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INTEGRATING INDIGENOUS KNOWLEDGE SYSTEMS (IKS) IN CLIMATE CHANGE POLICIES IN AFRICA: BARRIERS, STRATEGIES AND FUTURE DIRECTIONS. EMPHASIS ON AGRICULTURE

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Abstract

This article examines the crucial role of indigenous knowledge systems (IKS) in climate change adaptation and mitigation from an African perspective. Despite recognition in the Intergovernmental Panel on Climate Change (IPCC)'s Fifth and Sixth Assessment Reports (AR5 and AR6) as vital contributors to climate solutions, the inclusion of indigenous communities in climate research and policy remains limited. We review peer-reviewed literature to evaluate the extent and effectiveness of IKS in addressing climate equity and community resilience across Africa, highlighting disparities in its deployment. The urgency is underscored by projections indicating a temperature rise exceeding 3°C, even with compliance to Intended Nationally Determined Contributions. We discuss how traditional localized knowledge can address climate change, as acknowledged by the IPCC, and the decline of IKS due to modernization. The review aims to assess the significance of IKS in climate strategies, identify barriers to their incorporation into science-based guidelines, and suggest pathways for integrating indigenous insights into Africa's climate policies. By shedding light on these critical themes, we advocate for a collaborative approach that values indigenous voices in tackling the pressing challenges presented by climate change.

Key words**:** *adaptation, climate change policy, indigenous knowledge systems, mitigation*

INTRODUCTION

Climate change adaptation and mitigation stand among some of the most pressing challenges facing society today. They are complicated further by the unpredictable nature of future climate change impacts and the necessity for fair and equitable resource allocation [63]. Amidst these global struggles, vital contributions of indigenous communities have started to gain recognition, particularly in the Intergovernmental Panel on Climate Change (IPCC) Fifth and Sixth Annual Reports (AR5 and AR6), which underscore their potential to contribute towards innovative solutions to our warming planet [2, 6]. The IPCC's AR6 reiterated the effectiveness of IKS in addressing environmental challenges and recognized these systems as equal contributors to climate science and policy [6, 18]. IKS embodies knowledge and practices shaped by generations of cultural heritage, evolving through harmonious interactions with the environment [60]. Yet, the advance of technology and modernization has led to a decline in the application of IKS to global issues [27].

Scholars increasingly acknowledge the significant role and critical relevance of IKS across various disciplines including combating the consequences of climate change [29, 30]; traditional medicine; agroforestry and biodiversity [19, 24]. However, the documentation of IKS benefits in tackling climate challenges remains inadequate leading to their underrepresentation in climate change research and policy discussions [2, 50]. This article aims to fill that gap through a comprehensive review of peer-reviewed literature, providing robust evidence for the role of IKS in climate mitigation and adaptation efforts from an African perspective. It addresses key questions about the significance of IKS in combating climate change and explores the potential for its integration into Africa's climate policies.

Moreover, it seeks to identify barriers to incorporating IKS into science-based guidelines, with the ultimate goal of enhancing engagement with indigenous communities whose knowledge is essential for fostering healthy ecosystems across Africa.

MATERIALS AND METHODS

The study employed the systematic literature review methodology [13, 50, 64] for its comprehensiveness and adaptability in examining peer-reviewed knowledge. This approach facilitates an in-depth exploration of evidence regarding the validity of IKS in climate change mitigation and adaptation. It allows for the analysis of existing evidence, evaluation of current understanding, and identification of promising avenues for future research. This review aimed to provide a holistic overview of accumulated knowledge while highlighting patterns, trends, knowledge clusters, and research gaps. Information was gathered from peer-reviewed academic publications, working papers, and reports dating back to the year 2000, a pivotal year following the recognition of IKS at the 1992 Rio Earth Summit.

An initial search across four databases: Web of Science, ScienceDirect, Scopus, and Google Scholar using key terms: 'climate change' OR 'global warming' OR 'climate variability', combined with 'adaptation' OR 'mitigation' OR 'response', and 'indigenous knowledge systems (IKS)' OR 'traditional ecological knowledge (TEK)' OR 'local knowledge (LK)', yielded 2,380 results, prompting further refinement of filters (Fig. 1).

