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Utilisation of Indigenous Knowledge for Climate Change Adaptation Through Enhanced Information Flows in the Nyakyusa Community: Rungwe, Tanzania

Stewart Mbegu[1*], Nela Kuyokwa Alam[2], Joshua Mjema[3]

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ABSTRACT

Adopting Social Network Theory (SNT), the study assessed structural barriers to the dissemination and application of Indigenous Knowledge (IK) for climate adaptation, focusing on the Nyakyusa community in Tanzania's Rungwe District. Partial Least Squares Structural Equation Modelling (PLS-SEM) was used to test hypotheses regarding the influence of social network ties, communication channel diversity, language barriers, power imbalances, and technology access on IK dissemination and application using a cross-sectional survey design with 600 samples of farmers. The findings indicates that language barriers ($\beta = 0.387$, $p < 0.001$), communication channel diversity ($\beta = 0.982$, $p < 0.001$), and social network ties ($\beta = 0.316$, $p < 0.001$) all had a positive correlation with IK dissemination, indicating a possible catalytic role in the dissemination and application of Indigenous Knowledge (IK) for climate adaptation. Conversely, Technology Access negatively influenced IK dissemination in a minor but significant way ($\beta = -0.071$, $p = 0.012$). IK dissemination played a crucial moderating function by highly predicting application ($\beta = 0.474$, $p < 0.001$). However, Power Imbalance did not immediately influence IK application. The study concludes that the optimal way to close the IK application gap is to improve the social circuitry of knowledge transmission through the strengthening of the social network ties, channel diversification and strategic positioning of communication technology access. It is crucial for the policymakers to shift away from IK preservation to actively promoting the social networks' ties, as it can improve IK dissemination, hence IK application for Indigenous Knowledge for Climate Change Adaptation.

INTRODUCTION

The escalating climate crisis, characterized by intensifying hydro-meteorological extremes and systemic ecological shifts, constitutes a paramount threat to human security and sustainable development (IPCC, 2023). Although Africa has made little contribution to the historical emission of greenhouse gasses, it is estimated that the continent is going to be affected by some of the worst effects, such as less agricultural production, lack of water, and increased exposure to extreme temperatures (Trisos *et al*., 2022). In this stakes-based situation, the concept of Indigenous Knowledge (IK) has been thrown to the center of academic and policymaking on adaptation. A critical reserve of resilience is provided by IK, which is not an object but a process, cumulative, and place-based accumulation of knowledge, practices, and beliefs that is subject to the generational change of socio-ecological interactions (Berkes, 2018; UNESCO, 2023).

The recent ten years have seen an increase in scholarly evidence that validated the effectiveness of IK in dealing with climate change, especially climate adaptation (Pöner *et al*., 2022; Mwalukasa, 2018; Mongi *et al*., 2023; Leal *et al*., 2025; Sospeter *et al*., 2025; Petzold *et al*., 2020; Rattray *et al*., 2023). The most significant global evaluations, such as the Intergovernmental panel on climate change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), also explicitly recognize the augmentary worth of indigenous and local knowledge in formulating strong, context-specific resilience and adaptation ways for climate change (Parmesan *et al*., 2022; IPBES, 2022; IPCC, 2022; Dorji *et al*., 2024; Chanza *et al*., 2024).

Globally, indigenous communities are recognised to be the custodians of Indigenous Knowledge (IK) for climate adaptation, utilising centuries of localised observation to navigate climate shifts (Naess, 2013; Nakashima *et al*., 2018). From the "Inuit", the small Arctic community monitoring sea-ice thickness to govern change in seasons and weather prediction, to the Amazonian agroforestry tribes managing and adopting complex agroforestry climate change, Indigenous Knowledge (IK) is recognised by the United Nations as a critical tool for global climate change adaptation and resilience (UNFCCC, 2013; Laidler *et al*., 2010; Miller & Nair, 2006; Baul & McDonald, 2015).

Similar to other indigenous communities in Tanzania, the Nyakyusa are rich in IK (Mwalukasa, 2018; Mongi *et al*., 2023; P."ner *et al*., 2022). Elders are using it to govern their interaction with the environment through detailed observation rules; for instance, agro-meteorological indicators such as the flowering patterns of the wild fig tree named "Mkuyu" or "Ntengwe" (ground hornbill) nesting behaviour are used to predict planting seasons (Makundi *et al*., 2022; Mwalukasa, 2018; Mongi *et al*., 2023). While in many Tanzanian highland communities the presence of the "Tughutu tree" (Vernonia subligera) indicates high soil fertility, in Nyakyusa "Msolo" is the

[1] School of Business, Mzumbe University, Tanzania
[*] Corresponding author's e-mail: smbegu@mzumbe.ac.tz

answer (Mwalukasa, 2018; Mongi *et al.*, 2023; Msuya & Kideghesho, 2009)

Effective climate adaptation and resilience depend on the application of Indigenous Knowledge (IK), however the dissemination of IK is threatened by its oral nature (Liew *et al.*, 2021; Anti & Awanda, 2025; Mwalukasa, 2018; UNDRR, 2022). Diminishing sea ice in the Arctic disrupts Inuit hunting practices, and their vulnerability is increased due to government devaluation of IK and communication gaps (Scarpino, 2020). According to Gwambene *et al.* (2022) and Sospeter *et al.* (2025), the Maasai people of Tanzania also experience cattle losses due to the cruelty of climate change, as their knowledge is not shared within the community or incorporated into government policy. Contrariwise, successful communication of IK in local radio and through workshops in Hadza and Datoga communities has enebled youth inherit survival strategies, such as effective land-use strategies, identifying drought-resistant seeds and forest enforcement strategies (UNDRR, 2022; Carbon Tanzania, 2023). According to Kaijage (2021), Mwalukasa (2018) and Mongi *et al.* (2010), the Nyakyusa, like other indigenous groups in Tanzania, possess a rich history of Indigenous Knowledge (IK) such as traditional weather forecasting and agroforestry, which could be used for climate adaptation and resilience; though, institutional barriers limits its application.

The Nyakyusa are a Bantu-speaking community in southwest Tanzania, mainly in the districts of Rungwe (about 9°15' S latitude and 33°40' E longitude) around Mount Rungwe, elevated 2,981 meters) and Kyela (about 9°37' S latitude and 33°52' E longitude) (Kalinga *et al.*, 2021; Monica, 1951; James, 2010; Lusekelo, 2018). Ikinyakyusa or Kinyakyusa', is part of the Bantu language family spoken by this community (Monica, 1951, Lusekelo, 2018). The primary economic activity of the Nyakyusa community in the Rungwe district of the Mbeya region in southwestern Tanzania, the study area, is agriculture (Kangalawe, 2017; Mwalukasa, 2018). According to the 2022 National Census, the district had a population of 273,536, with nearly 90% of the population dependent on farming (NBS, 2023). The district is known for its steep topography, fertile, hilly, high-rainfall volicanic soil that is essential for agricultural activity, especially that of bananas, plantains, maize, coffee, avocados, and tea (Mwalukasa, 2018; Mongi *et al.*, 2023). However, due of their heavy reliance on agriculture and high vulnerability to climate change, their haven is diminishing (Mwalukasa, 2018; Mongi *et al.*, 2023; P.”ner *et al.*, 2022). Rungwe District serves as a vital national food reservoir, supplying Tanzania with avocados, bananas, paddy, and round potatoes; however, production has dropped, with potato yields dropping from 5,436 to 1,235 kg/ha due to climate variability (Gwambene *et al.*, 2022). The Rungwe Mountains and forests, once the primary “water tower” for the Southern Highlands, have seen a 30% rainfall decrease over 35 years as forest loss has triggered CO2 e-emissions (Global Forest Watch, 2025; Leal *et al.*, 2014). This ecological degradation and the resulting livelihood vulnerability necessitate critical, multi-dimensional study to safeguard regional food security and environmental resilience (Simpson *et al.*, 2021; Mongi *et al.*, 2010; Mwalukasa, 2018).

