Preservation of Velvet Bean Mucuna pruriens Through Informal Seed Sources in Machinga District Malawi

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Case Report

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Abstract

Informal seed systems remain a cornerstone of agro biodiversity conservation in sub-Saharan Africa, yet they are often overlooked in agricultural policies. Therefore, this study investigates the role of farmer-managed seed systems in preserving the neglected and underutilized legume velvet bean (Mucuna pruriens) in Machinga District, Malawi. A mixed-methods design combining surveys (n = 222), focus group discussions, and key informant interviews was used. Findings reveal that local vendors, kinship exchanges, own seed saving, community seed banks, and cross-border sourcing from Mozambique constitute a diverse and adaptive seed network that buffers farmers against environmental and economic shocks. Farmers' decisions to cultivate velvet beans are influenced by food security needs, ecological benefits, cultural practices, and perceived medicinal uses. However, preservation faces threats including droughts, storage limitations, labor-intensive harvesting, and erosion of intergenerational knowledge. Using the Indigenous Knowledge Systems Theory, the study highlights how farmer-led seed practices represent both cultural heritage and vital biodiversity assets. Strengthening these informal networks through training and policy recognition is essential to sustaining on-farm biodiversity and safeguarding neglected crops like velvet beans.

1.0 Introduction

Agricultural biodiversity or agrobiodiversity forms the ecological foundation of resilient and sustainable agri-food systems [1]. It encompasses the variety and variability of plants, animals, and microorganisms that underpin food production, nutritional quality, ecosystem regulation, and livelihood security [12]. By maintaining genetic variability, agrobiodiversity enhances the adaptive capacity of crops to climatic stresses, pests, and diseases [22]. Across sub-Saharan Africa, this diversity is not only a biological resource but also a socio-cultural asset embedded in the traditions, values, and daily practices of farming communities.

Despite its critical importance, agrobiodiversity is increasingly threatened by modernization, commercialization, and climate variability. Formal seed systems dominated by certified, improved, and hybrid varieties often promote uniformity and high yields, sometimes at the expense of genetic diversity and local adaptability [25]. In contrast, informal seed systems, managed by farmers through saving, exchanging, bartering, and purchasing seed from local networks, have historically sustained the genetic richness of traditional and underutilized crops. These farmer-managed systems continue to provide more than 70% of seed used in sub-Saharan Africa [2]. They are adaptive, decentralized, and culturally embedded, enabling smallholder farmers to maintain local varieties in the face of environmental and economic shocks.

Among the crops preserved through informal seed systems are underutilized legumes, neglected crops, or orphan crops (NOCs). Though locally significant for nutrition, soil fertility, and cultural practices, these crops remain overlooked in research, breeding, and agricultural policy [20]. Velvet bean (*Mucuna pruriens*) is one such crop. It provides multiple benefits: improving soil fertility through nitrogen fixation,

suppressing weeds such as *Striga hermonthica*, serving as high-protein feed and food, and containing medicinal compounds including L-DOPA, used in treating Parkinson's disease [33, 5]. Beyond these functions, *M. pruriens* contributes to ecological sustainability, enhances soil organic carbon, and reduces dependence on synthetic fertilizers, positioning it as a candidate for climate-smart agriculture [30, 14, 18].

Globally, *M. pruriens* has attracted increasing research attention due to its agronomic, ecological, and nutritional potential. Studies in tropical Africa demonstrate its ability to rehabilitate degraded soils, improve household nutrition, and function as a green manure in sustainable farming systems [3, 5]. Despite these advantages, its cultivation remains largely confined to smallholder systems, constrained by limited market access, low awareness, minimal formal extension support, and exclusion from national seed systems [26, 8]. Consequently, the crop's genetic resources and cultivation practices depend heavily on informal seed networks, emphasizing the need to understand how these systems operate in practice.

In Malawi, velvet bean locally known as *Kalongonda* has a long history in traditional cropping systems, particularly in southern Malawi [11]. Farmers cultivate it for soil fertility restoration, *Striga* suppression, and livestock feed during the dry season [23]. Its nutritional and medicinal properties, including use in treating male infertility and snake bites, further anchor it within Indigenous knowledge systems [17]. Machinga District is particularly relevant for this study due to its combination of historical velvet bean cultivation, soil fertility challenges, and cross-border seed exchanges with Mozambique, making it an ideal site to examine informal seed dynamics.

Despite its ecological, nutritional, and cultural importance, velvet bean remains a marginal crop in Malawi. National agricultural policies continue to prioritize maize, soybean, and groundnut, leaving underutilized legumes outside mainstream research, extension, and subsidy programs [29]. Smallholder cultivation is primarily for subsistence, soil fertility management, or cultural purposes rather than commercialization [9]. A key constraint is seed access: velvet bean is absent from the national seed catalogue and formal certification channels, forcing farmers to rely on informal sources such as self-saved seed, exchanges with relatives, local markets, community seed banks, and occasional cross-border flows from Mozambique [37, 38]. These informal systems are resilient and adaptive but vulnerable to labor shortages, climatic variability, storage limitations, market uncertainty, and erosion of intergenerational knowledge. Without systematic support, these networks risk weakening, which could lead to genetic erosion and threaten long-term cultivation.