Screening was performed using Reporting Standards for systematic review analysis (Fig. 1) across four databases: Web of Science, ScienceDirect, Scopus, and Google Scholar. We also reviewed the IPCC WGII and WGIII AR6 reference list for pertinent publications related to indigenous issues. To refine our selection to relevant works on "climate change mitigation" and "climate change adaptation," we applied a combination of filters. For mitigation, we included terms such as "mitigation," "GHGs," "carbon dioxide (CO_2)," and "decarbonization." For adaptation, we utilized terms like "resilience," "adaptation," "risk management," and "disaster reduction," while also considering synonyms. We screened document titles, abstracts, and keywords to ensure comprehensive data retrieval. Our search covered publications from 2000 to 2023.

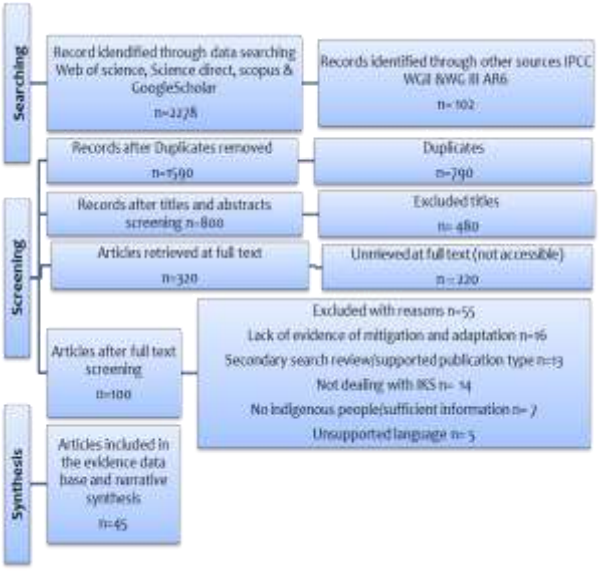

Fig. 1. The inclusion/exclusion criterion of publications used in the study
Source: Adapted from [15].

Inclusion and exclusion criteria were adapted from [15, 50, 64], focusing on prominent themes such as 'indigenous knowledge systems (IKS),' 'traditional knowledge,' and 'native science'.

Data extraction involved coding each publication according to specific subcategories related to metadata, as well as spatial and temporal distribution across Africa. This coding process was informed by concepts derived from literature focused on climate change and indigenous communities.

To ensure a robust review of the literature and assess the likelihood of disciplinary bias, we analyzed the journal disciplines of all papers cited in the Working Group II (WGII) and Working Group III (WGIII) submissions for the Sixth Assessment Report (AR6) [57]. This analysis, populated in the Web of Science (WoS), provided a comprehensive understanding of the conceptual framework underpinning the AR6 assessment report.

While this descriptive reporting review offered a broad overview of the evidence base, it had several limitations.

Studies focused solely on climate change without adequately addressing adaptation and mitigation were excluded.

Retrospectively, incorporating broader search terms such as "indigenous science", "ethnoscience" or "folk knowledge" could have expanded study findings. Additionally, resource constraints, including time limitations and manual processes, restricted our focus to key indicators of interest regarding temporal and spatial scales during the coding process.

Moreover, the mapping of the evidence base was constrained by the lack of consideration for other relevant databases that might not align with our predefined format.

During the coding and data extraction phase, we did not conduct separate validity and consistency checks typical of full systematic reviews, which are crucial for validating findings.

Nonetheless, we acknowledge that this step is essential for comprehensive evaluations that include critical appraisals of study results.

RESULTS AND DISCUSSIONS

This section presents findings and discussions under four broad themes.

These are: IKS publication typology and their distribution in Africa; IKS used in climate change adaptation; IKS used in climate change mitigation; and IKS integration in climate change policies (barriers, integration approaches, and strategies to overcome them).

IKS publication typology and their distribution in Africa

This review highlighted the growing recognition of IKS in addressing climate change in Africa, particularly since 2014 (Fig. 2).

There was a clear regional disparity in research output, with Southern Africa leading significantly, as illustrated in Fig. 3.

The 33 articles from Southern Africa (73% of total IKS articles in Africa) could reflect the robust research infrastructure and collaborative networks in countries like South Africa and Zimbabwe. These nations not only have diverse ecosystems but also a rich tapestry of indigenous practices that have been documented and studied extensively. These studies showcase that IKS can enhance biodiversity conservation and resilience to climate change. In contrast, the scarcity of IKS publications in Central and North Africa raises important questions. For instance, the lack of research in Central Africa might be linked to challenges like limited academic funding or geopolitical instability, which can hamper research initiatives. This situation underscores the need for targeted efforts to bolster research output in these regions, perhaps by fostering partnerships with international institutions or enhancing local academic capacity.