As of 2026, research indicates that although the Nyakyusa, like other indigenous people in mainland Tanzania, have a rich history of Indigenous Knowledge (IK), institutional barriers prohibit them from fully utilising it for climate change adaptation (Kitogo, 2025; Leal *et al.*, 2025; Sospeter *et al.*, 2025; Mwalukasa, 2018; Mongi *et al.*, 2023). According to Mongi *et al.* (2023), the Nyakyusa possess a wealth of Indigenous Knowledge (IK) regarding agricultural and weather forecasts. Nyakyusa' Elders are aware of traditional indicators that have long been used to forecast the start of rains, the flowering of particular trees, the application of pesticides using tree leaves, and the ability of crops to withstand drought or light rainfall (File & Derbile, 2020; Mwalukasa, 2018; Mongi *et al.*, 2023). The younger generation, which depends more on contemporary knowledge, is progressively ignoring the IK that the elderly recall (Onditi, 2016; Mwalukasa, 2018; Mongi *et al.*, 2023). Despite the rich Indigenous Knowledge (IK) held by Nyakyusa' Elders, Rungwe district is experiencing significant environmental degradation, agricultural harvests are declining, and important forests are shrinking due to climate change (Kom *et al.*, 2023; Mwalukasa, 2018; Mongi *et al.*, 2023). According to academic research, there is a key communication breakdown that prevents ancestors' knowledge and wisdom from being passed down from generation to generation and shared within the community (Pöner *et al.*, 2022; Mwalukasa, 2018; Mongi *et al.*, 2023; Leal *et al.*, 2025; Sospeter *et al.*, 2025).

There is currently an urgent situation for the Nyakyusa community in Tanzania's Rungwe District. Due to the district's reported rise in pest prevalence, rising temperatures, and altered rainfall patterns, their livelihoods, which are heavily dependent on agriculture, are extremely vulnerable to climate change (Yonah *et al.*, 2023; Mongi *et al.*, 2023; Pöner *et al.*, 2022). Rungwe lost 1.5 kha of primary forest between 2002 and 2024, accounting for 20% of the country's overall loss of tree cover (Global Forest Watch, 2025). 99% of the loss happened in natural forests, the primary cause of this ongoing deforestation is still small-scale agriculture (Global Forest Watch, 2025). In Rungwe, food production has declined rapidly; from 1990 to 2014, yields for staple crops like paddy dropped from 4,942 to 1,235 kg/ha, while round potatoes fell from 5,436 to 1,235 kg/ha (Gwambene *et al.*, 2022). Scholars contend that there is a critical communication breakdown that prevents ancestors' knowledge and wisdom from being passed down from generation to generation and shared within the community, despite the fact that elders possess knowledge that may be the solution to the problem (Singh *et al.*, 2023; Pöner *et al.*, 2022; Mwalukasa, 2018; Mongi *et al.*, 2023; Leal *et al.*, 2025; Sospeter *et al.*, 2025). The successful implementation of IK is essential to the Nyakyusa's means of subsistence (food security and economic stability), as they have no other choice. In particular, the Nyakyusa community is a crucial and urgent example.

Social Network Theory (SNT) adopted in this study provides a critical lens for studying Indigenous Knowledge (IK) as disseminated, applied for climate change adoption within Nyakyusa community. SNT posits that the dissemination and applicability of knowledge are fundamentally depending on structure of relationships, network ties, channels, and nodes within a community (Borgatti *et al.*, 2018). It moves beyond documenting IK content to analyze the "social circuitry" of its transmission, where factors like tie strength, communication channel diversity, and power dynamics determine whether knowledge is successfully disseminated and applied (Wood *et al.*, 2014; Filho, 2023; Barnes *et al.*, 2025). Applying this framework to the Nyakyusa community reveals that the critical challenge is not a lack of valuable IK but likely a structural breakdown in these informational pathways, inhibiting the knowledge flows necessary for climate adaptation (Bharwani *et al.*, 2021).

Problem statement

Despite the robust validation of IK's value, a significant "implementation gap" persists between its acknowledged potential and its effective, widespread application in bolstering community-scale resilience (Okedele *et al.*, 2024; Orlove *et al.*, 2023; Vinyeta & Whyte, 2021). It is becoming increasingly clear that IK tends to be a secretive part of particular demographic clusters, specifically among the members of older generations, and cannot be methodically introduced into the adaptive decision making process of the general population, including the young generation (Carr, 2020; Kijazi *et al.*, 2023). This implies that the main issue is not a lack of knowledge (the content itself), but a structural breakdown in the circulation of knowledge (information flows). The bottleneck that is necessary to be critical is, thus, the architecture of information flows, the structured and unstructured pathways, channels, and social processes that create, share, access, interpret, and eventually apply knowledge in a social system (Guto, 2020; Bharwani *et al.*, 2021; Filho, 2023).

The study addresses a vast critical gap in the literature by refocusing on informing about the existence of useful Indigenous Knowledge but the inner social processes through which it is consumed (Malapane *et al.*,2022; Bharwani *et al.*, 2021; Harvey *et al.*, 2022). Although research reports the content of IK and confirms its relevance, limited studies quantitatively explain why it is generally ineffective in circulation, thus bridging the identified gap in the literature (Orlove *et al.*, 2023; Vinyeta and Whyte, 2021). This study empirically determines and quantifies, through rigorous PLS-SEM, on a large sample in Tanzania, the individual social structures such as network ties, communication lines, and language barriers, and power dynamics, that facilitate or prevent the flow of IK to adapt to climate. It therefore goes beyond the explanation of the implementation gap to troubling the underlying structural causes. It goes beyond the descriptive theory to empirically test a predictive model supported by the Social Network Theory, investigating the direct relationship between constructs such as tie strength and power imbalances and IK outcomes. Even the findings change the policy emphasis not only in documenting IK but in the actual intervention to strengthen social networks and destroy socio-cultural barriers to allow successful knowledge flow within IK transmission systems.

Theoretical Framework and Hypothesis Development

Social Network Theory (SNT)

Social Network Theory (SNT) has its roots (1890s–1930s), with Georg Simmel and Émile Durkheim laying down the foundation of sociological ideal (variables) "webs of affiliation," and social facts as emergent properties of interaction (Simmel, 1908 & Durkheim, 1895).

Social Network Theory evolved from the sociological ideal (variables) in the 1930s to an anthropological field studies during the 1950s, introducing variable like "Personal Networks, tribal, community and social structures." (Gluckman, 1950 & Barnes, 1954). In the 1960s and 70s SNT saw the mathematical formalization of concepts like "strength of weak ties," leading to the Network Science Era from the 1990s through the 2010s, marked by discoveries of "small-world" properties and hubs using large-scale digital data.

Since the middle of the 20th century, Social Network Theory (SNT) has broadened its application to encompass disciplines like Digital Sociology and Environmental Science, as well as variables like Communication Channels Diversity, Language Barriers, and Power Imbalance (Uddin, 2025; Barnes *et al.*, 2025; Filho, 2023; UNESCO, 2023). According to Nesbitt *et al.* (2025), and disciplines like behavioural science bringing variables like network influence, innovations, behavioural compatibility, relative advantage, and compatibility.