Existing literature in Malawi and the broader Southern African region has largely emphasized agronomic and ecological aspects of *Mucuna pruriens*, including nitrogen fixation, soil fertility enhancement, weed control, and nutrient provision [15, 23]. Breeding and agronomic studies prioritize trait mapping and yield improvement over understanding the social and cultural dimensions of seed access and farmer practices [18]. Consequently, there is a significant knowledge gap regarding how informal seed systems function to maintain the availability, quality, and diversity of velvet bean in smallholder farming contexts.

The Indigenous Knowledge Systems and Technologies (IKST) framework provides a valuable lens for studying these dynamics. By emphasizing the interplay between cultural practices, community trust, and ecological adaptation, the framework illustrates how seed management encompasses both technical and socio-cultural processes [34]. Applying IKST enables a deeper understanding of how farmer-managed seed practices conserve agrobiodiversity, transmit intergenerational knowledge, and support resilient agricultural systems.

This study addresses a critical research gap by investigating the sources of velvet bean seeds in Machinga District, Malawi. Specifically, it examines the roles of individual seed saving, kinship exchange, local vendors, community seed banks, and cross-border flows in sustaining the crop's availability and genetic diversity. It further explores how these informal channels interact with cultural, ecological, and socio-economic factors to support long-term preservation.

The study is scientifically and policy relevant. Scientifically, it contributes empirical evidence on the operation of informal seed systems for underutilized legumes in Malawi and highlights their role in agrobiodiversity conservation. From a policy perspective, findings may inform strategies to strengthen and integrate farmer-led networks into national seed programs, ensuring continued availability of culturally and ecologically important crops. Ultimately, empowering farmers as custodians of biodiversity is essential for sustaining agricultural diversity, food security, and ecological resilience.

1.1 Conceptual Framework

The conceptual framework illustrates the relationships between informal seed sources, Indigenous Knowledge Systems Theory (IKST), socio-economic factors, ecological factors, and the resulting outcomes of seed availability, preservation of velvet bean diversity, and knowledge transmission in Machinga District. Informal seed sources include friends, relatives, neighbors, local vendors, self-saved seeds, cross-border flows, and community seed banks [27]. In many smallholder contexts in sub-Saharan Africa, informal and community-managed seed systems including farmer-saved seed, exchanges through social networks, local markets, and community seed banks remain the principal source of planting material for neglected and underutilised crops [6, 7]. Household socio-economic characteristics (age, gender, education, household size) and ecological factors (soil fertility, climate variability, drought, and pest risk) influence how farmers access and manage seeds. Collectively, these factors determine the sustainability of velvet bean cultivation, the maintenance of agrobiodiversity, and the continuation of traditional seed practices within Machinga's smallholder farming systems [35].

Research question: What are the main sources of velvet bean seeds used by farmers in Machinga District, and how do these sources preserve agrobiodiversity and cultural practices?

Objective: The aim of this study was to investigate the sources of velvet bean seeds within the informal seed system in Machinga District, Malawi.

2.0 Materials and method

3.2 Study area

The study was conducted in Machinga District in Malawi's Southern Region, where most households rely on smallholder farming. Maize is the staple food and dominates agricultural production, while tobacco, rice, cotton, and widely cultivated legumes such as groundnuts and pigeon peas support food security, soil fertility, and livestock feed [21]. This farming system, together with the district's agro-ecological diversity and localized seed practices, provides a suitable context for analysing informal velvet bean (*Mucuna pruriens*) seed systems [24].

Machinga was purposively selected for three linked reasons: first, regional assessments within Southern Africa, including Malawi, show increasing attention toward the expansion and conservation of underutilized legumes, and examining areas where these legumes persist at the household level provides insights into farmer-managed seed flows that remain poorly documented [27]. Second, the presence of active farmer seed exchange practices and community seed initiatives in Machinga offers a living laboratory for studying how velvet bean seed is sourced and conserved [21]. Third, feasibility and access were ensured as Local Extension Planning Area (EPA) coordinators and district agricultural officers reported ongoing velvet bean cultivation pockets and facilitated sampling and field arrangements, making the combination of technical access and agronomic relevance justify the purposive selection [13].

Moreover, Machinga has a long history of cultivating velvet bean (locally known as "kalongonda") as a traditional intercrop, often used as a green-manure or soil-fertility legume rather than in formal commercial agriculture [11]. In Malawi and other smallholder contexts, informal seed systems including community seed banks, local markets, and farmer-to-farmer exchanges supply the majority of planting material for underutilized crops, with formal seed systems covering only a small fraction of farmers' needs [37, 29]. Community-managed seed flows contribute significantly to seed access and food security, reinforcing the importance of these informal networks in rural farming systems [37].

