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Mapping A Contextualized Southern Africa's Innovation Ecosystem: The Emerging Role of Higher Education in Promoting Inclusive Innovation and Rural Industrialization

Vhonani O Netshandama[1,*], Simbarashe Kativhu[2], Tumelo Sekgobela[3]

Abstract

Higher education institutions (HEIs) are increasingly recognized as strategic actors in shaping innovation ecosystems that can respond to persistent socio-economic inequalities in the Global South. In Southern Africa, where rural underdevelopment, youth unemployment, weak industrial bases, and uneven innovation capacities remain pressing concerns, universities are under growing pressure to move beyond their traditional teaching and research mandates and contribute more directly to inclusive development. This paper examines the emerging role of HEIs in promoting inclusive innovation and rural industrialization within a contextualized Southern African innovation ecosystem. Drawing on a qualitative mapping exercise conducted by the University of Venda's Directorate for Community Engagement, Entrepreneurship, Inclusive Innovation and Commercialization, the study integrates institutional cases, policy documents, and regional literature with global theoretical perspectives, including Mode 2/3 knowledge production, the quadruple and quintuple helix models, and the scholarship of engagement. The findings show that HEIs have significant potential to function as brokers, convenors, and place-based anchors that facilitate co-creation, entrepreneurship, inclusive commercialization, and rural value-chain development. Evidence from selected Southern African institutions illustrates emerging practices such as innovation hubs, community engagement platforms, agribusiness support and socially oriented incubation. However, these contributions remain constrained by fragmented policy environments, resource limitations, urban-biased commercialization pathways, weak regional knowledge flows and academic incentive systems that continue to privilege conventional scholarly outputs over social impact. The paper argues that a more context-sensitive and development-oriented innovation ecosystem is required, one that embeds engagement, indigenous knowledge, and inclusive commercialization within the core mission of universities. It concludes that HEIs can play a transformative role in advancing equitable innovation and rural industrialization in Southern Africa, provided that institutional reforms and supportive policy frameworks are aligned to local realities and developmental priorities.

***Author for Correspondence**
Simbarashe Kativhu
E-mail: Simbarashe.kativhu@univen.ac.za

[1]Professor, Department of Community Engagement, Entrepreneurship, Inclusive Innovation and Commercialization, University of Venda, Thohoyandou, South Africa
[2]PhD Scholar, Department of Rural Development, University of Venda, Thohoyandou, South Africa
[3]Lecturer, Department of Social Work, University of Venda, Thohoyandou, South Africa

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INTRODUCTION

Innovation has become an important driver of socio-economic development worldwide, but its benefits are still unevenly distributed in the Global South. In Southern Africa, persistent rural underdevelopment and high youth unemployment are some of the challenges that are constraining

inclusive growth (African Development Bank (AfDB, 2022) [1]. It is against this background that higher education institutions (HEIs) have been recognized as key actors in shaping innovation ecosystems that foster entrepreneurship, technology transfer, and rural industrialization (Kruss & Visser, 2017 [17] Mouton *et al*., 2021) [23]. Beyond their traditional roles in teaching and research, universities are now expected to act as brokers, convenors, and place-based anchors of inclusive development (Hall & Tandon, 2017) [13].

This extended role reflects a broader paradigm shift in knowledge production where universities are moving away from discipline bound and elite-oriented models towards more transdisciplinary and impact-oriented approaches. These transformations are important in Southern Africa, where HEIs operate in contexts marked by fragile economies, high dependence on natural resources and urgent developmental challenges. Chikozho (2020) [6] argue that establishing community engagement directorates and technology transfer offices are now viewed as pathways to align university missions with national and regional development agendas.

Kruss & Visser (2017) [16] suggest that the developmental role of HEIs must be understood within the broader context of the knowledge-development nexus, where the capacity to translate research into societal value determines innovation outcomes (Manzini, 2012;) [20]. In Southern Africa, this nexus is mainly mediated by national innovation policies and the extent of civic participation in innovation processes (Cloete et al., 2018) [7]. Consequently, strengthening the university and society interface is a strategic imperative for inclusive growth and regional resilience.

However, despite isolated successes, significant barriers remain. Many HEIs have incentive systems that privilege academic publications over societal impact and weak institutional capacities for brokerage and partnership management (Kruss *et al*., 2015 [17] Mouton *et al*., 2021) [23]. Moreover, commercialization efforts are often urban-biased to privilege high-tech ventures that fail to reach marginalized rural communities (Chataway *et al*., 2014) [5]. These tensions raise important questions about how universities can reconfigure themselves to better promote inclusive innovation, entrepreneurship, and rural industrialization in sustainable and context-sensitive ways.

The current study responds to a growing scholarly consensus that innovation systems in the Global South require localization and decolonization to be effective (Chikozho, 2020 [6] Hart, Daniels & September-Brown, 2023) [14]. This entails reconfiguring universities as developmental anchors that shape and diffuse innovations aligned with local priorities. The paper thus contributes to emerging Southern epistemologies of innovation by foregrounding inclusivity, participation, and social responsiveness in university-led innovation.

This paper addresses these questions through a synthesis of theoretical frameworks and empirical studies as well as a mapping exercise undertaken. It draws on the literatures of Mode 2/Mode three knowledge production, quadruple, and quintuple helix innovation systems, and the scholarship of engagement to argue that HEIs must adopt institutional reforms that enable them to act as co-creators, brokers, and developmental anchors. This paper aims to evaluate and examine how HEIs in Southern Africa impact or contribute to inclusive innovation, entrepreneurship, commercialization, and rural industrialization. It further critically assesses the contribution of HEIs in ensuring inclusivity and transformation. By consolidating insights from Southern African case studies, the paper outlines pathways through which universities can drive inclusive economic transformation.