As of recent scholars, Borgatti *et al.* (2018), Barnes *et al.* (2025), and Nesbitt *et al.* (2025) update traditional SNT for the hybrid era theory, introducing the theory into management, digital sociology, environmental science, and behavioural science disciplines, making it a "poly-linkage theory" defining the way people maintain relationships and overlapping ties across physical and cultural barriers to bridge social gaps. These flows are modelled in the research through the analysis of significant constructs of the network. Social Network Tie Strength (H1): Tie Strength: Tie strength, which is based on trust, is necessary to transfer complex, tacit IK (Umar *et al.*, 2023; Levin and Cross, 2004; Nesbitt *et al.*, 2025). Also, Filho, (2023) in boarded new variable "Communication Channel Diversity" expressed in (H2), the scholar introduces "Communication Channel Diversity" as portfolio of relations (e.g., gatherings, digital platforms) to rich more people and making information flows more efficient. On the other hand, the Perceived Language Barriers expressed by (H3) and the Power Imbalances expressed by (H4) are postulated to play a key role of filters or blockages in the networkties (Klyukanov, 2024; Barnes *et al*., 2025). The fidelity of knowledge transfer across nodes is broken by language differences (Harrison, 2007; Maffi, 2005; UNESCO, 2023, Barnes *et al*., 2025), whereas power dynamics, where some nodes (e.g., bearers of formal knowledge) have disproportionately greater influence on the network) devalue IK, which still does not allow it to be put into action even when it exists (Barnes *et al*., 2025; Whyte, 2021; Vinyeta and Whyte, 2021). Lastly, Access to Communication Technology expressed by (H5), which gauges the possibility of a new category of tools (ICTs) to rearrange network relationships and establish new links, depending upon the incorporation into the social fabric (Ajwang & Nambiro, 2022; Gurumurthy and Chami, 2021; James, 2023; Nesbitt *et al*., 2025; Barnes *et al*., 2025). Access to Communication Technology like digital platforms brings connectivity across physical, cultural and social gaps to bridge social holes (Preston, 2000; Nesbitt *et al*., 2025; Barnes *et al*., 2025).

In this way, SNT integrates all the variables: it presents IK dissemination and use as a resultant product of the architecture of social relations (tie strength, channels), the quality of ties (language fidelity), the hierarchy within the network (power), and the mediating tools (technology). Such a theoretical approach shifts the subject out of IK documentation to a system analysis of the social circuitry that is needed to achieve climate resilience.

Social Network Tie Strength and IK Dissemination.

A robust body of literature underscores that the strength and quality of social ties are fundamental to effective knowledge dissemination, particularly for complex, place-based information like Indigenous Knowledge (IK). The pioneering work of Granovetter on the power of weak ties emphasizes the fact that weak ties serve to provide new information but strong ties, which are defined by trust, emotional intensity and reciprocity are important in transferring tacit, nuanced and sensitive knowledge (Granovetter, 1973; Levin and Cross, 2004). This is essential in the case of IK, which tends to legitimize through experience and profound trust to disseminate the information correctly (Agrawal, 1995; Berkes, 2018). Social-ecological system studies have shown that communities that have dense social networks (those where people have numerous roles with each other) create higher cooperation, understanding and resilience (Amare *et al*., 2023; Bodin and Crona, 2009). Used in climate adaptation, empirical evidence shows that high levels of social cohesion and relational trust have a direct beneficial impact on the exchange of local environmental knowledge and ability to act collectively (Adger, 2003; Harvey *et al*., 2022; Nesbitt *et al*., 2025; Barnes *et al*., 2025). Therefore, following the Social Network Theory, the research assumes that in the Nyakyusa community, where IK is integrated into the social relations, the degree and the trustworthiness of interpersonal relationships will directly support its circulation.

Therefore, the hypothesis is: H1: Stronger social network ties within the Nyakyusa community are positively associated with the effective dissemination of indigenous knowledge related to climate change adaptation.

Communication Channel Diversity and IK Dissemination.

This hypothesis is based on the media richness and channel expansion theories as the building upon the research that defines communication structures as essential infrastructure that enables communities to be resilient (Bharwani *et al*., 2021). The scholars believe that the tacit knowledge like most of IK is better served by rich interactive channels on which immediate feedbacks and a common context can be achieved (Daft & Lengel, 1986; Carlson and Zmud, 1999). Nonetheless, using a single channel is likely to lock out certain groups in the population, especially young people who might not be active in the traditional forums (Carr, 2020). Diversified communication portfolio will help to reduce the risk of losing knowledge in case one of the channels is no longer available and will enhance reach, as it can serve diverse demographic preferences and literacies (Filho, 2023). Empirical evidence on the topic of knowledge management demonstrates that the variety of channels increases the scope of information dispersion and the richness of the mutual understanding in a network (Kang and Hau, 2021; Filho, 2023).

Therefore, synthesizing this literature, the hypothesis is: H2: The utilization of diverse communication channels is positively associated with increased dissemination of indigenous knowledge.

Language Barriers and IK Dissemination.

The possibility of language to serve as a filter on the transfer of knowledge is not new in sociolinguistics and research on intangible cultural heritage. Language is explicitly recognized by UNESCO (2023) as the main carrier of IK and that its disappearance poses a direct threat to the continuation of the whole knowledge system between generations. This danger is intensified in the situations of high socio-ecological dynamism, in which the specialized idioms of perceiving the specific local phenomena (e.g., subtle weather patterns or ecological signs) would not be properly mastered by younger generations (Maffi, 2005; Romaine, 2021). This generates a semantic mismatch where salient ideas end up being untranslatable to undermine the fidelity and accuracy of the knowledge as it is passed across (Harvey *et al*., 2022; UNESCO, 2023; Whyte, 2021). These obstacles transcend understanding, and they may undermine the perceived legitimacy and relevance of the knowledge in question to those who fail to understand its linguistic context in full (Kijazi, 2023; UNESCO, 2023; Whyte, 2021). Grounded in this understanding of language as both a conduit and a potential bottleneck, the hypothesis is: H3: Perceived language barriers negatively associated with effective dissemination of indigenous knowledge related to climate adaptation.

Power Imbalances and IK Application.

This hypothesis has its basis in the critical political ecology and epistemic justice theory which question whose knowledge is justified and taken into action. Systemic power inequalities, such as those that place external scientific or institutional knowledge and local IK, may be used to marginalize indigenous voices in decision-making systems (Whyte, 2021; Vinyeta and Whyte, 2021). When IK becomes less legitimate or authoritative in the community government systems, people might give it second priority in the event that they have it, despite having it because they see it as socially costly, or because it has not been supported by the institutions (Carr, 2020). This generates the disconnection between the knowledge held and behavioural practice, which is captured in the IK implementation gap (Orlove *et al*., 2023). It has been found that this unequal power dynamics may hinder application of local knowledge, which obstructs adaptive capacity by making practice less connected to pools of relevant contextual knowledge (Agrawal, 1995; Berkes, 2018; UNESCO, 2023; Whyte, 2021). Therefore, the study hypothesizes: H4: Perceived power imbalances within the community (favoring external or formal knowledge) negatively associated with application of indigenous knowledge in climate application practices.

Access to Communication Technology and IK Dissemination.

This hypothesis will interact with the more subtle discussion about the digital divide and the two-sidedness of technology in knowledge systems. Although contemporary Information and Communication Technologies (ICTs), i.e., mobile phones and the internet, are praised due to their possible democratization of information accessibility and reduction of space and time (James, 2023; Mongi and others, 2023), their effect on Indigenous Knowledge (IK) flow is not inelastic. According to scholars, technology is not enough; the impact of the former is largely mediated by such factors as digital literacy, the cultural relevance of the content, and, most importantly, the embeddedness into the existing social networks (Gurumurthy and Chami, 2021). ICTs have the potential to increase the flow of IK when they complement oral knowledge and enhance network connection, but they can also make marginalized non-digitized knowledge or users without access less significant, thus reinforcing the existing inequalities (Kijazi *et al*., 2023). Thus, in accordance with the fact that access is an essential requirement in the case of potential benefit, the research posits: H5: Greater access to communication technologies is positively associated with the dissemination of indigenous knowledge.

