IJERLAS
International Journal of Educational Review, Law And Social Sciences

BUILDING CLIMATE CHANGE ADAPTABILITY THROUGH INTEGRATING INDIGENOUS AND SCIENTIFIC KNOWLEDGE SYSTEMS IN LESOTHO

Alouis Chilunjika
University of Johannesburg, Department of Public Management, Governance, and Public Policy.
Corresponding Email: chilunjika@gmail.com.

Abstract

Climate change as a human security threat has weakened the ability of states to deal with severe weather patterns, droughts, land degradation, flooding, and other climate-related changes. This has significantly affected poor communities in developing countries as they are prone to low precipitation, high temperatures, and high poverty levels. In light of this, communities in Lesotho have for generations been adapting to climate induced hazards and risks by developing situation specific livelihood practices and building resilience of their households and communities. Nonetheless, in recent years, the increasing intensity and frequencies of climate extremes have revealed the limitations of indigenous and local knowledge in dealing with the scourge of climate change. As such, the need for the integration of indigenous and scientific knowledge systems in coping with and adapting to climate change. The study being qualitative in nature relied on the extensive review of purposively selected written sources which include journal articles, books, book chapters, Government publications, newspapers, magazines as well as a Key Informant interview to collect data which was analysed using thematic and content analysis techniques. The study established that, integrating traditional and scientific knowledge systems in dealing with climate change vulnerability and impacts in Lesotho is critical for policy makers to develop multi-level, multi-dimensional, multi-hazard and multi-disciplinary adaptation and resilience-building strategies and solutions that are sustainable, cost-effective and participatory. The integration of the scientific and indigenous knowledge and practices will help in proactively identifying current and future risks and hazards thus enabling the better implementation of climate-change policies in Lesotho.

Keywords: ***Climate change, climate adaptability, resilience, Indigenous knowledge systems, Scientific knowledge systems, Lesotho.***

1. INTRODUCTION

Pandey (2019) argues that climate change was identified under the 13th Sustainable Development Goal (SDG) as one of the chief challenges of our time that is highly likely to hinder the attainment of sustainable development in the world. Similarly, SDG 13 seeks to urgently abate the adverse impacts of climate change on the lives and livelihoods of all people. In light of this, Chilunjika and Gumede (2021:13) argued that climate change has been referred to as a security threat that has weakened the ability of states to deal with severe weather patterns, droughts, land degradation, flooding, and other climate-related changes. Climate change has significantly affected poor communities in developing countries, particularly those in sub-Saharan Africa (SSA). The proneness of these sub-Saharan African communities to the scourge of climate change is exacerbated by low precipitation, high temperatures, and high poverty levels. Lesotho is one such country in the SSA which is also not immune to the scourge of climate change due to its topographical and ecological positioning. Lesotho's climate as noted in its National Climate Change Policy (2017) is generally classified as temperate with alpine characteristics, that is the country experiences relatively cold winters and hot summers as temperatures tend to be lower than in other countries at similar latitudes mainly due to their higher elevations. The location of Lesotho exposes her to the influences of both the Indian and Atlantic oceans, with wide differences in temperature (World Bank, 2021). Accordingly, Prevention Web (2022) argues that Lesotho's topography and location influences its temperate climate thus increasing the country's vulnerability to climate variability and long-term climate change. According to Malephane (2022) Lesotho is already experiencing the impact of climate change and these include increased frequency of extreme weather events such as droughts and floods, less farming and more food insecurity, land degradation and depletion of the country's natural resources including loss of biodiversity. Accordingly, there has been the overall trend in population and its percentage change over the years (1923-2006) in Lesotho which has shown high irregularity, which is an indication of the rise in temperature due to climate change. This has negatively affected the crop yields, and resultantly increased instances of pest infestation, drought, flooding and hailstorms. The fluctuation in rainfall has brought an eminent shift in the planting season and excluded certain crops like peas, beans in the mountain areas. Additionally, the changing climate has also decreased yields as it has led to poor development of buds, pest infestation, drought, flooding and hailstorms. Lesotho has exhibited high vulnerability, low readiness and low resilience to climate change. According to the Notre Dame Global Adaptation Initiative Country Index (ND-GAIN, 2021) which summarises countries' vulnerability and resilience to climate change, Lesotho was ranked at number 124 out of 182 countries implying that it has high vulnerability and low readiness for adaptation to climate change. This clearly shows how vulnerable Lesotho is to the scourge of climate change.

