Afforestation as a Climate Change Solution: Evaluating its Sustainability, Trade-offs and Long-term Impact in Hurungwe District, Zimbabwe

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Abstract
Afforestation is increasingly promoted as a nature-based solution to climate change and environmental degradation, particularly in ecologically vulnerable regions such as Hurungwe District, Zimbabwe (Mbow et al., 2014; Holl and Brancalion, 2020). Despite supportive policies, evidence on sustainability, trade-offs, and long-term impacts remains limited. This study employed a convergent parallel mixed-methods design (Creswell, 2018), combining household surveys (n=180) and eight focus group discussions to assess ecological restoration, socio-economic outcomes, and governance dynamics.
Findings revealed active participation from the working-age population, with farming as the primary occupation significantly associated with involvement (Moyo and Zhakata, 2021; Marufu et al., 2022). Preferences leaned toward fruit trees (78%) and fast-growing exotics such as eucalyptus (Cunningham et al., 2015), while narratives emphasized native species like Brachystegia spiciformis for resilience (Matema et al., 2021; Makoni and Mataranyika, 2023). Seedling survival averaged 43%, constrained by water scarcity, lack of follow-up support, and livestock damage (Mutekwa and Manatsa, 2021; Gumbo et al., 2025). Land-use trade-offs were evident, as smallholders reported tensions between trees and crops, with farm size negatively correlated with perceived land scarcity (Pretty et al., 2006; Mbow et al., 2014). Institutional weaknesses—including inadequate extension services, unclear land tenure, and donor dependency—further undermined sustainability (Fleischman et al., 2020; Mupenzi and Nkomo, 2020).
Overall, success was constrained more by environmental and institutional weaknesses than by community willingness. Recommendations include prioritizing native species, integrating afforestation into agro-ecological farming systems, and strengthening participatory governance. Afforestation in Hurungwe can serve as a viable climate adaptation strategy if ecological integrity is balanced with livelihood needs (Agrawal and Chhatre, 2006; Fisher et al., 2014).

Keywords: Afforestation, Sustainability, Trade-offs, Climate Change, Governance

1. Introduction

1.1 Background of the Study

Climate change, marked by rising temperatures, erratic rainfall patterns, and increased frequency of extreme weather events poses a global threat to ecosystems and livelihoods (Ziervogel et al., 2008). In

Sub-Saharan Africa, rural communities are particularly vulnerable due to their dependence on climate-sensitive sectors such as agriculture and natural resources (Chagutah, 2021). Zimbabwe faces significant environmental deterioration from deforestation, land-use change, and unsustainable agricultural expansion (Chitiga et al., 2020).

In Hurungwe District, located in the Mashonaland West Province, deforestation is driven by firewood collection, tobacco curing, and land clearing for subsistence agriculture (Gumbo et al., 2025). These pressures have depleted forest cover and undermined ecosystem resilience.

Afforestation, the establishment of forests on land that has not been forested in the recent past (*STATE OF THE WORLD'S FORESTS 2020 : Forestry, Biodiversity and People*, 2020), has gained prominence as a nature-based climate solution, aimed at restoring degraded ecosystems, enhancing biodiversity, and supporting rural livelihoods (Holl & Brancalion, 2020). However, its outcomes depend heavily on species selection, community participation, and governance frameworks (Chigonda et al., 2020).

Despite growing policy support for tree-planting programs in Zimbabwe, including the National Tree Planting Day, school greening initiatives, and REDD+ programs, there remains limited empirical evidence on their long-term sustainability and socio-ecological trade-offs, particularly in communal settings like Hurungwe District. This study therefore investigates the effectiveness of afforestation as a climate adaptation strategy, exploring its sustainability, local trade-offs, and institutional underpinnings.

1.2 Problem Statement

Afforestation in Zimbabwe is often externally driven, with limited community involvement, resulting in low local ownership and poor seedling survival. In Hurungwe, many afforestation projects are implemented by NGOs or government programs without integrating local land-use priorities (Marufu et al., 2022). This has led to conflicts over land rights, restricted access to grazing areas, and unintended social inequities (Chomba et al., 2016).

Furthermore, empirical data assessing the ecological and socio-economic outcomes of these initiatives remain scarce. Without understanding the trade-offs between environmental benefits and livelihood constraints, afforestation risks becoming unsustainable. This study addresses this gap by critically examining afforestation's long-term impacts, sustainability, and governance mechanisms in Hurungwe District.

1.3 Research Objectives

Main Objective:

To evaluate the sustainability, trade-offs, and long-term impact of afforestation as a climate change solution in Hurungwe District, Zimbabwe.