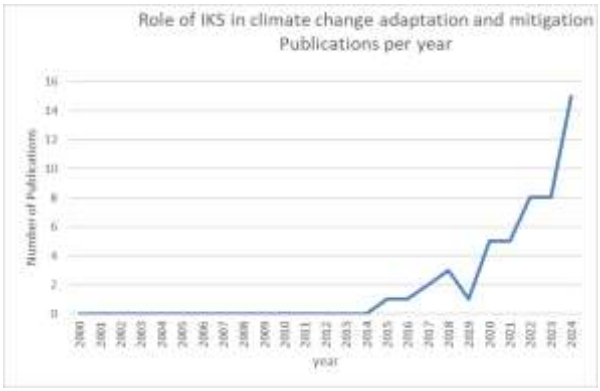

Fig. 2. The trend of IKS articles in Africa from 2000-2024

Source: Graph generated by authors from literature that met the inclusion/exclusion criteria for this review.

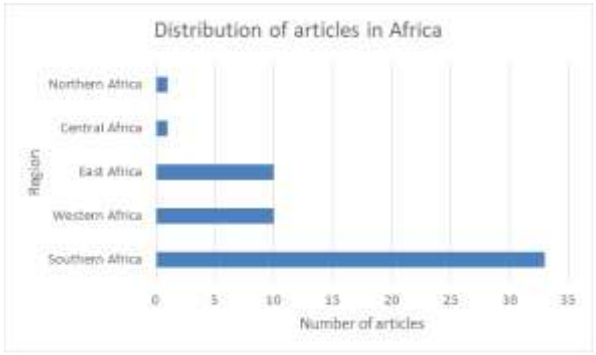

Fig. 3. Distribution of IKS articles across geographical regions of Africa

Source: Graph generated by authors from literature that met the inclusion/exclusion criteria for this review.

These findings resonate with the broader trend acknowledged in the IPCC reports, emphasizing that integrating IKS with scientific approaches can yield more effective

climate adaptation strategies. For future research, it would be beneficial to explore case studies from the underrepresented regions to uncover unique indigenous practices that could contribute to holistic climate solutions. This could pave the way for a more inclusive understanding of climate resilience across the continent.

IKS used in climate change adaptation

IKS has been used by communities in Africa to adapt their farming systems to climate change in a plethora of ways. Table 1 shows the adaptation options where IKS has been utilized.

Table 1. IKS climate change adaptation options

Adaptation option	Examples	References
Cultivar improvements	Breeding of locally adapted traditional seed varieties. Climate-proof varieties, pest and disease resistance. Animal breeding.	[1, 44, 48]
Farm-level water management and storage	Rainwater harvesting.	[3, 27, 36]
Soil moisture retention	Conservation farming (*pfumvudza*), mulching, zai pits.	[20, 49, 55]
Irrigation	Canal Stone bands	[8]
Community-based adaptation	Traditional norms, taboos, sacred groves, selective logging, traditional rituals, ceremonies	[37, 38]
Farm-level land management	Terracing Use of contours	[41, 42]
Sustainable land management approaches	Control of land degradation Manuring Rotational grazing Agroforestry	[39, 47, 58]
Agro-ecological principles and practices	Intercropping, crop rotation, mixed farming	[10, 45]
Disaster risk management	Early warning systems, safety nets	[20, 27, 35]
Ecosystem-based adaptation	Wetland restoration, upstream forest ecosystem management Maintain biodiversity	[7, 40, 53]

Source: A synthesis made by authors based on literature mentioned in the table.

The IKS adaptation options and where they have been utilised in Africa are discussed in greater details as follows:

Cultivar improvements

Indigenous communities have been cultivating and preserving a diverse range of climate-resistant crop varieties that are adapted to local ecosystem conditions [1]. These traditional crop varieties often demonstrate resilience to climate challenges, such as temperature tolerance, resistance to pests and diseases [41, 44]. These practices have been observed in dry to semi-arid regions of Uganda, Sudan, Congo, Tanzania and Zimbabwe [36].

Farm level water management

Traditional methods for collecting water include the construction of ponds, tanks, and other water-harvesting structures [27]. IKS-based strategies help to mitigate the effects of climate change-induced water scarcity resulting from unpredictable rainfall patterns. Rainwater harvesting is widely practiced in various regions such as the Sahel region, East Africa, Southern Africa, West Africa and notably in the Horn of Africa.

