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Is indigenous knowledge serving climate adaptation? Evidence from various African regions

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Summary

Motivation: Communities across the global south use their rich indigenous and local knowledge (ILK) to predict weather events and climate hazards. ILK may assist efforts to address climate change challenges in Africa. and make subsequent decisions regarding climate adaptation.

Purpose: The article documents evidence of the ILK's potential in reducing vulnerability to climate change and/or improving the resilience of communities. The study also reflects on major barriers that hinder the improved mainstreaming of ILK into adaptation strategies.

Methods and approach: The present study uses two main methods: a literature review and a presentation of case studies from a sample of African countries where ILK informs adaptation options, including indigenous land-tenure practices and weather prediction. The selected case studies highlight the historical legacy of ILK and its effectiveness in reducing vulnerability and the impacts of climate change.

Findings: The results indicate that, despite being acknowledged as a valuable resource for climate adaptation, current national adaptation policies on the African continent still show serious gaps in effectively integrating indigenous and local knowledge systems within the legal frameworks to reduce vulnerability.

Policy implications: ILK should be better integrated with modern climate change adaptation strategies to anticipate more effective responses. Both rural communities and relevant government agencies should complement the use of ILK with climate change strategies, so as to maximize its contribution to the effective implementation of climate change policies.

Keywords: adaptation, Africa, climate change, indigenous knowledge, local knowledge, weather forecasting

1 INTRODUCTION

Traditionally, African communities rely on indigenous and local knowledge (ILK) to anticipate or respond to climatic variability (Apraku et al., 2021; Donkor et al., 2017; Mafongoya et al., 2017; Silova et al., 2017; Zvobgo et al., 2022). The use of ILK in farming systems, including livestock management, is widespread across Africa, such as in early-warning systems (Jiri et al., 2015; Mapfumo et al., 2016; Soropa et al., 2016) or as indicators of the quality of the rainy season (Mengistu, 2011; Soropa et al., 2016). In Kenya, the flowering of coffee trees is an indication that the rainy season is near (Kangalawe et al., 2011), while the blossoming of peach trees in Botswana, South Africa, Tanzania and Zimbabwe is linked to the beginning of the rainy season (Kolawale et al., 2014; Mapfumo et al., 2016). Soil-fertility management is another area where ILK is used, whereby indigenous farmers classify soils according to their potential for crop production and crop yield (Osbahr & Allan, 2003). For many decades, ILK land-management practices have also been shown to conserve carbon in soils (Osunde, 1994; Schafer, 1989).

There is a growing interest in documenting ILK for its intrinsic heritage value and its practical use in potentially supporting relevant and locally acceptable climate change adaptation (Audefroy et al., 2017; Leal Filho et al., 2021a,b; Mugambiwa, 2018). Though a great deal of empirical research has been devoted to ILK, this type of knowledge has not yet been adequately articulated in adaptation and mitigation planning, especially in the global south (Ajani et al., 2013; Donkor et al., 2019; Ford et al., 2016; Leal Filho et al., 2021c; Zvobgo et al., 2022). The main criticism of indigenous and local knowledge is in its locally specific influence, endemic to a social group, which may limit its scalability (Apraku et al., 2021). ILK is also predominantly preserved in the memories of elders and is handed down orally to the following generation (Battiste, 2007), but the intergenerational transmission of knowledge is currently under threat, particularly due to urbanization and the perceived declining reliability of ILK by the younger population (Fernández-Llamazares et al., 2015, Rankoana, 2022). The literature also points to some barriers that constrain the deployment of ILK in support of climate change adaptation. The validation of ILK is considered a major barrier due to its patterns that differ from scholarly theoretical and methodological approaches. For example, indigenous and local systems are often embedded in tacit knowledge, i.e. oral recitations, songs, dances, hunting or farming practices, etc. (Brondízio et al., 2021; Ohajunwa and Mji, 2018).

Because of these limitations, *modern* knowledge systems are often considered to be far more reliable. The challenge to ILK is in its preservation and transmission, together with a demonstration of its effectiveness. At the same time, the knowledge deficit on climate risk is compounded by the limited capacity of modern knowledge systems to capture the local context and community values and aspirations (Ford et al., 2016a). This poor articulation of local needs and expectations hinders the increased use of seemingly adequate scientific-led technologies (Kebebe et al., 2015). The tension between the two knowledge systems suggests the need for climate strategies to combine, in a balanced way, both traditional and modern knowledge, particularly where they complement each other.

The impacts of climate change on local communities go beyond immediate threats to food supply, for which there is evidence that climate change has reduced total agricultural productivity growth in Africa by 34% since 1961, more than in any other region (Ortiz-Bobea et al., 2021). Climate change also affects water availability (Biao, 2017; Descroix et al., 2018; Thompson et al., 2017), health (Agusto et al., 2015; Beck-Johnson et al., 2017), and human settlements, which are particularly exposed to floods, droughts, and heat waves (Douglas, 2017; Kundzewicz et al., 2014). Acknowledging the value of ILK for a better-integrated adaptation to climatic risks, especially in regions that rely on rain-fed agriculture, may contribute to the overall goal of sustainable climate adaptation (Sustainable Development Goal (SDG) 13). With the sixth assessment of the Intergovernmental Panel on Climate Change (IPCC), there is already an attempt to articulate the complementarity between ILK and scientific knowledge (Leal Filho et al., 2022), whereas previous assessment reports have largely excluded ILK because of a lack of empirical evidence to demonstrate acceptable levels of validity (Clarence et al., 2011).