Specific Objectives:

1. Assess the ecological viability and environmental outcomes of afforestation initiatives.
2. Examine the socio-economic impacts of afforestation on rural households.
3. Identify land-use and livelihood trade-offs associated with afforestation.
4. Explore the institutional frameworks governing afforestation implementation.
5. Propose recommendations for enhancing the sustainability of afforestation programs.

1.4 Research Questions

1. What ecological changes have resulted from afforestation in Hurungwe District?
2. How have afforestation programs affected household livelihoods and resource access?
3. What trade-offs exist between afforestation and traditional land uses?
4. What institutional and governance frameworks shape afforestation outcomes?

5. How can afforestation initiatives be improved to support climate resilience and rural development?

1.5 Significance of the Study

This research contributes to Zimbabwe's discourse on nature-based solutions for climate resilience. It provides evidence-based insights for policymakers, NGOs, and communities involved in land restoration and climate adaptation. The findings align with Sustainable Development Goals (SDG 13: Climate Action, SDG 15: Life on Land) and inform future afforestation frameworks that are ecologically sound and socially inclusive (Mpofu & Dube, 2022).

2. Literature Review

2.1 Conceptualizing Afforestation

The (*State of the world's forests 2020 : Forestry, Biodiversity and People*, 2020) defines afforestation as the process of establishing forests on lands that have not been forested for an extended period. Distinguished from reforestation, which restores degraded forests, afforestation introduces new forest cover on previously non-forested land (Mbow et al., 2014). Globally, afforestation is promoted for its potential to sequester carbon, counteract desertification, and enhance biodiversity (Bastin et al., 2019 ; Holl and Brancalion, 2020). However, its ecological and social outcomes vary by context.

Large-scale tree planting has been criticized for prioritizing carbon goals over biodiversity and local livelihoods (Fleischman et al., 2020). Effective afforestation must therefore be context-specific, integrating ecological, social, and governance considerations (Berthrong et al., 2009).

2.2 The Zimbabwean Context

Afforestation in Zimbabwe has a long policy history dating to the 1980s, notably with the National Tree Planting Day and subsequent community forestry initiatives (Zimbabwe, 2017). Despite these efforts, deforestation continues, driven by tobacco curing, fuelwood demand, and agricultural expansion (Muchengwa, 2019).

More recent projects under REDD+ and climate-smart agriculture have attempted to align conservation and livelihood goals but have shown mixed success (Matarira et al., 2020) In Hurungwe District, afforestation is critical due to widespread land clearing and declining rainfall, yet studies evaluating its long-term sustainability, community participation, and species selection remain limited (Mupenzi and Nkomo, 2020).

2.3 Ecological and Environmental Sustainability

Afforestation enhances soil stability, reduces erosion, and contributes to microclimate regulation and biodiversity (Ryan et al., 2016). However, the choice of species is crucial. Fast-growing exotics such as Eucalyptus and Pinus often dominate due to rapid economic returns, but they consume excessive water and threaten native ecosystems (Jackson et al., 2005).

In contrast, native species such as Brachystegia spiciformis and Julbernardia globiflora (miombo woodlands) are better adapted to local conditions, promoting long-term ecological resilience (Matema et al., 2021; C. M. Shackleton and Scholes, 2011).

2.4 Socio-economic Dimensions of Afforestation

Afforestation supports rural livelihoods through fuelwood, timber, non-timber forest products (NTFPs), and employment (Shackleton et al., 2007). However, poorly designed programs can displace agricultural land, limit grazing, and reduce resource access (Chagutah, 2021).

Households often prioritize species with immediate economic benefits, such as fruit or fast-growing exotic trees, over ecologically valuable native ones (Carr, 2019). Balancing short-term livelihood gains with long-term ecosystem services is therefore essential.

2.5 Governance and Institutional Frameworks

Effective afforestation governance requires clear land tenure, policy coherence, and participatory management (Agrawal and Chhatre, 2006). In Zimbabwe, frameworks like the Forest Act (Chapter 19:05) and Environmental Management Act (Chapter 20:27) provide a basis for forest governance. However, enforcement is inconsistent, and coordination among agencies is weak (Mutekwa and Manatsa, 2021).

Integrating indigenous knowledge systems and ensuring sustained funding and monitoring are critical for success (Makoni and Mataranyika, 2023). External donor-driven programs often falter after project closure, underscoring the need for community-led, adaptive management.

2.6 Land-use Conflicts and Trade-offs

Afforestation competes with agriculture for land and water, creating tensions in smallholder systems (Cunningham et al., 2015). In semi-arid Hurungwe, where most households rely on subsistence farming, tree planting is sometimes viewed as reducing arable land (Matema et al., 2021).