Climate change is changing our economy and communities in diverse ways. Scientists warn that if we do not aggressively reduce the emissions of the greenhouse gases (GhGs) which are responsible for climate change now, the results will inevitably be catastrophic (Chilunjika and Uwizeyimana, 2015:203). As such there is need for frantic and conscious efforts to cushion the country from the undesirable extremities of climate change by bolstering the country's resilience and adaptability to climate change. To support this, Nkomwa, Joshua, Ngongondo, Monjerezi and Chipungu, (2014) assert that in order to take full advantage of the potential of new opportunities that may come with climate change and avert the human suffering that may be associated with its adverse effects, more robust and coordinated national development policies should be put in place to mitigate and adapt to climate change for the best advantage of the poor who have limited resources with which to influence and increases adaptive capacity. In Lesotho, there have been indigenous observations and interpretations of meteorological phenomena that guided seasonal and inter-annual activities of local communities for millenia. This traditional knowledge may prove useful for understanding the potential for certain adaptation strategies that are cost effective, participatory and sustainable.

Governments are making relentless and conscious to formulate policies to deal with the undesirable effects of climate change. These policies should integrate IKS in programmes addressing adaptation to climate change and vulnerability. According to Mafongoya and Ajayi (2017) IKS contributes to climate science by offering observations and interpretations at a much smaller spatial scale with considerable temporal depth and highlighting aspects that may not be considered by climate scientists. However, these IKS are threatened because in most cases, the disseminated information is not properly appraised or documented, leading to a potential loss of knowledge. To widen the scope of climate adaptation and resilience building efforts, the government of Lesotho through their meteorological services should start integrate IK systems such as phenological data into their advisories to provide broad based climate change adaptation and resilience building. Additionally, the synchronisation of IK and SK systems will help to increase Lesotho's adaptive capacity to climate change by diversifying livelihoods and coming up with the best-of-both-worlds type of solutions to climate change. This will serve to ensure sustainable and relevant adaptation strategies.

2. RESEARCH METHODOLOGY

The study being qualitative in its approach and orientation relied on the interpretivist research philosophy. Data were collected from purposively selected journal articles, books, book chapters, newspapers, Government publications among others. Data was gathered from purposively selected written records such as journals, book chapters, books, newspapers, government publications among others. In addition, an in-depth interview was done with one purposively selected Key Informant. These data sources were reviewed and analysed to assess the building of climate change adaptability through the integration of indigenous and scientific knowledge systems in Lesotho. Following the completion of the investigation, content analysis and thematic data analysis were performed on the collected data to categorize them into themes by determining the presence of words, themes, or concepts from qualitative data.

2.1 Understanding the concept of climate change

According to the Chilunjika and Gumede (2021:16) climate change denotes “any variation in climatic patterns due to either human activity (anthropogenic) or natural variability over time”. Moving on, climate change is also defined as a change in the state of the climate that can be identified by fluctuations in the mean and/or the variability of its properties and that continue for a protracted period, usually decades or longer (Busby, 2017; Chilunjika and Uwizeyimana, 2015). This therefore leads to an alteration in the biophysical settings that are affected by a shift in the climatic outlook by disparities in the mean state of the climate. In light of this, climate change entails long-term processes and trends in weather change reflected by hotter temperatures and more severe weather patterns; thus, differing from inter-annual changes in weather patterns (Messer, 2010). In support of this, it can be noted that the commonly mentioned indicators of changing climatic patterns include delayed and unpredictable onset of rainfall, declining rainfall trends, warming temperatures and increased frequency of prolonged dry spells (Nkomwa *et al*., 2014). To this effect, changes in climatic patterns also take the form of more destructive storms, wind-blown rains, and wind-swept seas, as well as more destructive droughts, which all pose untold risks to human security.

Wilkinson, Kirbyshire, Mayhew, Batra and Milan (2016) state that climate risk refers to the combination of the probability of the manifestation of a weather or climatic occurrence, and the consequences of that occurrence, which can be intensive or extensive in nature. As part of the climate risks, Lesotho has experienced extreme rainfall which has resulted in soil erosion, land degradation, loss of ecosystem and ecosystem services, alien species invasion, salinisation of ground water and food trails containing pesticides and fertiliser. Similarly, more than 90% of disasters in Lesotho are related to climate variability and change, specifically drought, snowfall, hailstorms, strong wind, localised floods, and early frost and pest infestations. According to World Bank (2011) recent hailstorms, heavy rains and flash-floods have resulted in significant damage to houses, vehicles, roads, schools and health centres as well as key crops, maize, beans and sorghum. In addition, for the months of December 2010 and January 2011, Lesotho saw unprecedented rains, floods and rockslides that destroyed crops, livestock and property. These climate risks are a direct manifestation of climate variability that has swept across Lesotho.

