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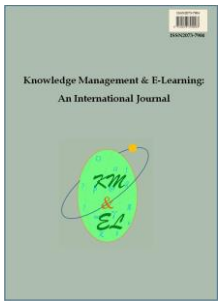

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Indigenous knowledge integrated system for sustainable university industry linkage and community development

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Abstract: Indigenous community knowledge is indeed essential for the sustainable development of community and University-Industry Linkage (UIL) initiatives. It provides valuable local contextualized expertise, engages local indigenous stakeholders, bridges the gap between academia, industry, and the community, incorporates local traditions and indigenous cultural practices, and creates a long-term impact on society, universities, and industries towards achieving sustainable development goals. Therefore, this study aims to examine the existing indigenous knowledge models for sustainable UIL and community development, thereby developing a unique indigenous knowledge model showing how it transforms the UIL and community development to sustainable development through integrated systems nexus. The study utilizes an in-depth literature review as its methodological approach, examining existing data from literature and conceptual frameworks of innovation development models. The results obtained from this comprehensive review indicate that many research findings have portrayed indigenous knowledge as a primitive method of knowledge sharing. However, the findings of this current research, along with a few other studies, demonstrate that indigenous knowledge serves as a foundation and baseline for UIL and community development, aligned with indigenous culture. This allows for the easy communication and diffusion of knowledge to the user community through their native way of life. The findings have also revealed the dynamic interaction among indigenous communities, industry, universities, and government, showing how these stakeholders collaborate synergistically to achieve sustainable development goals for both the community and UIL initiatives. The model is distinctive in that it introduces the Indigenous

Quadruple Helix Nexus Model, which provides a novel perspective on contemporary knowledge. This model highlights the interplay and collaboration among indigenous communities, industry, universities, and government, emphasizing the unique contributions and interactions of each stakeholder group in shaping and advancing knowledge in the present context. In conclusion, this study has assessed the existing literature related to indigenous knowledge and its linkage with UIL and introduced a unique helix model that integrated the community, industry, university and government.

Keywords: Knowledge management; Knowledge sharing; Indigenous knowledge; Sustainable development; University-industry linkage; Quadruple helix

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1. Introduction

Many studies believe that Indigenous Knowledge (IK), which forms part of knowledge management, has crucial functions and importance in the knowledge management process (creation/production, storage, processing/codification, transfer and utilization) and therefore requires significant attention.

There is no argument for using traditional/indigenous knowledge to solve problems in all aspects of disciplines. However, the traditional knowledge's contribution to the integration of University–Industry Linkage (UIL) has not received substantial attention in existing research. This means university-industry partnership is a relatively new phenomenon that emerged during the past century and has strongly expanded in scope and number over recent decades (Liévana, 2010). As the UIL is a recent phenomenon, it has not been sufficiently linked to indigenous knowledge and its contribution to development.

When discussing indigenous knowledge of countries around the world, one example is Ethiopia, which is known for using society-built knowledge. Ethiopia has a long and rich tradition of endogenous knowledge in education, most notably with the Orthodox Church, which has been powerful in the area of contemporary Ethiopia for over 1000 years (Pankhurst, 1974). There is also the Koranic education tradition, which has its own significance (Gemechu, 2016). These indigenous traditional schools play a great role in advancing technology and socioeconomic matters. A study conducted by Davis (2008) highlighted that one of the reasons for utilizing and cultivating indigenous knowledge systems is to accurately represent the perspectives and backgrounds of people within a country. During the past decade or so, there have been instances where a lack of understanding of local knowledge has led to the failure of development projects. Ignorance of local knowledge refers to a situation where project implementers or decision-makers overlook or disregard important cultural, social, economic, or environmental factors that are specific to a particular region or community. This lack of awareness or consideration can hinder the effectiveness and sustainability of development interventions. Davis (2008)

also reasoned out the importance of using IK in cultural development which has emerged as a significant thrust in development discussion, and the international community has become increasingly aware, particularly in the field of pharmaceuticals, of the potential international applications of some of the knowledge contained within indigenous knowledge systems.

Innovative indigenous knowledge is now recognized as crucial for any developing nation to achieve cumulative growth, both economically and socially. These innovations, as they will mostly take the form of appropriate modifications to existing services and products, will require further critical interventions and hand-holding efforts for their transition into markets. The concepts of national and regional innovation systems use the geographical dimension as a point of departure to explain technological development and innovation arising from the interactions of institutions and organizations as key players (Yokakul & Zawdie, 2010). Higher education institutions (HEIs) are recognized as hubs of research, change, and excellence in knowledge, which enhances the skills of individuals in society through the acquisition, generation, and transfer of knowledge (Mubarak et al., 2012; Shateri & Hayat, 2020).

Even though Ethiopia was one of the first for many sciences, civilizations and developments including education, it is always looking for experiences from Western and developed countries. Using indigenous knowledge and experiences in different fields of industries is indispensable for development. Knowledge generation through the process of learning and knowledge utilization is a central issue in the (triple helix) system (Yokakul & Zawdie, 2010). According to this study, the triple helix model primarily emphasizes the government, university, and industry as key actors. However, it fails to recognize the importance of integrating the quadruple helix model, which includes the indigenous community as a crucial stakeholder in knowledge transfer to the government, university, industry, and indigenous community. The community knowledge, which is indigenous, is very essential to link and enhance the university-industry development process. Indigenous knowledge shares its experiences and contextual experts and techniques in linking universities with industry through government policy development. Consequently, the indigenous knowledge integration system to the mentioned four pillars of the community has been overlooked, and only the model played its role in the innovation of business systems.

In general, using and developing indigenous knowledge helps to preserve generational knowledge, conserve indigenous resources, help the proper use of resources, and help in controlling nature and maintaining ecosystems.

1.1. Problem statement

Indigenous knowledge integration into the curriculum of education systems has been addressed by some studies (Banes & Cruz, 2021). However, this study only focused on the relationship that imposes the integration of IK into course curriculums in the context of western knowledge. The studies overlooked the integration of indigenous knowledge into the roles of government, industry, university, and indigenous community. The integration of indigenous knowledge into industry, university, government, and community has not been adequately addressed as a form of business innovation within modern society.

However, the importance of indigenous knowledge to modern knowledge systems and development has been given less value and attention (Ocholla & Onyancha, 2005).

Ethiopian indigenous knowledge is being overwhelmed by western modern knowledge, and it is losing indigenous knowledge which has played a big role in the country's development, especially educational systems.

The indigenous knowledge system is the foundation for modern ones, even though they are undermined and unconsidered – especially in developing countries (Tom, Sumida & McCarty, 2019). The lack of awareness regarding the contributions of indigenous knowledge has been identified in various areas such as teaching, UIL, technology transfer (TT), medicine, culture, ethics, generational knowledge building, and the development of countries. Additionally, it has been recognized that indigenous knowledge serves as the foundation for universities and education centers.

The unconcerned consideration of indigenous knowledge in the triple helix model has been noted as a problem in various studies. The triple helix model traditionally focuses on the collaboration between government, university, and industry as the key actors in knowledge generation and utilization (Yokakul & Zawdie, 2010). However, it fails to incorporate the crucial role of indigenous communities as a fourth helix in the knowledge transfer process.

To address this gap, the quadruple helix model integrates indigenous communities as an essential actor alongside government, university, and industry. This model recognizes the unique knowledge, perspectives, and contributions of indigenous communities in the innovation and development process. Therefore, this study aims to develop a set of fundamental research questions that will be addressed and establish clear objectives in the subsequent sections.

1.2. Research question and objective

Indigenous knowledge has been given less consideration in the sustainable development of communities and UIL initiatives. Given the numerous challenges that researchers have noticed regarding the contribution of indigenous knowledge to the sustainable development of communities and UIL, this research aims to answer the research question: "*What are the factors that hinder the utilization of indigenous knowledge, and how can an integrated indigenous knowledge model be developed for the sustainable development of communities and the university-industry linkage?*" The relationship between the community, industry, university, and government is characterized by interdependence, and it should be built upon principles of mutual respect, collaboration, and the recognition of indigenous rights. By working together, these stakeholders can establish frameworks that facilitate the appropriate utilization of indigenous knowledge, leading to sustainable development outcomes that benefit the community, industry, government and university as a whole.

Therefore, the primary objective of this study is to investigate the current status of indigenous knowledge in relation to community and UIL sustainable development. Furthermore, the study aims to develop an integrated system that facilitates the contribution of indigenous knowledge to community and UIL sustainable development. The subsequent sections of this study will include a theoretical analysis, the study approach and methodology, a discussion of results, model development, and a concluding remark.