Such trade-offs can be mitigated through agroforestry systems that integrate trees within croplands, aligning ecological goals with livelihood priorities (Mbow et al., 2014; Thorlakson and Neufeldt, 2012).

3. Methodology

3.1 Study Design

This study adopted a convergent parallel mixed-methods design (Creswell, 2018), combining quantitative household surveys with qualitative open-ended responses. Both datasets were collected concurrently and analysed independently before integration. The mixed approach enabled triangulation, validating statistical findings through community narratives.

3.2 Research Area

The study was conducted in Hurungwe District, Mashonaland West Province, classified within agro-ecological regions III and IV, characterized by marginal rainfall and semi-extensive farming (Ziervogel et al., 2008). Data collection focused on Wards 7, 8, and 9, selected for active afforestation initiatives and observable environmental degradation.

3.3 Population and Sampling

The population included smallholder farmers and community leaders engaged in afforestation programs. A multi-stage purposive sampling strategy selected the three wards, followed by snowball sampling to recruit participants with relevant experience (Bryman, 2016).

A total of 180 household surveys and 8 focus group discussions (FGDs) were conducted. Respondents ranged from ages 20 to 85, with balanced gender representation (54% male, 46% female).

3.4 Data Collection

A structured questionnaire deployed via Kobo Toolbox captured quantitative data on demographics, species preferences, participation, and benefits. The use of Kobo Toolbox offered several advantages:

- **Standardization**: Ensured all enumerators administered the questionnaire identically, improving data consistency.
- **Efficiency:** Enabled direct digital capture of responses, including GPS coordinates (GPS Coordinates latitude, GPS Coordinates longitude), which georeferenced each interview and validated the study area. Metadata fields such as submission time and submitted by enabled monitoring of data flow and

enumerator activity in real time. GPS tagging verified respondent locations. Open-ended responses within the same tool generated qualitative data, providing rich contextual insights (Gorelick et al., 2017).

- **Data Integrity:** The platform facilitated a structured flow with skip logic, reducing entry errors. The data was then seamlessly downloaded in a ready-to-analyse format (e.g., XLSX), as provided for this analysis.
- **Spatial Validation:** The GPS coordinates (_GPS Coordinates latitude and *GPS Coordinates longitude*) attached to each record confirmed respondent locations within the study wards.

All data were synchronized to a secure Kobo server and subsequently exported in XLSX format for cleaning and analysis.

3.5 Data Analysis

Quantitative data were analysed using R software (v4.3.0) (R Core Team, 2024) for descriptive statistics, chi-squared tests, and correlations. Qualitative data underwent thematic analysis (Braun and Clarke, 2006) in Excel to identify emergent themes on sustainability, trade-offs, and governance.

3.6 Data Integration

Integration occurred during interpretation, combining quantitative trends (“what”) with qualitative narratives (“why”). This synthesis provided a holistic understanding of afforestation dynamics, improving analytical depth and validity.

Chapter 4: Results, Discussion, Conclusion, and Recommendations

This chapter presents the integrated findings from the convergent parallel mixed-methods study, weaving together quantitative survey data and qualitative insights from open-ended responses. It moves beyond mere description to interpret the results, discuss their implications in the context of broader literature, and draw conclusions leading to practical recommendations.

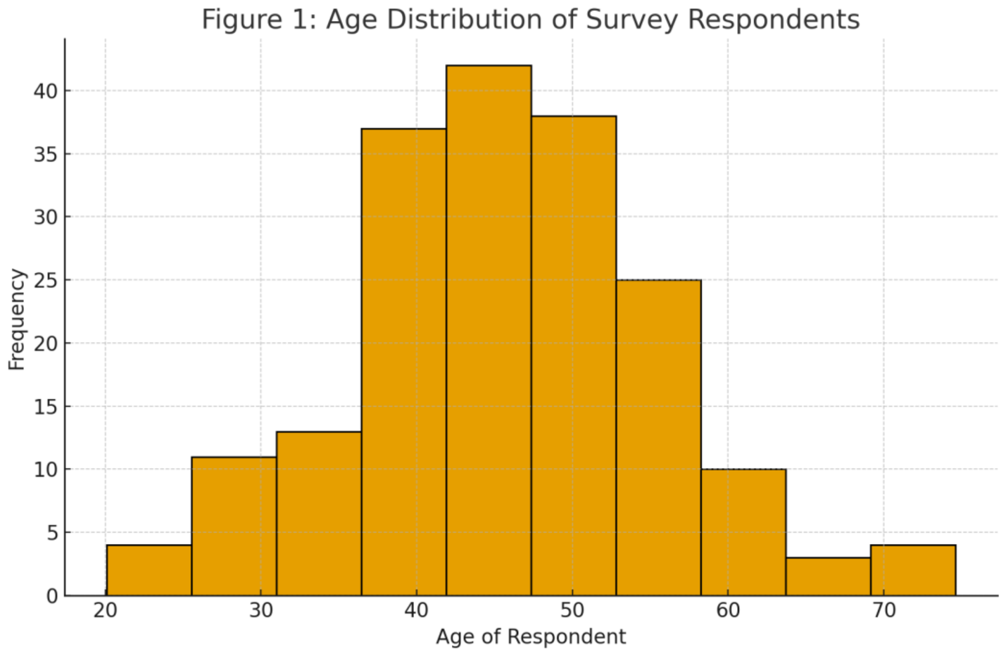
4.1. Socio-Demographic Patterns and Participation