The overlapping concepts of “local” and “indigenous” knowledge have been used interchangeably in the literature. Indigenous knowledge (IK) is embedded in specific systems of cultural meanings or restricted to a particular geographic location (Mistry, 2009). Rÿser (2011) defined IK “*as the knowledge that an Indigenous (local) community accumulates over generations of living in a particular environment*.” Darr and Mears (2017) speak of local knowledge as being deeply rooted in a specific social context based on practical experience. Integrating both terms, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) suggests that local indigenous knowledge refers to the understandings, skills, and philosophies developed by societies with long histories of interaction with their natural surroundings (Adger, 2014; IPCC, 2019; UNESCO, 2017). In this article, and in line with IPCC terminology, the combined terms are termed ILK and are used interchangeably due to the long history of local knowledge in the case studies identified, where in contrast to other regions of the world, it is generally challenging to disaggregate local knowledge from indigenous knowledge.

This article focuses on case studies across Africa where the deployment of ILK is linked to reductions in poverty or vulnerability to climate change, and it reflects on the overall outcomes for climate change adaptation. It documents evidence of the ILK’s potential in reducing vulnerability to climate change and/or improving the resilience of communities. The study also reflects on major barriers that hinder the improved mainstreaming of ILK into adaptation strategies and suggest some measures to protect indigenous peoples’ interests and stop “side-lining and marginalising ILK as negligible or insignificant” (Leal Filho et al., 2021b).

2 METHODOLOGY

There is a perceived need for studies aiming to identify how ILK may assist efforts to address climate change challenges in Africa. But in order to succeed, research should not only identify current trends, but also establish a framework that allows lessons to be learned. Consistent with this approach, this article deploys two approaches, namely (i) a literature review; and (ii) case studies for weather-forecasting analysis. Combined, these two approaches cater for a greater understanding of how ILK is being used in support of climate change adaptation.

2.1 Literature review

An analysis of the literature was undertaken to capture insights on ILK, based on selected academic literature published in peer-reviewed journals. There was no time limit for the selection of the publications. This choice was made purposely to increase the chances of including all relevant literature. The selection of the cases was guided by the following research questions: (1) What knowledge do community members use to address climate challenges? (2) What is the rationale of ILK? and (3) How effective is this knowledge in predicting and coping with climate risk?

The journal articles were identified through Web of Science and Scopus. Topic=(local OR indigenous OR traditional AND knowledg* AND adapt* AND Africa AND Sector)

AFRICA – afric* OR algeria OR angola OR benin OR botswana OR "burkina faso" OR burundi OR "cabo verde" OR cameroon OR "central african republic" OR chad OR congo OR "democratic republic of congo" OR "cote d'ivoire" OR djibouti OR egypt OR "equatorial guinea" OR eritrea OR eswatini OR ethiopia OR gabon OR gambia OR ghana OR guinea OR guinea-bissau OR kenya OR lesotho OR liberia OR libya OR malawi OR mali OR mauritania OR morocco OR mozambique OR namibia OR niger OR nigeria OR rwanda OR senegal OR "sahrawi arab democratic republic" OR "sierra leone" OR somalia OR "south africa" OR "south sudan" OR sudan OR tanzania OR togo OR tunisia OR uganda OR zambia OR zimbabwe

Sector = agricultur* OR "water resource" OR forest* OR energy OR "human health".

Only empirical articles published in English that focused on ILK use to serve human responses to climate challenges were considered. Publications in other major languages used across the continent (i.e. Arabic, French, and Portuguese) were not included in this assessment. In addition, review articles and more theoretically grounded publications were also excluded. The review yielded 924 publications, from which 557 were excluded as their scope did not match the inclusion criteria, and 367 were considered for further ILK analysis.

2.2. ILK case studies for weather forecasting

Case studies that assessed the reliance of ILK forecasts or that indicated the climate indices or hazard forecasts were prioritized. The cases were also selected based on the ILK-related adaptation response type that contributed to one of the following: i) poverty reduction; ii) improvement in the livelihoods of the indigenous groups and communities; or iii) evidence of risk reduction, either directly or perceived by the authors. Ten case studies that fit the above criteria were selected for analysis (see Table 1).

3 RESULTS—ILK FOR CLIMATE ADAPTATION

Table 1 also summarizes the actual ILK adaptation types and responses as identified in the study. It demonstrates how African communities use ILK to predict weather and climate hazards and points out the role of these predictions in decision-making that is key for climate adaptation. It also provides some quantified insights that smallholders rely widely on ILK for farming-related decisions, e.g. timing of planting, seed varieties, water and pasture storage, preservation of food and seeds, relocations, and holiday and event planning. Overall, the cases illustrate a wide variety of adaptive practices used by farmers, fisherfolk, and communities. The sample also shows a specific geographical focus on countries in West and Southern Africa.