2. Theoretical analysis and framework

2.1. Underpinning thoughts on indigenous knowledge

Throughout history, indigenous peoples have been responsible for the development of many technologies and have substantially contributed to science. Science is the pursuit of knowledge, and approaches to gathering that knowledge are culturally relative. Indigenous science incorporates traditional knowledge and indigenous perspectives, while non-indigenous scientific approaches are commonly recognized as Western science. Together, they contribute substantially to modern science (Alsarayreh & Aljaafreh, 2023; Gemechu, 2016; Tom et al., 2019).

Indeed, the term '*knowledge*' encompasses a broad range of meanings and can be understood and defined in various ways. Sources define knowledge as the process of becoming familiar with or aware of someone or something. It can encompass various aspects, including facts (descriptive knowledge), skills (procedural knowledge), or objects (acquaintance knowledge). The acquisition of knowledge contributes to understanding and can involve gaining information, developing competencies, or establishing familiarity with a particular subject or domain (Wikipedia, 2022). Knowledge requires management, which is becoming increasingly popular in all sectors of the global economy. This is due to its recognized importance in fostering knowledge creation, codification, and transfer, as well as its ability to significantly enhance the knowledge capital of an organization. The transfer of existing knowledge and the creation of new knowledge are important, and both should be considered in knowledge management (Azizi et al., 2021). This knowledge has two sources: scientific knowledge, which is knowledge focusing more on western or modern thought, and Indigenous Knowledge, which is knowledge embedded in an explicit culture of a society living in specific geographic areas (Teshome & Sobha, 2017). The comprehension of the connections between locally generated or endowed knowledge and the advancement of regional economies is of paramount importance in the pursuit of regional economic development (Ahmad et al., 2023; Eyong, 2007).

The IK is the ancient or traditional knowledge that emerged with societies during the existence of human beings on Earth and developed gradually within communities. The issue of indigenous knowledge has been recognized as a key element of social and economic development, especially at rural and community levels (Yokakul et al., 2011). Indigenous knowledge is also referred to as '*traditional'* or '*local'* knowledge – terms that are frequently used interchangeably in the literature (Ellen et al., 2000). Indigenous knowledge characteristically occurs in the form of tacit knowledge, which cannot be expected to serve as a basis for trade or knowledge exchange at the local or global level since it is not documented or codified (Yokakul et al., 2011). Although indigenous knowledge is often not documented or codified, there are various approaches that can facilitate its transfer. These include leveraging oral tradition and storytelling, promoting intergenerational learning, engaging in community-based documentation, fostering collaborative partnerships, incorporating indigenous knowledge into formal education, and utilizing digital technologies (Mubarak et al., 2012).

According to Ocholla and Onyancha (2005), Indigenous Knowledge can be seen as a dynamic repository of the collective knowledge, skills, and attitudes that belong to a community across generations. They lament that IK has been neglected, vindicated, stigmatized, illegalized and suppressed among the majority of the world's communities (Pandey, 2014). Indigenous peoples, with their decades of personal experience combined

with that of their ancestors, harbor vast knowledge about the environment and the ecological relationships within them (Assefa, 2022). The field of sustainable development uses various terms to designate this concept, including indigenous technical knowledge, traditional environmental knowledge, rural knowledge, local knowledge, and farmer's or pastoralist's knowledge. IK can also be broadly conceptualized as the knowledge that an indigenous (local) community accumulates over generations of living in a particular environment. This definition encompasses all forms of knowledge, technologies, know-how skills, practices and beliefs that enable the community to achieve stable livelihoods in their environment (Pandey, 2014).

According to the United Nations (UN) definition in 2007, the term '*Indigenous*' refers to groups of people who possess distinctive social, cultural, and economic characteristics that set them apart from other sections of the national communities. It is also understood as local or traditional knowledge that indigenous people have brought down with them from earlier times via oral tradition. Indigenous knowledge can also refer to the technical insight or wisdom gained and developed by people in a particular locality, through years of careful observation and experimentation with the natural phenomena around them.

2.2. Definition of variables and their operational association

Indigenous knowledge refers to the knowledge and practices developed by indigenous communities over generations, often rooted in their deep understanding of local ecosystems, traditional values, and sustainable resource management (UNESCO, 2017). This knowledge is valuable for addressing complex societal and environmental challenges.

A university is an institution of higher education and research that offers academic programs leading to undergraduate and postgraduate degrees (Chankseliani et al., 2021). Universities play a vital role in society by providing education, conducting research, and contributing to the advancement of knowledge in various fields.

Industry refers to the sector of the economy that involves the production of goods or provision of services through commercial activities (Scandura & Iammarino, 2022). It encompasses a wide range of businesses and organizations involved in manufacturing, construction, mining, energy production, technology, finance, transportation, healthcare, and more.

Government refers to the system or body responsible for governing and administering a country, state, region, or community. It is typically composed of elected or appointed officials who make decisions, enact laws, and implement policies to maintain order, provide public services, and promote citizen well-being.

In Africa, there are several key elements of indigenous knowledge that can be integrated into university-industry linkages (UIL) for sustainable community development (Boadu, 2022). The relationship between industry, government, indigenous communities, and universities is closely interconnected. Each stakeholder brings unique perspectives, knowledge, and resources, and their collaboration is essential for addressing complex challenges and driving sustainable development. In this context, a close interconnection characterizes the relationships between industry, government, indigenous communities, and universities. It signifies their deep interaction, mutual reliance, and shared objectives. Within this interconnected relationship, several essential elements shape the dynamics of knowledge exchange and co-creation, collaborative research and innovation, policy

development and advocacy, social and environmental responsibility, as well as local engagement and empowerment. The implications of these relationships are discussed further under the quadruple helix model. In the organizational context including education ones, Vuori and Okkonen (2012) indicated some catalytic factors for knowledge sharing in higher education institutions, including contributing to the organization's success, obtaining incentives and rewards, feeling empowered, acquiring knowledge in return, enhancing its reputation, and adding value to knowledge and confidence, confirming that participation in knowledge-sharing is worthwhile.

2.3. Importance of IK to local communities and the Ethiopian context

Lee and Yew (2022) indicated that KM is necessary to create sustainable development within a community. Long before the development of modern science, which is quite young, indigenous people have developed their ways of knowing how to survive and also ideas about meanings, purposes and values. They have also taken care of the natural landscape for thousands of years. It has become customary to refer to this kind of knowledge as indigenous knowledge or traditional knowledge (Horsthemke, 2004; Purcell, 1998). At its most elemental level, IK can be considered the foundation upon which local communities make determinations about local issues. These decisions pertain to various areas of endeavor, including water and other resource use, conservation and management, agriculture, and health care issues, as well as providing information and public outreach and education within a local community (Tharakan, 2017).

Indigenous knowledge is important for several reasons. First, local knowledge can help find the best solution to a development solution. Second, familiarity can help extensionists and researchers understand and communicate better with local people (Pandey, 2014). Third, indigenous knowledge represents the successful ways in which people have dealt with their environments. The theme of utilizing existing knowledge to create appropriate solutions occurs repeatedly throughout the development literature. Using indigenous knowledge can help find the best solutions for a culture. The solutions created must be economically and culturally acceptable to the society being aided. When an innovation has parallels with indigenous practices, there is often widespread acceptance of the innovation.

IK is substantially important for inclusive innovations that are novel to the context and consist of heterogeneous products, processes, institutions, services, business models, and supply chains (George et al., 2012). An approach to fostering inclusivity in innovation policies involves integrating poverty reduction strategies and smart specialization with the application of indigenous knowledge. Recently, in Sub-Saharan Africa, IK has been incorporated into official development and/or innovation policies (e.g., in Botswana, Ghana, Namibia, South Africa, and Tanzania) (Jain, 2014). Furthermore, IK is often the best accessible and applicable knowledge for the daily livelihoods of poor rural communities in developing countries (Hagar, 2003; Domfeh, 2007).

In addition to scientific scholars, prominent development agencies like the World Bank Group (1998) have acknowledged the potential of socially and economically marginalized communities to utilize indigenous knowledge for innovation and development. From a more straightforward perspective, these organizations assert that indigenous knowledge can be utilized in its original form or combined and integrated with the knowledge of others to create innovative products and services.

The most fundamental reason why indigenous knowledge is important is that it demonstrates the extensionist's clear understanding of the present situation and enables improved communication between scientists and local communities (Pandey, 2014). With familiarity with cultural customs, a rapport can be built between the scientist and people who are local embracing respect. This mutual respect fosters a relationship as partners who are looking for a solution together and encourages participation on a local level. Indigenous knowledge may suggest alternative techniques to extensionists, development professionals, and scientists. These techniques apply to the local system but may be utilized in other societies (Puffer, 1995). Another important aspect to take into account is that solutions that are not acceptable can lead to the waste of millions of development dollars. This sort of prevention is especially important in these times of threatened cuts in spending in development programs.

