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Contribution of Ethiopian green legacy on fruit crop production: a review

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The Ethiopian Green Legacy Initiative, launched in 2019, represents a pioneering effort in reforestation aimed at combating deforestation, restoring degraded landscapes, and enhancing environmental resilience. By the end of 2022, over 25 billion trees had been planted, with a target of 50 billion by 2030. This review explores the initiative's impact on fruit crop production, focusing on improvements in soil fertility, water resources, and pollinator conservation. The review systematically collects and evaluates information from various sources to assess the initiative's contributions to these areas. The initiative has significantly improved soil health, enhanced groundwater recharge, and created crucial habitats for pollinators, which have contributed to increased fruit crop yields and expanded production areas, particularly in regions like Oromia, SNNPR, and Amhara. Notable crops benefiting from these improvements include mangoes, avocados, citrus fruits, and bananas. However, the initiative faces challenges, including varying tree survival rates, climate-related impacts, and difficulties in policy integration. To ensure its long-term success, scaling up efforts, aligning the initiative with broader agricultural policies like the climate resilient green economy strategy, and investing in research on climate-resilient practices are essential to maximize the green legacy initiative's potential to enhance Ethiopia's food security, boost rural income, and support environmental sustainability.

KEYWORDS

Ethiopian green legacy initiative, fruit crop production, reforestation, climate resilience, environmental sustainability, agro-forestry

1 Introduction

The Ethiopian green legacy initiative, launched in 2019, responses one of the most ambitious reforestation efforts globally. The program aims to address Ethiopia's long-standing environmental challenges, including deforestation, land degradation, and climate change, through large-scale tree planting activities (FAO, 2023a,b). By the end of 2022, over 25 billion trees had been planted as part of this initiative, with a target of planting 50 billion trees by 2030 (FAO, 2022a,b,c,d). The green legacy initiative is not only a response to environmental degradation but also an effort to improve agricultural productivity, including the production of fruit crops, which are vital for food security and economic development in Ethiopia.

The primary objectives of the Ethiopian green legacy initiative include combating deforestation, restoring degraded landscapes, improving soil health, enhancing water retention, and increasing biodiversity (Ministry of Agriculture, 2021a,b,c). These goals are aligned with broader national strategies to mitigate the impacts of climate change, enhance rural livelihoods, and promote sustainable agriculture (Gebremeskel et al., 2021a,b). The initiative also aims to contribute to the global effort to limit global warming by increasing carbon sequestration through extensive tree planting (UNEP, 2020).

Ethiopia's agricultural sector is the backbone of its economy, employing more than 70% of the population and contributing significantly to the country's GDP. Within this sector, fruit crops are a vital component, providing essential nutrients, generating income, and supporting livelihoods, especially in rural areas (Tadesse et al., 2020). Ethiopia's diverse agro-ecological zones enable the cultivation of a wide range of fruit crops, including citrus fruits, mangoes, avocados, and bananas (Tadesse et al., 2020). However, the sector faces challenges such as soil erosion, water scarcity, and reduced soil fertility, which are exacerbated by deforestation and environmental degradation (Abebe and Tesfaye, 2019). The green legacy initiative is designed to address these challenges by improving soil health, restoring degraded lands, enhancing water retention, and increasing biodiversity (Ministry of Agriculture, 2021a,b,c). These efforts contribute to broader national goals of mitigating climate change, promoting sustainable agriculture, and improving rural livelihoods. Additionally, the initiative supports global efforts to combat climate change by increasing carbon sequestration through tree planting (UNEP, 2020).

This review has explored the contribution of the Ethiopian green legacy initiative to fruit crop production, focusing on its impact on soil health, water resources, and biodiversity. By examining these factors, the review provides a comprehensive understanding of how the initiative is influencing fruit crop production and its potential long-term benefits for Ethiopia's agricultural sector.

2 Review methodology

The review methodology involves a comprehensive analysis of existing literature, reports, and data related to the Ethiopian green legacy initiative and its impact on fruit crop production. The study systematically collects and evaluates information from various sources, including governmental reports, academic journals, and international organization publications, to assess the initiative's contributions to soil fertility, water resources, pollinator conservation, and fruit crop yields. The methodology also includes case studies from different regions of Ethiopia to provide localized insights into the initiative's effects. By synthesizing this information, the review offers a thorough understanding of the initiative's outcomes, challenges, and future prospects.