Concerning shorter-term predictions linked with climate variability, as illustrated by Table 1, ILK of the natural environment has proven helpful for farmers and pastoralists as early-warning and alert signs. Even so, the evidence of effectiveness is not generalizable across all geographic areas or indicators. In sub-Saharan Africa, established forms of ILK include observations of and inferences drawn from animal behaviour, cloud type and cover, or specific vegetation phenomena. The early-warning, alert signs, or indicators have been useful in specific contexts for predicting weather conditions and/or climatic impacts, including the onset of rains, rainfall yield (high or low amount of rainfall), and drought. Yet indigenous and local predictions can be in disagreement, as shown in Kenya, where Borana herders' predictions varied (Ayal et al., 2015). For the Borana herders, intestine reading, followed by animal body language and plant body language have been perceived as reliable and acceptable prediction methods, but the accuracy of indigenous weather forecasting appears to have reduced now and then, due to recent natural and social developments affecting Borana ILK holders, e.g. loss of specific trees relevant for forecasting, absence of documentation, dwindling oral transmission, or the influence of alcoholism, modern education, and Christianity, leading to increased mismatches between ILK-based forecasts and reality and the declining popularity of ILK weather forecasting (Ayal et al., 2015).

The rather high usage and acceptance of ILK, however, at least for weather prediction, might also be explained by a lack of access to science-based weather information or time-delayed dissemination of such forecasts. For example, in Borana, Ethiopia, ILK weather forecasting was the main source of weather-related information used by 97% of the farmers and pastoralists. The complementarity of indigenous and modern sources of climate-related information is a challenge. This is illustrated by the preference of 68% of farmers in Lushoto, Tanzania, who mostly rely on indigenous sources for farming decisions (Radeny et al., 2019). The same study showed that access to science-based forecasts reduced the use of ILK forecasts, such as in Uganda, where no farmers used ILK due to better access to radio weather forecast data (Radeny et al., 2019). In contrast, in Kalify, Kenya, the adoption of ILK forecasts was still high despite most smallholders having access to weather forecasts. However, those farmers still perceived a lack of accuracy of such radio forecasts, which reduced trust in this information source (Mwaniki & Stevenson, 2017).

Concerning longer-term predictions linked with climate change and its impacts, the majority of the ILK forecasts in the case studies (see Table 1) predicted the onset of rains, season quality and length, but only a few offered long-term climate hazard predictions (e.g. for Zimbabwe Jiri et al., 2015; for Ethiopia, Tanzania and Uganda Radeny et al., 2019). In most cases, it may be expected that ILK will continue to be used predominantly to predict the onset of rains and particular weather events like storms, which are short-term predictions to address climate variability, but it remains unclear if these indicators are contributing to long-term climate predictions beyond seasonal forecasts.

Complementing Table 1, Table 2 summarizes the distinctive benefits of ILK and related practices in local climate change adaptation strategies, underscoring the value and importance of securing these knowledge systems for vulnerability reduction, poverty alleviation and sustained local livelihoods.

Table 1.

Common indicators used by communities and smallholder farmers for weather and climate hazard prediction informed by indigenous and local knowledge possessed across Africa

No.	Indicator category	Indicator type	Weather/ Climate Hazard	Economic activity	Region/ Country	Implications on adaptation	Primary focus of adaptation action	Relevance/ Reliance	Source
1	Flora; Fauna	Animal behaviour, e.g. cattle, wild animals and insects; Reading of local plant body languages	Short-term weather, prediction, onset rains, season quality, droughts	Pastoral	Borena, Ethiopia	Pastoralists and agro-pastoralists adjust their farm decisions and save pasture and water if drought is predicted.	Vulnerability reduction, risk reduction and cost-efficient management	96% of respondents	(Ayal et al., 2015)
2	Weather/ Meteorological; Fauna; Fauna, Astrological	Cloud type and cover, direction and strength of wind, very high night temperatures. Animal behaviour included birds, insects, and some large animals. Flowering of specific trees as indicative of the onset of the rainy season. Interpreting alignment of the moon and stars, size and appearance of the star, and appearance and form of cloud cover.	Seasonal quality forecasting, onset rains, particular storms, long-term forecasting	Smallholder farming, pastoral	Borana (Ethiopia), Lushoto (Tanzania) and Hoima and Rakai (Uganda)	Use IK forecast to plan agricultural calendar among the planting dates, possible seed variety based on predicted season length and quality.	Poverty reduction through risk diversification	In Borana, Ethiopia, IK weather forecasting is the main source of weather information (97%), in Lushoto, Tanzania 68% use IK forecasts.	(Radeny et al., 2019)

