrens

Acacia decurrens, commonly known as green wattle, was first introduced to Ethiopia in the 1970 and become intensively expand in early 1990 primarily for soil conservation,

fuelwood production, and reforestation purposes [1, 3], Over time, the species has been increasingly adopted by smallholder farmers in the highlands, particularly in the Awi Zone, due to its rapid growth, adaptability to acidic soils, and multiple economic uses such as charcoal, timber, and poles [3, 15]. Early adoption focused on experimental and government-supported plantations but later shifted toward smallholder-led initiatives that integrated the species into agroforestry and taungya systems [8, 9]. The spatio-temporal expansion of A. decurrens plantations in Northwestern Ethiopia has been well-documented. Remote sensing and field studies indicate a significant increase in plantation cover over the past two decades, with both large and small-scale plots spreading across former croplands, grazing areas, and degraded landscapes [2, 13, 23]. Seasonal and annual monitoring shows that expansion has been particularly rapid in areas with high population density and limited arable land, highlighting the role of socio-economic pressures in shaping land use dynamics [9, 12].

Multiple drivers have fueled the widespread adoption and expansion of A. decurrens. Market demand for charcoal remains a key economic incentive, providing households with additional income and livelihood diversification [3, 4]. Policy frameworks promoting tree planting, reforestation, and soil conservation have also encouraged farmers to allocate land to *A. decurrens* plantations [20, 24]. Land scarcity and competition with traditional cropping systems further incentivize the establishment of fast-growing tree species, while the high energy demand for fuelwood and charcoal in rural and urban areas drives continued plantation expansion [12, 7]. Collectively, these factors have resulted in a complex socio-ecological landscape where *A. decurrens* plays a central role in shaping both livelihoods and land use patterns in the Ethiopian highlands.

3.3. Socio-Economic Dimensions

Acacia decurrens plantations have become an important component of rural livelihoods in the highlands of Northwestern Ethiopia (Table 1). Several studies report that smallholder farmers derive multiple economic benefits from the species, including income from charcoal production, which contributes significantly to household cash flow and food security [3, 4, 15]. Beyond income, the plantations create employment opportunities for local communities in activities such as planting, maintenance, harvesting, and charcoal production, enhancing livelihood resilience against seasonal agricultural variability [16, 17]. Charcoal and energy value chains associated with *A. decurrens* are particularly influential in the regional economy (Table 1). The species' fast growth and high calorific value make it a preferred source for fuelwood and charcoal, supporting both domestic energy needs and small-scale commercial enterprises [9, 22]. Studies indicate that improved charcoal production techniques, when combined with sustainable harvesting practices, can enhance energy efficiency while simultaneously reducing environmental degradation [4, 11].

Access to benefits from *A. decurrens* plantations is, however, not evenly distributed, and gender dynamics play a significant role in shaping equity outcomes. Women often have limited access to decision-making regarding land allocation and benefit sharing, despite being involved in labor-intensive activities such as nursery management and fuelwood collection [16, 21]. Addressing these disparities is essential for ensuring equitable distribution of socio-economic gains and enhancing the sustainability of plantation systems.

The adoption of *A. decurrens* by smallholder farmers is influenced by a combination of socio-economic and institutional factors. Household characteristics, landholding size, proximity to markets, and prior experience with tree cultivation significantly affect adoption decisions [7, 8]. Institutional support, including access to seedlings, technical guidance, and market information, further facilitates participation, highlighting the importance of integrated extension services and policy incentives [1, 24]. Collectively, these socio-economic dimensions underscore its economic resilience.

Table 1. *Summary of Studies on the Socio-Economic Dimensions of Acacia decurrens Plantations in Northwestern Ethiopia.*

Study	Focus Area	Key Findings	Socio-Economic Implications
[3]	Income from A. decurrens	Charcoal production from *A. decurrens* provides substantial household income and supports food security.	Enhances rural livelihoods and reduces poverty among smallholders.
[4]	Charcoal production and sustainability	Integration of improved charcoal production techniques increases energy efficiency and environmental sustainability.	Promotes low-carbon income generation and livelihood resilience.
[15]	Household economic benefits	A. decurrens serves as a major income source, stabilizing cash flow during off-farm seasons.	Strengthens smallholder adaptive capacity to seasonal variability.
[16]	Employment and gender participation	Plantations create jobs in planting, maintenance, and charcoal processing; women contribute significantly but face limited benefit access.	Highlights gender disparities and the need for equitable benefit-sharing mechanisms.