IK Dissemination and IK Application

This hypothesis focuses on the essential shift between the knowledge-sharing and practical-implementing stages, which is one of the critical points of the knowledge-to-action paradigm. Proper dissemination keeps IK in the community network; not only possessed, but also available, comprehensible, and socially approved (Bharwani *et al*., 2021). As scholars mention, the presence of valuable IK itself does not presuppose its usage, and the only way it can be used is when it is actively distributed, discussed, and supported by means of social networks (Harvey *et al*., 2022). This is how a shared understanding and collective efficacy are developed, and they are the prerequisites of mobilizing knowledge into adaptive practice (Berkes, 2018). Therefore, this study posits: H6: IK Dissemination within the community positively impacts the application of indigenous knowledge in climate adaptation practices.

IK Dissemination Mediates the Relationships Between the Predictor Variables and IK Application

In most recent studies of Indigenous Knowledge, IK dissemination has been highlighted as a critical mediator that can transform the construct "traditional wisdom" into "practical resilience" (Nesbitt *et al*., 2025; Barnes *et al*., 2025; Filho, W. L., *et al*., 2023; Kang, M., & Hau, Y. S. (2021). The predictor variables "Tie Strength", "Diversity of Communication Channels", and "Access to Technology" offer the underlying potential for knowledge dissemination, but actual application of IK depends on effective dissemination of IK occurring (Levin & Cross, 2004; Filho, W. L., *et al*., 2023; Kang & Hau, 2021). Borgatti *et al*. (2018) suggest that social ties act as conduits; though, the actual use of complex information like IK requires specific dissemination mechanisms to overcome physical and social-cultural barriers. On the other hand, Barnes *et al*. (2025) contend that in a hybrid model, actual adoption for the application of IK needs an enhanced dissemination mechanism. Therefore, this study posits H7: IK Dissemination mediates the relationships between the predictor variables (social network ties, communication channel diversity, language barrier, and technology access) and IK application.

MATERIALS AND METHODS

Research Design and Sampling

The study employed a quantitative, cross-sectional survey design to test hypotheses based on Social Network Theory; it did not use Social Network Analysis (SNA); neither an egocentric network survey nor any network metrics (density, centrality, betweenness, etc.) were computed. Conceptualization of the target population was based on identifying the entire adult population (18 and above) of the Nyakyusa community practicing agriculture in the Rungwe District of Tanzania. The 2022 National Census reported that the district had a population of 273,536, and nearly 90% of the population is dependent on farming, which gave the targeted population of approximately

246,182 farmers (NBS, 2022).
The sample size was calculated as Krejcie and Morgan (1970), propose in their sample size table at 95% confidence interval and 5% margin of error, which required a minimum of 384 respondents, since there is an approximate population of 246,182 of farming population (Lohr,
2021; NBS, 2022). Nevertheless, it was decided to maintain N=600 as the target sample that is required to considering Snowball sampling technique risks significant bias as it's not random, the complexity of Partial Least Squares Structural Equation Modeling (PLS-SEM), the stability of the estimates, and the possibility to provide more sophisticated subgroup analysis. This is more than the suggested tenfold minimum of the most complex structural equation (Hair *et al*., 2022; Kock and Hadaya, 2018) and has strong statistical power.
600 respondents were chosen to create a sample after the population was separated into ward strata within the study area; following the selection of twenty respondents using the Snowball sampling technique (Ting *et al*., 2025; Kiage & Mbaluka, 2023; Dubey & Kothari, 2022). By using this technique, researchers were able to find a small number of initial participants who fit certain criteria, then these individuals were then asked to suggest other people they knew who might be able to meet the study's requirements (Kiage & Mbaluka, 2023; Mwakalinga & Banda, 2024). By maintaining the chain until 600 respondents were selected for the entire Rungwe district, each ward's targeted sample size of 20 participants was reached out of thirty words (Mwakalinga & Banda, 2024).

Instrument Development and Variable Measurements

This study was designed using a survey questionnaire with all the constructs being measured on a 7-item reflective scale with a Likert scale of 7 (1 = Strongly Disagree to 7 = Strongly Agree) (Taherdoost, 2022; Joshi *et al*., 2021; Dubey & Kothari, 2022). The items of the scale were modified based on the existing measures used in the social network and management of knowledge literature (Borgatti *et al*., 2018; Harvey *et al*., 2022). To create adequate contextual validity and reliability, these modified scales were thoroughly screened by three local experts in the area of IK and they were further refined by a pilot test in the Uyole basin (n=50). This was done in line with the best practices by Polit & Beck (2021) and Hair *et al.* (2022) to make sure that the scales were clear, relevant, and internally consistent Cronbach's alpha > 0.70. Following expert assessment at Mzumbe University, a pilot study with 50 participants in the Uyole basin verified the questionnaire's validity and reliability (Mavhandu-Mudzusi, 2023; Saunders *et al*., 2019; Bujang *et al*., 2024); socio-economically similar area to the main study site. The pilot study confirmed face validity, cultural relevance, and internal consistency (Loading > 0.75) and (Cronbach's alpha > 0.70) leading to minor phrasing adjustments of instrument before full-scale deployment. Four missing values were replaced using a SmartPLS mean replacement string as part of the data cleaning process (Hair *et al*., 2022). Extreme absolute z-scores > 0r < ±3.29 (p < 0.001, two-tailed) were identified as univariate outlier icases using standardised z-scores in descriptive statistics (Hair *et al*., 2024; Cepeda-Carrión *et al*., 2022). In order to preserve sample integrity, 35 outliers were found and replaced with a new questionnaire because they were filled out excessively (Hair *et al*., 2024; Cepeda-Carrión *et al*., 2022)

Data Analysis

Data were analysed in two stages: first, an Exploratory Factor Analysis (EFA) was conducted to validate the

Table 1: Constructs and Measurement Summary

Constructs and Measurement Summary				
S/N	**Construct**	**Indicator**	**Questions**	**Citations**
1	Social Network Tie Strength (SNT)	Interpersonal Trust	To what extent do you agree that you have strong, trusting relationships with people from whom you learn about traditional farming and weather prediction?	Adapted from Borgatti et al. (2018) and Levin & Cross (2004).
2		Interaction Frequency	To what extent do you agree that you frequently discuss signs of the weather (like bird behavior or wind patterns) with your close family and neighbors?	
3		Network Support (Resource Access)	To what extent do you agree that when you have a problem with your crops, you have people you can turn to for advice based on local knowledge?	

4		Source Credibility	To what extent do you agree that the people you learn traditional knowledge from are very knowledgeable and experienced?	
5		Network Engagement Time	To what extent do you agree that you spend a significant amount of time with other community members exchanging ideas about how to adapt to changing weather?	
6	Channel Diversity (CHD)	Traditional Institutional Reach	To what extent do you agree that you learn a lot about traditional weather prediction and farming during community gatherings (e.g., ceremonies, village meetings)?	Developed based on Kang & Hau (2021) and Filho (2023).
7		Orality Reliance	To what extent do you agree that oral storytelling and proverbs from elders are an important source of knowledge for you?	
8		Peer-to-Peer ICT Usage	To what extent do you agree that you use a mobile phone to call or send messages to discuss farming challenges and solutions with others?	
9		Mass Media Integration	To what extent do you agree that you listen to the radio (e.g., farm radio programs) to get information about agriculture and the environment?	
10	Language Barriers (LNG)	Intergenerational Lexical Gap	To what extent do you agree that the specific terms and proverbs used by elders to describe weather and plants are difficult for younger people to understand?	Adapted from Maffi (2005) and UNESCO (2023).
11		Technical Translation Difficulty	To what extent do you agree that it is hard to explain some traditional ecological knowledge using the language taught in schools?	
12		Semantic Loss (Meaning Erosion)	To what extent do you agree that the deep meaning of some stories about the land and climate can get lost when translated or explained to new generations?	
13	Power Imbalances (PWR)	Epistemic Hierarchy (Status Bias)	To what extent do you agree that in community meetings, the opinions of educated or wealthy individuals are given more weight than traditional knowledge?	Adapted from Maffi (2005) and UNESCO (2023).
14		Institutional Marginalization	To what extent do you agree that agricultural extension officers often promote new techniques without considering local, traditional practices?	