Tradition is defined as the local knowledge or indigenous knowledge that is unique to a given culture or society (Bridges & Ridley, 2000). Ethiopia has a long and rich tradition of endogenous education most notably with the Orthodox Church which has been powerful in the area of contemporary Ethiopia for over 1000 years (Pankhurst, 1974). There is also the Koranic education tradition, which has its own significance (Tessema, 2017). These indigenous traditional schools play a great role in advancing technology and socioeconomic matters. Ethiopia is rich in different IK in such areas as architecture, medicine, agriculture and cottage industry. For example, in rural parts of Ethiopia, if someone is struck by lightning, the survivor will be immediately brought into contact with moist ground or dung. This practice is substantiated by static electricity theory though the rural people are unable to explain it (Organization for Social Science Research in Eastern and Southern Africa, 2022; Pandey, 2014).

Even though Ethiopia is among the leading countries for many sciences, civilizations and developments including education systems, the country is always looking for experiences from Western and developed countries. In this study, the matured and innovative experience of global and Ethiopian traditional knowledge in the context of university-industry and community linkage is formulated (Pandey, 2014).

In conclusion, it is crucial to understand the profound significance of indigenous knowledge to the local communities in Ethiopia. By embracing and truly valuing this knowledge, we not only enhance the sustainability of development initiatives but also protect and celebrate the rich cultural diversity that exists within these communities.

2.4. Indigenous knowledge and university – Industry linkage

University-industry partnerships are a relatively new phenomenon that emerged over the past century and have strongly expanded in scope and number in recent decades (Liévana, 2010; Ishengoma & Vaaland, 2016). The linkages encompass a wide range of collaborations, including student placement schemes, staff exchanges, consultancy services, continuing professional development, joint research and development efforts, as well as more recent areas such as small enterprise development. These areas involve the creation of spin-offs for the joint commercialization of research and development products and the formation of consortia for collaborative research and development on an international scale. There is little understanding of how organizations significantly share and create knowledge (Azizi et al., 2023).

The role of UIL in productivity and economic growth is driven by innovation, which relies on research and human capital. The linkage also contributes to social interconnectedness through its contribution to the social, cultural and environmental development of societies (Reynolds et al., 2019). This practice needs to be well researched in universities and research institutions so that it could be commercialized in industry.

In Ethiopia, the unit for UIL within institutions does not have a long history. However, UIL has been practiced in different forms, both formally and informally, to promote economic growth through enhancing production and service efficiency and effectiveness. Recent studies have witnessed a growing interest among scholars, the private sector and policymakers in the importance of the university-industry-government relationship (UIG) in fostering regional growth (Union of International Associations, n.d.).

Higher educational institutions (HEIs) are major contributors to the society of emerging economies, shaping society and contributing to the state economy by producing highly educated individuals (Chughtai et al. 2022). Universities and other public research institutions play a central role within innovation systems for basic research generation, technology transfer, and knowledge diffusion to firms (Bercovitz & Feldman, 2006; Daniele & Andrea, 2018; Hall et al., 2000; Mowery & Shane, 2002; Mowery et al., 2010; Thursby & Thursby, 2011). These processes are ensured by university-industry (UI) interactions in their various modes (i.e., joint publications; joint research projects; co-patenting; spin-off), and their crucial role being recognized by both researchers and policymakers (Link & Scott, 2005; Perkmann et al., 2013).

It is summarized from the studies' findings that university-industry linkage focuses on the interaction of university with industry collaborating with government, while policy development emanated from these tripartite parties. However, the studies have ignored indigenous community knowledge, and social and economic contexts. This ignorance has brought weak interaction of indigenous communities with UIL and limitations in improving UIL through the intermediation of indigenous knowledge and society.

2.5. Government role in indigenous knowledge and UIL

The role of government in using indigenous knowledge for the improvement of UIL is highly recognized. There is still a widespread tendency to regard traditional knowledge as unorganized and '*primitive*' or as a treasure to store and document for posterity before it is lost, rather than seeing the dynamics that reinforce the creation and dissemination of knowledge, in which local communities are key central characters (Torri & Laplante, 2009). The Indigenous knowledge is important for several reasons including the familiarity of the knowledge that can help researchers and dissemination understand and communicate better with local people and represents the successful ways in which people have dealt with their environments (Puffer, 1995). In the view of research explanations, the knowledge of local people is an enabling component of development (Kurantin, 2012). Development projects cannot offer sustainable solutions to local problems without using local knowledge (Warren et al., 1995).

Indigenous technologies and practices are often cheaper than western ones. They depend on skills and resources that are readily accessible in the local area and typically involve minimal or no financial investment. According to Briggs (2005), the utilization of indigenous knowledge is regarded as a fundamental pillar that can ensure the resilience of developing economies amidst limited resources and decreased support from donors. Hence,

indigenous knowledge needs to be well experimented with, researched and applied via the linkage established between universities and industry including the effort of government support.

The importance of government involvement in the preservation of indigenous knowledge is recognized and not overlooked in policy development. Governments need to recognize that cultural heritage and traditional knowledge of indigenous peoples and local communities significantly contribute to conservation and can enhance national and global action development change (Briggs, 2005; Cassidy et al., 2011). This study has indicated that some government officials who have trained in western countries either fail to "*see*" indigenous knowledge, or discount it as outdated and irrelevant. The potential relationship between government policy and IK is central to rural livelihoods, particularly with regard to natural resources (Cassidy et al., 2011). Most government officers still cite "the national interest" as an explanation for why IK may not be accommodated. Balancing the local interests of every rural community can pose challenges for the central government in terms of managing the country coherently and cohesively. While government policies increasingly pay lip service to IK and promote its use it is normal to hear that the Government is committed to the integration of IK in development policy. The inclusion of considering local interests in government documents is a widely recognized and acknowledged practice, often insisted upon by donors. This ensures that, at least on paper, the importance of recognizing and addressing local interests is given due attention.

Relying less on external supplies reduces dependency on resources that may be expensive, limited in availability, and irregular in supply. So, indigenous knowledge provides effective alternatives to western technologies. It gives local people and development workers extra options when designing development projects. Instead of searching only among western technologies for feasible solutions, they can choose from indigenous knowledge or combine indigenous and western technology which in turn ensures the nation's development.

In general, regarding indigenous knowledge, the government's role includes recognition and protection, support for documentation and preservation, education and curriculum development, Indigenous participation and decision-making, Policy development, funding and support, data collection and research, and collaboration and knowledge sharing. To ignore people's knowledge is almost to let failure take place in development. Indigenous Knowledge is considered the basis for self-sufficiency and self-determination because people are familiar with indigenous practices and technologies. They can understand, handle, and maintain them better than introduced western practices and technologies. Further still, indigenous knowledge draws on local resources.

2.6. Indigenous community

Innovation must spread within a community by the members of the social system (Ogbodoakum et al., 2022) to create a learning environment which in turn influences the development of the community (Lee & Yew, 2022). Indigenous peoples form unique social and cultural communities that maintain strong ancestral connections to the territories and natural environments where they currently reside, previously resided, or from which they were removed. These connections are based on shared histories and traditions tied to particular lands and their natural resources. The community development model (CDM) is one of the most attractive tools that is mostly discussed to improve the standard of living and quality of life (Sabran, 2003). Research has evidenced that community development

helps to improve the social and economic quality of a particular community (Abas et al, 2020). These researchers stated that community development is an integration of two terms which are 'community' and 'development'. In other words, a community is a group of people who have something in common such as norms, religion, values, or identity and live in the same geographical territory (Cavaye, 2006).

Studies have shown that universities around the globe have seen pursuing UILs more aggressively in recent years than ever before (Ghafoor, 2013). This indicates that the universities have assumed a new role of contributing to nation-building through helping industry. But this remained only for the industry, disregarding indigenous society and their knowledge contribution to the diffusion of UIL and its implementation.

Therefore, it is realized that the studies have focused on the industry and university linkage and the benefits they have in mutual relations. While research collaborations between academic institutions and private enterprises can mutually benefit by sharing ideas, work, and commercial outcomes (Azizi et al., 2023; Shateri & Hayat, 2020; Umer et al., 2023), it is problematic if the contributions of Indigenous communities are excluded or ignored. Past research has not always recognized or acknowledged the knowledge and expertise that Indigenous peoples bring based on their long history with the lands and resources in question. The undermining of indigenous knowledge is a strategy of eroding the knowledge of the indigenous people by replacing it with western knowledge. In the end, it is taking the generation to the practice of western knowledge and gradually colonializing the indigenous people's knowledge and replacing it with scientific knowledge. The scientific knowledge alone which does not incorporate indigenous peoples' knowledge will not sustainably develop the society.