2.2 Climate change in Lesotho

Before exploring the manifestation, vulnerability and intensity of climate change and its associated impacts in Lesotho, it is prudent to firstly understand the topography, climate patterns and the landscape ecosystems of Lesotho. Lesotho is a small landlocked country in Southern Africa, surrounded by the Republic of South Africa, located between latitudes 28 degrees and 31 degrees South and longitudes 27 degrees and 30 degrees East (World Bank Group, 2021). The country’s 30 355 square kilometres of land area is characterised by a rugged terrain (Mekbib, Olaleye, Johane and Wondimu, 2017), with elevations ranging from 1,388 metres to 3,482 metres with a limited portion of the country’s land being considered as arable (UNDP, 2021). According to the World Bank Group (2021) the location and geography of Lesotho exposes her to climatological patterns from both the Indian and Atlantic Oceans resulting in significant variability in temperatures. Similarly, the topographical variability and the microclimatological influences define the four ecological zones of the country which are: the Lowlands (17%), the Foothills (15%), the Mountains (59%) and the Senqu River Valley (9%). These ecological zones are characterised by distinct ecological and climatic differences with the majority of the socio-economic activities being restricted to the lowlands, the foothills and the Senqu River Valley, leaving the mostly barren and rugged mountainous region mainly for grazing, water resources development (especially hydropower development) (UNDP, 2021).

According to UNDP (2021) the climate of Lesotho is characterised by the occurrence of dry spells and wet spells over recorded time. These fluctuations in climate have had serious impacts on the environment. Dry spells on one hand, are associated with food shortages, famine, disease epidemics, invasion by exotic plants and destructive insects, dust bowls and the initiation of down cutting by rivers. On the other hand, wet spells are also associated with extreme rainfall, flash-floods, hailstorms among others. Annual precipitation is highly variable on diurnal, monthly and annual time scales, generally ranging between 10 and 30 degrees Celsius; with high winds of up to 20 metres per second that can be sometimes received during thunderstorms. Based on the latest climatology, 1991 to 2020, the mean temperature for Lesotho is 12.8 degrees Celsius, with average monthly temperatures ranging between 15 degrees Celsius (November to March) and 6 degrees Celsius (June, July) (World Bank, 2021). Mean annual precipitation is 761.2mm, with highest rainfall occurring between October to April, with extremely low levels of precipitation occurring between May to September.

In light of this, it can be noted that Lesotho has fragile ecosystems because of its topography, type and pattern of rainfall, erodibility of soils, land use patterns and other habitats such as bogs and sponges (Prevention Web, 2022). Accordingly, the World Bank Group (2021) indicated that, in Lesotho, high aridity and periods of intense drought exacerbate the loss of biological diversity, deterioration of rangelands and reduce crop and animal productivity via desertification, thus making the country increasingly vulnerable to climate change. Moving on, Lesotho's geographical characteristics and socio-economic conditions, particularly for its rural population also make it one of the most vulnerable countries to the impacts of climate change. To support this, World Bank (2021) noted that climatic and socio-economic environments in semi-arid areas in Lesotho make communities vulnerable to food insecurity which leads to unsustainable agro-ecological systems, crop failure and unproductive rangelands. The country is additionally vulnerable due to its high dependence on rainfed agriculture and reliance on regional, imported energy supplies.

In highlighting the manifestations of climate change in Lesotho, Prevention Web (2022), noted that Lesotho is already experiencing the negative effects of climate change, including increased frequency of extreme events, *inter alia*, droughts, increased rates of soil erosion and desertification and reduced soil fertility. Additionally, it can be argued that the productivity of major crops and animals has declined significantly in recent years due to poor land and rangeland conditions. The country is likely to become generally hotter and drier across projected future climates. Likewise, Lesotho will also continue to experience extreme events like droughts and floods and other climate related hazards in addition to continued rainfall variability and increasing temperatures. In support of this, the UNDP Report (2021) noted that Lesotho is expected to experience a change in temperature and precipitation patterns, toward dryer and hotter conditions. In addition, the intensity and frequency of extreme events such as floods and drought are expected to increase, especially in the western and northern lowlands. According to the Ministry of Energy (2013) some areas of Lesotho are expected to have below normal rainfall through the end of the century between 50-100 mm per annum in the Lowlands, Foothills and the Senqu River Valley zones. Significant changes in precipitation and temperature could have severe impacts on people's livelihoods, particularly in the Highlands, the Foothills and the Senqu River Valley, where increasing temperatures and decreasing precipitation might lead to a substantial decrease in crop harvests.