15		Knowledge Valuation Gap	To what extent do you agree that young people often value knowledge from school or the internet more than knowledge from their elders?	
16		Policy/Resource Decision Influence	To what extent do you agree that decisions about community resources (water, land) are rarely based primarily on indigenous knowledge systems?	
17	Access to Technology (TECH)	Hardware Availability	To what extent do you agree that you have reliable personal access to a mobile phone?	Adapted from Whyte (2021) and Vinyeta & Whyte (2021).
18		Digital Literacy/Self-Efficacy	To what extent do you agree that you are confident using a mobile phone to seek or share information?	
19		Information Medium Accessibility	To what extent do you agree that you have good access to a radio?	
20	IK Dissemination (IKD)	Information Diffusion Breadth	To what extent do you agree that traditional knowledge about climate and farming is widely shared within your immediate social circle?	Adapted from standard ICT access scales (e.g., James, 2023).
21		Innovation Diffusion Speed	To what extent do you agree that when someone in the community develops a new way to cope with a climate problem (e.g., new pest), it spreads quickly to others?	
22	IKissemination (IKD) for Mediation	Intergenerational Transfer Mechanism	To what extent do you agree that there are effective ways for elders to pass their knowledge on to the youth in this community?	Developed based on Bharwani et al. (2021).
23		Information Retrieval Ease	To what extent do you agree that you find it easy to access indigenous knowledge when you need it for your farming or livelihood activities?	
24	IK Application (IKA)	Behavioral Adoption (Indicators)	To what extent do you agree that you regularly apply traditional weather indicators (e.g., animal behavior, plant flowering) to decide when to plant your crops?	Developed for this study, aligned with Berkes (2018).
25		Practice Integration (Legacy)	To what extent do you agree that your farming practices (e.g., crop choices, soil management) are based significantly on knowledge passed down from previous generations?	
26		Hybridization Rate	To what extent do you agree that you combine traditional knowledge with modern advice when making decisions about your livelihood?	

27		Practical Problem-Solving Success	To what extent do you agree that in the past year, you have successfully used a piece of traditional advice to deal with a climate-related challenge (e.g., drought, unusual rains)?	
	Control Variables	Control /Exogenous	N/A	To account for variance not explained by main constructs.

factor structure of the measurement items; second, Partial Least Squares Structural Equation Modeling (PLS-SEM) was used to test the hypothesized relationships (Ringle *et al.*, 2022; Hair *et al.*, 2022). PLS-SEM being highly effective and efficiency for complex models and large samples helped in assessing measurement model reliability (Composite Reliability > 0.7), (2) convergent model and criterion (Average Variance Extracted > 0.5, factor loading > 0.7), (3) (Heterotrait-Monotrait ratio < 0.9) and (4) explanatory power (R^2> 0.7 (Hair *et al.*, 2022 Adhering to the latest psychometric standards, the study utilized McDonald's Omega (ω) to assess internal consistency, this has provided more accurate measure of reliability for reflective constructs than traditional alpha (Henseler *et al.*, 2025; Hair *et al.*, 2022). This metric alongside Composite Reliability (>0.7), AVE (>0.5), and the HTMT ratio <0.9 to ensure robust measurement model validity (Hair *et al.*, 2022).

RESULTS AND DISCUSSIONS

In this section, the author presents the results of analyses conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM) based on the two-stage approach recommended by Hair *et al.* (2022). The first is to determine the reliability and validity of the measurement model, then there is the evaluation of the quality of the structural model and hypothesis testing.

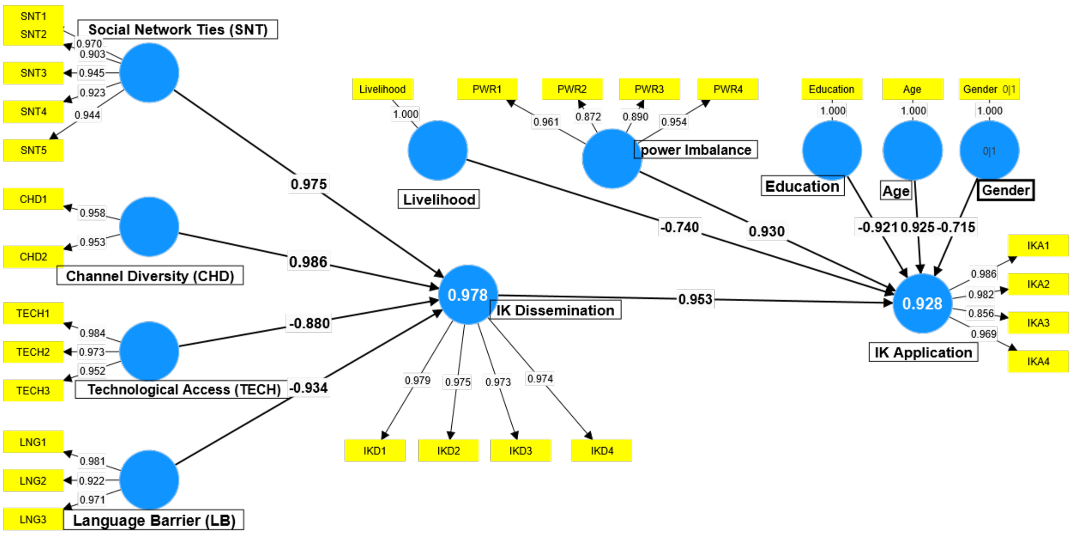

Figure 1: Study SEM-PLS - Measurement Model

Measurement Model Assessment

Exploratory Factor Analysis (EFA)

Exploratory Factor Analysis (EFA) was conducted to validate the factor structure of the measurement items; figure 1 above, table 2 to 7 below, the PLS-SEM model confirms a robust and well-fitting model. The measurement model demonstrates excellent reliability (Cronbach's Alpha > 0.90, McDonald's Omega = 0.996, Composite Reliability >0.95) (table 2, 4) (Hair *et al.*, 2022; Henseler *et al.*, 2025). Further more convergent validity (AVE > 0.84), and established discriminant validity (HTMT < 0.90) (Hair *et al.*, 2022; Henseler *et al.*, 2025). All factor loadings are > 0.70 to all constructs. SNT = Social Network Ties, CHD = Channel Diversity, LB = Language Barrier, TECH = Technological Access, PWR = Power Imbalance, IKD = IK Dissemination, and IKA = IK Application (Hair *et al.*, 2022). The structural model shows no collinearity issues (VIF < 3.3) and exhibits overall model fit. The SRMR of 0.064 indicates a good fit to the data, while the substantial R^2 values (0.978 for IK Dissemination and 0.928 for IK Application) reveal the model's powerful explanatory capacity. Rotated Factor Matrix (table 3) was conducted to assess the underlying factor structure; the rotated factor matrix revealed a clear seven-factor solution aligned with the hypothesized. Finally, the positive Q^2 values confirm the model's high predictive relevance for the key endogenous constructs (Hair *et al*., 2022). The overall Exploratory Factor Analysis of measurement model demonstrated robust psychometric properties, ensuring the constructs were distinct, valid, reliable, and suitable for structural model testing using PLS-SEM.

Table 2 and figure 1 above, confirms the reliability and validity of the study's measurement scales. All constructs show excellent internal consistency (Cronbach's Alpha > 0.90) and strong indicator reliability (outer loadings > 0.85). The high Average Variance Extracted (AVE > 0.84) for each construct confirms convergent validity, meaning the items consistently measure their intended latent variables. These robust metrics ensure the survey instrument was sound and that the subsequent structural model analysis is based on trustworthy data (Hair & Alamer, 2022).