Community-based learning is important for sustainable development and active citizenship. A community approach to lifelong learning for sustainable development helps people to re-identify, re-evaluate, and further develop local and indigenous knowledge based on still-relevant but frequently neglected traditional wisdom. It enables people to take direct, practical action to tackle the challenges of a rapidly changing, increasingly global world.

2.7. Indigenous knowledge for sustainable development

Indigenous knowledge contribution has been extensively discussed in research as playing an important role in making indigenous communities more sustainable. Current views consider that IK is an important tool that holds promise for agriculture, food security, and sustainable development and is able to provide alternative development approaches (Abdullah & Hassan, 2015). In this study, sustainable development has become a subject matter and was first used by the World Commission on Environment and Development in its report, quoting it as "*our common future*". This report defined sustainable development (SD) as meeting present needs or using natural resources without compromising the ability of future generations to meet their needs or destroying the environment. This definition implies that among natural resources, indigenous peoples with their indigenous knowledge support community development while sustainably using persisted indigenous knowledge, in turn contributing to UIL.

If we consider the important role of education as one of the core components of Indigenous knowledge systems, research has highlighted how incorporating Indigenous educational practices and approaches can help support sustainable indigenous communities.

Learning promotes peaceful and inclusive societies for sustainable development, provides access to justice for all and builds effective, accountable, and inclusive institutions at all levels (Gope et al., 2017). In healthcare, different herbs and trees are collected from the bush, prepared, and used to treat or prevent infants' and adults' diseases to ensure healthy lives and promote well-being at all ages. Additionally, in agriculture, farming activities done with the use of IK are less expensive and readily accessible means or methods of preventing and treating diseases, confirming sustainable consumption and production patterns (Gope et al., 2017).

Studies showed that for decades, traditional knowledge has been compared and contrasted with scientific knowledge, always putting the latter in a position of privilege compared to the former (Sultana et al., 2018). However, since the development of knowledge systems rarely occurs in isolation, seeing indigenous knowledge and scientific knowledge as two separate and isolated entities does not describe the real situation. This century, researchers and users of knowledge should pay attention to modern technologies often introduced from other places rather than relying on indigenous knowledge, considering it primitive resulting in the erosion of traditional knowledge and the loss of an invaluable resource for human and sustainable development (Sultana et al., 2018).

In general, if we want to bring sustainable development to society, we need to focus on community-based knowledge to mainstream Western knowledge into traditional knowledge. That means traditional knowledge is a portal that carries scientific knowledge into the future. It enables people to take direct, practical action to tackle the challenges of a rapidly changing, increasingly global world. It also helps people gain new knowledge and skills to improve their lives in sustainable ways, for example through eco-friendly farming or by working to address social and economic inequalities.

2.8. The helices models

2.8.1. Innovation of triple helix model

Usmani (2023) has indicated a remarkable contribution of KM to knowledge sharing, knowledge integration, and knowledge transformation. Interactions between universities, industries, and governments have given rise to new intermediary institutions (Safiullin et al., 2014). The triple helix model of innovation refers to a set of interactions between academia (the university), industry, and government, to foster economic and social development, as described in concepts such as the knowledge economy and knowledge society. In innovation helical framework theory, each sector is represented by a circle (helix) as shown in Fig. 1. The initial modeling has advanced from two dimensions to show more complex interactions, for example over time. Interactions between universities, industries, and governments have given rise to new intermediary institutions (Safiullin et al., 2014). The triple helix innovation framework has been widely adopted and, as applied by policymakers, has participated in the transformation of each sector.

The triple helix symbolizes a union between government, business/industry, and university, which are the key elements of an innovative system. The triple helix models deal with the innovation of products or services more than knowledge-based. Innovation is more defined in terms of continuously improving existing products or services, creating new products or services, or adopting new products or services in places where they did not originate.

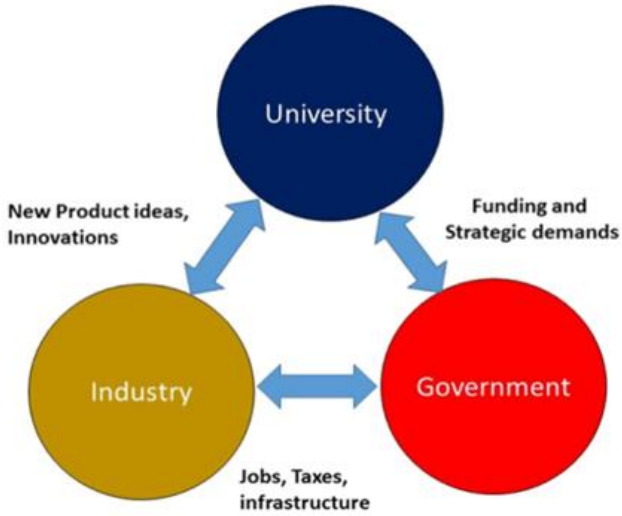

Fig. 1. The structure of triple helix (Safiullin et al., 2014)

The three triple helix models only focus on products and services. The knowledge context is different as it incorporates indigenous communities and society to maintain indigenous knowledge. Therefore, this indicates that another model is needed to link indigenous societies and their knowledge to the three pillars shown in innovation.

2.8.2. Innovation quadruple helix model

Building on the triple helix model, the quadruple helix model adds a fourth component to the framework of interactions between university, industry, and government – the public, consisting of civil society and the media (Simona et al., 2016). The framework aims to bridge the gaps between innovation and civil society, and it claims that under the triple helix model, emerging technologies do not always match the demands and needs of society, thus limiting their potential impact. The framework consequently emphasizes the societal responsibility of universities, in addition to their role of educating and conducting research (Steenkamp, 2019). The quadruple helix is the approach that the European Union intended to take for the development of a competitive knowledge-based society (Cresson, 1997).

In this section, the public pillar was introduced into the UIL from the perspective of the university community engagement and product or service utilization. It does not reflect bilateral support of each other in transforming knowledge from indigenous peoples. It includes scientific people rather than indigenous society who have knowledge from all histories. The quadruple helix of innovation also lacks incorporation of indigenous peoples even though it adds the public wing from society equipped with western knowledge. It does not reflect what indigenous communities contribute to the university-industry linkage improvement or interaction. How society serves the university has not been discussed in the meantime in so far studies.

A quadruple helix system must be seen as a widening of the triple helix system by including a fourth helix – civil society – in the innovation system model (da Costa Mineiro et al., 2021; Grundel & Dahlström, 2016). The same studies' results have shown that a

wide range of possible definitions of a fourth helix can be applied in policy as well as in research. Starting from a more democratic perspective, the fourth helix can be defined as including citizens, NGOs, labor unions and others to more growth-oriented perspectives as consumers and users.

While the quadruple helix model of innovation depicted in Fig. 2 includes civil society in the innovation process, it does not specifically account for how indigenous knowledge flows within indigenous communities. By conceptualizing civil society broadly as "*all of society from the community*," the model fails to distinguish indigenous communities and the distinct ways traditional knowledge is shared, validated, and advanced intergenerationally among indigenous peoples based on their cultural practices and close ties to traditional lands and territories. In not recognizing indigenous communities as unique knowledge systems in their own right, the quadruple helix framework does not fully capture how indigenous knowledge is generated and circulated within these societies.

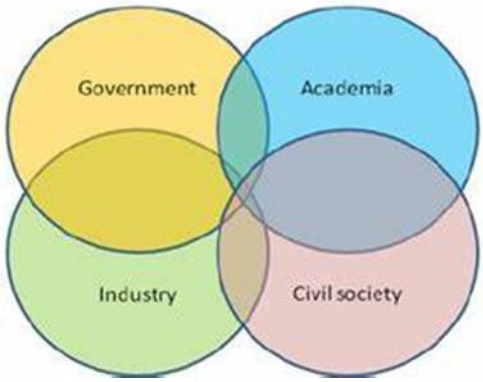

Fig. 2. Quadruple helix model for innovation (modified from Schütz et al., 2019)

The study conducted by Schütz et al. (2019) has stated that greater public involvement in research and innovation can serve to legitimize research trajectories and produce more welcome, sustainable innovations by reorienting research and development toward public preferences. However, this concept speaks about community regarding accepting new ideas and knowledge rather than indigenous ones. Therefore, the quadruple helix model from the perspective of indigenous knowledge does not incorporate indigenous society.