According to World Bank (2021) the high evapotranspiration rate and the virtual absence of permanent surface water over large parts of the country also combine to make water a scarce resource. Lesotho has also been vulnerable to climate hazards and the frequency and intensity of climate related hazards has increased and this has resulted in large number of the population particularly vulnerable to food insecurity. Water, agriculture, forestry, human health and livestock are the country's most vulnerable sectors with respect to climate variability and change (World Bank, 2021). Additionally, the increased frequency of intense precipitation events will lead to heightened risk of flooding, riverbank overflow and flash flooding. This may also result in soil erosion and water logging of crops, thus reducing the yields with the potential to increase food insecurity, particularly for subsistence-scale farmers.

IJERLAS
International Journal of Educational Review, Law And Social Sciences

The country's current vulnerability also stems from the fact that its economic growth is dependent on climate sensitive sectors which are subject to highly variable precipitation. Higher temperatures increase aridity and can lead to livestock stress and reduced crop yields, with impacts to economic and food security (Malephane, 2022). In addition to variable climate and climate sensitive economy, the majority of Lesotho's population is dependent on rain-fed subsistence agriculture coupled with the fact that these communities do not have sufficient resources to address the loss of fertility and climate variability (Lesotho National Communication, 2021). The temperature increases experienced in Lesotho have led to hydrological losses, which impact or change the quantity and quality of water resources. Additionally, there is evidence that climate change has already negatively affected crop yields in Lesotho. There has been a decline in both the area planted and the yield of most important cereal crops due to recurring droughts in the last few years (Lesotho National Communication, 2021; Lesotho Climate Change Portal, 2017). Similarly, the livestock sector, which also plays an important role in Lesotho's economy through wool and mohair production, has also been declining due to climate change.

As such, there is need for the development of climate change adaptation interventions and measures to improve the resilience and adaptability of both crops and livestock productivity to climate change which in turn will contribute to food security and poverty alleviation. Over and above, it can be argued that the changing climate has brought about an eminent shift in the planting season, which has excluded certain crops like peas and beans in the mountain areas. Climate change has also reduced yields causing poorly developed buds, greater pest infestation, drought, flooding and hailstorms. A shift in precipitation patterns ultimately leads to a shift in sowing and harvesting seasons, from the unexpected and disastrous situations can arise before crops are harvested. In the mountains, locally known as *mantsonyane*, and the foothills rainfall is higher, but the cropping season is much shorter due to the early onset frost, thus the climate favours animal farming (Mekbib *et al*., 2017). An increase in precipitation in winter may cause increased activity in frontal weather systems, which may result in heavier snowfall and strong, devastating winds that often bring disasters and human suffering posing significant risks to crop production and animal husbandry in Lesotho. In light of this, there is need for people to adjust to the changing environment in response to the actual or expected climatic stimuli or their effects, which moderate harm or exploits beneficial opportunities (IPCC, 2014). Thus, communities, particularly, rural farming ones have over years relied on indigenous knowledge systems (IKS) as a means of adapting to constantly varying and changing climate (Nyong, Adesina and Elasha, 2007).

2.3 Indigenous Knowledge Systems and Climate Change in Lesotho

Traditional or indigenous knowledge on weather and climatic patterns have been used for years by the local communities to help forecast and manage climate change. Indigenous knowledge is synonymously known as traditional knowledge, traditional ecological knowledge, local knowledge, farmers' knowledge, ethnoscience, folk knowledge and indigenous science is some knowledge or know-how that has been accumulated across generations. IK has been defined by Berkes (2012) as the cumulative body of knowledge, practice and belief, evolving by adaptation processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with their environment. This IK has been cumulatively developed from the experience gained over centuries and adapted to local culture and environment. In further defining IK, the World Intellectual Property Organisation (n.d) noted that traditional knowledge is know-how, skills, innovations or practices that are passed between generations in a traditional context and that form part of the traditional lifestyle of indigenous and local communities who act as their guardian or custodian. In light of this, it can be argued that IK is multi-faceted and it guides societies in their innumerable interactions with their natural surroundings as a result of the interplay that exists between people and places thus giving rise to a diversity in knowledge systems that are once empirical, symbolic, pragmatic and intellectual, traditional and adaptive.

IK is considered a social capital for the poor and it is relied upon for livelihood security and food production. Accordingly, Mafongoya and Ajayi (2017) argued that valuable local knowledge of relevance to climate change assessment and adaptation is held by rural societies and these knowledge systems are transmitted and renewed by each succeeding generation, ensuring the well-being of people by providing food security, environmental conservation and early warning systems for disaster management. According to Nkomwa *et al*., (2014) local communities are able to recognise the changes in their climate and local environment and this local knowledge would have been accumulated over generations and guides human societies in their innumerable interactions with their surrounding environment. IK by its nature is characterised by being repetitive, localised to a particular place, oral transmission through intrinsic dramatization, practical engagement in everyday life, constant refinement by experience, trial and error (Messer, 2010).