METHODOLOGICAL APPROACH

This study draws on a mapping exercise to assess how HEIs in Southern Africa engage with inclusive innovation, entrepreneurship, commercialization, and rural industrialization, while situating these practices within global innovation system frameworks.

Mapping Design

To ensure methodological rigor, the mapping process followed a systematic qualitative synthesis procedure. Triangulation was applied by cross referencing institutional documentation with peer reviewed empirical studies and regional policy frameworks. Credibility was enhanced through iterative coding to ensure inter-coder reliability and consistency in the identification of themes across cases. This triangulated approach provides robustness and mitigates institutional reporting bias often found in self-evaluative studies.

The mapping combined three methodological strands. The first one is the documentary and Policy Analysis, where national innovation strategies, higher education policies, and SADC regional frameworks were reviewed to identify formal expectations of HEIs in the innovation ecosystem. The paper also gave attention to the South Africa's White Paper on Science, Technology, and Innovation (2019), Botswana's Research, Science, Technology, and Innovation Policy, and Namibia's innovation frameworks. Institutional Case Mapping was also conducted, where data were collected from institutional reports, strategic plans, and grey literature from HEIs across Southern Africa. For instance, the University of Fort Hare, the Namibia University of Science and Technology, and the University of Botswana. Special focus was placed on units explicitly dedicated to innovation and community engagement, such as technology transfer offices, entrepreneurship incubators, and rural outreach programs.

Comparative Literature Synthesis

Empirical studies on HEIs' roles in innovation systems in Southern Africa (Kruss *et al*., 2015 [17] Cloete *et al*., 2018 [7] Mouton *et al*., 2021) [23] were systematically reviewed and compared with global conceptual frameworks (Mode 2/3, helix models, engagement scholarship).

Analytical Lens

The conceptual framework synthesizing Mode 2/3 knowledge production, quadruple/quintuple helix models, and the scholarship of engagement was operationalized as the primary analytical lens. Each case and policy document was coded against the four thematic dimensions: inclusive innovation, brokerage/anchoring, commercialization, and rural industrialization. This allowed for systematic identification of patterns and best practices.

Scope and Limitations

While the reliance on institutional reports introduces a potential bias towards formalized initiatives, this was balanced through the inclusion of grey literature, independent policy reviews, and expert consultations. Future research could incorporate field-level interviews and participatory validation with university and community actors to deepen empirical grounding and strengthen causal inference on HEIs' developmental impact.

Conceptual Framework

The conceptual framework guiding this review integrated three interrelated strands of scholarship. These included the Mode 2/Mode three knowledge production, quadruple/quintuple helix innovation systems, and the scholarship of engagement, to provide an analytical lens for understanding the evolving role of higher education institutions (HEIs) in Southern Africa's innovation ecosystems.

Firstly, Mode 2/3 knowledge production (Gibbons *et al*., 1994 [12] Carayannis & Campbell, 2009) [3] represents a departure from traditional discipline-bound research (Mode 1) toward transdisciplinary, socially distributed, and problem-oriented forms of knowledge. These frameworks shows the need for HEIs to co-produce knowledge in real-world contexts to engage directly with communities, governments, and industries to generate solutions for developmental challenges like rural industrialization (Kruss & Visser, 2017 [17]. Secondly, the quadruple and quintuple helix models expand the classical triple helix of university–industry–government relations (Etzkowitz & Leydesdorff, 2000) [9] by incorporating civil society, media, culture, and the environment as key

dimensions of innovation (Carayannis & Campbell, 2010) [4]. Within the Southern African context, where ecological vulnerabilities intersect with deep socio-economic inequalities, these models highlight universities as brokers that facilitate collaboration across multiple actors and as *anchors* stabilizing local innovation ecosystems (Kruss *et al*., 2015 [17] Mutula, 2019) [25].

Thirdly, the scholarship of engagement (Boyer, 1996 [2] Hall & Tandon, 2017) [13] provides a normative framework for embedding engagement into the academic mission of universities. It foregrounds the co-creation of knowledge with societal partners and proposes institutional reforms in promotion and reward structures to recognize engagement as a critical scholarly practice (Cloete, Maassen & Bailey, 2018 [7] Mouton, Louw & Kruss, 2021) [23]. This is salient in Southern Africa, where HEIs must align research and curricula with pressing developmental needs.

These frameworks converge on the notion of the engaged university. An institution that generates context-sensitive knowledge (Mode 2/3), mediates multi-actor collaboration (quadruple/quintuple helix), and institutionalizes societal engagement as a scholarly core (scholarship of engagement). In the context of this review, the framework provides guidance for mapping HEIs' contributions to inclusive innovation, entrepreneurship, commercialization, and rural industrialization. It also identifies challenges, such as resource scarcity, fragmented governance, and misaligned incentive structures. By situating the analysis within these theoretical traditions, the current review paper contributes to ongoing global discourses on knowledge democratization, innovation for inclusive development, and sustainable commercialization (Chataway, Hanlin & Kaplinsky, 2014 [5] Scoones, Edelman & Hall, 2019) [27], while grounding the discussion in the lived realities of Southern African higher education systems. A diagrammatic presentation of the conceptual framework is presented in Figure 1.