3	Flora; Fauna; Astrological	Fruit-tree production, behaviour of birds and insects.	Long- and short-term rainfall predictions; onset rain, drought.	Smallholder farmers	Chiredzi, Zimbabwe	Farmers adopted different strategies in crop, field and farm management practices to cope.	Vulnerability reduction through risk diversification		(Jiri et al., 2015)
4	Fauna; Flora; Astrological	Animal behaviour – the behaviour of ducks and cows. Tree behaviour - mango and tamarind trees flowering, new leaves for Baobab tree. Dark clouds and wind speed and direction to predict the onset of the rains.	Storms, onset of the rainy season.	Smallholder farmers	Kilifi, Kenya	Make key planting dates for various crops.	Vulnerability and risk reduction through foresight planning	62% of the farmers rely on IK forecasting	(Mwaniki & Stevenson, 2017)
5	Weather/ Meteorological; Fauna; Fauna; Astrological	Constellation of stars, animal behaviour, cloud cover and type, blossoming of certain indigenous trees, appearance and disappearance of reptiles, to migration of bird species.	Storms, season quality, droughts, onset of rain, cessation of rainfall	Smallholder farmers	Free-State, South Africa	Farmers use the predictions to prepare land, choose seed variety types (drought-tolerant if poor rainy season is predicted, and long-term variants if predicting good season), plan sowing dates and the overall agricultural calendar.	Vulnerability and risk reduction through foresight planning and effective management		(Zuma-Netshiukhwi et al., 2013)

6	Fauna; Fauna	Army of locusts moving in the same direction indicates a looming drought, animal behaviour – snakes moving same direction, bees flying one direction, much noise from frogs in the afternoon – all indicate drought is coming; horse playfully jumps and butterflies fly together means good rainy season.	Drought, season quality	Smallholder farmers, communities	Eastern Cape, South Africa	Using IK drought predictions, farmers and communities preserve food in advance and seeds for the next season.	Poverty reduction through effective foresight planning	64.4% relied on indigenous knowledge in their farming practice and drought risk reduction	(Muyambo et al., 2017)
7	Weather/ Meteorological; Fauna; Fauna	Appearance of butterflies, acacia roots shooting depicts the end of growing season, decline in wind speed means end of rainy season, tree flowing (*dombeya rotundifolia*) indicates time for planting.	Onset rains, lowland flooding, storms, cessation of rainy season	Local communities, smallholder farmers	Sinazongwa, Zambia	Locals use IK flood predictions to move people and personal belongings to the upland areas prior to flooding. Use IK onset of rainy season to plan timing of planting.	Vulnerability and risk reduction through effective management		(Kanno et al., 2013)
8	Flora; Fauna; Astrological	Lunar observation – approaching full moon signifies approaching ocean flooding, cloud study – thick dark clouds signify approaching heavy rain, behaviour of aquatic animals – migration pattern of a crab species signifies freshwater flooding.	Flooding	Coastal fisheries	Coastal communities in Nigeria	Through IK flood forecasts, holidays for school children are issued, markets are closed, fishermen are cautioned	Vulnerability and risk reduction through effective management		(Fabiyi and Oloukoi, 2013)

9	Weather/ Meteorological; Fauna; Fauna.	Moon appearance and position, star quantity and appearance, air temperature, wind direction, and animal behaviour to predict short-term traditional drought.	Drought, rainy season start and quality and storms	Smallholder farmers	Gaza, Mozambique	Used the predictions to make farm-related decisions, such as the type of crops to plant each season, when to start planting and precautionary measures to take to avoid losses or prevent hardship	Vulnerability and risk reduction through foresight planning and effective management	92% of the farmers rely on IK predictions	(Salite, 2019)
10	Fauna; Fauna, Weather/ Meteorological	Use phenology of vegetation - –appearance of new leaves and flowers, observe baobab trees, appearance of certain insects and butterflies. Observe the behaviour of birds, domestic birds – ducks and ducklings. Cloud type and cover, air temperature (cool air temperature).	Rain onset, storms	Local communities, smallholder farmers	Yendi, Ghana	IK predictions enabled farmers to prepare their lands for crop cultivation to feed themselves and sell part of the farm produce to earn income	Poverty reduction through effective operations and income generation	40.8% reported using IK predictions. 55% of them ranked IK forecast as the most reliable method, 25% reported IK as reliable. Overall, 80% rely on LIK forecasts.	(Adanu et al., 2021)

Notes: The relevance or reliability is as attributed by authors in the articles, which in some cases are based on the comparison of farmers' indigenous knowledge prediction type to the observed/scientific predictions.

Table 2.