IK is used in the seasonal predictions of climate, based on tree phenology, animal behaviour and astronomical observations to facilitate decision making in managing and adapting to climate risks. IKS has been used in seasonal forecasting whereby, tree phenology, animal behaviour and astronomical observation are the basis of seasonal forecasting (Mafongoya and Ajayi, 2017). For example, in establishing the link between behaviour and climatic patterns in Lesotho it was noted from an interview with Phamotse, M (2022) that if there are sparrows flying and singing in their numbers it is an indication that there will be rains. Additionally, if there are white butterflies (*lirurubele tse tsoue*) flying towards the Northern parts of Lesotho before December, it is an indication that there is going to be a normal harvest (Phamotse, M., 2022). Additionally, it was also noted that when the wildebeest (*pulumo*) give birth to their young ones (*pulungoana*) it is an indication that there is going to be a good harvest that particular year. In the event that there will be a drought in the ensuing year, they similarly abort (Phamotse, M., 2022). Moving on, another IK related climatic pattern indicator is when the stork birds (*linonyana tsa mokotatsie*) are migrating it means that the winter season is gone and that summer is fast approaching.

2.4 IKS and Climate Change Management

IKS is also used in climate change management whereby there is the use of underutilised and neglected crop and livestock species which are adapted to cope better with high temperatures, heat stress, low rainfall and diseases and provide farmers with food and nutritional security during droughts and climate shocks. IK has also been traditionally used to promote environmental conservation with practices like shifting cultivation, intercropping, minimum tillage and agro-forestry. Additionally, IKS have also been used to enhance disaster management by growing drought tolerant and early maturing indigenous crops, gathering wild fruits and vegetables, cultivating wetlands and diversifying and selling livestock (Rankoana, 2022). IKS also plays a crucial role in early preparedness as most communities have an array of early warning indicators and well-developed structures to which the wisdom of the community is applied to interpret and deal with disasters quickly and efficiently (Mekbib, *et al*., 2017). By and large, the use and application of appropriate IK can promote environmental conservation (land, grasslands, forests, wetlands and biodiversity) and management of disasters in terms of prevention, mitigation, recovery, prediction, early warning, preparedness, response and rehabilitation.

The indicators farmers mostly rely on include fruit production and tree phenology, animal behaviour, wind and atmospheric phenomena and spiritual manifestations in the form of divinations, visions and dreams (Mafongoya and Ajayi, 2017). Specific measures have been taken to adapt to changing climatic conditions in Lesotho and these measures vary from one agro-ecological zone to another. In the mountains some farmers are experimenting to find out which crops are best suited to the short and shifting growing period. While in the dry Senqu River Valley, they do water harvesting as well as practise mulching and the returning of residue to the fields, which is a favourable way of moisture retention. While in the foothills at Pitseng village farmers have shifted the sowing seasons for different crops to cope with shifting seasons, they also plough the land whilst the plant residue is still there (Mekbib *et al*., 2017).

In addition to the aforementioned indigenous climate adaptability mechanisms used in Lesotho there is the Machobane Farming System (MFS) which is an indigenous farming technology which pivots around the integration of cropping and livestock rearing activities. In light of this, Mekbib *et al*., (2017) argue that the MFS is an indigenous farming practice established by Dr Machobane in 1955 and reintroduced in the early 1990s which is highly adaptable and resilient to climate change, enabling farmers to harvest a variety of crops throughout the year. According to the founder of the indigenous farming practice, Dr Machobane, climate change constraints can be overcome by the rational exploitation of the resource base, that is, using a simple, low input technique based on intercropping and crop diversification with the localised application of manure and ashes. Accordingly, Machobane and Robert (2004) assert that applying plant leaf litter or remains (mulching), organic amendments (animal manure) and wood ash are well recognised by farmers using the MFS as the manure provides nutrients for plant uptake and enhances long term soil fertility by improving its physical properties.