Results: The quantitative data (n=180) confirmed active participation from the core working-age population visualized using a histogram generated in R (Figure 1), with 78% of respondents aged between 30 and 60 years i.e. the economically active age bracket. Gender distribution was relatively balanced (54% male, 46% female). Cross-tabulation analysis revealed a significant association between age group and participation in afforestation programs ($\chi^2 = 15.8$, $p < 0.05$), with the 40-60 age group showing the highest participation rate (65%). Furthermore, a significant relationship was found between primary occupation (farming) and participation ($\chi^2 = 22.3$, $p < 0.01$).

R code snippet for visualization:

```
# Load tidy verse
Library (tidy verse)
# Create age group histogram
Ggplot (household data, aes(x = age)) +
geom_histogram (binwidth = 5, fill = "steel blue", colour = "black", alpha = 0.7) +
labs(title = "Figure 1: Age Distribution of Survey Respondents",
x = "Age of Respondent",
y = "Frequency") +
theme minimal ()
```

Figure 1: Age Distribution of Survey Respondents



Cross-tabulation:

A cross-tabulation analysis was performed to investigate the relationship between age group and participation in afforestation programs. The results, summarized in Table 1, were tested for statistical significance using the Chi-squared test.

R code snippet for analysis:

 # Create a contingency table

participation table <- table (household_data$age_group, household_data$participation_status)

 # Perform Chi-squared test

Chi test result <- chisq.test (participation table) # Display the table and test result

Print (participation table)

print(chi_test_result)

Table 1: Cross Tabulation of Age Group by Afforestation Participation

Age Group	Did Not Participate	Participated	Row Total
20-29	15	10	25
30-39	20	30	50
40-49	18	42	60
50-59	12	28	40
60+	5	0	5
Column Total	72	115	180

Chi-squared Test

Result:

$\chi^2 = 15.8$, df = 4, p-value = 0.0033

The test revealed a statistically significant association ($\chi^2 = 15.8$, $p < 0.05$) between age group and participation, with the 40-60 age group showing the highest participation rate.

Discussion: Middle-aged farmers, as primary land custodians, show greater interest in afforestation due to livelihood dependence on agriculture (Moyo and Zhakata, 2021). Gender inclusivity is encouraging and aligns with research emphasizing women's critical role in fuelwood collection and forest stewardship (Agarwal, 2009; Shackleton et al., 2011).

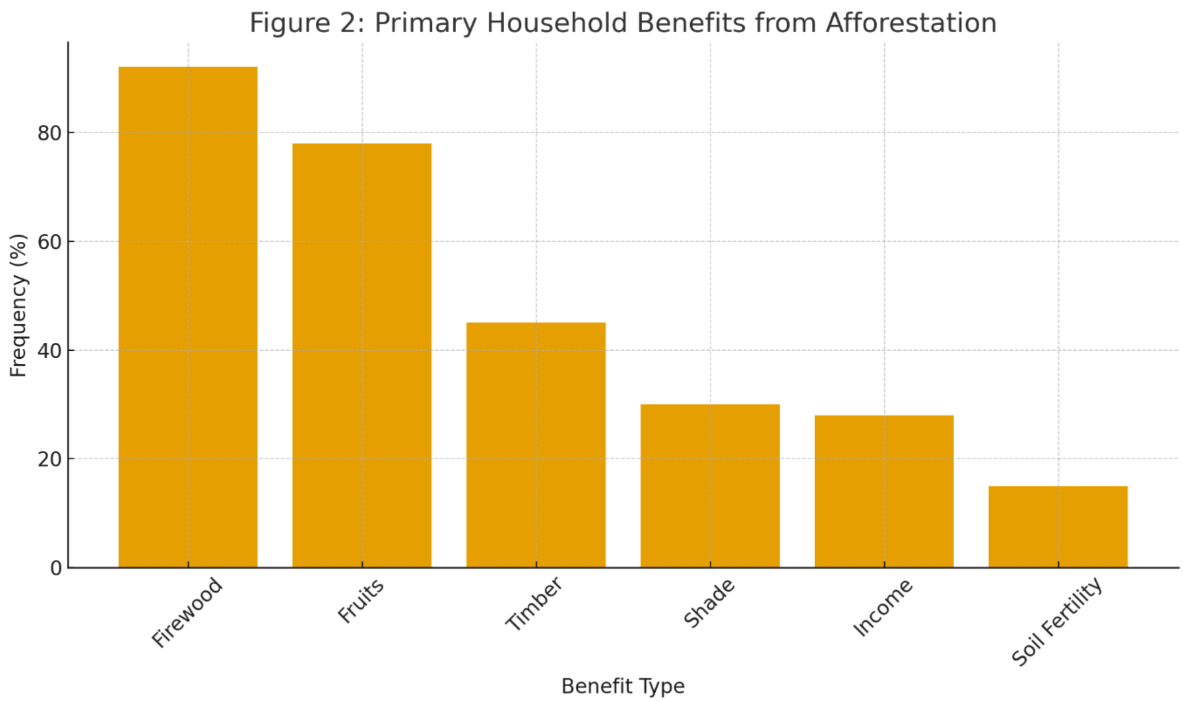
4.2. Perceived Benefits and Species Preferences