Benefits of ILK knowledge/practices in climate change adaptation strategies

Consequence of Climate change	Climate change adaptation ILK knowledge/practice	Role/benefits of ILK
Increased climate extremes, e.g. flood, drought, heat stress	Indigenous weather forecasting using biotic and abiotic indicators	Help to adjust crop-planning date, pasture, and water management
	Changing crop-planning date, use early-maturing crop variety	Reduce crop failure
Aggravation of erosion	Re-terracing of collapsed slopes, changes in land use to match slope stability. Fallowing, re-seeding, trench, bench terracing, vegetative barriers, rainwater harvesting, check dam, tree plantation, contour ploughing	Reduce the velocity of runoff, facilitate runoff percolation and increase soil moisture
Reduced availability of pasture	Rotation grazing, hay making, temporary migration with their herds	Reduce death of livestock
	Using emergency fodder in droughts (jackfruit leaves, sugarcane tops, banana stems, water hyacinth, etc.)	Increases population of livestock during difficult periods, reduces drought risk on livestock
Water scarcity + pollution	Rainwater harvesting, digging walls	Used for domestic purpose and livestock in bad times
	Water management	Effective use of water resources, social justice through socially accepted allocation criteria
	Micro irrigation to augment shortfall in rain	Stimulate soil and water conservation through integrated watershed management
Aggravated livestock + crop diseases and pests	Use traditional medicines and treatments, sell aged and less productive livestock, shift to disease-tolerant crop variety and livestock species	Reduce livestock death, crop failure, and increase production
Decreased crop yield	Crop diversification, rely on drought and flood-tolerant crop variety	Increase production and reduce crop failure

	Micro cropping, crop rotation	Farmers maximize land use while reducing the risks associated with single crop failure
	Cultivation of varieties adapted to the depth of flooding	Boost the productive capacity of the soil; enhance food security during climate-induced flooding, cultivation of multi-purpose crops
	Raised field agriculture	Help crops cope with unpredictable weather patterns
	Mulching/cover cropping	Reduced soil loss, improves water-holding capacity of soil, reduces soil erosion, reduced evapotranspiration
	Manure	Improve soil fertility and soil moisture
	Planting deeper than usual	Ensure crop survival, enhance food availability
	Planting ahead of rains	Ensure crop survival, reduce the risk of crop failure, enhance food availability
	Intensive manure application	Improve soil fertility, increase food availability
Food insecurity + malnutrition	Local climate forecasts (e.g. Krishi Panchang)	Boost farm productivity during extreme events
	Postponed festival, marriage ceremony, change their eating habit	Help to save food items and money
	Seasonal migration	Increase household income and ensure food security
	Multi-species composition of herds to survive extremes	Reduces drought risk on livestock, increase food availability
	Culling of weak livestock for food during drought	Reduce loss of livestock, reduce drought risk on livestock.
Soil erosion + desertification	Re-terracing of collapsed slopes, changes in land use to match slope stability	Enhance soil conservation by controlling water runoff and promoting slope stability
	Agroforestry: Planting of particular species of trees and other agricultural crops, vegetables	Control soil erosion, preservation of patches of forests, food availability, carbon sequestration, reforestation, reducing vulnerability to flash floods

	Mixed land use, Crop rotation	Conserve land cover and preserve the productive capacity of the soil, minimize pests and diseases, reduce chemical use, and erosion
Environmental degradation + desertification	Land-use change, cover with economically valuable and environmentally friendly trees	Improve the ecosystem services and hence, income of the community and individuals

Adapted from: Nadeem et al. (2009); Nyong et al., (2007); Pandey et al. (2003); Patel, (2007); Rivera-Ferre, et al. (2013); (UNPFII, 2007).

4 DISCUSSION

In Africa, indigenous and local knowledge is mostly used to enhance agricultural productivity, food security, livelihoods and to provide income to reduce vulnerability and alleviate poverty. However, most of the adaptation options in the case studies are incremental responses to climatic changes (such as improving planting schedules, switching to other seeds, and preventive measures) with some potential to cause future maladaptation. For example, wetland cultivation by indigenous and local people results in the disappearance of wetlands, including all the associated biodiversity they support (Kingsford et al., 2016; Menbere & Menbere, 2018).

Drawing partly from the case studies assessed, Table 2 highlights the roles and benefits of ILK and the practices for not only incremental climate change adaptation but also for securing local livelihoods, for example, through diversifying agricultural production, farming income, and even migration. However, culture lock-ins can have maladaptive outcomes where ILK adaptation type and practices are not reducing the climate risk (Antwi-Agyei et al., 2018).

Furthermore, ILK-based adaptation practices are difficult to upscale due to inherent cultural and geographical boundaries (Crate et al., 2017; Everard et al., 2019; Martinez-Levasseur et al., 2017). Thus, ILK's contribution to transformative adaptation—by definition a fundamental, systemic change—has been limited. Transformative adaptation recognizes the importance for departures from business-as-usual approaches to more systematic responses to climate change and management of unavoidable climate risks (Termeer & Biesbroek, 2017; Wilson et al., 2020). The concept of intentional transformative adaptation (ITA) (Coloff et al., 2021) suggests an opportunity for ILK to be integrated into overall adaptation efforts. Integrating ILK may be helpful in supporting superordinate transformative action by empowering local communities and facilitating community buy-in, which is important in raising the acceptability of specific climate change adaptation procedures (Austin et al., 2017; Filho et al., 2022; McGregor et al., 2014).