Mekbib *et al*., (2017) indicated that ash on the other hand provides nutrients such as potassium and has a liming effect on acidic soils, thus MFS sustains soil fertility by releasing nutrients slowly and conserving moisture. In addition, MFS ensures complete crop cover throughout the year, because winter crops (e.g., wheat, peas) are planted in April to May (for harvest in January to March) and summer crops (e.g., maize, beans, sorghum) are planted in August to October (for harvest in November to December). After harvesting the residues are left in the field to build up humus that serves as sources of nutrients (fertiliser) for the next cropping season or cycle. MFS also encompasses different crop management practices which include minimum tillage, weeding, natural pest control, intercropping, crop rotation, relay inter-cropping and relay harvesting. MFS was noticeably less affected by climate change than other farming systems due to the sustenance of soil fertility that is maintained by the slow release of nutrients and the conservation of soil moisture make the MFS more resilient to climate change impacts. To support this, Machobane and Robert (2004) noted that it is evident that the MFS practising villages in the mountains and foothills remain unaffected and appeared green throughout the year. Although there are discernible challenges for the widespread application of the MFS, it is a climate friendly farming system that has the potential to be easily disseminated thereby enabling Basotho people to produce high yields of a variety of crops throughout the year.

2.5 Scientific Knowledge Systems and Climate Change

SKS entails the collection of new information about the world that is obtained through experimentation and data collection (Narayanan and Glick, 2023). Significant progress has been made by science in comprehending the causes of climate change and its effects, and it is starting to contribute to a solid understanding of the effects that people are already experiencing and may experience in the future decades. This comprehension is essential because it enables decision makers to situate climate change within the larger framework of major issues confronting countries (The National Academies of Engineering, Medicine, and Sciences, 2010). In light of this, scientists are in the process of coming up with some evidence based scientific solutions to deal with the scourge of climate changes as well as enhance climate change adaptability and build climate change resilience.

In terms of climate change, SKS include biotechnologies, smart technologies, remote sensing, genetic engineering, artificial insemination etc. To this effect, providing fishermen, farmers, and other producers greater tools to use evidence-based research and innovation, such as agricultural biotechnology, to produce more on less land, water, inputs, and resources (Zara, 2023; Popp, Jahn, Matlock and Kempter, 2012). Raising living standards, improving food security and nutrition, decreasing poverty, and lowering the industry's detrimental environmental effects can all be achieved through increasing agricultural output. To expatiate on these technologies that are used in the SKS domain, plant and animal breeders can create plants and animals that are more readily adapted to changing environmental conditions, such as drought, higher temperatures, new illnesses, and other stressors, by using agricultural biotechnology (Narayan and Glick, 2023).

Additionally, fossil fuels can be replaced with biofuels, thus lowering greenhouse gas (GHG) emissions and slowing down climate change. Agricultural waste, crop wastes and algae can be converted into biofuels like ethanol and biodiesel using techniques like microbial fermentation and biotechnology. Crops that have undergone genetic modification (GM) can aid in lowering GHG emissions in agriculture. Accordingly, Kaphengst and Smith (2013) argued that gains in genetically modified (GM) yields not only reduce production emissions but also lessen emissions associated with changing land use. Moving on, agricultural biotechnology-derived products, like longer-lasting fruits and vegetables and cover crops that produce sustainable biofuels, may help lower GHG emissions by minimizing food waste. Climate change can also be mitigated using remote sensing technologies. Remote sensing is vital in evaluating glacier change, tracking changes in coastal areas, identifying changes in permafrost landforms, mapping surface geology and vegetation, as well as tracking changes in land use near parks, and more (Masterson, 2024).

Parks are moulded by ongoing disruption and change. Similarly, remote sensing technologies, location based methods like weather stations and satellite data will also help to track patterns of landscape change as well as assisting researchers in creating new strategies for planetary resource management. In a climate adaption scenario, earth observation is also essential for early warning systems, such as predicting hurricanes before they occur. Additionally, supercomputing/ quantum computing is becoming increasingly accessible to aid in weather and climate modelling. Due to its ability to predict processes like fluid dynamics, which are crucial to weather forecasting, quantum computing is anticipated to advance climate modelling and adaptation. Internet of Things (IoT) technology is being utilized to collect and disseminate new types of data, like temperature and air quality variations. For example, people in the impacted area can receive notifications on their mobile phones from sensors that identify wildfires. Artificial intelligence (AI) is being used to create much more accurate and sophisticated weather and climate models. AI, for instance, has added data on sea surface temperature to ocean models, something that human experts were unable to accomplish (Masterson, 2024). The scientific community now has a better knowledge of ocean current speed because of this. Artificial intelligence has also led to advancements in climate adaptation, such as drought-resistant crops and smart sewer systems that prevent floods after high rainfall.

Nonetheless, judgments pertaining to climate change might benefit from scientific research in a number of ways. Clarifying the hazards that climatic changes pose to natural and human systems will be made easier with continued research into the mechanisms, causes, and effects of climate change (National Academies of Sciences, Engineering, and Medicine (NASEM), 2010). Science can assist in both improving current alternatives and identifying new ones for reducing the rate of climate change or adjusting to its effects. The evaluation of the benefits and drawbacks of various solutions to climate change, including unintended consequences, trade-offs and co-benefits among various action sets is another crucial task for science in climate change. Climate related decision making can be aided by scientific studies on new, more efficient information-sharing and decision making technologies and methods.