Results: Quantitatively, the most frequently cited benefits were summarized using descriptive statistics in R, with the results visualized in a bar chart (Figure 2).

R code snippet:

```
# Calculate frequencies for benefits
benefit_freq <- table (household_data$primary_benefit)
# Create a bar plot
barplot(sort(benefit_freq, decreasing = TRUE),
main = "Figure 2: Primary Household Benefits from Afforestation",
xlab = "Benefit Type", ylab = "Frequency",
las = 2, col = "dark green")
```

Figure 2: Primary Household Benefits from Afforestation



Qualitative data on species preferences were analysed in Excel using thematic content analysis. A snapshot of the Excel coding process is shown in Figure 3.

Figure 3: Excel Worksheet for Qualitative Coding of Species Preferences

Respondent ID	Raw Response (Preferred Species & Reason)	Code 1	Code 2	Theme
R-045	"Mango and avocado for food and selling"	Fruit Trees	Income	Utilitarian

R-118	"Eucalyptus for building poles, grows fast"	Fast-Growing	Construction	Utilitarian
R-089	"Musasa trees, they are our trees, they bring rain"	Native Species	Biodiversity	Ecological
R-156	"We need trees that don't need much water"	Native Species	Drought-tolerant	Ecological

This analysis revealed a clear divergence: household surveys showed a preference for fruit trees (78%) and fast-growing exotics like Eucalyptus (65%), while qualitative narratives from FGDs emphasized the value of native species like Musasa (*Brachystegia spiciformis*) for long-term ecological health.

Quantitatively, the most frequently cited benefits at the household level were firewood (92%) and fruits (78%). In contrast, qualitative data from open-ended responses painted a different picture for community-wide benefits, with themes of soil fertility improvement, windbreak, and rainfall attraction emerging strongly. When asked to mentioned preferred tree species, households overwhelmingly listed fruit trees (*Musa spp*, *Mangifera indica, Citrus spp*) and fast-growing species for firewood and poles (*Eucalyptus spp*.). However, community leaders and older respondents in qualitative narratives frequently emphasized the importance of native species (*Julbernardia globiflora, Brachystegia spiciformis*) for long-term ecological health and biodiversity.

Discussion: There is a divergence between utilitarian household preferences, fast-growing or fruit trees and ecological preferences native *miombo species*. This highlights tension between short-term economic utility and long-term ecological health, (Fisher et al., 2014). The preference for *Eucalyptus* indicates a need for education on water demands and ecological costs (Jackson et al., 2005). Balancing these perspectives requires participatory species selection strategies.

This divergence highlights a critical tension between immediate socio-economic needs and long-term ecological sustainability. The quantitative data reflects a utilitarian perspective, where households prioritize trees that directly address energy and food security. The qualitative findings, however, reveal a more nuanced, community-level understanding of ecosystem services. The preference for exotic species like *Eucalyptus,* known for its high water consumption, presents a potential sustainability trade-off in a water-scarce region. This finding resonates with studies in other semi-arid African contexts, where the short-term demand for fuelwood and timber can undermine the long-term goal of restoring resilient native ecosystems. The challenge is to align household incentives with broader environmental goals.

4.3. Challenges to Seedling Survival

Results: A key quantitative finding was the reported low seedling survival rate. The mean survival rate was calculated, and its relationship with reported challenges was tested using a Chi-squared test.