ILK is widely recognized by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the Convention on Biological Diversity (CBD) as a valuable resource for adaptation processes, particularly for ecosystem-based adaptation (Ford et al., 2016; Nalau et al., 2018; UNFCCC, 2013). Despite this recognition, the need for improved integration of ILK and scientific knowledge, also termed “bridging knowledge systems” (Tengö et al., 2017), in science–policy processes is still limited (Diver, 2017; Tengö et al., 2014; Tengö et al., 2017).

Table 3 offers an overview of how current National Adaptation Plans (NAPs) in the ten assessed case-study countries have currently integrated and dealt with ILK. It is seen that many NAPs recognize the need to integrate ILK and explicitly list this in the official documents. However, it is unclear how this is translated into concrete projects and initiatives on the ground. Here, more research is needed.

Table 3.

Overview of existing National Adaptation Plans (NAPs) mentioning ILK in the 10 African case-study countries

Country	**NAP Key Focus**	**ILK reference**	**Source**
Ethiopia	Integrate currently disparate sectoral and regional adaptation initiatives in order to mainstream climate change adaptation holistically within Ethiopia's long-term development path. Mainstream and institutionalize the implementation of climate change adaptation in the country's development governance structures to ensure continuity and consistency of pragmatic efforts, and by strengthening the institutional memory. Mobilize resources from public and private climate finance sources and from both domestic and international sources to enable the country to implement its climate change adaptation initiatives and to develop appropriate technical, material and expert capacities. Establish resilient systems that can withstand disasters and risks imposed by climate change through building collaborative partnerships among the relevant stakeholders and enhancing the thematic integration among different development sectors.	Enhancing research and development of traditional ecological knowledge (TEK) systems, such as local climate change adaptation practices, skills, and institutions.	Ethiopia pp. 26, 28, 62,
Tanzania	Build the capacity of Tanzania to adapt to climate change impacts. Enhance resilience of ecosystems to the challenges posed by climate change. Enable accessibility and utilization of the available climate change opportunities through implementation. Enhance participation in climate change mitigation activities that lead to sustainable development. Enhance public awareness on climate change. Enhance information management on climate change. Put in place a better institutional arrangement to adequately address climate change. Mobilize resources including finance to adequately address climate change	Promoting effective documentation of indigenous knowledge on climate change adaptation and mitigation in diverse sectors. Promoting appropriate indigenous knowledge practices.	Tanzania pp. x, 57, 68, 69, 71,
Uganda	--------------------------------		

Zimbabwe NAP process on-going, NAP roadmap document published)	Strengthening the role of private sector in adaptation planning. Enhancing the capacity of government to develop bankable projects through trainings. Improving management of background climate information to inform climate change planning. Crafting a proactive resource-mobilization strategy for identifying and applying for international climate finance as requests for funds are primarily reactive at present, focusing on emergency relief rather than climate change risk reduction, preparedness, and adaptation. Developing a co-ordinated monitoring and evaluation policy for programmes and projects, as many institutions within the government currently lack a systematic approach to monitoring and evaluation.	Findings to be based on and guided by the best available science and, as appropriate, traditional and Indigenous knowledge.	Zimbabwe pp. 7,
Kenya	Highlight the importance of adaptation and resilience-building actions in development. Integrate climate change adaptation into national and county-level development planning and budgeting processes. Enhance the resilience of public and private sector investment in the national transformation, economic and social and pillars of Vision 2030 to climate shocks. Enhance synergies between adaptation and mitigation actions in order to attain a low-carbon climate-resilient economy. Enhance resilience of vulnerable populations to climate shocks through adaptation and disaster risk reduction (DRR) strategies.	Mostly IK Via academia and research institutions Public Benefit Organizations information and communication technologies (ICT) sector.	Kenya_NAP pp. 13, 31, 37, 38,

South Africa	Reduce human, economic, environmental, physical and ecological infrastructure vulnerability and build adaptive capacity. Develop a co-ordinated Climate Services system that provides climate products and services for key climate-vulnerable sectors and geographic areas. Develop a vulnerability and resilience methodology framework that integrates biophysical and socio-economic aspects of vulnerability and resilience. Facilitate mainstreaming of adaptation responses into sectoral planning and implementation. Promote research application, technology development, transfer, and adoption to support planning and implementation. Build the necessary capacity and awareness for climate change responses. Establish effective governance and legislative processes to integrate climate change in development planning. Enable substantial flows of climate change adaptation finance from various sources. Develop and implement an M&E system that tracks implementation of adaptation actions and their effectiveness.	Based on best available science on observed climate and projected climate changes as well as relevant traditional knowledge on climate impacts and potential responses. Invest in knowledge. Severe Weather Warning System (SWWS) integrates risk knowledge. Develop and implement an effective communication and outreach programme.	South-Africa pp. 16, 21, 33, 47, 84
Zambia (NAP process on-going – to be completed in Q1/2023)	Strengthen institutional co-ordination and collaboration for adaptation planning in Zambia. Establish a system of integrating climate change adaptation in plans and budgets. Develop an overarching national plan that prioritizes medium- to long-term high-level adaptation actions for key economic sectors affected by climate change. Strengthen the capacity for implementing the NAP. Develop a strategy for mobilizing financial and other resources for NAP implementation in Zambia.		Zambia
Nigeria	Reduce vulnerability to the impacts of climate change by building adaptive capacity and resilience. Facilitate the integration of climate change adaptation, in a coherent manner, into relevant new and existing policies, programmes, and activities, in particular development planning processes and strategies, within all relevant sectors and at different levels, as appropriate.	Guided by the best available science indigenous knowledge networks.	Nigeria pp. 15, 21, 33,