Study	Focus Area	Key Findings	Socio-Economic Implications
[17]	Rural employment and livelihood diversification	Plantation-related employment reduces vulnerability to agricultural shocks.	Encourages local economic diversification and rural resilience.
[19]	Energy value chain	A. decurrens preferred for fuelwood and charcoal due to high calorific value and fast growth.	Strengthens local energy security and small-scale energy enterprises.
[22]	Energy efficiency and commercialization	Charcoal and fuelwood value chains contribute significantly to local markets.	Enhances regional economic linkages and household incomes.
[11]	Environmental impacts of charcoal production	Sustainable charcoal practices reduce forest degradation.	Supports policy for eco-friendly rural energy systems.
[21]	Gender and equity analysis	Women involved in nursery and harvesting activities but excluded from major decision-making.	Calls for gender-sensitive interventions in plantation management.
[7]	Adoption determinants	Land size, market access, and tree management experience influence adoption.	Suggests strengthening extension and training for wider adoption.
[17]	Institutional factors and farmer participation	Institutional support, technical guidance, and access to seedlings drive adoption.	Reinforces the need for integrated extension services.
[1]	Policy and institutional frameworks	Supportive policies and market incentives enhance farmer participation.	Calls for sustained institutional and policy backing.
[24]	Seedling access and extension services	Availability of quality seedlings and information improves adoption rates.	Promotes coordinated government-community initiatives.

3.4. Environmental Implications

The expansion of *Acacia decurrens* plantations in Northwestern Ethiopia has brought significant changes to land use and land cover patterns (LULC) (Table 2). Empirical studies indicate that the rapid proliferation of these plantations often replaces croplands, grazing areas, and degraded lands, leading to observable shifts in the landscape [9, 12, 13]. Remote sensing analyses further reveal that plantation expansion has accelerated over the past two decades, reshaping spatial patterns of vegetation and affecting the availability of arable land for traditional agriculture [2, 23]. These changes carry both positive and negative implications: while degraded lands are rehabilitated and soil erosion reduced, the displacement of food crops and grazing land can create trade-offs for local livelihoods.

Acacia decurrens also influences soil fertility, soil organic carbon, and nutrient dynamics. Studies have shown that well-managed plantations improve soil organic carbon stocks, particularly under optimized planting density and rotation systems [10, 22]. Additionally, the integration of *A. decurrens* with crop systems, such as taungya practices, can enhance soil nutrients and overall productivity of intercropped species [9, 18]. However, intensive charcoal harvesting and monoculture practices may lead to nutrient depletion if not managed sustainably.

The species' expansion has mixed effects on biodiversity and ecosystem services. While plantations contribute to carbon sequestration, fuelwood supply, and soil stabilization, they can also reduce native vegetation cover and alter habitat structure, thereby affecting local flora and fauna [20]. The simplification of ecosystems in monoculture plantations may limit biodiversity, although agroforestry approaches incorporating *A. decurrens* show potential for balancing economic and ecological objectives.

Management challenges, including pests, diseases, and plantation maintenance, further influence the environmental outcomes of *A. decurrens*. Reports indicate that insect pests, fungal pathogens, and improper silvicultural practices can reduce plantation productivity and compromise soil and biomass benefits [11, 19]. Effective management strategies, including appropriate spacing, pruning, and integrated pest management, are essential to optimize ecological benefits and ensure sustainable plantation systems. Collectively, these environmental implications highlight the need for context-specific management and policy interventions to balance productivity, ecosystem health, and biodiversity conservation.

Table 2. Summary of Studies on the Environmental Implications of Acacia decurrens Plantations.