Soil moisture retention

Indigenous communities utilize IKS-based techniques such as *zai pits* and *pfumvudza* to effectively manage climate variability. *Zai pits* have been traditionally employed for many centuries in the northern and central regions of Burkina Faso, Niger, Mali, Chad, and Nigeria [49, 55]. This age-old technique is a successful IKS-based method for addressing climate change and degradation. It is a technology which consists in planting each plant in a small pit of about 20-30 cm in width, 10-20 cm in deep and filled with manure. In this way, the rainfall water could be collected in the zai pits helping the crop to grow. The technology could be applied in ten regions where precipitations vary between 300- 800 mm per year.

Pfumvudza is a climate-smart IKS-based approach that focuses on enhancing soil moisture retention, improving soil fertility, controlling erosion, and diversifying crops. It has been widely adopted in Zimbabwe, Malawi, Zambia, and parts of East Africa [27].

This technology helps the small farmers to create planting basins, where seeds from high production potentials varieties and mulching are incorporated.

Community-based adaptation

Indigenous communities have effective methods for passing down knowledge between generations and have social institutions in place to govern resource use and adapt to climate change [29]. These

methods help to maintain and strengthen traditional knowledge systems [37]. People with traditional knowledge share their expertise with younger generations through oral traditions, rituals, ceremonies, and community-based education systems [38].

Sustainable land management practices

Indigenous pastoralist communities have developed extensive knowledge and practices for managing rangelands including rotational grazing, mobility patterns, and the use of traditional indicators to determine grazing periods and areas [39, 58]. Additionally, pastoralists in Kenya, Ethiopia, and Uganda use ecological and anthropogenic indicators such as soils, vegetation, and livestock production to understand land degradation trends [47, 51]. These adaptive strategies promote sustainable livestock production, mitigate climate risks, and help maintain the health and productivity of rangeland environments [7].

Agroecological principles

Agroecological farming practices often include principles that promote sustainable and resilient agricultural systems. These principles include intercropping, crop rotation, mixed farming, and the use of traditional seed cultivars that are well-suited to local conditions [10, 45]. This type of farming enhances soil fertility, biodiversity, and water conservation, which in turn contributes to climate change resilience [49, 55].

Disaster management

Scholars have also documented the utilization of certain bird sounds in Tanzania for weather and seasonal forecasting and linked increased breeding of wild animals with a better seasonal outlook across Africa [30, 48]. The shedding and sprouting of new flashes of leaves, flowering, and profuse fruit are also indicators of predicting the onset of seasonal widely used in Burkina Faso and Tanzania [20]. In addition, rainmaking ceremonies are common in Zimbabwe, Uganda, and Burkina Faso [40 48, 52]. Aboriginal people have devised erudite systems for observing and predicting weather patterns based on symbolic moral relationships between animal behaviour, cloud formations, wind patterns, and celestial observations [27, 35]. This is extensively used across Southern Africa in traditional weather forecasting systems, agricultural planning and resource management, and disaster preparedness [32].

Ecosystem-based adaptation

IKS encompass a range of strategies that have been developed and refined over generations to help maintain biodiversity, carbon sequestration, and ecosystem services [53]. These strategies draw from traditional knowledge, practices, and innovations for instance, agroecological farming practices such as vibrant organic knowledge of forest ecosystem management and conservation [7, 40]. These practices include selective logging, sacred groves, community-based forest management, and traditional norms and taboos that regulate resource use [38].

IKS used in climate change mitigation

Climate change mitigation refers to the efforts made to minimize greenhouse gas (GHG) emissions or remove them from the atmosphere. In Africa, IKS provides a variety of options for sustainable land management practices such as agroforestry, terracing, contour ploughing, and organic fertilizers to mitigate climate change [31, 55].

Table 2 shows some of the options for sustainable land management. These methods help in conserving the soil, enhancing its fertility, and preventing erosion, thereby improving soil health and preventing land degradation [42]. By promoting carbon sequestration, these strategies contribute to mitigating climate change.

Table 2. IKS climate change mitigation strategies

Climate mitigation option	Examples	References
Solar energy	Sun drying of vegetables, fish	[54]
Wind energy	Using wind in winnowing, pumping water	[54]
Energy efficiency	Cookstoves, biogas from organic waste	[62]
Improved forests	Sacred groves, traditional norms, taboos	[47, 51]
Crop/ grassland management	Agroforestry, terracing, contour ploughing, fertility enhancement, soil erosion control, mosaic burning	[12, 42, 55]

Source: A synthesis made by authors based on literature mentioned in the table.