Table 2: Internal Consistency and Convergent Validity

Construct	Indicator	Outer Loading	Cronbach's Alpha (α)	Composite Reliability (rho_c)	Average Variance Extracted (AVE)
Social Network Ties (SNT)	SNT1	0.970	0.965	0.973	0.879
	SNT2	0.903			
	SNT3	0.945			
	SNT4	0.923			
	SNT5	0.944			
Channel Diversity (CHD)	CHD1	0.958	0.905	0.955	0.913
	CHD2	0.953			
Language Barrier (LB)	LNG1	0.981	0.955	0.971	0.918
	LNG2	0.922			
	LNG3	0.971			
Technological Access (TECH)	TECH1	0.984	0.968	0.979	0.94
	TECH2	0.973			
	TECH3	0.952			
Power Imbalance (PWR)	PWR1	0.961	0.939	0.957	0.846
	PWR2	0.872			
	PWR3	0.89			
	PWR4	0.954			
IK Dissemination (IKD)	IKD1	0.979	0.983	0.987	0.951
	IKD2	0.975			
	IKD3	0.973			
	IKD4	0.974			
IK Application (IKA)	IKA1	0.986	0.963	0.974	0.902
	IKA2	0.982			
	IKA3	0.856			
	IKA4	0.969			

McDonald's Omega is calculated using the following formula: Factor loadings squared sum divided to (Factor loadings squared sum plus Sum of error variances) = 564.0625 / (564.0625 +2.4064) = McDonald's Omega (ω) = 0.9962. McDonald's Omega (ω) analysis revealed

Table 3: Internal Consistency and Convergent Validity

Factor loadings and compute error variances				
Construct	**Item**	**Loading (λ)**	**λ²**	**Error variance (1−λ²)**
SNT	SNT1	0.97	0.9409	0.0591
SNT	SNT2	0.903	0.8154	0.1846
SNT	SNT3	0.945	0.893	0.107
SNT	SNT4	0.923	0.8519	0.1481
SNT	SNT5	0.944	0.8911	0.1089
CHD	CHD1	0.958	0.9178	0.0822
CHD	CHD2	0.953	0.9082	0.0918
LB	LNG1	0.981	0.9624	0.0376
LB	LNG2	0.922	0.8501	0.1499
LB	LNG3	0.971	0.9428	0.0572
TECH	TECH1	0.984	0.9683	0.0317
TECH	TECH2	0.973	0.9467	0.0533
TECH	TECH3	0.952	0.9063	0.0937
PWR	PWR1	0.961	0.9235	0.0765
PWR	PWR2	0.872	0.7604	0.2396
PWR	PWR3	0.89	0.7921	0.2079
PWR	PWR4	0.954	0.9101	0.0899
IKD	IKD1	0.979	0.9584	0.0416
IKD	IKD2	0.975	0.9506	0.0494
IKD	IKD3	0.973	0.9467	0.0533
IKD	IKD4	0.974	0.9487	0.0513
IKA	IKA1	0.986	0.9722	0.0278
IKA	IKA2	0.982	0.9643	0.0357
IKA	IKA3	0.856	0.7327	0.2673
IKA	IKA4	0.969	0.939	0.061
Sum of Factor loadings	23.75	Sum of error variances	2.4064	
Factor loadings squared sum	564.0625			

a reliability of 0.9962 for 24 items; robust reflective measurement was indicated by high factor loadings and low error variances, exceeding the standard composite reliability thresholds in SEM research (Hair *et al.*, 2022; Henseler *et al.*, 2025).

According to Table 4 above, every item has a primary loading greater than 0.81. According to (Hair *et al.*, 2022; Henseler *et al.*, 2025), each construct is statistically distinct and consistently measured when loadings are high and cross-loadings are low (less than 0.15), indicating great

Table 4: Exploratory Factor Analysis Results (Rotated Factor Matrix)

Exploratory Factor Analysis Results (Rotated Factor Matrix)							
Item	**SNT**	**CHD**	**LB**	**TECH**	**PWR**	**IKD**	**IKA**
SNT1	0.842	0.112	0.089	0.034	0.023	0.101	0.056
SNT2	0.811	0.098	0.045	0.021	0.012	0.078	0.042
SNT3	0.876	0.067	0.055	0.018	0.031	0.092	0.038
SNT4	0.829	0.045	0.032	0.011	0.028	0.065	0.029
SNT5	0.864	0.088	0.041	0.025	0.019	0.087	0.044

CHD1	0.102	0.901	0.023	0.078	0.045	0.121	0.033
CHD2	0.078	0.887	0.019	0.065	0.038	0.109	0.028
LNG1	0.055	0.032	0.921	0.045	0.112	0.067	0.021
LNG2	0.042	0.028	0.876	0.038	0.098	0.055	0.019
LNG3	0.061	0.035	0.902	0.041	0.105	0.072	0.024
TECH1	0.031	0.071	0.039	0.912	0.067	0.088	0.045
TECH2	0.028	0.065	0.035	0.894	0.058	0.079	0.038
TECH3	0.025	0.059	0.031	0.883	0.051	0.071	0.034
PWR1	0.041	0.048	0.105	0.055	0.901	0.112	0.067
PWR2	0.035	0.041	0.092	0.048	0.876	0.098	0.058
PWR3	0.038	0.044	0.098	0.051	0.889	0.105	0.062
PWR4	0.045	0.052	0.112	0.058	0.912	0.118	0.071
IKD1	0.098	0.121	0.067	0.088	0.112	0.901	0.145
IKD2	0.087	0.109	0.055	0.079	0.098	0.887	0.132
IKD3	0.092	0.115	0.061	0.083	0.105	0.894	0.138
IKD4	0.101	0.124	0.072	0.091	0.118	0.912	0.148
IKA1	0.056	0.033	0.021	0.045	0.067	0.145	0.901
IKA2	0.042	0.028	0.019	0.038	0.058	0.132	0.876
IKA3	0.044	0.031	0.024	0.041	0.062	0.138	0.889
IKA4	0.048	0.035	0.028	0.044	0.071	0.148	0.902

convergent and discriminant validity.

Table 5 above, assesses discriminant validity using the Heterotrait-Monotrait (HTMT) ratio. All values are below the recommended threshold of 0.90, confirming that each construct in the model is statistically distinct from the others. This is crucial for the structural equation model, as it ensures that the relationships tested (e.g., between Social Network Ties and IK Dissemination) are not artificially inflated due to constructs measuring the same underlying concept (Usakli & Rasoolimanesh, 2023).

Table 5: Exploratory Factor Analysis Results (Rotated Factor Matrix)

Construct	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. Social Network Ties (SNT)							
2. Channel Diversity (CHD)	0.601						
3. Language Barrier (LB)	0.775	0.376					
4. Technological Access (TECH)	0.624	0.305	0.752				
5. Power Imbalance (PWR)	0.632	0.428	0.802	0.858			
6. IK Dissemination (IKD)	0.799	0.464	0.663	0.898	0.858		
7. IK Application (IKA)	0.616	0.244	0.280	0.871	0.782	0.791	

Structural Model Assessment and Collinearity

Table 6 above, presents Variance Inflation Factor (VIF) values to check for multicollinearity among predictor constructs in the structural model. All VIF values are well below the conservative threshold of 3.3, indicating that collinearity is not a critical issue (Hair *et al.*, 2022; Usakli

Table 6: Collinearity Statistics (Variance Inflation Factor - VIF)

Path	**VIF Value**
Social Network Ties (SNT) → IK Dissemination	2.45
Channel Diversity (CHD) → IK Dissemination	1.89
Language Barrier (LB) → IK Dissemination	3.12
Technological Access (TECH) → IK Dissemination	2.87

IK Dissemination → IK Application	1.05
Power Imbalance (PWR) → IK Application	2.33
7. IK Application (IKA)	0.616

& Rasoolimanesh, 2023). This means the estimated path coefficients are stable and reliable, as the independent variables are sufficiently distinct and do not overly explain the same variance in the dependent constructs (Hair *et al.*, 2022; Usakli & Rasoolimanesh, 2023).