Study	Focus Area	Key Findings	Environmental Implications
[10]	Land use and land cover change	Expansion of A. decurrens plantations replaced croplands and grazing lands.	Altered land use patterns and reduced agricultural area.
[13]	Landscape transformation	Plantation proliferation reshaped local landscapes and land cover composition.	Contributed to both land rehabilitation and loss of cropland.
[9]	Land cover dynamics	Remote sensing showed significant increase in A. decurrens area over two decades.	Reduced grazing land, but improved vegetation cover on degraded lands.
[2]	Remote sensing analysis	Detected accelerated plantation expansion and vegetation structure shifts.	Improved green cover but reduced arable land for farming.
[23]	Spatial pattern analysis	Identified rapid plantation expansion in highland zones.	Necessitates balanced land use planning to avoid livelihood conflicts.
[10]	Soil organic carbon	Managed plantations increased soil organic carbon stocks.	Supports climate mitigation and soil fertility improvement.
[22]	Soil fertility and management	Optimal plantation density enhances nutrient cycling and soil fertility.	Encourages sustainable silvicultural practices.
[18]	Agroforestry and soil nutrients	A. decurrens-based taungya systems improved soil nutrients and crop yield.	Promotes integrated land-use and soil restoration.
[9]	Soil and nutrient dynamics	Intercropping with A. decurrens increased soil productivity.	Strengthens ecosystem services through sustainable integration.
[20]	Biodiversity and ecosystem services	Monoculture plantations reduce native vegetation and habitat diversity.	Indicates need for mixed or agroforestry systems to maintain biodiversity.
[19]	Pests and diseases	Pests and fungal pathogens affect productivity and soil benefits.	Highlights importance of integrated pest management.
[11]	Plantation management	Unsustainable charcoal and poor management practices degrade soil quality.	Calls for improved management and regulation to sustain ecological gains.

3.5. Governance, Policy, and Institutional Perspectives

The expansion and management of *Acacia decurrens* plantations in Northwestern Ethiopia are strongly influenced by governance structures, policy frameworks, and institutional support. Local and national policies promoting reforestation, soil conservation, and sustainable fuelwood production have created incentives for smallholder farmers to adopt *A. decurrens* plantations [20, 24]. These policies often intersect with broader rural development strategies, including land rehabilitation programs and climate adaptation initiatives, which encourage the integration of fast-growing tree species into degraded and marginal landscapes [1, 2]. Best practices and management guidelines have been developed to optimize the productivity, ecological benefits, and socio-economic returns of *A. decurrens* plantations. Recommended approaches include appropriate planting density, rotation length, intercropping with food crops, and improved charcoal production methods to enhance both energy efficiency and soil fertility [10, 11, 22]. Research highlights the importance of adopting context-specific management strategies that balance economic objectives with environmental sustainability and biodiversity conservation [3, 16]. Market linkages and regulatory frameworks further shape the viability and expansion of *A. decurrens* plantations. Access to local and regional markets for timber, poles, and charcoal influences farmers' adoption decisions and the economic sustainability of plantations [7, 15]. Institutional support, including access to seedlings, extension services, and technical guidance, enhances smallholder participation and adoption rates, while regulatory frameworks help prevent overexploitation and unsustainable harvesting practices [1, 19]. Together, governance, policy, and institutional mechanisms are critical in ensuring that *Acacia decurrens* plantations contribute positively to rural livelihoods, environmental conservation, and climate adaptation strategies in Northwestern Ethiopia.

3.6. Opportunities and Challenges

Acacia decurrens plantations offer significant economic opportunities for smallholder farmers in the highlands of

Northwestern Ethiopia. The species provides multiple revenue streams, including income from charcoal production, which enhance household livelihoods and serve as a buffer against agricultural shocks [3, 4, 15]. Beyond direct income, the plantations create employment in nursery management, plantation maintenance, and charcoal production, contributing to local economic development and resilience [16-17]. Despite these benefits, *A. decurrens* expansion introduces trade-offs with food security and land access. Studies indicate that converting cropland and grazing areas to plantations can reduce the availability of land for staple crops and livestock, potentially affecting household nutrition and food production [10, 13]. Balancing economic gains with the need to maintain sufficient agricultural land remains a critical challenge for smallholder communities.

Environmental sustainability concerns also arise from large-scale monoculture plantations. While *A. decurrens* can improve soil organic carbon, rehabilitate degraded lands, and mitigate erosion, inappropriate management practices—such as excessive planting density, unsustainable harvesting, and poor pest control—may lead to soil nutrient depletion, biodiversity loss, and altered ecosystem functioning [16, 18, 19]. These environmental risks highlight the need for integrated management approaches that optimize both productivity and ecosystem health.