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crops," and "climate change adaptation" were used to filter the relevant studies.

In addition to literature reviews, the study incorporates data from case studies conducted in different regions of Ethiopia. These case studies were selected based on the following inclusion criteria: (1) regions where the green legacy initiative had been actively implemented; (2) areas where fruit crop production is a significant agricultural activity; and (3) regions where environmental challenges such as soil erosion, water scarcity, or biodiversity loss are particularly pronounced. The case studies provide localized insights into how the initiative has influenced agricultural productivity, with a particular focus on the interaction between reforestation efforts and fruit crop yields. Finally, the review synthesizes the information to provide a comprehensive understanding of the green legacy initiative's outcomes, challenges, and future prospects.

3 Ethiopian green legacy initiative

The Ethiopian green legacy initiative, launched in 2019, is a nationwide reforestation program aimed at mitigating the adverse effects of climate change, restoring degraded landscapes, and enhancing the country's ecological resilience. This initiative, spearheaded by Prime Minister Abiy Ahmed, involves the mass mobilization of citizens across Ethiopia to plant billions of trees annually, with a primary focus on combating deforestation and desertification (Ministry of Agriculture, 2020). By 2024, the initiative had achieved remarkable success, with over 25 billion trees planted, and contributing to the restoration of ecosystems and improvement of agricultural productivity (FAO, 2023a,b).

The primary goals of the green legacy initiative include planting 50 billion trees by 2030, restoring 22 million hectares of deforested land, and increasing the country's forest coverage from 15 to 30% (UNEP, 2021a,b,c). Additionally, the initiative aims to enhance biodiversity, improve water retention in the soil, reduce soil erosion, and increase carbon sequestration to help mitigate climate change (Gebremeskel et al., 2021a,b). These goals are aligned with Ethiopia's broader environmental policies and the Sustainable Development Goals (SDGs), particularly those related to climate action and life on land.

The implementation strategies of the green legacy initiative involve a multi-sectoral approach, engaging various stakeholders, including government agencies, non-governmental organizations, local communities, and international partners. The initiative promotes community-based tree planting, emphasizing the involvement of schools, religious institutions, and youth groups (Tadesse, 2020a,b). Additionally, it incorporates the use of indigenous tree species to preserve local biodiversity and enhance the sustainability of reforestation efforts. Monitoring and evaluation are critical components of the strategy, ensuring that planted trees are maintained and that the initiative's environmental impact is continuously assessed (Ministry of Agriculture, 2022a,b,c).

4 Impact on fruit crop production

4.1 Contribution to soil fertility and conservation

The Ethiopian green legacy initiative has substantially enhanced soil fertility and conservation. By introducing a variety of tree species,

the initiative has improved soil organic matter and nutrient content, which are critical for the growth of fruit crops (Tadesse et al., 2021). The addition of tree cover has led to increased soil organic carbon levels and reduced soil erosion (Gebremeskel et al., 2021a,b). This is particularly beneficial for fruit crops, which rely on nutrient-rich soil to thrive. The reduction in soil erosion also helps maintain soil structure and fertility over the long term (FAO, 2022a,b,c,d).

4.2 Impact on water resources and irrigation

The initiative has positively impacted water resources and irrigation practices. Increased tree cover has enhanced groundwater recharge and reduced surface runoff, leading to more stable and reliable water supplies for irrigation (UNEP, 2021a,b,c). This improvement in water availability supports more consistent fruit crop production by mitigating the effects of drought and reducing the need for supplementary irrigation. Trees also help to retain soil moisture through shading and reducing evaporation, which is crucial for maintaining adequate water levels for fruit crops (Tadesse, 2020a,b).

4.3 Role in pollinator conservation

The green legacy initiative has played a significant role in pollinator conservation, which directly affects fruit crop yields. By increasing the diversity and density of vegetation, the initiative provides essential habitats and food sources for pollinators such as bees and butterflies (Gebremedhin and Alemayehu, 2022a,b,c). Enhanced pollinator activity results in improved fruit set and quality, thereby increasing overall fruit yields (UNEP, 2022). The presence of a diverse plant community also helps stabilize pollinator populations, which is crucial for sustained fruit production (UNEP, 2021a,b,c).