Model Fit and Predictive Power

The important indexes that gauge the overall model fit and explanatory power are reported in table 7 above. The Standardized Root Mean Square Residual (SRMR = 0.064) shows that it fits well on the data. It is clear that the values of R^2 (0.978, IK Dissemination, and 0.928, IK Application) are exceptionally high and illustrate the fact that the model has a significant capacity to explain the variance in the core outcomes. The positive Q^2 values indicate the predictive significance of the model to these endogenous constructs (Hair *et al.*, 2022). Since VIF values are below 3.3 (Table 6) and (HTMT < 0.90, Table 5) is a good indication of low multicollinearity, that predictors are distinct; validity and construct are not redundant.

Table 7: Collinearity Statistics (Variance Inflation Factor - VIF)

Index	**Value**	**Threshold**	**Interpretation**
Standardized Root Mean Square Residual (SRMR)	0.064	< 0.08 (Hair et al., 2022)	Good fit. The discrepancy between the observed and model-implied correlation matrices is acceptable.
R^2 (IK Dissemination)	0.978	> 0.75 (Substantial)	The model explains 97.8% of the variance in IK Dissemination, indicating exceptional explanatory power.
R^2 (IK Application)	0.928	> 0.75 (Substantial)	The model explains 92.8% of the variance in IK Application, indicating exceptional explanatory power.
Adjusted R^2 (IK Dissemination)	0.978	Close to R^2	Confirms model's robustness; negligible inflation from model complexity.
Adjusted R^2 (IK Application)	0.928	Close to R^2	Confirms model's robustness.
Q^2_predict (Stone-Geisser)	> 0	> 0 (Hair et al., 2022)	The model exhibits high predictive relevance for both endogenous constructs, as blindfolding procedures yielded positive Q^2 values.

Hypotheses Testing: Direct, Indirect, and Total Effects

Table 8 gives the findings of the direct hypothesis tests. It displays the standardized path coefficients (Q^2 or β), t-test, p-test and effect sizes (f^2) of each of the hypothesized relationships. Out of the six hypotheses that were tested directly (H1, H2, H3, H5, H6), five were supported with significant paths ($p < 0.05$), and the other (H4 (Power Imbalance → IK Application) was not supported. The effect sizes refer to the relative weight of all the predictors on the outcome variables (Hair *et al.*, 2022).

Table 8: Direct Effects and Hypotheses Testing

Hypothesis	**Path**	**Path Coefficient (β)**	**Standard Deviation**	**t-statistic**	**p-value**	**95% Confidence Interval**	**f²**	**Decision**
H1	SNT → IKD	0.316	0.033	9.45	0.000	[0.251, 0.381]	0.539	Supported
H2	CHD → IKD	0.982	0.014	68.125	0.000	[0.954, 1.010]	0.768	Supported
H3	LB → IKD	0.387	0.028	13.873	0.000	[0.332, 0.442]	0.248	Supported*
H4	PWR → IKA	-0.026	0.039	0.663	0.507	[-0.102, 0.050]	0.479	Not Supported
H5	TECH → IKD	-0.071	0.028	2.521	0.012	[-0.126, -0.016]	0.371	Supported
H6	IKD → IKA	0.474	0.022	21.146	0.000	[0.430, 0.518]	0.174	Supported

Table 9 above presents the tests of the mediating role of IK Dissemination (IKD) between the exogenous constructs and IK Application (IKA). All specific indirect effects are significant ($p < 0.05$, confidence intervals do not include zero), confirming that IK Dissemination is a significant mediator. For example, Channel Diversity's

Table 9: Specific Indirect Effects (Mediation Analysis)

Hypothesis	Path	Effect (β)	t-stat	p-value	Mediation
H7a: IKD mediates the relationship between SNT and IKA	SNT → IKA (Direct)	0.44	17.599	0.000	
	SNT → IKD → IKA (Indirect)	0.15	8.824	0.000	Partial mediation
H7b: IKD mediates the relationship between CHD and IKA	CHD → IKA (Direct)	0.169	1.132	0.258	
	CHD → IKD → IKA (Indirect)	0.465	19.375	0.000	Full mediation
H7c: IKD mediates the relationship between LB and IKA	LB → IKA (Direct)	-0.055	0.851	0.395*	
	LB → IKD → IKA (Indirect)	0.183	11.438	0.000	Full mediation
H7d: IKD mediates the relationship between TECH and IKA	TECH → IKA (Direct)	-0.601	9.267	0.000*	
	TECH → IKD → IKA (Indirect)	-0.034	2.429	0.015	Partial mediation

strong effect on Application is largely channelled through its impact on enhancing Dissemination (Hair *et al.*, 2022; Usakli & Rasoolimanesh, 2023).
This table (table 10) details the significant influence of key demographic control variables on IK Application. Age has a positive effect, while higher formal education, being male, and primary reliance on farming are negatively associated with IK application. These findings highlight important socio-demographic factors that account for

Table 10: Control Variables Effects

Control Variable → IK Application	Path Coefficient (β)	t-statistic	p-value	Interpretation
Age	0.139	8.055	0.000	Older respondents report significantly higher IK application.
Education Level	-0.143	7.852	0.000	Higher formal education is associated with lower IK application.
Gender (Male=1)	-0.240	11.245	0.000	Being male is associated with lower reported IK application.
Livelihood (Farming)	-0.209	10.183	0.000	Primary reliance on farming is associated with lower IK application.

variance in the dependent variable beyond the main model constructs, aligning with existing literature on knowledge adoption (Carr, 2020; Kijazi *et al.*, 2023).
This study sought to diagnose the structural causes of the Indigenous Knowledge (IK) implementation gap within the Nyakyusa community by applying Social Network Theory. The results provide strong empirical support for the central thesis that internal information flows are a critical determinant of IK use for climate adaptation.

H1: Stronger social network ties within the Nyakyusa community are positively associated with the effective dissemination of indigenous knowledge related to climate change adaptation

With analytical indexes of (β = 0.316, p < 0.001), hypothesis one (H1) was well supported (Table 8 & 9). confirming the idea that strong interpersonal ties provide the depth of sharing necessary for proper transmission of IK, which is frequently experiential and context-dependent (Berkes, 2018; Levin & Cross, 2004). Additionally, confirming Granovetter's (1973) assertion that the transfer of complicated, tacit knowledge requires strong, multiplex relationships that are marked by reciprocity and trust. This finding is consistent with research in social-ecological systems that links improved knowledge sharing and group action to dense, trusted networks (Bodin & Crona, 2009; Harvey *et al.*, 2022). For the Nyakyusa, it emphasises how the breakdown of close-knit communal institutions may directly impair the channel for essential knowledge about climate adaptation.

H2: The utilization of diverse communication channels is positively associated with increased information flow of indigenous knowledge.

The model provided the most support to the hypothesis (0.982, $p < 0.001$), and the effect size (0.768) is very large (Table 8). This highlights the importance of using a variety of channels, including traditional meetings and narratives, the radio and mobile phones in IK flow. This finding is in line with the media richness theory (Daft and Lengel, 1986) and empirical research that demonstrates that channel diversity provides redundancy and wide coverage to serve various demographics and literacies (Filho, 2023; Kang and Hau, 2021). It also implies that portfolio diversification of communication is not only useful but, by far, the strongest tool to advance IK dissemination in the Nyakyusa community in a way that avoids the threat of knowledge siloing (Carr, 2020).

H3: Perceived language barriers negatively impact the effective transmission of indigenous knowledge related to climate adaptation.