2.8.3. Evolution of helix models

The evolution of innovation helix models has been discussed through the advancement of innovation development over time. Studies have increasingly improved upon innovation helix models, and they have now come to conceptualize an evolutionary development of the model (see Fig. 3). Earlier formulations focused on single participants like industry, government or academia alone in a "*mono helix*" approach to innovation. Later, models expanded in complexity, with the sequential emergence of "*poly helix*" structures including the triple helix, quadruple helix, quintuple helix, and further poly helix models of innovation involving multiple participants. Over decades of research, the conceptualization

of innovation systems has grown to capture their multidimensional, dynamic nature through integrated and evolving poly helix frameworks.

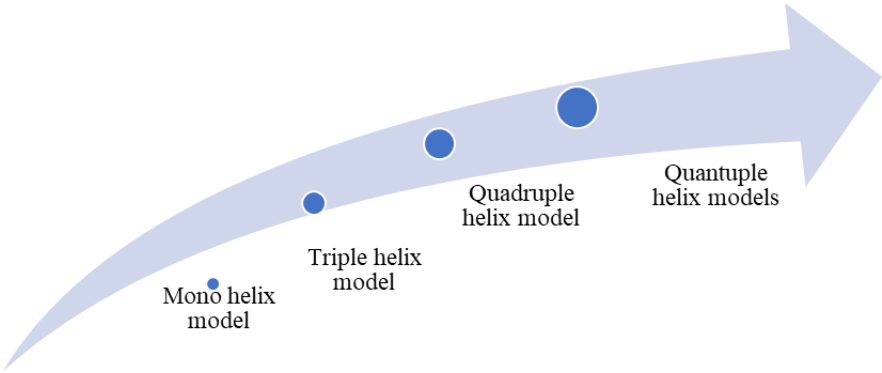

Fig. 3. Evolution of helix model development for innovation

Previous research examining various frameworks involving factors like helices or university-industry linkages in innovation has suggested models to understand these relationships. However, they have not demonstrated how incorporating indigenous knowledge can enhance innovative connections between universities, industry, and local communities. The models fail to illustrate the value added by including traditional, local, and indigenous forms of knowledge when connecting modern academic and commercial knowledge to more holistic partnerships. They do not capture how integrating indigenous contributions rooted in longstanding relationships with lands and environments can strengthen university-industry collaboration aimed at mutually beneficial innovation that respects diverse knowledge systems.

2.9. Existing gaps in research

As discussed earlier in Section 2, existing research gaps related to using indigenous peoples and knowledge have been identified. There is a lack of studies focused on the development of models, which has resulted in a dearth of knowledge in this area. Additionally, there are widespread misunderstandings regarding the integration of indigenous knowledge within indigenous communities. The marginalization of indigenous cultures by western-based educational systems calls for the urgency to revitalize the indigenous knowledge systems (IKS) of indigenous peoples to be at par with the era of globalization (e.g., Banes & Cruz, 2021).

The studies conducted related to innovative indigenous knowledge are not well articulated in global research findings. We have support from different research findings regarding African indigenous knowledge practices. African indigenous knowledge is the parts that are not systematized in modern knowledge (Kanu & Ndubisi, 2020). The studies conducted on different indigenous knowledge were more focused on the cultural value than integrating the knowledge into industry, community, government and university to take them into modern systems. Studies lack a focus on innovative indigenous knowledge and its importance to university-industry linkage and technology transfer components (Torri & Laplante, 2009).

The integration of the quadruple system is undermined regarding indigenous peoples' knowledge (Sultana et al., 2018). This indicated that the importance of indigenous

knowledge from indigenous communities for sustainable development of UIL is considered primitive knowledge, imposing the dominance of scientific knowledge. It would have been better to consider how to link scientific knowledge to indigenous knowledge to serve society without eroding the bottom line of all indigenous knowledge. Hence, in Section 4.3, a novel model is proposed that encompasses the triple helix of knowledge management parameters. This model addresses the previously overlooked parameters that have not been adequately studied so far.

3. Method of the study

3.1. Data collection methods

In order to address the research questions pertaining to the significance of existing indigenous knowledge to UIL and the community, as well as the challenges it encounters, and to explore ways of fostering synergy among various indigenous knowledge factors to develop a model, a comprehensive literature review methodology has been implemented in this study. This means it has followed an in-depth literature review to develop a new IK integrated system for the sustainable development of community and UIL initiatives. The study includes a thorough investigation of relevant literature on various topics such as knowledge, UIL, technology transfer, and indigenous knowledge. A comprehensive review of these literatures has been conducted to provide a robust foundation for the research. The data collected were recognized in terms of inclusion/exclusion criteria as shown in Table 1.

Table 1
Summary of inclusion and exclusion criteria

	Inclusion criteria		Exclusion criteria
1.	Papers published for the purpose of indigenous knowledge analysis	1.	Papers published for reporting without justification of the knowledge management models
2.	Papers published on innovative knowledge management and or innovation model related	2.	Articles or books more focused on empirical analysis of knowledge management system
3.	Types of articles published in reputable journals, easily accessible	3.	Papers with no contribution to IKM
4.	Articles published in English language only	4.	Papers that are not written in the English language
5.	Papers peer reviewed and published in journals related to knowledge	5.	Duplicate records after screaming excluded 55
6.	Papers deal with university industry linkage	6.	25 articles were rejected after a full article assessment
7.	Records identified through database searching were 185 and after screening by removing duplicates 130 used	7.	Finally, after identifying relevant papers to the topic, 27 papers were excluded
8.	Eligible articles full text assessment included, remaining was 105		
9.	Finally include legible article are 87 as listed in the references		

The purpose of inclusion and exclusion criteria in research is to ensure that the selected papers are highly relevant and focused on the topics of indigenous knowledge management and university-industry linkage. By implementing these criteria, researchers aim to select papers that directly address and contribute to the specific areas of interest, thus enhancing the quality and relevance of the study.

3.2. Literature data sources

Conducting a literature review on indigenous knowledge is crucial for investigating the existing contributions of indigenous knowledge to the community and understanding its potential role in achieving sustainable development, including the concept of the quadruple helix model. A literature review helps identify existing gaps and provides insights into how indigenous knowledge can be integrated into sustainable development initiatives. Data sources were obtained from Emerald, Elsevier, Taylor and Francis, Indigenous knowledge journals, *Knowledge Management & E-Learning*, and many other sources. In order to search the information, keywords, titles, phrases, and sentences were used. During the literature review of IK, 185 articles having IK in their titles were found in more than 55 publishers and journals. The H-indexed journals were used to give an estimate of the importance, significance, and broad impact of a scientist's cumulative research contribution. Literature reviews were more focused on journals that are indexed by Scopus, Web of Science, Google Scholar, PubMed, EBSCO, JIFACTOR, EMBASE, DOAJ, and ISI indexing bodies. While the authors of this paper incorporated some publications before 2016, their primary focus was on utilizing recent studies published between 2016 and 2023. These recent studies were selected to address the objectives of problem identification and the development of a new model for indigenous knowledge (see Table 2). In addition to these references, the reference lists contain additional studies that have been used as sources to support the research findings and provide a broader understanding of the topic.

Table 2
Summary of the literature review data sources (2016-2023)

Article	Journal name	Objectives of the study	Methods of data collection	Findings	Author(s)
Reconciling the impact of knowledge management processes on knowledge worker productivity.	Knowledge Management & E-Learning	• Creation and sharing of knowledge affect the • Knowledge-workers productivity through the knowledge utilization process	Quantitative type of method used	• Knowledge utilization is the sole frontline and primary knowledge management • To enhance the productivity of knowledge workers	Umer et al. (2023)
African Indigenous Knowledge: An Underutilized and Neglected Resources for Development.	Library Philosophy and Practice	• It sought to highlight challenges faced in the quest to • Incorporate IK into developmental goals and projects as well as to • Recommend ways through which Africans can promote IK in its developmental project	A desk research review conducted	• There is a need for policies, legislation, standards • Research capacitation, investment and local inclusion in indigenous knowledge research • Documentation and use	Khumalo & Baloyi (2017)
African Indigenous Knowledge Systems and the World.	Palgrave Macmillan	• To carry out a review of relevant research pieces of literature on the indigenous knowledge system of Africa and highlight its importance	A qualitative research method	• Most of the indigenous Knowledge, whether African or otherwise, is situated and exercised within culture; hence, the importance of culture to indigenous Knowledge cannot be over-emphasized	Ayeni & Aborisade (2022)
Community development model for poverty eradication of indigenous people in Malaysia.	International Journal of Society Systems Science	• Development of a community model aimed at eradicating poverty among indigenous people in Malaysia	A focus group discussion	• A comprehensive model that emphasizes community participation, capacity building, and sustainable development	Abas et al. (2020)