Given this background, Machinga represents an appropriate and representative site for investigating how informal seed networks sustain velvet bean cultivation, conservation, and knowledge transmission under smallholder conditions.

3.5 Research design

A convergent mixed-methods design was adopted to generate complementary quantitative and qualitative evidence. Quantitative surveys produced descriptive, cross-tabulated data on the sources and frequency of velvet bean seeds across households; qualitative methods (FGDs, KIIs) explored meanings, social mechanisms, and local conservation practice. Combining methods enabled triangulation and richer interpretation of how informal seed systems function. This approach follows established practice in seed-systems research where mixed methods reveal both distributional patterns and social drivers [16].

3.6 Sampling strategy, target population, sample size

A multi-stage sampling approach was employed for this study. The target population comprised velvet bean farmers, EPA agricultural coordinators, and lead farmers in Machinga District. The district was first stratified into Extension Planning Areas (EPAs), from which two were purposively selected based on EPA coordinators' reports indicating the highest prevalence of velvet bean cultivation, ensuring that sampling concentrated on areas where the crop and its seed networks were most active. Within the selected EPAs, villages were randomly sampled using lists provided by EPA coordinators. Systematic sampling was then applied to select farming households for the structured questionnaire, relying on household registers or walking lists where official records were unavailable.

A sample of 222 households was calculated using Cochran's formula for finite populations at a 95% confidence level and 5% margin of error, providing adequate statistical power for estimating seed-source proportions. EPA coordinators played a key facilitative role by identifying villages with active velvet bean production, providing household lists, and introducing research teams to community leader's actions that enhanced response rates and minimized sampling bias, a recommended approach in agricultural surveys where farmer registers are often incomplete [27].

3.7 Data Collection

Data were collected between September 2024 and February 2025, covering the late cropping and early post-harvest months, when farmers are generally able to recall seed sources, quantities, and seed-saving practices with reasonable accuracy. Enumerators received three days of training on the survey instruments, ethical procedures, and appropriate local language phrasing, with role-plays and mock interviews used to ensure consistency in data collection. Multiple data collection methods were employed, including a structured questionnaire, Focus Group Discussions (FGDs), and Key Informant Interviews (KIIs). The structured household questionnaire data on primary velvet bean seed sources, frequency of access, perceived seed quality and trust in sources, seed quantities saved or purchased, and socio-demographic variables such as age, gender, education, household size, and farm area. The questionnaire was drafted in English, translated into the local languages (*Chichewa*) which is commonly used in the study EPAs, and pre-tested in a neighboring village to ensure comprehension and possible achievement of objective without leaving important details. Feedback from the pre-test led to adjustments in wording and response categories.

A total of nine FGDs were conducted, comprising four women-only groups, three men-only groups, and two mixed-gender groups. FGDs explored seed exchange norms, rituals and practices associated with seed saving, informal seed pricing and exchange, perceived varietal traits, and gendered patterns of seed access. Separating men and women was important because gender norms in rural Malawi can influence who participates, what is shared, and how openly sensitive topics are discussed. Mixed groups were arranged to include both younger and older participants, capturing intergenerational perspectives. FGDs provided triangulation for survey data and helped reveal the social meanings behind seed-sharing behaviours. KIIs were conducted with EPA coordinators, agricultural extension officers, local seed

vendors, and community seed bank leaders to obtain insights on institutional and market perspectives, seed flows, quality concerns, and policy or programmatic interventions. KIIs linked household-level practices to broader institutional and market contexts.

3.9 Data analysis

Data entry and management was done in Microsoft excel (2016). Quantitative data were double-entered and checked for consistency, while outliers and missing values were verified against the original questionnaires. For qualitative data, FGDs and KIIs were audio-recorded with participant consent, transcribed verbatim, and translated into English when necessary, with all transcripts cross-checked by a second researcher for accuracy. These measures collectively minimized measurement errors and enhanced the reliability and validity of both quantitative and qualitative datasets.

The survey data were analyzed using Statistical Package for Social sciences (IBM SPSS version 26). Descriptive statistics, including frequencies, percentages, and cross-tabulations, were used to summarize household characteristics and the distribution of seed sources, obtained from survey. Associations between categorical variables such as primary seed source by gender of household head or by education level were examined using chi-square tests, as these tests are appropriate for assessing independence rather than causal relationships. Where relevant, cross-tabulations included both cell counts and percentages to clearly illustrate patterns. Seed-source distributions were further visualized using bar and pie charts, following standard approaches in seed-systems research for characterizing and comparing discrete categories across groups. Data obtained from FGDs and KIIs were analyzed thematically following a reflexive thematic analysis approach. Coding proceeded iteratively: initial open coding to capture meaningful units, focused coding to develop candidate themes, and review/refinement to ensure themes clearly related to the research objective (seed sources and their social meaning). Thematic analysis is appropriate here because it systematically identifies patterns across participants' narratives and is widely used in agricultural and local knowledge research to make sense of social drivers of practice. Representative quotes were selected to illustrate each theme and to contextualize quantitative patterns.