.Mozambique	Mozambique becomes resilient to the impacts of climate change, reducing to a minimum the climate risks to people and property, restoring and ensuring the rational use and the protection of the natural and physical capitals. Identify and make use of the opportunities to reduce greenhouse gas (GHG) emissions that simultaneously contribute to the sustainable use of the natural world and the access to financial and technological resources at affordable prices and the reduction of the pollution and the environmental degradation, promoting low-carbon development. Build the institutional and human capacity as well as explore opportunities to access technological and financial resources to implement the NCCAMS.	Local knowledge must be used and integrated, for example, in water purification. Transmit local knowledge on observed weather phenomena and mechanisms for adapting to extreme weather events. Facilitate the interaction between scientific and local knowledge about climate change. Systematize and document scientific, technical and local climate change knowledge.	Mozambique pp. 30, 45
Ghana	Articulation of the country's vision of climate change adaptation, its adaptation objectives and principles, the roles played by stakeholders within the national government, and priority adaptation actions to be undertaken. It will also provide a reference point for bringing together various adaptation planning efforts from different sectors, sub-national structures and scales of decision-making. Align the NAP process with existing policies, strategies and adaptation research. Identify specific themes that are particularly relevant and/or unique to the country context. Serve as a basis for stakeholder engagement.	Traditional or indigenous knowledge to cope with the adverse impacts of climate change. Important to document indigenous knowledge into early-warning systems and research.	Ghana pp. 14

Source: Authors' compilation.

A matter that remains unclear is how the integration of ILK into transformative forms or national adaptation planning can happen in practice. To effectively bridge knowledge systems, Nalau et al. (2014) both highlighted and criticized an inherent bias of adaptation that needs to be dissolved: current models of ILK integration as well as scientific knowledge scrutinize neither Western thinking nor the current notions of development or adaptation options. Tschakert et al. (2016, p. 24) highlighted the limitations of this kind of thinking "[...] *purely scholarly driven research design would not have allowed us to appreciate the central importance of creative and co-produced learning environments over more rigorous research design, analysis, and evaluation which, while allowing for certain types of learning opportunities, block others*." Indigenous communities may, in turn, perceive the integration of knowledge systems as a different kind of colonization (Nalau et al., 2014). There are ways and means to overcome such barriers and go beyond local, place-based impacts, as highlighted in Tengö et al.'s (2017) review. Two key aspects are:

- Engagement of knowledge carriers and institutions: adaptation involving ILK represents a collaborative, iterative, and inclusive process in which everyone participating has stakes in decision-making, although participation does not guarantee, in and of itself, that ILK is adequately and appropriately built into adaptation (UNFCCC, 2013, p. 4). Moreover, collaboration is likely to fail if the relationship among the involved actors is not based on trust, if power asymmetries exist, marginalized groups are overlooked, and if it does not follow cultural, ethical, and legal protocols (Nalau et al., 2014; Tengö et al., 2014; Thomas et al., 2019).
- Building trust and communication: Local knowledge is generally context-specific and manifests differently across place and time, so ILK may be contradictory to scientific and technological understandings of universal knowledge and development (Klenk et al., 2017). According to Tengö et al. (2014), the difference in understanding of ILK, i.e. differing worldviews and experiences, can be a potential source of disagreement. Language and literacy may also represent barriers for understanding and participation (UNFCCC, 2013).

There is a growing consensus among climate scholars and development practitioners that research on climate change adaptation should not only rely on "Western" knowledge alone, and the engagement of diverse knowledge systems is crucial for effective and context-specific climate adaptation planning (Ban et al., 2017; ; Mantyka-Pringle et al., 2017; Trippl et al., 2018). If there is a common agreement regarding the benefits of integrating ILK into formal climate change adaptation strategies, there is, however, relatively limited empirical evidence portraying how it can take place in practice. From our perspective, this paradigm shift would require a range of actions, and we outline three shifts that could help to transform climate research approaches to be more inclusive.

First, a change of the programmatic mindset that guides most scientific work is required. Scientists only trust evidence generated through a “rigorous” Western science-based protocol with statistically analysed data that demonstrate acceptable levels of reliability and validity (Tranfield et al., 2003). This mental shift would create space for the decolonization of climate science that is heavily guided by colonial legacies such as languages and approaches (Liboiron, 2021; Schipper et al., 2021, Trisos et al., 2021). The change would also allow scientists to reconsider what “science” means and what can be labelled as scientific outcomes. Climate research is exclusionary, framed by Western science-based approaches, and though traditional knowledge does follow the same path, this knowledge system is grounded on careful observation of environmental changes that indigenous communities have relied on for many decades to cope with climate challenges (Ankrah et al., 2021; Hosen et al., 2019; Liboiron, 2021).