Indigenous Knowledge and Community Development in Africa: A Framework to Explore the Approaches, Philosophies and Practices in Ghana. World Sustainability Series.	Springer	• A framework to explore the approaches, philosophies and practices in Ghana	31 traditional and community development leaders were interviewed through in-depth and semi-structured interviews	• IK ideals are deeply rooted in informal governance and relational structures, norms, values and other cultural realities in most indigenous societies	Boadu (2022)
The Quadruple and Quintuple Helix in Innovation Environments (Incubators and Science and Technology Parks).	Innovation & Management Review	• A framework to explore the approaches, philosophies and practices in Ghana	Integrative review as a methodological approach and systematized studies regarding the main research objectives	• A lack of standardization on the representation of the quadruple • Helix, but the example of associations and community centers as representatives of the civil society	da Costa Mineiro et al. (2021)
Influence of motivational factors on knowledge sharing methods and knowledge creation process in an emerging economic context.	Knowledge Management & E-Learning	• Aims to extend our understanding of motivational factors (MF) that improve the knowledge-sharing intention of employees thereby leading to creating knowledge successfully	Quantitative research methodology	• Motivational factors positively influence knowledge sharing and knowledge creation	Azizi et al. (2023)
Using the Quadruple Helix Approach to Accelerate the Transfer of Research and Innovation Results to Regional Growth.	European Union Committee of the Regions	• Investigates the theory and the operationalization of the so-called '*helices models*' where the main protagonists of innovation-generating processes (industry, university, government, and, at a later stage, civil society) interact to accelerate the transfer of research and innovation results to regional growth	The perspective of local and regional authorities (lras) and in the light of the potential impact that the operationalizati on at the regional level	• Helix models highlight the need to better focus efforts on operationalization aspects at the territorial level	Simona et al. (2016)
Knowledge Hiding Behaviors as Moderator Between Machiavellianism, Professional Envy and Research Productivity: Empirical Evidence From Emerging Economy.	Knowledge Management & E-Learning	• Examines the direct impact of Machiavellianism and professional envy on research productivity (individual and group) with the moderating role of knowledge-hiding behaviors	Convenience sampling, an online survey through Google Docs was conducted	• Machiavellianism and professional envy have a significant negative influence on individuals and as well group-based research productivity	Chughtai et al. (2022)
Co-shaping the Future in Quadruple Helix Innovation Systems: Uncovering Public Preferences toward Participatory Research and Innovation.	She Ji: The Journal of Design, Economics, and Innovation	• To identify desirable and productive forms of interaction between the scientific community and the public	Interviewed 50 laypersons with participatory research and innovation experience	• The desire for more extensive opportunities to introduce scientific and technological considerations as part of bidirectional exchanges between academia and society	Schütz et al. (2019)

Triple Helix and Its Evolution: A Systematic Literature Review.	Journal of Science and Technology Policy Management	• To identify the most extensively studied topics with respect to the triple, quadruple and quintuple helix models developed to explain these links	Systematic review	• Despite growing concern about society and the environment, issues related to the three helixes of universities, industries and governments continue to be the most often studied	Galvao et al. (2019)
The Integration of Indigenous Knowledge Systems (IKS) in the Tertiary Level Curriculum of Benguet State University La Trinidad Campus.	Mountain Journal of Science and Interdisciplinary Research	• To establish baseline data on the experiences of the faculty members of Benguet State University in the integration of IKS into the curriculum	Informant interview and focus group discussion	• Existence or absence of policies of IK in educational curriculum	Banes & Cruz (2021)
A Quadruple and Quintuple Helix Approach to Regional Innovation Systems in the Transformation to a Forestry-Based Bioeconomy.	Journal of the Knowledge Economy	• To understand the possible preconditions for the transformation of a regional innovation system (RIS) into a quadruple and quintuple helix system applied to the development of a sustainable forestry-based bioeconomy	Participatory transdisciplinary and transdisciplinary research design	• The quintuple helix model developed	Grundel & Dahlström (2016)
Identification of Indigenous Knowledge Components for Sustainable Development among the Santhal Community.	American Journal of Educational Research	• Aims to know the indigenous practices and their utilization pattern for sustainable development among the Santhal community	Extensive library work and field survey	• Proves traditional practices are important for the sustainability of society in three dimensions which are social, environmental and economical.	Gope et al. (2017)
"Open innovation" and "Triple Helix" Models of Innovation: Can Synergy in Innovation Systems Be Measured?	Journal of Open Innovation: Technology, Market, and Complexity	• To investigate Government, industry and university relationship	Literature review	• The Triple Helix provides a model of innovation in which the three parties are specified in terms of selection environments and the interaction processes among them	Leydesdorff & Ivanova (2016)
Indigenous knowledge as vital contribution to sustainability.	International Review of Education	• Indigenous knowledge assessment	Literature review	• Indigenous knowledge is vital for the sustainability of the community	Tom et al. (2019)
Quadruple Helix Models for Sustainable Regional Innovation: Engaging and Facilitating Civil Society Participation,	Economies	• To contribute to RIS3 policy and practice regarding the mechanisms through which governments can engage civil society and facilitate its participation in a territorial EDP with other QH actors	Case study with an experimental approach	• Impact of the quadruple helix model on the organization	Roman et al. (2020)
Student perceptions of knowledge management and institutional readiness for online classes amid Covid-19 pandemic.	Knowledge Management & E-Learning	• Examines institutional knowledge management and readiness to sustain online course delivery	A qualitative research design	• The adaptability, flexibility, and approachability of the virtual learning experience are critical to determining an institution's readiness for online classes	Nair & Solanki (2023)
Role of Indigenous Knowledge in	International Journal of	• To review the role of indigenous knowledge in sustainable development,	Secondary data	• There are mass implications of indigenous knowledge in	Sultana et al. (2018)

Sustainable Development.	Development Research	list the most used indigenous knowledge and sectors of the contribution of indigenous knowledge.		sustainable development. Indigenous knowledge play's role in conserving nature, food production, forestry development, medicine, sustainable practices, land and resource management and ecotourism, climate change and disaster risk reduction.	
The quadruple helix model of innovation for Industry 4.0'.	Acta Commercii – Independent Research Journal in the Management Sciences	• To provide balancing perspectives for understanding the primary movements, management theories and sub-revolutions underpinning the emerging FI	Qualitative exploration	• The primary movements underpinning the FIR are triple management theory, up-scaling agility, university-business cooperation and triple helix ecosystem partnerships and epochal society	Steenkamp (2019)
Innovation and the Triple Helix Model: A Case Study in Brazilian Incubators.	European Journal of Social Science	• To analyze how strategic actions of incubators lead to the development of innovations	A descriptive and qualitative multiple case study	• The fundamental pillar for the development of innovation in the incubators was the strengthening of university-industry-government interaction, in accordance with the triple helix approach	Bach et al. (2016)
Indigenizing School Curricula for Life Skill Development.	Kerala Sociologist	• To discuss the importance of indigenizing school curricula for life skill development	Qualitative	• School curricula designed in many parts of developing countries promote western values	Teshome & Sobha (2017)
Indigenization for Restoration of Ethiopians International.	Journal of Multidisciplinary Research and Development	• He restored Ethiopianism through the indigenization of our system of education	Qualitative	• Helps to produce honest people	Tessema (2017)

3.3. Research design

The research process for this study involved several steps. Firstly, the researchers selected a topic of interest. Secondly, they conducted a comprehensive literature search to gather relevant information. The third step involved developing their argument based on the literature findings. Subsequently, the researchers surveyed the literature to gather additional insights. In the fifth step, they critically analyzed and evaluated the existing literature. The sixth step involved discussing and identifying a model for integrating indigenous knowledge (IK) into the sustainable development of indigenous communities and UIL initiatives. Finally, based on the preceding steps, the researchers developed a new model for the IK integrated system, as presented in this study.

3.4. Cyclical process of literature review steps

The seven steps are categorized into three major phases. The first five steps belong to the Exploration Phase, the sixth step is the Interpretation Phase, and the seventh step is the Communication Phase. The methodology of this study involves three distinct phases (Onwuegbuzie & Frels, 2016).

The literature review method in this study adhered to the Seven-Step Model of the comprehensive Literature Review (CLR). This model comprises seven steps: Exploring Beliefs and Topics, initiating the search, Storing and Organizing Information, Selecting/Deselecting information, expanding the search to include One or More MODES (like Media, Observation(s), documents, expert(s), secondary data), analyzing and synthesizing information, and presenting the CLR Report. The study followed these seven steps and presented a new conceptual framework during the result discussion. These steps are visualized in the diagrammatic illustration provided in Fig. 4.