3.0 Results

Survey findings from 222 households in Machinga District showed that farmers accessed velvet bean seeds primarily through social networks of relatives, friends, and neighbours (57.0%), followed by local vendors (33.7%), their own saved seed (5.8%), and cross-border exchanges with Mozambique (3.5%, Table 1). A chi-square goodness-of-fit test confirmed that these differences were statistically significant ($\chi^2 = 171.39$, $p < 0.001$), indicating that farmers do not rely on all seed sources equally. These quantitative patterns were further supported and contextualized through FGDs and KIIs, which explained the social, economic, and environmental dynamics shaping access to seeds.

Table 1
Sources of velvet bean seeds among surveyed households (n = 222) in Machinga District, Malawi.

Seed Source	Percentage (%)	Frequency (n)
Friends, relatives & neighbours	57.0	127
Local vendors	33.7	75
Own saved seed	5.8	13
Cross-border (Mozambique)	3.5	8

3.1 Friends, Neighbours, and Relatives

Social networks emerged as a major source of velvet bean seeds, with 57.0% of survey respondents reporting obtaining seed from friends, neighbors, or relatives. Qualitative discussions confirmed that seed sharing within these networks is widespread and typically unconditional, reflecting strong traditions of mutual support. As one participant stated,

"If a friend has seeds, they share freely. There is no expectation of repayment, because everyone might need help at some point." (FGD4)

FGDs further revealed three informal mechanisms that structure these exchanges. First, surplus sharing occurs when farmers receive seeds only after the giver has finished planting, which protects household seed security but may delay planting for recipients. Second, reciprocal exchange is common, where seeds are returned after harvest often in greater quantity reinforcing trust and accountability. Individuals without a reputation for returning seeds may be denied access, highlighting the role of social credibility. Third, labor for seed arrangements has emerged, where seed-insecure farmers provide labor in exchange for velvet bean seeds. As one farmer noted:

"Now, if you don't have money, you cultivate someone's farm, and instead of payment, you receive velvet bean seeds." (FGD)

Together, these practices illustrate how informal seed systems function as social safety nets, balancing generosity, reciprocity, and resource constraints.

3.2 Vendors

Vendors constituted the most frequently reported seed source (33.7% of survey respondents). Farmers indicated purchasing velvet bean seeds from local markets or community-based vendors, especially when household stocks or social networks were insufficient. However, FGDs revealed concerns about pricing practices, with vendor's reportedly buying seeds cheaply during harvest and reselling them at higher prices during the planting season. One participant explained,

“We sometimes have no choice but to buy seeds from vendors at high prices, especially when we urgently need them for planting.” (FGD)

Despite affordability challenges and occasional seed hoarding, vendors remain essential for timely access, particularly in years of low production.

3.3 Own Seed Saving

Although valued, only 5.8% of surveyed households reported relying on their own saved seed. Participants attributed this decline to climate shocks, especially drought, which often forces families to consume seeds reserved for planting. Nevertheless, FGDs emphasized that self-saved seeds are considered the most reliable due to familiarity with variety performance and storage conditions:

“The best way to get velvet bean seeds is from our own harvest. We know how we store them, and they germinate well.” (FGD)

Farmers described using breathable sacks and separating seed from food grains to maintain purity and viability. Seed saving supports household autonomy but remains vulnerable to environmental stress.

3.4 Cross-Border Seed Sources

A small proportion of farmers (3.5%) reported accessing velvet bean seeds from Mozambique, particularly during drought years or when local supplies were exhausted. FGDs indicated that these exchanges are facilitated through kinship ties, labor arrangements, and shared Lomwe ethnic networks:

“We work on crop farms in Mozambique and receive seeds in return. This helps when our local crops fail.” (FGD)

This demonstrates that informal seed systems extend beyond national boundaries, with cross-border networks acting as resilience pathways during scarcity.