Second, limited funding flows to climate research in general, and more specifically to local knowledge evidence in the global south, is a major barrier. A recent study on thematic prioritization of funding for climate-change research in Africa shows that while institutions from the global north—principally Europe and North America—received 78% of funding for climate research, African institutions received only 14.5% (Overland et al., 2021). Most local and indigenous knowledge is generated in the global south—Africa, Latin America and Asia (David-Chavez & Gavin, 2018), and this funding discrepancy means that climate-related local knowledge is not fully captured in climate research to create space for the integration. This suggests that funding bodies need to set more dedicated allocations for documenting the practical integration of local knowledge. Tengö et al. (2017) call for substantial investments of both time and funds to support knowledge-holders and institutions, underscoring the large efforts needed to properly consider the diverse contexts in which ILK exists.

Finally, the integration of local knowledge/indigenous knowledge and scientific knowledge should not just be seen as a combination of the two knowledge systems. The integration should be part of a more elaborated co-production process where climate scholars and local/indigenous communities interact effectively and are interested in questioning how local knowledge resonates in the scientific framing or vice-versa (Abu et al., 2020). It is about co-generation of knowledge, not a category of stakeholder, often researchers, pretending to know enough about local needs and aspirations to be able to offer solutions that are sufficiently finished to require little or no subsequent local adaptation (Chilisa, 2017). This co-operation calls for an ethical shift, humility from both “scientists” and local communities for mutual learning with no “asymmetry of power” that gives one group more power over the direction that the co-operation takes (Kant & Norman, 2019; Liboiron, 2021). Here we challenge climate research to be more flexible with regard to its approach that should not only be grounded in the Western perspective of “science.”

5 CONCLUSIONS AND LESSONS LEARNED

This article has provided an overview of the role and extent to which ILK has been deployed in support of climate change adaptation strategies. The evidence gathered here suggests that, in different contexts, this knowledge can serve the purposes of using previous experience as a tool to address particular events.

Whereas it is not new in the field of social sciences (Audefroy & Sanchez, 2017), ILK is seen to have some specific features. First, ILK is often neither rigid nor static, but it is dynamically shaped by external influences and socio-cultural transformation (Theodory, 2016). Second, it can be applied in various contexts related to climate change adaptation (Galloway & McLean, 2010; Green & Raygorodetsky, 2010; Naess, 2013), most especially in relation to extreme climate events. One of the major events that drew the attention of scientists (Orlove et al., 2010) to the issue of the relevance of ILK in relation to extreme events was that of the 2004 tsunami in the Indian Ocean. It was reported that those living in local communities drew on it to deal with the aftermath of the disaster (Hiwasaki et al., 2014).

At present, many scholars are beginning to pay more serious attention to the issue of ILK. Article 7.5 of the Paris Agreement also gave credence to the vital role of integrating local and indigenous knowledge in understanding climate change and developing relevant actions for adaptation (LINKS, 2018). The UN Sustainable Development Goals (SDGs) also emphasize the role of ILK as a cross-cutting issue, which may help in achieving the SDGs, especially in respect of addressing poverty (Leal Filho et al., 2021). For instance, fisherfolk are known to be able to forecast imminent extreme events such as hurricanes, floods, or tsunami by observing winds, clouds, the colour of the sky, and the movement of birds and animals (Audefroy & Sánchez, 2017). Several other indigenous practices have been used in adapting to the impacts of climate change, as outlined in this article.

This study has some limitations. The first is that its scope is limited to certain ILK practices used in Africa and did not consider issues relevant to other geographical regions. Second, the research was limited to a review of the literature combined with case studies and exchanges with a limited set of specialists. But despite these limitations, the study provides a valuable contribution to the literature since it illustrates how ILK is being used across a number of communities in western, eastern and southern Africa. Also, the case-study approach used serves the purpose of illustrating some specific features related to the extent to which ILK is being used across a number of countries, many of which are not often included in previous studies.
One lesson from the article is that there need to be greater efforts to better integrate ILK with modern climate change adaptation strategies. By doing so, more effective responses can be anticipated. In addition, in order to yield the expected benefits, ILK should be compatible with the socio-cultural context of the community where it is used, since local circumstances among them may vary. Finally, there is a need to build the capacity of both rural communities and relevant government agencies to complement

the use of ILK with climate change strategies, so as to maximize its contribution to the effective implementation of climate change policies.

AUTHOR CONTRIBUTION STATEMENT

Walter Leal Filho: Conceptualization, writing - contribution to conclusions, final editing.

Franziska Wolf: Conceptualization - conceptual revision, writing - contributions to results, discussion, conclusions, editing and final editing of all parts, corresponding author.

Edmond Totin: Conceptualization - conceptual revision, writing - contributions to introduction, results, discussion, conclusions, editing and final editing of all parts.

Luckson Zvobgo: Writing - contributions to introduction, methodology, interpretation and final editing of case studies, final editing.

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DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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