The integration of these frameworks enables a multi-scalar interpretation of university–society relations: Mode 2/3 underscores the epistemological transformation of knowledge production; the helix models emphasize systemic and institutional linkages; and the scholarship of engagement provides a normative framework for academic reform. (Figure 1) This integrated lens offers a heuristic for analyzing how HEIs can operationalize inclusive innovation across governance, research, and teaching functions. Such an approach aligns with contemporary global discourses on mission-oriented universities and the emerging African scholarship advocating for innovation justice (Kruger & Steyn, 2024) [15].

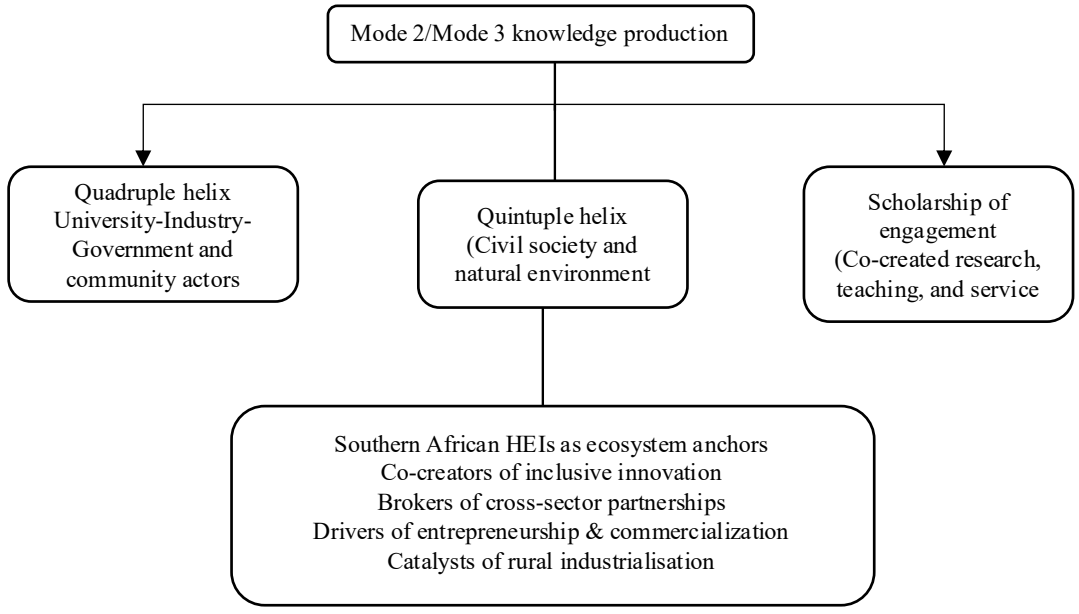

Figure 1. Conceptual framework.

LITERATURE REVIEW

The literature on innovation and higher education has expanded considerably over the past two decades. There is growing attention to how universities in the Global South can function as agents of inclusive development. In the Southern African context, scholarship emphasizes that higher education institutions (HEIs) must change their traditional roles to catalyze societal transformation (Kruss & Visser, 2017 [17] Mouton *et al*., 2021) [23]. This review synthesizes empirical studies and policy analyses across four interlinked domains. These included inclusive innovation, brokerage, commercialization, and rural industrialization.

Systemic Gaps

Knowledge Systems Misalignment

A persistent structural gap in Southern Africa's innovation landscape lies in the epistemological disjuncture between Indigenous Knowledge Systems and formal scientific innovation systems. Despite growing recognition of the value of indigenous epistemologies in promoting context sensitive and sustainable innovation, policy, and institutional frameworks mainly privilege Western technoscientific paradigms (Hart, Daniels & September-Brown, 2023) [14]. This exclusionary orientation undermines local capacities for problem solving and disregards the community-based practices that have long sustained livelihoods in agriculture, health, and natural resource management. As a result, innovation policies tend to reproduce dependency on imported technologies and external expertise than nurturing endogenous innovation ecosystems rooted in local knowledge. Integrating IKS into formal innovation frameworks requires epistemic pluralism acknowledging multiple ways of knowing and embedding co-production mechanisms between universities, traditional authorities, and communities (Cloete, Maassen & Bailey, 2018 [7] Hall & Tandon, 2017) [13]. Such integration would enable locally grounded, socially legitimate innovation systems that reflect Africa’s ecological and cultural specificities.

Limited Regional Knowledge Flows

Regional collaboration in science, technology, and innovation across the Southern African Development Community (SADC) is mainly aspirational rather than operational. Despite regional frameworks like the SADC Protocol on Science, Technology, and Innovation (2022) promoting transnational cooperation, practical implementation has been derailed by divergent intellectual property regimes and uneven research capacities among other challenges (Fessehaie & Rustomjee, 2018) [11]. Cross-border research initiatives are mostly driven by donor agendas and short-term projects rather than sustained institutional partnerships. This results in poor knowledge mobility and limited collective learning across national innovation systems. Moreover, linguistic, and policy differences between member states further derail the diffusion of innovation and the scaling of best practices. Kruss & Visser (2017) [16] laments that the absence of harmonized research governance frameworks undermines the potential of regional universities to act as collective knowledge nodes and brokers of inclusive innovation. Strengthening regional research networks and harmonizing intellectual property protocols could foster a more integrated innovation space in Southern Africa.