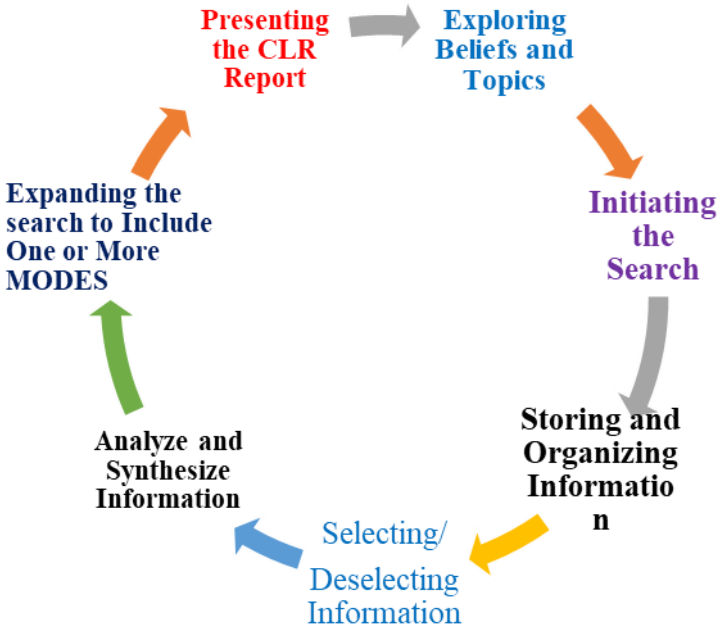

Fig. 4. Process of literature review methodology steps and cycles

3.5. Research framework

In summary, this study consisted of several key components. It is initiated by identifying the problem and establishing clear objectives. A thorough literature survey was conducted, followed by a review and gap analysis to determine existing knowledge and research gaps. The research methodology was then developed, and data analysis was carried out. The findings were discussed in relation to both the literature and practical implications. Furthermore, a model for the development of indigenous knowledge, considering the identified gaps, was proposed for the sustainable development of traditional communities. Finally, the study concluded with overall remarks and conclusions. For better clarity, this study has used the overall flow of the research indicated in Fig 5.

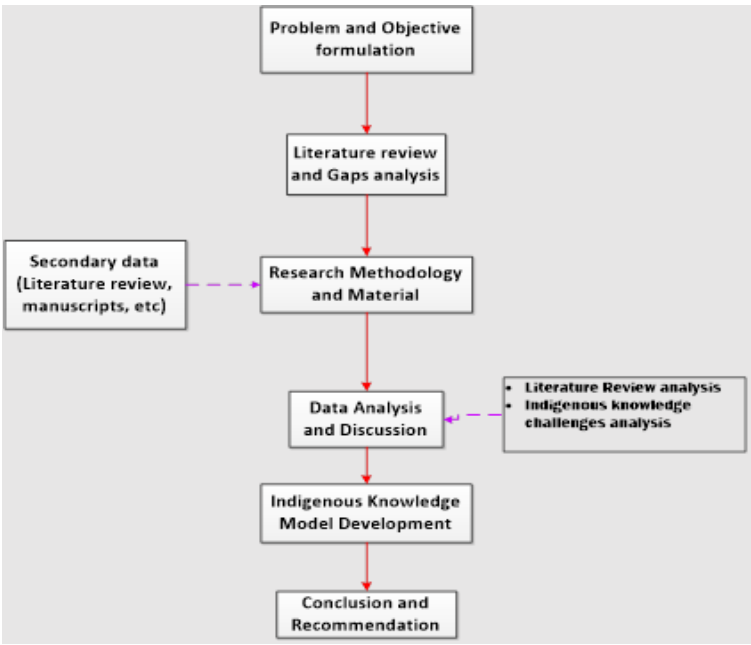

Fig. 5. Research flow process framework

4. Results and model development

4.1. Introduction

As mentioned in the literature review section of this article, several helix models have been proposed to illustrate the dynamics and interrelationships among academia, industry, government, and community in relation to UIL and community development. However, these models have limitations and require further refinement to effectively address the challenges associated with UIL and community development. Specifically, while the community is acknowledged as a component within the quadruple model, the impact of indigenous knowledge on UIL and community development initiatives has not been extensively investigated. Therefore, this section of the paper presents the key findings that establish the foundation for an integrated model that embraces indigenous knowledge for UIL and community development.

4.2. Integrated model for UIL and community development: Consolidated results

The results have been categorized into four distinct categories, and each of these elements is further elucidated below:

1. The impact of western knowledge on UIL and community development
2. The involvement of the indigenous community in UIL and community development

3. The learning style is utilized to promote sustainable UIL and community development
4. Policy considerations for effective UIL and community development

Despite the widespread recognition of indigenous knowledge as a crucial foundation for self-sufficiency and self-determination, the reality reveals a different narrative. The exposure of indigenous people to western knowledge undermines the intrinsic value and significance of indigenous knowledge within their society. It is undeniable that indigenous individuals possess a profound understanding of their own practices and technologies, granting them superior proficiency in comprehending, handling, and preserving them compared to introduced western practices and technologies. Moreover, indigenous knowledge is rooted in and draws upon local resources, ensuring its sustainability. However, erosion of indigenous knowledge occurs when western knowledge takes precedence and replaces it. This gradual process results in a shift towards western knowledge, colonizing indigenous knowledge and ultimately substituting it with scientific knowledge.

Despite their relevance to innovation management, helix models do not adequately incorporate the indigenous community's contribution to sustainable UIL and community development. The indigenous community's knowledge has been ignored in infusing indigenous knowledge into UIL and community development. This ignorance weakens the interaction of the indigenous community with sustainable UIL and community development. Ignoring people's knowledge almost guarantees failure in sustainable development, which encompasses meeting present needs and using natural resources without compromising the ability or destroying the situation for future generations. This definition also implies that among natural resources, indigenous people and their indigenous knowledge support the development of UIL and the community.

In helix models, knowledge generation through the learning process is a crucial concern. However, learning has primarily relied on knowledge derived from the modern scientific domain, neglecting the importance of experiential learning (Dianita & Tiarani, 2023; Hondzel & Hansen, 2015). The current learning system predominantly focuses on theoretical knowledge rather than practical application. Nevertheless, community-based learning plays a vital role in achieving sustainable development and fostering active citizenship. Adopting a community-oriented approach to lifelong learning promotes the revitalization, reassessment, and further development of local and indigenous knowledge, drawing upon traditional wisdom that is often overlooked but remains relevant. This approach empowers individuals to directly engage in practical endeavors, addressing the challenges posed by a rapidly changing and increasingly interconnected world. Moreover, it equips people with new knowledge and skills to enhance their lives in sustainable ways.

While many helix models prioritize the interaction between universities and industries in collaboration with government policies for UIL and community development, they often overlook the infusion of indigenous community knowledge into policy formulation (Hayward et al., 2021). This oversight leads to weak interaction between the indigenous community and the sustainable development of UIL and the community as a whole. Neglecting the interests and perspectives of the indigenous community in policy formulation poses challenges to the effective engagement of the government in UIL and community development efforts.

4.3. Indigenous knowledge integrated model for sustainable UIL and community development

Expanding upon the previous research findings, this section of the paper presents a model that advocates for an integrated approach, leveraging the inherent value of indigenous knowledge to drive sustainable UIL and foster community development (see Fig. 6). The main objective of the model is to reduce the influence of Western knowledge on UIL and community development, enhance the engagement of the indigenous community in UIL and community development, promote community-based learning approaches, and emphasize the significance of policy development in facilitating effective UIL and community development.

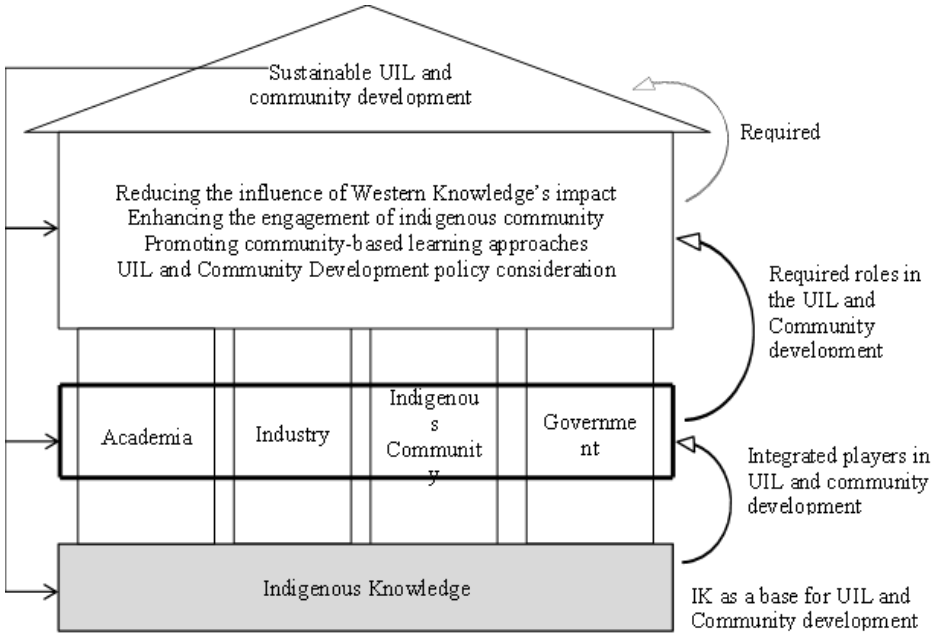

Fig. 6. Indigenous knowledge integrate model for UIL and community development

The model recognizes the importance of indigenous knowledge as a foundation and input for academia, industry, the indigenous community, and the government to interact and create a conducive environment for UIL and community development. Indigenous knowledge is positioned at the base of the model, highlighting that it serves as a fundamental building block that must support UIL and community development.