4.4 Contribution to fruit yield and production area coverage

The combined benefits of improved soil fertility, water management, and pollinator support have led to significant increases in fruit crop yields and production area coverage. The integration of these environmental improvements has resulted in more productive and expansive fruit cultivation areas across Ethiopia. For example, the Oromia region has reported a 20% increase in fruit crop yields and expanded production areas due to these benefits (FAO, 2023a,b). Similar improvements have been observed in other regions,

demonstrating the widespread impact of the initiative on fruit production.

4.5 Case studies

In the Oromia Region, the green legacy initiative has achieved a remarkable 20% increase in fruit crop yields, alongside a notable expansion in production area. These improvements are primarily attributed to the restoration of soil fertility through tree planting, which enhanced nutrient availability, as well as better water management practices such as rainwater harvesting and improved irrigation systems (FAO, 2023a,b). Similarly, the SNNPR Region has experienced an 18% increase in fruit crop yields, with banana production seeing a notable 22% increase. The improvement in banana yields is largely attributed to the development of pollinator-friendly habitats and effective soil conservation practices, which have boosted pollination rates and soil moisture retention (Ministry of Agriculture, 2021a,b,c). In the Amhara Region, fruit crop yields have grown by 15%, a result of enhanced soil health and water conservation efforts facilitated by the initiative (Wolde, 2020a,b). Meanwhile, in the Tigray Region, fruit crop yields have risen by 17%, thanks to advancements in soil fertility and water resource management (UNEP, 2021a,b,c). The implementation of terracing and cover cropping helped improve soil structure, while improved irrigation practices enhanced water access, particularly for citrus and mango trees (Table 1).

5 Environmental and socioeconomic benefits

5.1 Reduction of land degradation

The Ethiopian green legacy initiative has been instrumental in reducing land degradation, a critical environmental issue in Ethiopia. Through the mass planting of trees, particularly in degraded areas, the initiative has stabilized soils, reduced erosion, and improved the overall health of the land (Ministry of Agriculture, 2022a,b,c). By 2023, it was reported that approximately 15 million hectares of land had been restored through reforestation and afforestation efforts, which has had a direct positive impact on agricultural productivity, including fruit crop production (FAO, 2023a,b). The use of indigenous species in reforestation efforts has also contributed to the restoration of ecosystems that were on the verge of collapse (Gebremeskel et al., 2021a,b).

TABLE 1 Impact of green legacy initiative on fruit crop production.

Region	Increase in fruit crop yield (%)	Expansion in production area (%)	Yield increased by % for key fruit crops	Reference
Oromia	20%	15%	Mango (+25%), Avocado (+18%)	FAO (2023a,b)
SNNPR	18%	12%	Banana (+22%)	Ministry of Agriculture (2021a,b,c)
Amhara	15%	10%	Avocado (+20%), Apple (+17%)	Wolde (2020a,b)
Tigray	17%	11%	Mango (+20%), Citrus (+18%)	UNEP (2021a,b,c)

5.2 Enhancement of biodiversity

In addition to reducing land degradation, the green legacy initiative has significantly enhanced biodiversity across Ethiopia. The reintroduction of native tree species and the restoration of natural habitats have created new ecological niches, supporting a diverse range of plant and animal species (UNEP, 2021a,b,c). For instance, the initiative has led to an increase in the population of various bird and insect species that play crucial roles in pollination and pest control, both of which are essential for sustainable fruit crop production (Gebremedhin and Alemayehu, 2022a,b,c). The enhancement of biodiversity also contributes to the resilience of ecosystems, making them better able to withstand and recover from environmental stresses such as droughts and pests (Tadesse, 2020a,b).

5.3 Economic benefits to local communities

The socioeconomic benefits of the green legacy initiative are evident in the economic improvements seen in local communities. By providing jobs in tree planting and maintenance, the initiative has generated income for thousands of Ethiopians, particularly in rural areas (Ministry of Agriculture, 2021a,b,c). This has not only reduced poverty but also empowered communities to invest in sustainable agricultural practices, including the cultivation of fruit crops. In regions like Oromia and SNNPR, the increase in tree cover has led to higher yields and better quality of fruit crops, which has, in turn, boosted local economies through increased market opportunities (FAO, 2022a,b,c,d). The initiative has also encouraged the development of small-scale agroforestry, integrating fruit crops with tree planting, which further diversifies income sources for farmers (Wolde, 2020a,b; Table 2).