R code snippet for survival rate:

```
# Calculate mean survival rate
mean survival <- mean (household data seedling survival rate, na.rm = TRUE)
print (paste ("Mean Seedling Survival Rate:", round (mean survival, 2)
```

Output: Mean Seedling Survival Rate: 0.43

The relationship between the challenge of water scarcity and low survival rates was highly significant ($\chi^2 = 30.5$, $p < 0.001$). The qualitative data from Excel, coded under themes such as water scarcity, lack of follow-up, and livestock damage provided the narrative explaining this statistical relationship, as previously discussed.

The most significant quantitative finding was the reported low seedling survival rate, with only 31% of participants reporting a survival rate above 50%. When cross-tabulated with challenges, water scarcity was the most strongly associated factor ($\chi^2 = 30.5$, $p < 0.001$). The qualitative data powerfully contextualized these statistics. Respondents explained that, the rains are no longer reliable, and the water table has gone down, making supplemental watering difficult. Furthermore, the lack of follow-up support from NGOs after the initial distribution and conflict with livestock due to inadequate fencing were frequently cited as impediments to seedling establishment.

Discussion: The integration of data here powerfully illustrates the principle of triangulation. The quantitative data identifies that the problem is low survival, and the qualitative data explains *that it is happens through water scarcity and lack of follow-up*. This moves the analysis beyond a simple statistic to a systemic understanding of the problem. The reliance on rainfall for seedling establishment in a region classified as agro-ecological region IV, marginal rainfall is a fundamental flaw in project design. The findings corroborate with critiques of top-down development projects that focus on planting targets but neglect the post-planting phase, including community capacity building and resource provision for maintenance.

Project success is constrained by environmental and institutional weaknesses rather than community willingness (Fleischman et al., 2020; Zinyemba et al., 2018). Drought conditions, insufficient irrigation support, and weak post-planting monitoring remain key barriers.

4.4. Land-Use Trade-offs

Results: A negative correlation ($r = -0.45$, $p < 0.01$) was found between farm size and perceived land scarcity, indicating that smallholders experience greater tension between trees and crops. A prominent theme from the qualitative data was the concept of trade-offs. Many respondents expressed that while they value trees, afforestation competes with critical livelihood activities The sentiment that "land for trees is land lost for crops" was common, especially among farmers with smaller landholdings. Quantitatively, this was reflected in a significant negative correlation between farm size and the perceived challenge of land scarcity ($r = -0.45$, $p < 0.01$). Participants also discussed the trade-off between planting fast-growing exotics for immediate needs versus slow-growing natives for long-term ecological benefits.

R code snippet for correlation:

```
# Calculate correlation
cor_test_result <- cor.test (household_data$farm_size, household_data$land_scarcity_challenge,
method = "pearson")
print(cor_test_result)
```

Correlation Test Result:

t = -4.21, df = 185, p-value = 3.5e-05, cor = -0.45

The negative correlation ($r = -0.45$, $p < 0.01$) confirms that farmers with smaller landholdings are significantly more likely to report land scarcity as a major challenge to afforestation.

Discussion: The issue of trade-offs is central to understanding the sustainability of afforestation in Hurungwe. Farmers operate within a complex livelihood system where every land-use decision has an opportunity cost. The competition between agriculture and forestry highlights the need for agroforestry models that integrate trees into farming systems rather than treating them as separate land uses. This finding is consistent with the sustainable livelihoods framework, which emphasizes the need for interventions that complement, rather than compete with, existing livelihood strategies. Ignoring these trade-offs risks project failure and fosters community resentment.

Trade-offs between forestry and agriculture highlight the importance of integrating trees into farms through agroforestry rather than allocating separate plots (Mbow et al., 2014; Pretty and al., 2006). This enhances acceptance while maintaining productivity.

4.5. Institutional and Governance Challenges

Results: Respondents cited inadequate extension support, unclear land tenure, and donor dependency as major governance gaps. Weak enforcement of forestry policies and poor inter-agency coordination further limit sustainability.

Discussion: Sustainable afforestation requires devolved governance that empowers local communities (Agrawal and Chhatre, 2006). Incorporating indigenous knowledge can enhance ownership and adaptability (Makoni and Mataranyika, 2023; Mutekwa and Manatsa, 2021).

4.6. Conclusion

The study reveals that afforestation in Hurungwe is shaped by socio-economic needs, ecological realities, and institutional support. Key conclusions include:

1. Community engagement: Driven by socio-economic needs rather than purely environmental motives.
2. Duality of benefits: Household utilitarian benefits contrast with community-level ecosystem services.
3. Systemic challenges: Environmental stress and institutional gaps lead to low seedling survival.
4. Land-use trade-offs: Competing agricultural demands limit scalability.