4.0 Discussion

Velvet bean seed sourcing in Machinga District is characterized by a diverse and largely informal set of pathways that provide farmers with planting material across different seasons. Survey findings from 222 respondents indicated that farmers obtain seeds from various sources. Social networks formed a major component of this system (57.0%), with farmers acquiring seed through sharing, surplus distribution after the donor has completed planting, reciprocal exchange where seed is returned after harvest, and labor-for-seed arrangements. Local vendors constitute the most common single source (33.7%), supplying seed throughout the year, and their role is prominent during periods when saved seed or shared seed is insufficient. Own seed saving (5.8%) continued providing a dependable source for many households, supported by traditional storage methods such as breathable sacks, separated storage spaces, and routine inspection, although losses from drought or pests sometimes limit the quantities available for planting. Other sources included cross-border exchanges (3.5%) with Mozambique occur

through established kinship connections and seasonal movements of people, and these transactions occasionally introduce seed types with different physical characteristics. Together, these pathways outline a seed system that incorporates multiple sources, seasonal flows, and locally embedded practices that determine how velvet bean seed is accessed and circulated within the district.

4.1. Social Networks as Seed Sources

In Machinga District, the predominance of seed sharing through social networks friends, relatives, and neighbors aligns closely with broader findings on informal seed systems across sub-Saharan Africa. For instance, seed system assessments emphasize that up to 90% of smallholder seed comes from informal sources such as social networks, own saved seed, and local markets [7]. Additionally, studies in East Africa show that informal seed networks, including exchanges among neighbors and family, remain the primary source of planting material for crops like beans and millet [31]. What sets Machinga apart, however, is the strong norm of unconditional sharing farmers give seeds without an immediate or formal expectation of repayment. In some other contexts, exchanges are more transactional; for example, in Ethiopia, social networks influence farmers' decisions to join cooperatives where seed access is linked to membership or reciprocity [28]. This unconditional generosity suggests a deeply embedded indigenous social technology: a trust-based system that functions without formal contracts or structured institutions, demonstrating how IKST (Indigenous Knowledge Systems Theory) can sustain seed access through relational norms rather than formal market mechanisms.

4.2. Surplus Sharing (Norm of Sharing When One Has More)

The surplus-sharing practice in Machinga where farmers only distribute seed once they have planted their own aligns with views that informal seed systems rest on social norms that regulate access and promote equity. For example, seed-system scholars have noted that social rules in farmer-managed seed networks help ensure fairness and protect vulnerable households [40]. However, unlike much of the literature that treats "sharing" simply as a general act of giving, findings of this study highlight an important temporal dimension: sharing happens only after personal needs are met, which introduces delays that may prevent some farmers from planting within optimal sowing windows. A time-lag in seed sharing has also been observed in other settings: for example, community-led seed systems in Malawi demonstrate that diffusion of new seed varieties via farmer networks can take several seasons, particularly when mediated through community seed banks, reflecting disincentives or capacity constraints in informal systems [29, 40]. From an IKST (Indigenous Knowledge Systems Theory) perspective, surplus sharing in Machinga is not just generosity it is a culturally embedded technology, balancing household risk with community obligation in a way that formal seed systems rarely replicate.

4.3. Reciprocal Exchange (Seed Returned After Harvest)

The norm of reciprocal exchange, where farmers return seeds (often with some increase) after harvest, is widely recognized in seed systems research. Informal commercial seed system studies note that trust, reputation, and repeated interactions often underlie seed trades among farmers, even when seeds

change hands in commercial-like settings [36]. Similarly, legume seed system reviews in sub-Saharan Africa report that farmers often retain seeds from improved or traditional varieties and re-distribute them in cycles, reinforcing both social bonds and varietal continuity [6, 7]. In Machinga, the defining feature is that the return is guided by cultural expectation rather than a contractual arrangement. Rather than formal repurchase or contract, it's a socially enforced norm backed by trust. This informal yet stable system illustrates IKST in action: the social architecture of trust and reciprocity sustains local seed turnover without external regulation, a feature that more formal systems rarely replicate at the same relational depth.

4.4. Labor-for-Seed Arrangements

The labor-for-seed exchanges in Machinga where farmers provide labor on someone else's field in return for velvet bean seed represent a particularly innovative form of seed governance. While the informal-sector literature does discuss barter and sale in local markets, most documented models of informal commercial seed systems do not mention labor-for-seed as a common currency [35]. However, the key difference lies in how Machinga institutionalizes labor as a structured and socially recognized currency for seed acquisition, rather than treating it as occasional or incidental support. While a few studies of community-based seed systems note that seed diffusion can involve exchanges of small goods or service-based contributions [39], systematic labor-for-seed arrangements are scarcely documented, making the Machinga case notably distinct.

4.5. Vendors / Local Markets as Seed Sources

Farmers in Machinga obtain velvet bean seed from local vendors, placing vendor networks firmly within the informal seed system. This pattern aligns with wider evidence that informal commercial seed markets play a central role in seed access where formal channels remain thin or unreliable. For example, rural markets across sub-Saharan Africa supply a large share of seed for legumes and other food crops, complementing farmer-to-farmer exchange when household stocks run low [41]. Similarly, informal markets act as important reservoirs of crop diversity and resilience, especially in marginal farming systems [19].