Human Capital Development Lag

A critical constraint to innovation-led growth in Southern Africa is the mismatch between higher education outputs and the skills demanded by evolving knowledge economies. Despite an expansion in university enrollments, graduate competencies in Science, Technology, Engineering, and Mathematics (STEM) and in entrepreneurship and digital literacy is limited (Mouton, Louw & Kruss, 2021) [23]. Most HEIs are oriented towards theoretical training than practice based and problem solving education.As a result, they end up producing graduates who are inadequately equipped for innovation-intensive sectors (Cloete et al., 2018) [7]. Furthermore, gendered, and socio-economic disparities in access to STEM education affect the inclusivity and diversity of the innovation workforce (Kruger & Steyn, 2024) [15]. This creates a human capital deficit that reduces universities' ability to serve as incubators of innovation and weakens regional competitiveness in high value sectors. Addressing this challenge requires curricular reforms that embed experiential learning, entrepreneurship education, and industry partnerships to cultivate the human infrastructure necessary for inclusive, innovation-driven development.

Weak Commercialization Pipelines

Although most countries in Southern Africa have established technology transfer offices, incubators, and innovation hubs, these structures operate in isolation and lack systemic integration across the region. Their outputs are predominantly concentrated in research intensive universities, leaving rural and teaching-oriented institutions marginalized (Mouton et al., 2021) [23]. The absence of robust linkages between research producers, industry actors, and community enterprises limits the flow of innovations from laboratory to market. Moreover, the prevailing commercialization models tend to replicate Global North approaches. They mostly focus on patent generation and spin offs that rarely align with local developmental needs (Cloete et al., 2018) [7]. Poor regional coordination further reduce the potential for scale up. On the other hand, insufficient venture capital and inadequate protection of community based intellectual property hinder inclusive entrepreneurship. Strengthening the commercialization ecosystem thus requires regionally networked incubators, community-integrated innovation value chains, and adaptive intellectual property frameworks that balance profit motives with social impact imperatives (Carayannis & Campbell, 2010 [4] Matlhape, 2020) [21].

Inclusive Innovation

The OECD (2018) [26] broadly define innovation as the transformation of ideas into products, processes that create social or economic value. However, the concept is contested in the Global South. Kruss & Visser (2017) [16] content that in Southern Africa, the prevailing innovation discourse reflect Western technology-centric models that prioritize competitiveness and economic growth but neglecting equity and contextual responsiveness. As Mouton, Louw & Kruss, (2021) [23] hinted, the Southern African System of Innovation (SASI) shows fragmented institutional linkages and limited community engagement with local knowledge systems. This structure reproduces urban and elite biases that marginalize grassroots and indigenous forms of knowledge that could drive inclusive development (Hart, Daniels & September-Brown, 2023) [14]. Consequently, a critical redefinition of innovation is required. The new definition needs to embraces social inclusion, contextual relevance, and epistemic plurality as central dimensions of the innovation process

It is against this background that the concept of inclusive innovation is a theoretical corrective and a practical imperative. It challenges the dominance of market-driven and technologically exclusive models by foregrounding participation, equity, and social relevance in the innovation process (Chataway, Hanlin & Kaplinsky, 2014) [5]. Within the Southern African context, inclusive innovation represents a paradigm shift toward locally grounded, need-responsive, and democratized systems of knowledge creation that deliberately integrate marginalized actors rural communities, women, youth, and informal enterprises into the design and diffusion of innovations.

Inclusive innovation refers to processes that intentionally expand access to the benefits of science, technology, and entrepreneurship to historically marginalized populations, particularly those excluded from formal innovation systems (Chataway, Hanlin & Kaplinsky, 2014) [5]. In the Southern African context, it represents a shift from elite and capital intensive innovation models towards more socially embedded and participatory approaches. Empirical evidence from South Africa demonstrates that university-led initiatives in renewable energy, agriculture, and public health can extend tangible benefits to underserved rural communities by combining technical expertise with indigenous knowledge systems (Kruss et al., 2015 [17] Fakir & Patel, 2018 [10] Mabogo & Phiri, 2020) [19]. Participatory agricultural extension programs linking universities and smallholder farmers in Limpopo Province have shown how co-created innovations enhance productivity but at the same time respecting local epistemologies. Nonetheless, as Chikozho (2020) [6] argues, national innovation policies within the Southern African Development Community (SADC) still prioritize high-tech and urban-focused sectors and neglect grassroots and frugal innovations that hold the greatest potential for rural transformation. Consequently, advancing inclusive innovation requires both policy realignment and institutional reforms that enable higher education institutions (HEIs) to act as developmental intermediaries brokering knowledge across academic, governmental, and community domains to co-produce contextually relevant and socially equitable innovations.

Nonetheless, as Chikozho (2020) [6] argued, challenges remain as many innovation policies in the Southern African Development Community (SADC) remain elite-focused and prioritizing high-tech sectors while neglecting grassroots and frugal innovations that are often most relevant for rural livelihoods. This suggests the need to reframe innovation agendas and position HEIs as champions of contextualized, low-cost, and socially responsive innovations that align with regional development priorities.