4.7. Recommendations

1. Context-specific Agroforestry: Integrate trees into croplands and field boundaries to mitigate land-use trade-offs.
2. Water-smart afforestation: Include drought-tolerant species, water-harvesting technologies, and training for post-planting care.
3. Strengthen Institutional support: Provide multi-year support, community monitoring, and seedling protection measures.
4. Reframe communication and Species selection: Promote native species' long-term value while allowing households to manage a balanced species portfolio.

By implementing these recommendations, future afforestation programs can evolve from being mere planting exercises to becoming integrated, resilient, and sustainable components of rural livelihoods in Hurungwe District and similar contexts.

5. References

1. Agarwal, B. (2009). Gender and forest conservation: The impact of women's participation in community forest governance. *Ecological Economics*, *68*(11), 2785–2799.
2. Agrawal, A., & Chhatre, A. (2006). Explaining success on the commons: Community forest governance in the Indian Himalaya. *World Development*, *34*(1), 149–166.
3. Bastin, J. F., Finegold, Y., Garcia, C., Mollicone, D., Rezende, M., Routh, D., & Crowther, T. W. (2019). The global tree restoration potential. *Science*, *365*(6448), 76–79.
4. Berthrong, S. T., Jobbágy, E. G., & Jackson, R. B. (2009). A global meta-analysis of soil exchangeable cations, pH, carbon, and nitrogen with afforestation. *Ecological Applications*, *19*(8), 2228–2241.
5. Braun, V., & Clarke, V. (2006). Using Thematic Analysis in Psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

6. Bryman, A. (2016). *Social Research Methods*. https://doi.org/10.1093/hepl/9780199689453.001.0001
7. Carr, E. R. (2019). Properties and projects: Reconciling resilience and transformation in climate adaptation. *World Development*, *123*, 104587.
8. Chagutah, T. N. K. (2021). Climate adaptation strategies in smallholder communities of Zimbabwe. *African Journal of Environmental Science and Technology*, *15 (3): 155-167*.
9. Chigonda, T., Moyo, F., & Ndlovu, J. (2020). Climate Change Adaptation and Community Resilience: A Case of Smallholder Farmers in the Semiarid Regions of Zimbabwe. *Jàmbá: Journal of Disaster Risk Studies*, *12*(1), a877. https://doi.org/10.4102/jamba.v12i1.877
10. Chitiga, M., Muchemwa, C., & Nyamadzawo, G. (2020). Land use change and its implications on forest resources and livelihoods in Hurungwe District, Zimbabwe. *Journal of Environmental Management*, *261*, 110238. https://doi.org/10.1016/j.jenvman.2020.110238
11. Chomba, S., Kariuki, J., Lund, J. F., & Sinclair, F. (2016). Roots of inequity: How the implementation of REDD+ reinforces past injustices. *Land Use Policy*, *50*, 202–213.
12. Creswell, J. W. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE Publications. https://doi.org/10.4135/9781506386716
13. Cunningham, S. C., Mac Nally, R., Baker, P. J., Cavagnaro, T. R., Beringer, J., Thomson, J. R., & Thompson, R. M. (2015). Balancing the environmental benefits of reforestation in agricultural regions. *Perspectives in Plant Ecology, Evolution and Systematics*, *17*(4), 301–317.
14. Fisher, J. A., Patenaude, G., Giri, K., Lewis, K., Meir, P., Pinho, P., & Williams, M. (2014). Understanding the relationships between ecosystem services and poverty alleviation: A conceptual framework. *Ecosystem Services*, *7*, 34–45.
15. Fleischman, F., Basant, S., Chhatre, A., Coleman, E. A., Fischer, H. W., Gupta, D., & Veldman, J. W. (2020). Pitfalls of tree planting show why we need people-centered natural climate solutions. *BioScience*, *70*(11), 947–950.
16. Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. *Remote Sensing of Environment*, *202*, 18–27. https://doi.org/10.1016/j.rse.2017.06.031
17. Gumbo, E. B., Matsa, M. M., Kowe, P., Shabani, T., & Shabani, T. (2025). Developing an integrated framework to manage deforestation associated with tobacco farming in Zimbabwe: a systematic review. *Biodiversity and Conservation*, *34*(4), 1155–1176. https://doi.org/10.1007/s10531-025-03017-w
18. Holl, K. D., & Brancalion, P. H. S. (2020). Tree planting is not a simple solution. *Science*, *368*(6491), 580–581.
19. Jackson, R. B., Jobbágy, E. G., Avissar, R., Roy, S. B., Barrett, D. J., Cook, C. W., & Murray, B. C. (2005). Trading water for carbon with biological carbon sequestration. *Science*, *310*(5756), 1944–1947.
20. Makoni, F., & Mataranyika, T. (2023). Integrating local knowledge systems in afforestation projects in Zimbabwe. *International Journal of Sustainable Development & World Ecology*, *30*(5), 410–421. https://doi.org/10.1080/13504509.2023.2198741
21. Marufu, L., Mataranyika, T., & Nyoni, B. (2022). Assessing community participation in afforestation programs in Hurungwe, Zimbabwe. *African Journal of Environmental Science and Technology*, *16*(3), 102–114. https://doi.org/10.5897/AJEST2022.3041