However, the Machinga context differs in a critical way. Farmers described vendor practices as exploitative particularly the pattern of buying seed cheaply during harvest and reselling it at sharply inflated prices at planting time. Such explicit price manipulation receives less emphasis in the seed-system literature, which often depicts local markets as functional gap-fillers rather than sites of opportunistic behavior. This study therefore highlights a tension often overlooked: the clash between communal norms of fairness within IKST-oriented seed systems and the commodification logic of vendor trade. From an IKST lens, this tension reveals how market-based practices or mechanisms can disrupt principles of reciprocity and collective stewardship, suggesting the need for interventions that strengthen accountability while aligning vendor behavior with community expectations.

4.6. Own Seed Saving

The practice of self-saving seed in Machinga, though adopted by only a minority, is highly prized for its stability, control over quality, and reduced dependency on external sources. This resonates with research on farmer- and community-managed seed systems, which shows that farmers value seed saving because it helps maintain preferred traits and build resilience [4]. Moreover, studies of community seed banks across smallholder contexts demonstrate how local seed selection, storage, and multiplication build adaptive capacity in the face of climate stress [32]. In Machinga, farmers apply IKST-rooted practices: they separate seed for consumption versus planting, store in breathable sacks, and continuously monitor seed quality. Yet, environmental shocks droughts or floods sometimes force them to consume their own saved seed, exposing the fragility of saving systems. This aligns with broader concerns that farmer-managed seed systems, while technically robust, remain vulnerable to survival pressures. The duality of strength and risk in self-saving underscores the need for backup arrangements (community seed banks) to reinforce resilience.

4.7. Cross-Border Seed Exchanges

The cross-border strategy in Machinga, where a small proportion of farmers access velvet bean seed from Mozambique via agreements often based on labor, is particularly striking and under-documented. While the informal seed literature recognizes cross-border flows in terms of trade and migration, few studies describe labor-mediated exchanges across national boundaries. Most models focus on barter or sale rather than negotiated labor ties [36]. Moreover, legume seed system reviews in sub-Saharan Africa typically emphasize local actors and market transactions, rarely addressing transnational, trust-based movement of seed [6, 10]. In this context, IKST extends beyond national boundaries, incorporating social trust, negotiation, and labor into a trans-local indigenous knowledge system. This mechanism demonstrates how smallholder farmers actively navigate political and economic constraints by mobilizing social networks beyond their immediate locale. It suggests that seed system interventions should not treat national borders as hard barriers: supporting and legitimizing cross-border social strategies may bolster resilience and seed diversity.

Conclusion

Taken together, these themes illustrate that Machinga’s seed system is deeply embedded in IKST: social norms of trust and reciprocity (surplus sharing, reciprocal exchange, post-plant sharing), adaptive economic strategies (labor-for-seed), local market integration, self-saving, and cross-border cooperation all function as technologies in their own right. While many of these practices reflect globally documented informal systems, the specific forms particularly labor-for-seed and cross-border labor-based exchanges stand out as novel and context-specific. These insights emphasize that any attempt to formalize or intervene in the seed system must not displace the indigenous technologies that maintain resilience, equity, and social cohesion.

Recommendations for policy and practice

Malawi's national seed policy should explicitly recognize and support farmer-managed systems as complementary to formal seed frameworks. This recognition would validate the role of kinship exchanges, local markets, and seed banks in biodiversity conservation.

Agricultural extension should go beyond promoting improved varieties to actively support biodiversity conservation. Extension officers could facilitate farmer training on velvet bean storage, intercropping, and seed selection to reduce genetic erosion.

Since cross-border exchanges are biodiversity corridors, regional collaboration between Malawi and Mozambique could help secure safe, legal, and beneficial seed flows. This would require harmonized seed regulations that balance phytosanitary control with genetic diversity conservation.

Investment in technical support (storage facilities, pest management, seed viability testing) can transform community seed banks into reliable biodiversity hubs. Linking seed banks with farmer cooperatives and local schools could enhance participation and knowledge transmission.

Vendors should be integrated into biodiversity conservation strategies through training in seed quality management, labeling, and collaboration with community seed banks. This would enhance trust while ensuring diverse varieties remain available in markets.

Supporting IKST methods, such as using ash, smoke, or plant-based repellents for seed storage, can complement modern technologies. Such practices enhance resilience by embedding conservation within farmers' cultural knowledge systems.

Programs should target youth with biodiversity education and incentives to participate in seed saving and exchange. This would counteract generational erosion of indigenous knowledge and sustain biodiversity practices for the future.

Recommendations for future research

a. Future studies should analyze the genetic diversity of velvet beans circulating in informal systems to document conservation outcomes at the molecular level.
b. Tracking seed flows over time would reveal how biodiversity is sustained or eroded under changing climatic, socio-economic, and policy conditions.
c. Comparative research on other underutilized legumes could broaden understanding of informal seed systems' role in biodiversity beyond velvet beans.