Nonetheless, the usage of SKS in enhancing climate adaptation and climate resilience is not immune to challenges. SKS in the context of climate change is encumbered by problems of ecological scale and consequent difficulties in sampling and experimentation. The usage of genetic engineering, remote sensing, artificial insemination among other technologies tend to demand quantitative data and it is very expensive especially for developing countries like Lesotho to acquire and install and operationalise these technologies (Narayanan and Glick, 2023). Some people feel that meddling with nature in this way via genetic engineering is unethical. Additionally, individuals in developing nations like Lesotho cannot buy GM crop seeds because they are frequently more expensive. Furthermore, GM crops may be dangerous; for instance, poisons from the crops have been found in the blood of certain individuals. Similar to this, pollen produced by the plants may be harmful and injure insects that spread it across plants, and GM crops may induce allergic reactions in humans (Zara, 2023).

2.6 Integrating IKS and SKS in dealing with Climate Change in Lesotho

The boundaries of science in climate change are increasingly being perforated to incorporate the indigenous ways of understanding the phenomenon and responding to climatic events due to the acknowledgement of both the growing threats of climate change and the value that indigenous science has for impact identification, mitigation and adaptation (Mafongoya and Ajayi, 2017). NASEM (2010) argued that the challenges caused by global climate change and extreme weather events are beyond the local experiences of knowledge holders, whether scientific or indigenous, as such, effective adaptation to climate change requires the best knowledge, which is based on collaborative research and which regards community knowledge holders, natural and social scientists. There is the potential for scientific and indigenous forecasts to play complementary roles in improving seasonal forecast use and decision making. According to Berkes (2012) these cross-scale and cross-cultural methods provide impartiality for adaptation to climate change on the ground.

It is therefore imperative for one to understand the different attributes of IK and scientific knowledge systems and how integrating them would be beneficial in dealing with the adverse climate change. Science collects dynamic data in a time series over a large area for example, while IKS focuses on diachronic data and long-term series in small areas for example, the use of indigenous indicators of forecasting in African villages or districts (Nkomwa *et al*., 2014). Science is based on the numerical data analysis of averages. IKS observe extreme weather events and unusual patterns, which is critical in climate change adaptation. Science demands quantitative data, while IKS demands the qualitative understanding of the system. Qualitative measures are rapid and inexpensive but they lack precision. IKS rely on hypotheses for problem solving. Science has powerful tools to explain the reasons for mechanisms. Science is objective and excludes peoples' feelings while IKS includes peoples' feelings, relationships and sacredness (Rankoana, 2022).

There are inherent weaknesses that are associated with IK and scientific systems. IKS and scientific knowledge both have some inherent weaknesses when they operate alone and in isolation. Currently scientific forecasting is unable to predict duration, amount or distribution of rainfall thus constituting a marked diversion from the farmers' forecasts in terms of parameters and scales they address. According to Roncoli, Jost, Kirshen, Sanon, Ingram, Woodin and Hoogenboom (2009) farmers' forecasts on number, type and timing of rainfall rather than total quantity, which is key in scientific forecasting. The problems of ecological scale and consequent difficulties in sampling and experimentation limit the predicting power of science and there is growing evidence that conventional scientific approaches may be insufficient in the face of climate change complexity. IKS on the other hand, also faces some risks. As the world warms, traditional weather indicators may become less and less valuable. Indigenous species will adapt to local climatic impacts in idiosyncratic and unpredictable ways. In this vein, animals may change their behaviour or range while plants may begin flowering at different times and these changes will make traditional knowledge less reliable. As such, understanding complex systems like climate change requires both.

While the global and regional and systematic observation systems do not incorporate IK when forecasting weather and climate patterns, the integration of science and IK to improve forecasting is very crucial. As such, there is need for dialogue and exchanges between indigenous people and scientists with the support of IK experts. IKS has shown potential in the development of locally relevant and sustainable adaptation strategies to a variable climate in the agricultural sector, mainly in the understanding of weather patterns through the use of natural indicators such as changes in the behaviour of local flora and fauna (Nkomwa *et al*., 2014:165). IK as their social nature, practicability and dynamism, provide scores of information at spatial and temporal scales that could provide scientists and meteorologists with useful information to support the production and dissemination of reliable forecasts. Scientists can provide meta-predictions at a large scale, while IKS specialise in location specific predictions. The critical strength of IK lies in its ability to see the interrelationships of disciplines and integrate them meaningfully. This holistic perspective and the resultant synergies show higher levels of developmental impact, adaptability and sustainability than Western modern knowledge. To this effect, IK becomes a very good source of readily available practices that are useful for identifying appropriate policies to respond to climate change.