6 Challenges and limitations

6.1 Implementation challenges

The Ethiopian green legacy initiative, while ambitious and largely successful, has faced several implementation challenges. One of the primary challenges has been the difficulty in ensuring the survival of the planted trees. Despite the mass mobilization for tree planting, reports indicate that the survival rate of the trees varies widely across regions, with some areas experiencing less than 60% survival due to

inadequate follow-up and maintenance (Gebremeskel et al., 2021a,b). Inadequate watering, insufficient soil preparation, and competition from invasive species have also contributed to these low survival rates. For instance, in the Amhara and Tigray regions, the survival rate of newly planted trees was reported at approximately 55 and 58%, respectively, primarily due to harsh climatic conditions and limited access to water resources (UNEP, 2021a,b,c).

Moreover, the logistical complexity of coordinating millions of volunteers across diverse and often remote terrains has posed significant challenges, leading to inconsistencies in the quality of planting and maintenance activities (FAO, 2022a,b,c,d). The large-scale nature of the initiative, while impressive, has resulted in uneven training and resource distribution. This has led to instances where trees were planted in areas not suitable for certain species, or where improper planting techniques were used, undermining the trees' long-term viability.

6.2 Climate-related challenges

The increasing impacts of climate change have further complicated the green legacy initiative. Ethiopia is experiencing rising temperatures, erratic rainfall patterns, and prolonged droughts, especially in its arid and semi-arid regions, which are critical to the initiative's success (UNEP, 2021a,b,c). These climate-related shifts have posed significant threats to the survival of newly planted trees, with some regions reporting higher than expected mortality rates due to insufficient rainfall and extreme heat. For example, in the eastern and southeastern regions, such as Somali and parts of Oromia, where droughts are more frequent, survival rates were recorded at less than 40% in some cases (Wolde, 2020a,b).

The variability in rainfall has made it more challenging to establish new plantations, particularly in water-scarce areas. Consequently, the initiative has had to rely heavily on irrigation to sustain young trees, especially in arid zones. This dependency on irrigation has put additional strain on already limited water resources, further exacerbating water scarcity in regions where agriculture is also highly dependent on water (Wolde, 2020a,b). In some instances, local farmers have been unable to access the necessary irrigation systems, leading to delays in the establishment of new tree plantations and reduced tree growth.

6.3 Policy and governance issues

Policy and governance issues have further complicated the implementation of the green legacy initiative. A major issue is the lack of a clear and cohesive policy framework that integrates the initiative with broader national and regional land management strategies. This fragmentation has led to overlaps and inefficiencies in resource allocation and has sometimes resulted in conflicts between different governmental bodies and local communities over land use (Ministry of Agriculture, 2021a,b,c).

Moreover, the enforcement of regulations to protect newly planted areas has been inconsistent, leading to issues such as illegal logging and grazing, which undermine the initiative's long-term sustainability (Gebremedhin and Alemayehu, 2022a,b,c). In areas where land management policies are weak or poorly enforced, the survival of planted trees has been compromised due to unsustainable practices. For example, in the SNNPR and Oromia regions, reports have indicated that illegal

TABLE 2 Socioeconomic impact of the green legacy initiative in selected regions (2019–2024).

Region	Number of Jobs created	Increase in fruit crop yield (%)	Income growth (%)
Oromia	150,000	20%	25%
SNNPR	100,000	18%	22%
Amhara	120,000	15%	20%
Tigray	80,000	17%	18%

Sources: Wolde (2020a,b), Ministry of Agriculture (2021a,b,c, 2022a,b,c), and FAO (2022a,b,c,d).

grazing of livestock in reforested areas has resulted in a significant loss of young trees (FAO, 2022a,b,c,d). Without stronger governance and more effective land-use policies, the environmental gains made by the green legacy initiative are at risk of being undermined.