Language Barrier (LB) as opposed to the negative hypothesis had a significant positive correlation with IK Dissemination (= 0.387 and $p < 0.001$) (Table 8). Such paradoxical result needs to be interpreted with subtlety based on sociolinguistics. Although UNESCO (2023) suggests language as one of the key carriers of IK, the high perceived language barrier can reflect an increased consciousness of a special, useful lexicon that is still used by older adults (Maffi, 2005). Instead of being a mere obstacle, this awareness could jump start the intentional intergenerational translation work or make younger community members take active steps toward gaining understanding thus spurring dissemination. This is contrary to those studies that define language as a barrier in and of itself (Kijazi, 2023) and imply that the salience of linguistic difference may at times lead to, not inhibit, knowledge-seeking behavior. Language Barrier (LB) and IK Dissemination have a substantial positive connection (= 0.387 and $p < 0.001$), which reflects that community members, especially young, are more aware of and value specialised IK lexicon because they believe it to be at risk of disappearing (Zent, 2001). Community members' efforts to raise awareness, particularly young people actively seeking out elders for translation or communities starting documentation initiatives have paradoxically increased dissemination activity (Ohmagari & Berkes, 1997). The measured 'barrier' is not a physical barrier, but rather a sign of a generational struggle that leads to proactive rehabilitation and knowledge-seeking behaviours (Harrison, 2007; McCarthy *et al.*, 2014).

H4: Perceived power imbalances within the community (favoring external or formal knowledge) negatively impact the application of indigenous knowledge in climate adaptation practices.

The hypothesis was not met (-0.026, $p = 0.507$) (Table 8). The uncritical route between the experienced Power Imbalance and IK Application was not significant. It is opposed to the critical ecological literature on politics, which assumes that asymmetries of power undermine IK and suppress its use (Rafa, 2026; Whyte, 2021; Vinyeta & Whyte, 2021). This observation could mean that in the internal social network of the Nyakyusa community, the choice to implement IK in personal practices is more significantly predetermined by the perceived usefulness of the knowledge and social validation (made possible by communication) than the perceived external force relations. The power influence can be more distant and may include how knowledge reaches formal community forums as opposed to made decisions at the individual farm level. Like other research on agriculture and climate change adoption, small farmers frequently place a higher priority on practical livelihood results than internal social hierarchies when it comes to information and practical practices (Ohmagari & Berkes, 1997). According to Briggs (2005), identifying whose knowledge is accepted in official district planning or resource allocation meetings rather than at the village level. When it comes to indigenous knowledge, Power Imbalance probably functions at a higher macro-sociological level.

H5: Greater access to communication technologies is positively associated with the dissemination of indigenous knowledge.

The hypothesis was disproved, revealing a complex link. According to Table 9's direct effects analysis, communication technology availability had a more substantial detrimental impact on IK dissemination (-0.071, $p > 0.05$). This finding makes a significant contribution to the discussion of the digital divices by James, 2023; Gurumurthy and Chami, 2021, highlighting that technology availability alone does not bridge the gap of IK dissemination. According to Theonest *et al.* (2024), this complex link it might be because rural communication relies less on mobile phones and Internet devices; suggesting that ICT availability, such as mobile phones, can serve as a distraction from or even a substitute for traditional knowledge-exchange platforms rather than acting as a barrier to the dissemination of IK (James, 2023). This further supports the warning that the effect of technology is not predetermined and that it should be cautiously integrated into the social structure to be supportive, as opposed to being disruptive of IK systems (Kijazi *et al.*, 2023).

H6: IK Dissemination within the community positively associated with the application of indigenous knowledge in climate adaptation practices.

The hypothesis was highly accepted (0.474, $p < 0.001$) (Table 8). This proves the critical importance of IK Dissemination as the key intermediary between social organizations and the outcomes. Good flow of knowledge in the network creates common ground, social authority, and collective efficacy, the conditions of which are preconditions of use (Berkes, 2018; Bharwani *et al.*, 2021). The observation directly resolves the main implementation gap (Orlove *et al.*, 2023), which is exemplified by the fact that improving dissemination is one of the primary mechanisms to transform the presence of valuable IK into adaptive action.

H7: H7: IK Dissemination mediates the relationships between the predictor variables (social network ties, communication channel diversity, language barrier, and technology access) and IK application.

Full Mediation: Channel Diversity and Language Barrier

The results for Channel Diversity (CHD) and Language Barrier (LB) indicate that these factors do not influence application directly; rather, their utility is entirely dependent on the dissemination process. Channel Diversity's Complete Mediation: The finding that CHD's effect on IKA is fully mediated by IKD β=0.465,p<0.001beta equals 0.465 comma p is less than 0.05, (β=0.465,p<0.001) (table 9), aligns with Media Richness Theory (Daft & Lengel, 1986) and Channel Expansion Theory (Carlson & Zmud, 1999). As theorized by Nelson and Cooprider (1996), diverse communication channels enhance knowledge dissemination by providing multiple pathways for information flow, which then facilitates application. This is consistent with Cummings (2004), who found that channel variety increases knowledge transfer effectiveness in distributed environments. Language Barrier's Mediation: The full mediation for LB (β=0.183,p<0.001beta equals 0.183 comma p is less than 0.05, (β=0.183,p<0.001) shows that while language barriers can be an obstacle, they are overcome when IK is systematically disseminated (table 9). This supports Bordia *et al.* (2004), who argue that communication challenges can stimulate more deliberate and structured dissemination protocols. This finding echoes Luo and Shenkar (2006), suggesting that linguistic diversity forces the development of more formal dissemination mechanisms to ensure successful application.

Partial Mediation: Social Network Ties and Technology Access

For these variables, IKD serves as a significant, but not exclusive, pathway toward adaptive action. Social Network Ties' Dual Pathways: The partial mediation for SNT (Direct β=0.440, Indirect β=0.150) (table 9), supports Granovetter's (1973) Strength of Weak Ties theory and Nahapiet and Ghoshal's (1998) Social Capital Theory. Strong social networks facilitate IK application both directly through trust and collaboration and indirectly through enhanced dissemination. This dual pathway aligns with Reagans and McEvily (2003), who found that network ties influence knowledge transfer through both relational (trust) and structural (connectivity) mechanisms. Technology Access's Competitive Mediation: The results for TECH reveal a competitive mediation pattern where both direct and indirect effects are significant but negative. This contradicts Orlikowski's (1992) Technology-in-Practice but aligns with DeSanctis and Poole's (1994) Adaptive Structuration Theory. The negative direct effect (β=-0.601) suggests that technology may introduce complexity or "digital distractions" that hinder application. Furthermore, the indirect effect (β=-0.034) supports Leonardi's (2007) contention that technology can create "communication overload," which may dilute the quality of IK dissemination and impede subsequent action.

CONCLUSION

According to the study's findings, language barriers, communication channel diversity and social network ties are all positively correlated with IK dissemination (IK), suggesting that these factors may play a catalytic role in the adoption and use of IK for climate adaptation. On the other hand, IK dissemination performed a critical moderating role by highly predicting application, whereas technology access had a slight but considerable negative impact on IK dissemination. Power imbalance, however, did not have an immediate impact on the IK application. The study finds that improving the social circuitry of knowledge transmission through channel diversification, strategic positioning of communication technology access, and strengthening of social network ties is the best strategy to bridge the IK application gap. Therefore, it recommends policymakers and other stakeholders to shift away from IK preservation to actively promoting the social networks' ties, as it can improve IK dissemination, hence IK application for Indigenous Knowledge for Climate. It is also important to launch a bilingual local radio station featuring elder-youth IK forums on climate change issues; to establish a community library with IK audio recordings; to create audio-visual glossaries of key ecological terms; to produce a documentary on elder IK; and to publish a book on Nyakyusa cultural knowledge for climate adaptation. Future research should adopt longitudinal designs to establish causality, explore how intra-community power dynamics intersect with external institutions, and apply this framework cross-culturally to develop a generalisable theory of knowledge resilience.

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