Moreover, the integration of academia, industry, the indigenous community, and the government forms a cohesive system that utilizes indigenous knowledge to mitigate the dominance of Western knowledge, enhance the engagement of the indigenous community, promote community-based learning approaches, and address policy considerations for effective UIL and community development. This model considers the roles of these stakeholders in creating sustainable UIL and community development.

Universities and academia play a vital role in implementing the community-based learning style advocated by the model. They should closely collaborate with indigenous communities, the government, and the industry to develop culturally relevant curricula,

teaching methodologies, and teaching materials. By incorporating indigenous knowledge into formal and informal educational settings, universities can foster a sense of pride, identity, and empowerment among indigenous learners, promoting lifelong learning and sustainable development. It is crucial for Ethiopian universities to fulfill their prominent roles in restoring and utilizing indigenous knowledge to foster UIL and community development.

Roles of the Industry: Industries are also responsible for the development, retention, and application of indigenous knowledge. They should protect indigenous knowledge from erosion and focus on its retention and marketing to ensure that its benefits are preserved for the localized people. The integration of academia and industry with the indigenous community should facilitate the effective applicability of indigenous knowledge. Therefore, industries must play an important role in promoting and utilizing indigenous knowledge in their operations, products, and services.

Roles of the Indigenous Community: The indigenous community has a responsibility to share their indigenous knowledge, cultural heritage, and lived experiences to support UIL and community development initiatives. Their active involvement, unique perspectives, and deep-rooted wisdom contribute to sustainable UIL and community development. Extensive research demonstrates that indigenous communities significantly contribute indigenous knowledge, practices, and initiatives that exhibit a more holistic, inclusive, and effective approach to development initiatives (e.g., Dianita & Tiarani, 2023; Hondzel & Hansen, 2015).

Roles of the Government and Policy-makers: The government plays a pivotal role in retaining indigenous knowledge. It should develop an enabling environment and comprehensive policies that encourage universities to incorporate indigenous knowledge and practices into their curricula to support sustainable UIL and community development. The policy should facilitate the link between universities and industries and promote the utilization of indigenous knowledge to foster UIL and community development. Additionally, the policy should assist industries in applying indigenous knowledge in their practices. It should be co-designed, inclusive, and responsive to the needs of universities, industries, and the community.

4.4. Significance of the study

The study recognizes the significant value of indigenous knowledge in advancing technology and socioeconomic matters, as highlighted by various authors (e.g., Jain, 2014; Masango & Mbarika, 2022; Nair & Solanki, 2023; Senanayake, 2006; Sultana et al., 2018) in their research. However, integrating indigenous knowledge into UIL activities and community development still presents challenges. Additionally, helix models have been utilized by several authors (e.g., da Costa Mineiro et al., 2021; Grundel et al., 2016; Leydesdorff & Ivanova, 2016; Schutz et al., 2019) to explore the integration of the indigenous community into sustainable development initiatives.

In the Ethiopian context, Assefa (2022) and Organization for Social Science Research in Eastern and Southern Africa (2022) have specifically highlighted the exclusion of indigenous knowledge and people's practices from development initiatives. Building on these understandings, this study identifies key challenges that previous research has not fully considered regarding the application of indigenous knowledge in UIL and community development. These challenges include the influence of Western knowledge on UIL and

community development, limited engagement of the indigenous community in UIL and community development, the absence of community-based learning approaches to promote UIL and community development, and inadequate policy considerations for the application of indigenous knowledge.

To address these challenges, this study proposes an indigenous knowledge-enabled model for sustainable UIL and community development. What sets this model apart from previous ones in the field is its recognition of indigenous knowledge as a foundation for sustainable UIL and community development. The model provides insights into how academia, industry, the community, and the government can leverage indigenous knowledge to reduce the influence of Western knowledge. Furthermore, the model emphasizes enhancing the engagement of the indigenous community and promoting community-based learning approaches to sustain UIL and community development. Finally, the model underscores the importance of developing policies that incorporate indigenous knowledge to facilitate sustainable UIL and community development.

5. Conclusion

This paper presents the results of various studies on innovation helix models and their relationship with indigenous knowledge. The study utilizes an exhaustive literature review technique to comprehensively examine the current significance of indigenous knowledge and its limitations. To address the research question regarding the factors hindering the utilization of indigenous knowledge, the study explores the development of an integrated indigenous knowledge model for sustainable community development and the establishment of strong linkages between universities, industries, and communities. The interdependent relationship among the community, industry, university, and government is identified as crucial variables. These variables are carefully considered, with a focus on promoting mutual respect, fostering collaboration, and recognizing indigenous rights.

The findings indicate that innovation helix models significantly differ from the development of an indigenous knowledge quadruple helix model, which plays a key role in driving the sustainable development of a community and UIL by leveraging the knowledge and contributions of indigenous communities. The study proposes an interactive and interlinking system that integrates academia, industry, the indigenous community, and the government. This cohesive system aims to utilize indigenous knowledge to address the dominance of western knowledge, enhance the engagement of the indigenous community, promote community-based learning approaches, and consider policy considerations for effective lifelong learning and community development.

The IK quadruple helix model serves as a powerful reminder of the human element in recognizing, respecting, and integrating indigenous knowledge. It acknowledges the invaluable contributions that indigenous knowledge brings to decision-making processes, policy frameworks, and development initiatives. By acknowledging and valuing indigenous knowledge, we honor the rich cultural heritage and wisdom possessed by indigenous communities.

The study recommends that the government, industry, university, and community collaborate and utilize indigenous knowledge in conjunction with the western knowledge platform. It emphasizes the importance of these stakeholders coming together and partnering to tap into the valuable insights and perspectives offered by indigenous knowledge while integrating it with the existing western knowledge framework.

In conclusion, indigenous knowledge is a crucial component for the sustainable development of UIL and the community. Recognizing and integrating indigenous knowledge within a developed collaborative framework is essential for achieving holistic and sustainable development outcomes.

5.1. Theoretical and practical implications

The theoretical implications of indigenous knowledge are significant as it challenges dominant Western paradigms and offers alternative frameworks for understanding the world. Indigenous knowledge emphasizes holistic thinking, interconnectedness, and the integration of spirituality into daily life. It recognizes the value of oral tradition, storytelling, and community-centered education, providing alternative perspectives on knowledge acquisition and transmission.

From a practical perspective, indigenous knowledge has implications across various fields such as ecology, agriculture, medicine, and sustainable development. Indigenous communities possess deep knowledge of their local environments, including traditional ecological knowledge that can contribute to conservation efforts and the sustainable management of natural resources. Indigenous agricultural practices offer insights into sustainable farming methods that promote biodiversity and enhance resilience. Additionally, indigenous medicinal knowledge can provide valuable perspectives on alternative healthcare approaches and the utilization of natural remedies.

By acknowledging and honoring indigenous knowledge, it becomes possible to foster collaboration and establish partnerships between indigenous communities and external stakeholders. This facilitates the exchange of knowledge and supports the preservation and revitalization of indigenous cultures. Incorporating indigenous knowledge into research, policy-making, and development initiatives promotes inclusivity and cultural sensitivity. Ultimately, integrating indigenous knowledge into various domains can contribute to the development of sustainable and equitable solutions for societal challenges.

5.2. Future directions

This study aims to explore the different factors that influence indigenous knowledge and its relationship with the helix model. The existing research primarily focuses on the quadruple helix model and its importance in promoting University-Industry-Learning (UIL) and sustainable development within communities. It is recommended that future studies investigate and present the long-term effects of indigenous knowledge on the sustainable development of UIL and communities.

Author Statement

The authors declare that there is no conflict of interest.

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