Declarations

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

Ajuna Peace Domitian and Joshua Kimeli conceptualised the study, collected data, conducted the analysis, and prepared the manuscript. Aubrey Chaputula and Frank Mnthambala contributed to manuscript editing and provided technical comments that enhanced the clarity and presentation of the final version. All authors read and approved the submitted manuscript.

Ethics Approval and Consent to Participate

This study was conducted in accordance with internationally accepted ethical standards for research involving human participants, including the principles of respect for persons, beneficence, and justice as outlined in the Declaration of Helsinki. Ethical approval for the study was obtained from the Mzuzu University Research Ethics Committee (MZUNIREC). Informed consent was obtained from all participants prior to their participation in the study. Participation was voluntary, and participants were assured of confidentiality and anonymity.

Clinical Trial Number

Clinical trial number: not applicable.

Human Ethics and Consent to Participate

Ethical approval for this study was obtained from the Mzuzu University Research Ethics Committee (MZUNIREC). Permission to conduct the study was granted by the relevant district authorities in Machinga and Mulanje districts, Malawi. All participants were informed about the purpose and procedures of the study and provided informed consent prior to participation. Participation was voluntary, and participants had the right to withdraw from the study at any time without penalty. Confidentiality and anonymity of all participants were maintained throughout the study

Consent to Publish

Consent to publish: not applicable.

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Data availability

Primary data supporting the findings of this study were collected in the Machinga district. Due to ethical requirements and confidentiality agreements, these data are not publicly accessible. However, anonymised excerpts may be made available on reasonable request to the corresponding author and subject to approval by the Mzuzu University Research Ethics Committee (MZUNIREC).