Indigenous communities across the African continent possess a wealth of knowledge regarding forest ecosystems, which they have

cultivated over generations to foster sustainable forest management and conservation [28, 40]. Their practices encompass various strategies such as the establishment of sacred groves, implementation of community-based forest management, and adherence to traditional norms and taboos that govern resource utilization. For instance, sacred groves serve as vital biodiversity hotspots while also contributing to the preservation of local flora and fauna.

In addition to forest management, indigenous communities play an instrumental role in reforestation efforts. By actively engaging in tree planting and restoring degraded landscapes, these communities help sequester carbon from the atmosphere—an essential process in mitigating climate change [47, 51]. For example, the Maasai in Kenya have been involved in initiatives to restore indigenous tree species, thereby enhancing carbon sequestration while reviving local ecosystems.

As mentioned in discussions on ecosystem-based climate change adaptation, indigenous pastoralist communities employ traditional knowledge to promote sustainable livestock management. Practices such as rotational grazing, strategic mobility patterns, and the use of indigenous indicators for determining optimal grazing periods and areas help mitigate overgrazing and land degradation [40, 47]. For instance, the Borana pastoralists in Ethiopia utilize traditional knowledge to manage their herds effectively, which has shown to enhance resilience against climate variability.

Moreover, many indigenous communities rely on traditional energy systems that incorporate energy recycling methods, including biomass, solar energy, and wind power [54]. These systems involve practices such as using improved cookstoves, producing biogas from organic waste, and harnessing solar and wind energy for various applications [62]. By reducing dependence on fossil fuels, these practices significantly contribute to greenhouse gas emissions reduction.

Indigenous communities also make substantial contributions to climate change mitigation through the protection of natural resources and biodiversity. Techniques such as no or minimised selective burning are integral to maintaining ecosystem health and reducing carbon dioxide emissions [55]. Lastly, the ecological knowledge held by indigenous knowledge holders encompasses critical insights into local ecosystems, including species interactions, habitat functions, and environmental processes. This knowledge can guide ecosystem-based solutions for protecting and restoring wetlands, mangroves, and other natural habitats that sequester carbon and provide essential ecosystem services [9, 12]. For example, the restoration of mangrove forests by coastal communities in Senegal not only enhances carbon storage but also protects against coastal erosion and supports biodiversity.

IKS integration in climate change policies: barriers and strategies to overcome them

Integrating IKS with modern scientific approaches presents a promising pathway for sustainable development, particularly in the face of climate change [11, 56]. However, several barriers impede this integration. Strategic approaches can help overcome these challenges. This section discusses barriers to the IKS-modern science integration, integration approaches and strategies for overcoming barriers:

Barriers to IKS integration in climate change policies

There are several barriers to integrating IKS in climate change policies ranging from lack of resources and support systems for farmers to the fragmented nature of the IKS itself among others (Table 3). These barriers are described briefly in Table 3.

Approaches for integrating IKS with scientific knowledge

The study identified three primary approaches for integrating IKS with scientific knowledge and hence potentially into climate change policies and these are:

Incorporationist Approach: This method seeks to effectively integrate selected indigenous knowledge into scientific frameworks, ensuring that valuable local insights enhance scientific practices [34, 43]. For instance, incorporating traditional weather

forecasting methods can complement scientific meteorological data for better agricultural planning.

Table 3. Barriers to integrating IKS in climate change policies

Challenge	Description	References
Lack of resources and support systems for indigenous people	Indigenous communities often lack the financial and technical resources to engage effectively in climate research and policy initiatives.	[33, 65]
Misalignment of IKS with modern science	IKS may not always align with modern scientific standards	[23]
Cultural misunderstandings	The pervasive cultural misunderstandings often lead to the dismissal of IKS as irrelevant or unscientific, undermining its inclusion in policy discussions.	[9]
Systemic institutional barriers	Existing institutional frameworks primarily reflect Western scientific paradigms, which can marginalize indigenous perspectives in climate governance.	[4]
Lack of representation	There is a general underrepresentation of indigenous communities in climate policy discussions leading to the exclusion of their valuable insights and experiences.	[61]
Intellectual property rights issues	Concerns over the appropriation of indigenous knowledge can create barriers to collaboration, which is essential for integrating IKS into climate policies.	[16]
Fragmented knowledge system	The diversity of IKS across different indigenous groups, complicate efforts to synthesize and apply this knowledge cohesively in climate policies.	[59]
Insufficient Collaboration Mechanisms	A lack of established frameworks for effective collaboration between indigenous knowledge holders and scientists, which limits the integration of IKS into climate policies.	[22]
Short-term focus of climate policies	The tendency of climate policies to prioritize immediate results often overlooks the long-term, holistic approaches characterized by IKS.	[46]

Source: A synthesis made by authors based on literature mentioned in the table.