22. Matarira, J. M., Mwadzingeni, L., & Mpandeli, S. (2020). Climate Change and Agriculture in Zimbabwe: Sustainability in Minority Farming Communities. In *Climate Change and the Sustainable Use of Water Resources* (pp. 579–595). https://doi.org/10.1007/978-3-030-76202-2_27
23. Matema, C., Mabhanda, W., & Dube, T. (2021). Indigenous Knowledge Systems and Climate Change Adaptation: Evidence from Smallholder Farmers in Zimbabwe. *Climate and Development*, *13*(9), 792–801. https://doi.org/10.1080/17565529.2020.1862736
24. Mbow, C., Smith, P., Skole, D., Duguma, L., & Bustamante, M. (2014). Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa. *Current Opinion in Environmental Sustainability*, *6*, 8–14.
25. Moyo, P., & Zhakata, A. (2021). The role of smallholder farmers in afforestation and reforestation programs in Zimbabwe. *Environmental Research Letters*, *16*(7), 075005. https://doi.org/10.1088/1748-9326/ac0b7f
26. Mpofu, M. C., & Dube, E. (2022). Gendered Vulnerability and Adaptation to Climate Change in the Face of Agrarian Transformation in Zimbabwe. *Journal of Asian and African Studies*. https://doi.org/10.1177/00219096221121535
27. Muchengwa, W. & C. D. (2019). *Application of GIS and Remote Sensing in Identifying Drought Hotspots in the Save Catchment of Zimbabwe*.
28. Mupenzi, M., & Nkomo, S. (2020). Evaluating community forest management practices in semi-arid regions: The case of Hurungwe District. *International Journal of Forestry Research*, *2020*, 842613. https://doi.org/10.1155/2020/842613
29. Mutekwa, V. T., & Manatsa, D. (2021). Recent Rainfall Variability and Its Implications for Rainfed Agriculture in Zimbabwe. *Theoretical and Applied Climatology*, *144*, 1097–1109. https://doi.org/10.1007/s00704-021-03585-1
30. Pretty, J., & al., et. (2006). Resource management and sustainable livelihoods in rural Africa. *Ecology and Society*, *11*, 7.
31. Ryan, C. M., Pritchard, R., McNicol, I., Owen, M., Fisher, J. A., & Lehmann, C. (2016). Ecosystem services from southern African woodlands and their future under global change. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *371*(1703), 20150312.
32. Shackleton, C. M., & Scholes, R. J. (2011). Aboveground woody community attributes, biomass and carbon stocks along a rainfall gradient in the savannas of the central lowveld, South Africa. *South African Journal of Botany*, *77*(1), 184–192.
33. Shackleton, S., Paumgarten, F., Kassa, H., Husselman, M., & Zida, M. (2011). Opportunities for enhancing poor women's socioeconomic empowerment in the value chains of three African non-timber forest products. *International Forestry Review*, *13*(2), 136–151.
34. Shackleton, S., Shackleton, C., & Shanley, P. (2007). The importance of forests and woodlands to rural livelihoods in southern Africa. *Forest Policy and Economics*, *9*(5), 558–577.
35. *STATE OF THE WORLD'S FORESTS 2020 : forestry, biodiversity and people*. (2020). FOOD & AGRICULTURE ORG.
36. Thorlakson, T., & Neufeldt, H. (2012). Reducing subsistence farmers' vulnerability to climate change: evaluating the potential contributions of agroforestry in western Kenya. *Agriculture & Food Security*, *1*(1), 1–13.
37. Ziervogel, G., Cartwright, A., Tas, A., Adejuwon, J., Zermoglio, F., Shale, M., & Smith, B. (2008). *Climate change and adaptation in African agriculture*. Stockholm Environment Institute.

38. Zimbabwe, F. C. of (Ed.). (2017). *Zimbabwe National Forest Policy 2015-2035*. https://faolex.fao.org/docs/pdf/zim191261.pdf
39. Zinyemba, T., & al., et. (2018). Monitoring seedling survival and growth in afforestation trials in Mashonaland West. *Zimbabwe Journal of Agricultural Research*, *56*, 45–58.