HEIs as Brokers and Anchors

The notion of universities as brokers and anchors derives from the recognition that HEIs convene diverse stakeholders, such as students, researchers, government, civil society, and industry into collaborative networks. In Southern Africa, this role is particularly salient in contexts where weak institutional linkages and fragmented policy frameworks hinder innovation ecosystems (Cloete *et al*., 2018) [7]. Evidence indicates that universities often act as conveners of localized innovation platforms, bringing together small and medium enterprises (SMEs) with local government and NGOs to address development challenges (Kruss & Visser, 2017) [17]. For example, the University of Fort Hare has facilitated rural agribusiness hubs that connect research outputs with cooperative farmers and municipal actors (Mnguni, 2019) [22]. At the same time, Namibia's University of Science and Technology piloted innovation sandboxes that brought civil society actors into co-design processes (Mutula, 2019) [25].

However, resource constraints and academic reward systems that privilege traditional publications over engagement undermine the university brokerage roles (Mouton *et al*., 2021) [23]. This reflects broader systemic issues in African higher education, where institutional brokerage is rarely embedded as a core function and partnerships normally rely on short-term donor funding (Kruss *et al*., 2015) [17].

Commercialization

The commercialization of knowledge and research products has always been a source of income generation for universities globally, but its lack of contextualization, and relevance for inclusive innovation development in Southern Africa is contested. Although technology transfer offices and incubators have proliferated across the region, evidence suggests that most commercialization efforts are largely urban-centered and elite-driven (Chataway *et al*., 2014 [5] Kruss & Visser, 2017) [17]. For example, evidence in South Africa shows that patents and spin-offs are mainly in biomedical and high-technology sectors with limited spillovers into rural economies (Mouton *et al*., 2021) [23]. (Fakir & Patel, 2018) [10] lament that participation is normally skewed toward graduates with existing resources in cases where business incubators exist. However, emerging models of inclusive commercialization show alternative pathways.

Rural Industrialization

Rural industrialization has regained recognition in African development debates. This is mainly in response to rising youth unemployment and the persistence of resource-dependent economies (AfDB, 2022) [1]. The concept involves strengthening local agro-processing and value-chain linkages in rural areas to reduce dependence on urban centers (Scoones *et al*., 2019) [27]. Higher Education Institutions mobilize research and partnerships to promote rural entrepreneurship and thus become a crucial partner. In Zimbabwe, university-led agribusiness training initiatives have shown potential to create sustainable rural employment opportunities (Mutangadura, 2019) [24]. According to Mnguni (2019), South African collaborations between universities and rural cooperatives have enabled the establishment of processing plants for marula and moringa to add value locally and support women entrepreneurs (Mnguni, 2019) [22].

However, as Kruss *et al*. (2015) [17] argued, rural industrialization initiatives in the Global South are normally derailed by inadequate infrastructure, weak financial ecosystems, and policy fragmentation. Moreover, many HEIs lack the institutional flexibility and mandate to embed rural industrialization into core strategies. Addressing these gaps requires institutional reforms and supportive regional policies that incentivize universities to anchor rural innovation ecosystems.

Literature showed opportunities and limitations in the role of HEIs in Southern Africa's innovation ecosystems. On a positive note, universities are now acknowledged as brokers and anchors. However, their institutional and systemic barriers limit their potential. These barriers include limited recognition of community engagement work, low staff and students participation and inadequate funding. Inclusive innovation remains unevenly prioritized, commercialization often serves urban elites, and rural industrialization is hindered by infrastructural and policy gaps. Emerging cases of engaged universities demonstrate that when properly resourced and incentivized, HEIs can play an important role in inclusive economic transformation even in the Global South.

Gender and Youth Dimensions

Literature highlights limited attention to gender and youth complexities and dimensions within higher education institutions' initiatives. The engagement with gender and youth dimensions is essential. Given the statistics and demographics in universities in Southern Africa, exploration of how to battle the barriers and integrate women and youth into innovation ecosystems should be considered (Kruger & Steyn, 2024) [15]. This should be considered by future researchers to ensure that there is intentional inclusion of women and youth, considering the demographics.

RESULTS AND DISCUSSION

The mapping exercise and literature synthesis provide a comprehensive picture of how HEIs in Southern Africa engage with innovation ecosystems, entrepreneurship, commercialization, and rural industrialization. The results are presented across four interrelated dimensions, which include inclusive innovation, HEIs as brokers and anchors, commercialization, and rural industrialization.

HEIs as Brokers and Anchors

The mapping process confirmed that HEIs act as conveners and brokers that connect various actors into innovation networks. This aligns with the expectations of the quadruple and quintuple helix frameworks, which position universities as intermediaries who promote collaboration across societal partners (Carayannis & Campbell, 2010 [4] Kruss *et al*., 2015) [17]. Empirical evidence showed that HEIs in South Africa and Namibia convene innovation platforms and agricultural cooperatives as well as renewable energy partnerships. For example, the University of Fort Hare has facilitated rural agribusiness clusters that integrate research outputs with cooperative farmers and municipal actors (Mnguni, 2019) [22]. Namibia's University of Science and Technology has piloted innovation sandboxes that bring civil society into co-design processes for locally relevant technologies (Mutula, 2019) [25].

Despite these successes, resource limitations, institutional reward systems that prioritize publications over engagement, and weak professionalization of brokerage functions still hinder universities progresss. As a result, engagement, and partnership activities are often project-specific and poorly integrated into core institutional strategies (Hall & Tandon, 2017 [13] Mouton *et al*., 2021) [23]. These results show that HEIs' potential as ecosystem anchors is under-realized, requiring structural reforms, strategic investment, and policy alignment.