Disclaimer

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Figures

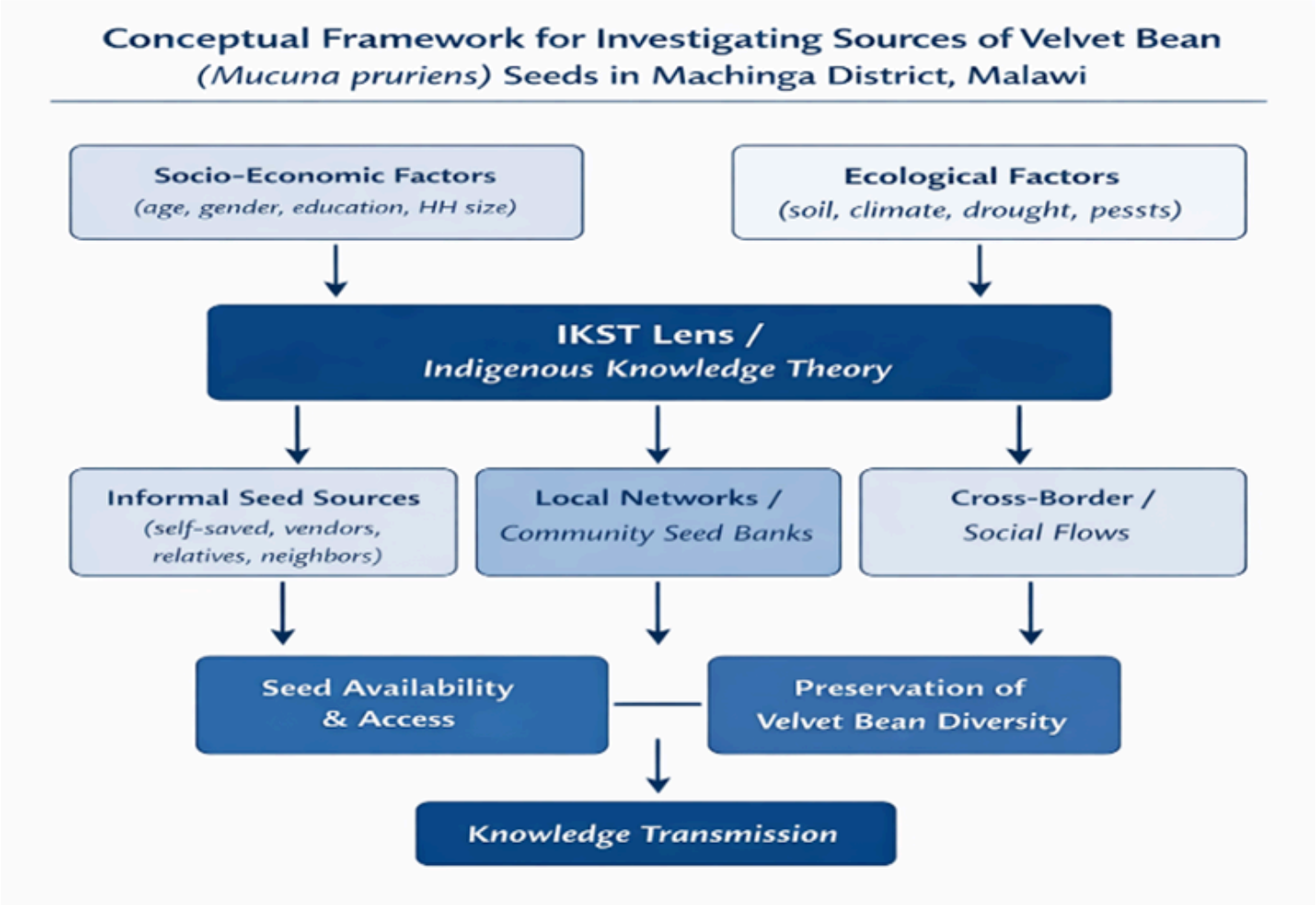

Figure 1

Conceptual Framework for Investigating Sources of Velvet Bean (Mucuna pruriens) Seeds in Machinga District, Malawi.

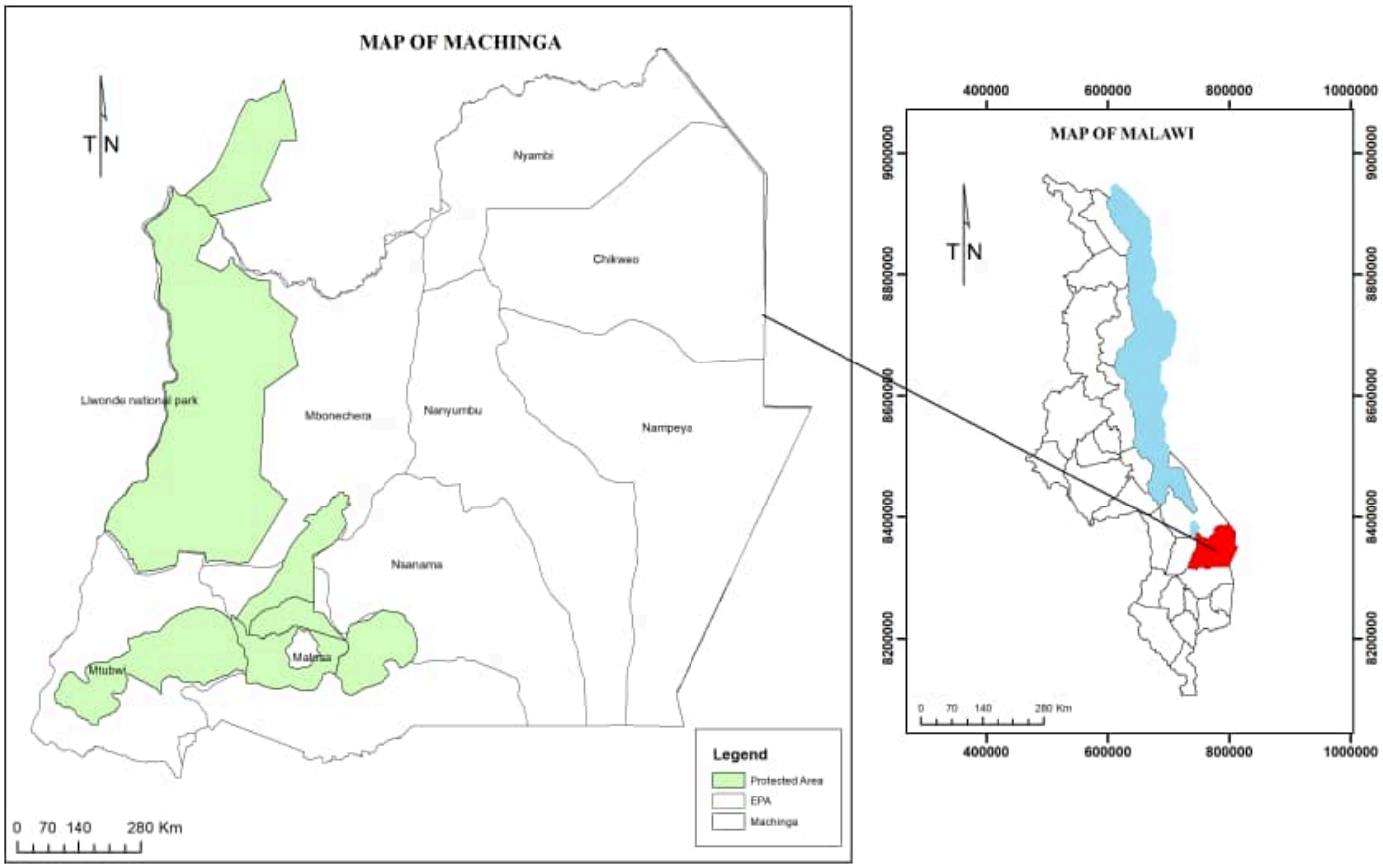

Figure 2

Map of the study area