Separatist Approach: This approach maintains IKS and scientific knowledge side-by-side without direct integration, allowing both systems to co-exist while acknowledging their distinct values [26]. This is often seen in policies that recognize indigenous rights while conducting separate scientific assessments.

Integrationist Approach: This aims to establish connections between IKS and scientific knowledge, creating a synthesis that respects and utilizes both systems [26]. For example, collaborative projects that incorporate community-led research alongside scientific study can yield richer, more applicable results.

The foregoing shows that to effectively integrate IKS into climate change policies and practices, several strategies should be employed. Policymakers must actively explore avenues to weave indigenous ecological knowledge, traditional land management practices, and medicinal plant knowledge into scientific frameworks [25].

Strategies for enhancing the integration of IKS into climate change policies

To counter the barriers to integrating IKS in climate change policies, there is need for coming up with a concoction of sure-proof strategies that have to be applied holistically and to be supported by all concerned. Through the implementation of these strategies, a more inclusive and effective approach to climate change adaptation policies which respect and harnesses the wisdom of indigenous communities, can be created. Table 4 discusses some of these strategies briefly.

Table 4. Strategies for enhancing the integration of IKS in climate change policies

Strategy	Description	References
Community engagement	This participatory approach empowers communities and ensures that policies are culturally relevant.	[5]
Holistic Approaches	Indigenous cultures often understand the interconnectedness of ecosystems better than most.	[5]
Data Integration	Combining scientific data with IKS can lead to more effective climate management strategies	[43]
Capacity Building	It is essential to provide resources and training for indigenous communities to participate in climate monitoring and adaptation strategies.	[17]
Policy Frameworks	Developing policies that explicitly recognize and protect Indigenous rights and knowledge systems is critical, for example the Community-Based Natural Resource Management (CBNRM) policy in Namibia	[21]
Funding and Investment	Allocating funding for projects that utilize IKS in climate resilience and adaptation is vital, for example the Green Climate Fund	[14]

Source: A synthesis made by authors based on literature mentioned in the table.

Future Directions

After examining IKS articles included in this study, and the findings discussed above, we are of the view that future research direction should prioritize the following:

-Appraising current climate change policies of African countries to identify gaps in the integration of IKS. This can be achieved through conducting comparative analyses of regions or countries where IKS is utilized against those where it is not, assessing outcomes and resilience. Successful case studies where IKS has been effectively integrated into climate adaptation strategies should be documented.

-Developing culturally sensitive research methodologies that integrate IKS with scientific approaches through creating guidelines for participatory research that not only respect IKS but place it at the same level of scientific knowledge, including community engagement techniques and validation processes.

-Development of educational programs that enhance understanding of IKS among policymakers and scientists. This can be done by holding workshops and training sessions that focus on the value of IKS in climate science, promoting interdisciplinary education.

-Unification or standardization of IKS and what they mean or represent. This will make IKS easy to validate, understand and therefore to integrate in climate change policy formulation.

-The combination of big data analytics and AI has the potential to revolutionize IKS. By analyzing large amounts of information, it can recognize patterns, forecast future climate scenarios, and facilitate evidence-based decision-making.

CONCLUSIONS

IKS represent a profound reservoir of local heritage wisdom, offering context-specific, nature-based solutions essential for addressing contemporary challenges. Research underscores that climate change is inherently complex, necessitating holistic, integrative, and participatory approaches. To effectively adapt and mitigate against climate change effects and imparts, it is imperative to align policy and legal frameworks across all levels. This alignment must incorporate both adaptation and climate mitigation strategies that actively integrate IKS. In order for this to take place there is need to research on the barriers hampering the process and to develop strategic methodologies to overcome the barriers leading to inclusive frameworks that incorporate IKS in climate change policies. These systems hold significant potential to provide innovative solutions to the ecological and socio-economic crises confronting our world today.

While some studies have explored the role of modern technologies in supporting IKS, there remains a substantial gap in research focused on the integration of IKS with scientific knowledge.

This integration is vital for fostering resilient communities and promoting sustainable ecological development.

By prioritizing this research, we can better harness the transformative power of IKS in our collective response to climate change.

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