Inclusive Innovation

The mapping showed that Universities have implemented participatory approaches, such as living labs, co-creation workshops, and community-based innovation hubs that integrate indigenous knowledge with technical research (Kruss *et al*., 2015 [17] Fakir & Patel, 2018) [10]. Collaborative agricultural research projects in Limpopo Province have enabled smallholder farmers to access improved seed varieties and post-harvest processing technologies, illustrating the practical application of Mode 2/3 knowledge production principles (Mabogo & Phiri, 2020) [19].

However, inclusive innovation remains fragmented and limited in scale. National innovation policies often favor high-tech and urban-oriented sectors, and institutional capacity to support grassroots innovation systematically is weak (Chikozho, 2020) [6]. These gaps highlighted the need for HEIs to integrate inclusive innovation into their core business for the benefit of rural communities.

Commercialization

Evidence form Southern Africa showed that HEIs are at the forefront of commercializing research outputs through patents and incubators in recent years. However, the mapping indicated that commercialization efforts are uneven and often urban-biased, primarily serving high-technology and biomedical sectors (Mouton *et al*., 2021) [23]. For example, the University of Cape Town has successfully established biomedical spin-offs targeting global markets, yet such initiatives have limited developmental impact in rural areas (Cloete *et al*., 2018) [7].

Rural Industrialization

The mapping also revealed that HEIs can play a catalytic role in rural industrialization through providing skills training and facilitating value-chain development, such as in the agro-processing clusters in South Africa and Zimbabwe, which generate local employment and add value to agricultural produce (Mnguni, 2019 [22] Mutangadura, 2019) [24]. Entrepreneurship education and incubation programs offered by universities like North-West University and the University of Limpopo support rural enterprise creation to bridge knowledge and practice.

Despite these positive interventions, barriers like rural infrastructure deficits, weak policy alignment between HEIs and national development strategies as well as limited financial support for rural enterprises reduce the scalability and sustainability of these initiatives (Kruss et al., 2015) [17]. Addressing these challenges is critical if universities are to act as key anchors of rural industrialization.

Table 1. Global frameworks vs. southern African experiences.

Dimension	Global frameworks	Southern African experiences	Key gaps/challenges
Knowledge Production (Mode 2/3)	Knowledge is co-produced, transdisciplinary, and application-oriented (Gibbons et al., 1994; Carayannis & Campbell, 2009).	Select HEIs (e.g. Fort Hare) co-develop research with farmers, SMEs, and local government.	Adoption limited to pilot initiatives; academic rewards still prioritise Mode 1 outputs (Mouton et al., 2021).
Brokerage/Anchoring (Helix Models)	Universities are brokers linking government, industry, civil society, and environment (Etzkowitz & Leydesdorff, 2000; Carayannis & Campbell, 2010).	South African and Namibian HEIs convene innovation platforms, agribusiness hubs, and sandboxes (Kruss & Visser, 2017; Mutula, 2019).	Resource scarcity, fragmented governance, and weak institutionalisation of brokerage functions.
Commercialisation	HEIs drive patents, spin-offs, incubators, and technology transfer, typically linked to urban innovation hubs.	Patents and spin-offs are concentrated in high-tech sectors in South Africa; Botswana incubates social enterprises (Mouton et al., 2021; Matlhape, 2020).	Predominantly urban/elite focus; rural SMEs, women, and youth are rarely integrated into value chains.
Inclusive Innovation	Expands benefits of science/technology to marginalised groups through grassroots, frugal, and social innovations (Chataway et al., 2014).	HEIs demonstrate inclusive practices in energy, agriculture, and health (Kruss et al., 2015; Fakir & Patel, 2018).	National policies favour high-tech sectors; grassroots and frugal innovations lack systemic support.
Rural Industrialisation	Embedded in global place-based regional development strategies.	Zimbabwe and South Africa: HEIs support agro-processing, cooperatives, and rural entrepreneurship (Mnguni, 2019; Mutangadura, 2019).	Infrastructural deficits, limited financing, and misaligned policies hinder scalability and sustainability.
Engagement Scholarship	Engagement integrated into teaching, research, and service; new metrics recognise social impact (Boyer, 1996; Hall & Tandon, 2017).	Institutional reforms include engagement directorates and entrepreneurship hubs (Cloete et al., 2018).	Engagement remains undervalued and underfunded; weak integration into promotion/reward systems.

Comparative Analysis of Global Frameworks and Southern African Experiences

Table 1 shows Southern African experiences in relation to the global frameworks, such as the tripple/quadrupple helix. Results showed that, Southern African higher education institutions (HEIs) are progressively aligning with global innovation frameworks, such as Mode 2 knowledge production, helix brokerage, inclusive innovation, and the scholarship of engagement. Nevertheless, this alignment is spartial as most instituions are still lagging behind. Universities, such as Venda and Fort Hare showed promise of co-developed research with farmers, SMEs, and municipalities which is consistent with global expectations of transdisciplinary and context-sensitive knowledge production (Carayannis & Campbell, 2009) [3]. Worryingly, institutional reward mechanisms continue to prioritize research outputs which demotivates staff from community engaged work (Mouton et al., 2021) [23]. On the other hand, most South African and Namibian HEIs convene innovation platforms and agribusiness hubs that mirror the helix models of brokerage but these remain resource-constrained, fragmented, and poorly institutionalized especialy in rural based univeristies (Kruss & Visser, 2017 [17] Mutula, 2019) [25]. This reflects broader structural challenges in higher education systems where engagement remains peripheral to core academic mandates.