3.7. Knowledge Gaps and Future Research Directions

Despite the growing body of research on *Acacia decurrens* plantations in Northwestern Ethiopia, several knowledge gaps remain that warrant further investigation. First, long-term ecosystem effects of these plantations are not fully understood. While studies have quantified short-term impacts on soil organic carbon, biomass accumulation, and land use changes [2, 9, 10], there is limited evidence on how plantation age, rotation cycles, and cumulative landscape-level expansion influence ecosystem functions and biodiversity over decades.

Second, the integration of *A. decurrens* into agroforestry and mixed land-use systems requires further exploration. While taungya and intercropping practices have shown potential for balancing crop productivity with tree growth [18, 22], additional studies are needed to optimize spatial arrangements, species combinations, and management practices for enhanced ecological and socio-economic outcomes.

Third, gendered impacts and social inclusivity in plantation benefits remain under-researched. Although existing studies highlight inequities in access to land, decision-making, and benefit-sharing [2, 16, 25, 26], more detailed investigations are needed to design policies and interventions that ensure equitable participation of women, youth, and marginalized households in plantation management and value chains.

Finally, advances in remote sensing and monitoring technologies offer opportunities to improve plantation assessment, carbon accounting, and landscape-level management. Recent modeling studies using high-resolution imagery and environmental variables [23] have demonstrated the potential for spatially explicit monitoring, yet these approaches are not yet widely applied across the Awi Zone or other highland regions. Expanding the use of remote sensing, coupled with ground-truthing, can facilitate evidence-based decision-making, support climate-smart practices, and inform sustainable plantation policies. Addressing these research gaps will enhance the understanding of *Acacia decurrens*' multi-dimensional impacts and guide future management, policy, and development strategies in the Ethiopian highlands.

4. Conclusion

This systematic review demonstrates that *Acacia decurrens* plantations in the highlands of Northwestern Ethiopia play a multifaceted role in shaping socio-economic, environmental, and climate outcomes. The species has expanded rapidly over the past two decades, driven by market demand for charcoal, land scarcity, and the need for energy security. Smallholder farmers derive substantial livelihood benefits from these plantations, including income generation, employment opportunities, and resilience against agricultural variability. Simultaneously, *A. decurrens* contributes to carbon sequestration, soil improvement, and landscape rehabilitation, although monoculture practices and intensive harvesting present trade-offs for biodiversity, soil fertility, and land use sustainability.

The review highlights that governance, policy frameworks, and institutional support are critical in shaping both the adoption and management of plantations. Best practices, including optimized planting density, integration with agroforestry systems, and improved charcoal production methods, can enhance ecological and socio-economic outcomes, while regulatory oversight ensures sustainable resource use. However, persistent challenges, such as trade-offs with food security, gender inequities, *Acacia decurrens* disease and pest expansion, and social conflicts over land and resources, necessitate inclusive and participatory approaches to plantation planning and management.

For policy and practice, the findings underscore the importance of promoting sustainable plantation management that balances economic benefits with environmental conservation. Recommendations include supporting smallholders with technical guidance and access to markets, integrating *A. decurrens* within mixed land-use and agroforestry systems, monitoring ecological impacts through remote sensing, and designing policies that ensure equitable benefit-sharing and gender inclusion. Pathways for sustainable plantation management involve combining climate-smart practices, adaptive governance, and evidence-based decision-making to enhance carbon sequestration, livelihood outcomes, and ecosystem

resilience. Collectively, these strategies can ensure that *Acacia decurrens* continues to provide long-term socio-ecological benefits in the Ethiopian highlands while minimizing negative trade-offs.

Abbreviations

A. decurrens	Acacia Decurrens
LULC	Land Use / Land Cover

Author Contributions

Ewunetu Tazebew: Conceptualization, Data curation, Formal Analysis, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Fekadu Tiruneh: Conceptualization, Data curation, Formal Analysis, Methodology, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing

Yibeltal Anbes: Formal Analysis, Methodology, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing

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Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

Authors declare no conflict of interest.

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