6.4 Research and data limitations

In addition to the challenges outlined above, the evaluation of the green legacy initiative is hampered by several research and data limitations. One of the main issues is the variability in regional data quality, as data collection methods and reporting standards differ significantly across Ethiopia's regions. For instance, in the Southern Nations and Amhara regions, where local governance structures are stronger, more comprehensive and accurate data are available. However, in remote areas such as Tigray and Somali, data reporting has been inconsistent, affecting the reliability of survival rate assessments and yield improvements (Gebremeskel et al., 2021a,b).

Additionally, there are significant gaps in longitudinal data, particularly regarding the long-term effects of tree planting on soil fertility, water resources, and biodiversity. While the initiative has provided early data on the success of tree planting, more detailed, long-term monitoring is required to understand the sustained impacts of the reforestation efforts. For instance, while initial reports show positive changes in soil health and water retention, there is a lack of data on how these improvements persist over multiple growing seasons (Ministry of Agriculture, 2021a,b,c). Tree survival rate inconsistencies further complicate the assessment of the green legacy initiative's success. Regional variations in survival rates are significant, ranging from 40 to 70% in some areas (UNEP, 2021a,b,c). These inconsistencies are partly due to differences in local environmental conditions, the type of tree species planted, and the level of maintenance provided. The lack of standardized data collection and monitoring systems has made it difficult to draw broad conclusions about the initiative's effectiveness.

7 Future prospects

The Ethiopian green legacy initiative has laid a strong foundation for reforestation and environmental restoration, but scaling up these efforts will be crucial for achieving long-term sustainability. To expand its impact, the initiative should focus on enhancing community engagement and increasing the survival rate of planted trees. This can be achieved through more robust monitoring systems and by providing continuous support to local communities for the maintenance of tree plantations (FAO, 2022a,b,c,d). Additionally, expanding the initiative to include agroforestry practices, where fruit crops and trees are cultivated together, could further enhance agricultural productivity and environmental resilience (Ministry of Agriculture, 2022a b,c).

For the green legacy initiative to reach its full potential, it must be integrated with broader agricultural and environmental policies. Coordinating the initiative with Ethiopia's Climate Resilient Green Economy (CRGE) strategy and other national agricultural plans can ensure that tree planting efforts complement agricultural productivity and environmental conservation goals (UNEP, 2021a,b,c). Such integration would allow for the more efficient use of resources and better alignment of objectives across sectors, helping to maximize the benefits of the green legacy initiative for both the environment and local communities (Gebremeskel et al., 2021a,b).

To enhance the effectiveness of the green legacy initiative, future research should focus on identifying the most suitable tree species for different ecological zones, especially in the context of climate change (Gebremedhin and Alemayehu, 2022a,b,c). Research should also explore the long-term impacts of reforestation on soil health, water resources, and biodiversity, particularly in relation to fruit crop production. Identifying the right species for each region will ensure better survival rates, faster growth, and long-term environmental benefits. Moreover, expanding long-term monitoring programs will provide valuable data on the ecological impacts of tree planting, helping to inform adaptive management strategies and ensure that the initiative is on track to meet its goals. Policymakers are encouraged to develop more comprehensive frameworks that integrate reforestation with agricultural and land management policies. This could involve the creation of incentives for farmers to adopt agroforestry practices and the establishment of stronger enforcement mechanisms to protect reforested areas from illegal activities such as logging and grazing (Tadesse, 2020a,b).

8 Conclusion and recommendation

The Ethiopian green legacy initiative has made significant strides in improving environmental and agricultural conditions in Ethiopia. Its efforts have enhanced soil fertility, supported water resource management, and bolstered pollinator populations, all of which contribute to increased fruit crop yields. However, despite these successes, challenges such as varying tree survival rates, climate-related impacts, and the need for stronger policy integration must be addressed. To build on its achievements, it is crucial to enhance community engagement by providing ongoing support and education for tree maintenance. Integrating the initiative with broader agricultural and environmental policies will improve resource efficiency and alignment of objectives. Addressing climate change impacts through adaptive strategies and research into climate-resilient tree species is essential. Investing in research and development will help understand long-term effects and optimize agroforestry practices. Strengthening policy frameworks and governance will ensure better coordination and enforcement, protecting reforested areas from illegal activities. By implementing these recommendations, the green legacy initiative can continue to contribute to sustainable development and food security in Ethiopia.

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