Regarding commercialization and inclusive innovation, regional practices show progress and persistent exclusion. Globally, commercialization is associated with patents, spin-offs, and incubators, and these mechanisms are visible in Southern Africa but remain concentrated in high-tech, urban-based sectors. While Botswana's social enterprise incubation provides an alternative pathway, rural SMEs, women, and youth remain marginalized (Matlhape, 2020 [21] Mouton et al., 2021) [23]. Evidence from South Africa further demonstrates that most small firms innovate through "Doing, Using, and Interacting" modes rather than formal science-driven processes, highlighting the need to support rural communities and innovations that are mainly invisible in policy frameworks (Lukhele & Ogundiran-Soumonni, 2021) [18]. Inclusive innovation in agriculture, renewable energy, and health are areas that has potential to foster rual industrialization and innovation the potential has not yet been fulfilled (Chikozho, 2020) [6]. This reproduces structural inequalities within the regional innovation system, with universities caught between global paradigms and local development needs.

Rural industrialization and engagement scholarship further show partial convergence. Higher education institutions in Zimbabwe and South Africa have catalyzed agro-processing clusters and cooperative development, aligning with global place-based development strategies (Mnguni, 2019 [22] Mutangadura, 2019) [24]. However, limited funding and misaligned policies are major barriers to upsacling of initiatives (Fessehaie & Rustomjee, 2018) [11]. Literature also confirmed that engagement scholarship, globally reframed as a rigorous academic domain with new metrics (Boyer, 1996 [2] Hall & Tandon, 2017) [13], is emerging in Southern Africa through institutional reforms, such as community engagement directorates and entrepreneurship hubs (Cloete *et al*., 2018) [7]. However, engagement remains undervalued and poorly embedded in promotion and tenure systems, despite growing examples, such as Unisa's formalized engaged scholarship projects. Generally, the synthesis shows that while HEIs in Southern Africa are experimenting with global innovation frameworks, their ability to act as developmental anchors depends on systemic reforms revising academic incentive structures, embedding inclusive commercialization pathways and aligning policy with the realities of rural and marginalized communities.

Comparative results on global frameworks and the Southern African experiences, which are presented in Table 1, revealed that the uneven adoption of global frameworks in Southern Africa reflects four interrelated mechanisms. First, academic incentive structures are closely tied to Mode 1 traditions, privileging peer-reviewed publications over co-created outputs (Mouton, Louw & Kruss, 2021) [23]. Secondly, institutional engagement units are often dependent on short-term donor or project-based funding which undermining their ability to sustain partnerships over time (Kruss et al., 2015) [17]. Thirdly, epistemic hierarchies promote the primacy of formal science, technology, and innovation (STI) while marginalizing the actionable modes of innovation that dominate in SMEs and rural enterprises (Lukhele & Ogundiran-Soumonni, 2021) [18]. Policy incoherence is also evident where national STI

strategies emphasize global competitiveness in high-tech sectors while providing limited support for rural innovation (Daniels & September-Brown, 2023) [8]. These mechanisms assist in explaining why global frameworks like Mode 2/3 knowledge production gain partial traction through pilot projects and the scholarship of engagement remain marginal within institutional cultures.

The SADC Protocol on Science, Technology, and Innovation articulates inclusive growth and regional industrialization as key priorities, but implementation has often privileged extractive industries and high-technology sectors (SADC, 2022) [28]. At the national level, policy divergences further shape institutional practices. For instance, South Africa's Department of Science and Innovation Revised Strategic Plan (2020–2025) prioritizes global competitiveness in biotechnology and ICT while offering limited instruments for rural industrialization.

Conversely, Botswana's innovation policy explicitly acknowledges social enterprise incubation as part of its national development strategy (Matlhape, 2020) [21]. These contrasting emphases filter down into university-level practices, explaining the dominance of commercialization-centric models in urban-based research universities and the more experimental approaches to inclusive innovation observed in institutions, such as Venda and Fort Hare. Situating institutional practices against this policy backdrop strengthens the argument that universities' developmental roles are mediated as much by external governance frameworks as by internal institutional dynamics.

Despite key gaps identified, higher education institutions in Southern Africa show potential for more insight alignment with frameworks used globally. Potential opportunities are focused in leveraging existing community engagement structures, employing frugal, inclusive, transformational, and innovative models, and appreciating the academic incentives to reward the community and societal impact.

Policy and Institutional Implications

The mapping and synthesis of Southern African HEIs' roles in innovation ecosystems revealed both opportunities and structural constraints. Translating these insights into actionable strategies requires coordinated interventions at both institutional and policy levels to enhance inclusive innovation, commercialization, and rural industrialization. Higher education institutions and policymakers should develop a comprehensive mechanism for monitoring and an evaluation framework to ensure sustainability. The establishment of a context-based monitoring and evaluation framework will ensure that it keeps track of the impact of interaction, engagements, rural industrialization, and commercialization initiatives. The metrics should include the diffusion of innovation, generate employment, and provide community benefits.

Reforming Academic Incentives and Reward Structures

A consistent barrier identified in the results is the misalignment of academic reward structures, prioritizing traditional scholarly outputs over engagement and applied research (Hall & Tandon, 2017 [13] Mouton *et al*., 2021) [23]. To address this, HEIs should develop promotion and tenure criteria that recognize engagement, co-created research, and social impact as core scholarly contributions. There is also a need to incentivize faculty participation in boundary spanning activities which include industry partnerships and rural entrepreneurship programs. Impact oriented metrics should be integrated to assess research outputs' societal and economic relevance alongside traditional publications. These reforms would align institutional incentives with the principles of Mode 2/3 knowledge production and the scholarship of engagement.

Strengthening Institutional Brokerage and Engagement Capacity

Results revealed that effective brokerage requires dedicated resources and strategic alignment with broader development priorities (Kruss & Visser, 2017) [17]. Therefore, there is need for scaling up directorates for community engagement, entrepreneurship, and inclusive innovation, with clearly defined mandates and operational autonomy. Secondly, there is a need for embedding innovation liaison

officers to connect research units with SMEs, local governments, and community-based organizations. Lastly, leveraging digital platforms and innovation hubs to facilitate multi-actor collaboration and scaling inclusive innovations is desirable. These measures will enhance HEIs' capacity to coordinate complex multi-stakeholder networks which are consistent with the quadruple/quintuple helix model.

Aligning Commercialization with Inclusive and Rural Priorities

Commercialization strategies in Southern Africa have largely favored urban, high-tech sectors, leaving rural populations underserved (Mouton *et al*., 2021) [23]. National policies and institutional interventions should promote inclusive commercialization pathways, such as cooperative-based ventures and community-integrated technology transfer. There is also a need for more seed funding and business development support targeted at rural and marginalized communities. Encouraging partnerships between universities, local governments, and private sector actors to co-develop value chains in agriculture and low-tech manufacturing is essential. These approaches align commercialization efforts with national and regional development goals to increase the developmental relevance of university research.

Facilitating Rural Industrialization

The results highlight the potential of HEIs to catalyze rural industrialization through skills development and entrepreneurship education. To strengthen this role, rural-based universities should integrate rural enterprise development into curricula and incubator programs. They should also coordinate with national and regional policy frameworks (, e.g., SADC industrialization strategies) to ensure policy alignment and resource support. Furthermore, there is a need to invest in infrastructure and logistical support to enable innovation and technology diffusion. These measures will allow universities to act as place-based anchors that bridge research, entrepreneurship, and industrial development in rural contexts.

Policy-Level Interventions

Beyond institutional reforms, policy interventions are essential to maximize HEIs' developmental impact. The national innovation strategies should explicitly incorporate rural and inclusive dimensions, recognizing HEIs as critical actors in implementing these priorities. There is also a need to upscale regional coordination through entities, such as SARUA and SADC, which can facilitate knowledge exchange and scaling of successful initiatives. Funding mechanisms should be designed to support long-term engagement and capacity building than short-term projects that limit sustainability. These institutional and policy measures provide a roadmap for transforming HEIs into engaged, inclusive, and context-sensitive agents of innovation and development across Southern Africa.

CONCLUSION

This review confirmed that higher education institutions (HEIs) in Southern Africa occupy a crucial position in the regional innovation ecosystems as they act as brokers, convenors, and place-based anchors of inclusive development. The mapping and literature synthesis revealed that universities are now slowly engaging in co-created research, entrepreneurship promotion and rural industrialization initiatives. Evidence showed that, the Southern African System of Innovation is conceptually robust but operationally fragmented. It remains more of a policy aspiration than a functional regional system. For the SASI to become a driver of inclusive industrialization and knowledge-based development, it must, strengthen regional coordination structures, build capacity for innovation management and localize innovation by engaging communities and indigenous knowledge holders.

Universities may contribute to inclusive innovation through participatory approaches that integrate indigenous knowledge and local expertise to enhance the socio-economic capabilities of rural communities. They play a brokerage role by convening diverse actors into collaborative networks that enable knowledge flow and entrepreneurial experimentation. Universities also engage in commercialization and rural industrialization, exemplified by agro-processing clusters, community-integrated incubators, and value-chain development initiatives. These activities demonstrate that HEIs have the capacity to link research and regional development in ways that extend beyond traditional

academic outputs. However, there could be a case to be made that Rural based HEIs require a different mode of commercialization, which recognizes local knowledges and the need for benefit sharing agreements to be negotiated in a mutually respectful manner

Furthermore, the review highlighted challenges that limit the full realization of HEIs' potential. Limited resources, misaligned reward systems, weak professionalization of brokerage functions, urban-biased commercialization models and fragmented policy support limit the inclusivity of innovation and industrialization efforts. Addressing these challenges requires reforming institutional incentive systems, professionalizing engagement units, and embedding inclusive innovation in core strategies. Policy-level interventions like aligning national innovation strategies with rural priorities and enabling regional coordination are also necessary.

In conclusion, Southern African HEIs have demonstrated substantial promise as engines of inclusive innovation, entrepreneurship, commercialization, and rural industrialization. Their transformation into fully engaged and development-oriented institutions depends on coordinated reforms integrating research, teaching, and societal engagement. By strengthening their brokerage capacity, supporting inclusive commercialization pathways, and anchoring rural industrialization initiatives, universities can contribute decisively to regional development and the sustainable realization of social and technological innovation across Southern Africa.

A contextualized innovation ecosystem in Southern Africa should be decolonial, inclusive, and transformative. Higher education institutions, especially rural universities must lead this shift by embedding community engagement, indigenous knowledge, and rural industrialization into their core missions. This can be achieved through participatory review for societal impact, which should be institutionalized as a tool for accountability, learning, and transformation. Moreover, there is a need for increased postgraduate student involvement to build capacity and foster innovation literacy. Lastly public-facing reports and publications are critical to disseminate impact and knowledge nationally and globally.

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