With time, the value of ethno-meteorological indicators will disappear as this is exacerbated by the fact that the educated younger generation are vouching for science in seasonal planning and reacting to climate change, and therefore do not see the need to conserve certain types of birds or natural resources for seasonal and weather information. Sadly, IKS in SSA are rapidly eroding and being lost due to the interruption of intergenerational knowledge transmission as a result of the absence of IKS in formal school curricula, globalisation, internal and external migration to urban cities and relatively easy access to imported food and popular culture (Adger, Barnett, Chapin and Ellemor, 2011). In addition, IK may prove useful for understanding the potential for certain adaptation strategies that are cost effective, participatory and sustainable (IPCC, 2014). In light of this, it can be noted that the indigenous observations and interpretations of meteorological phenomena have guided seasonal and inter-annual activities of local communities for millenia and the integration of IK particularly phenological data into the meteorological services provides users with more broadly-based information.

In this scenario, blending IKS with modern science will allow the development of hybrid skills as there is value-addition from bringing IK into climate change adaptation processes in a mutually agreed upon and beneficial manner. As highlighted above, IK indicators are not as reliable as they used to be due to changing climate, hence the need to integrate IK forecasts and scientific seasonal forecasts. In many African countries, between 60-70% of farmers still rely on IK indicators for seasonal forecasting. In support of this, Kolawole, Wolski, Ngwenya and Mmopelwa (2014) noted that there is evidence to show that famers have a natural inclination towards reliance on indigenous forecasts as opposed to scientific forecasts because they value their own experiences above scientific data since IKS has evidently allowed people to live in harmony with nature for generations. The fact that many farmers prefer using IK over scientific knowledge for forecasting makes it imperative for scientific knowledge to bear some imprints of IK. Thus, understanding how local communities perceive and predict rainfall variability is key to communicating scientific weather forecasts.

The use of both IKS and science takes advantage of their relative strengths. The integration of scientific knowledge with IKS methods of seasonal forecasting is needed to increase the utility of knowledge in managing climate change adaptability. According to Mafongoya and Ajaya (2017) with appropriate design and planning, geographical information systems and mapping tools can facilitate the inclusion of specific sets of IKs, such as the distribution of specific trees used for phenological indicators, in climate observation schemes. Such Information Communication and Technology (ICT) based projects are typically designed to include a specific factor of IK. In addition to being used to combine data from science and IK for climate observation, ICT tools can be harnessed to document and promote the transmission of IK for adaptation. Facilitating access to scientific knowledge and technologies such as early warning systems may help decrease indigenous peoples' vulnerability to climate change.

Government policies and activities in Lesotho need to be formulated on the basis of multi-disciplinary action research that brings together IK holders and both natural and social scientists to build a mutual understanding and reinforce the need for change. The creation of policies that can improve adaptive capacities and indigenous people's statuses and this could be achieved by including the indigenous people as joint decision makers in local and national adaptation initiatives. The co-knowledge of IKS and scientific knowledge might usher in the sustainable and long-lasting way-forward of countering climate change. Collaboration between IK holders and mainstream scientific research generates new co-produced knowledge relevant for effective adaptation action at local level in Lesotho since this this knowledge is learned, identified and applied within the farmers' cultural settings. The local people and communities can relate to this local knowledge. The integration of scientific knowledge with local knowledge might allow farmers to recognise that rainfall patterns have different impacts on each crop depending on when and how they occur. Therefore, combining the knowledge of local resource-dependent people with evidence provided by formal climatology analysis, holds the potential to reduce uncertainty and increase the relevance of future assessments.

2.7 Concluding Remarks

Globally, there are indications of a changing climate in scientific data gathered from both contemporary technology, such as satellites and devices, and natural sources, such as ice cores, rocks, and tree rings. There is ample proof that the planet is warming up, from rising global temperatures to ice sheets melting. The study indicates that there is evidence of climate change in Lesotho as revealed by extreme weather and climatic events such as violent storms, floods and droughts which pose some serious risks particularly to the poor indigenous communities as they have low adaptive capacity as they depend almost exclusively on the climate sensitive resources of their environment for their livelihoods. Lesotho is prone to the impacts of climate change due to its topographical and ecological positioning. Climate change has had far-reaching impacts on Lesotho as the majority of the population mainly depend on natural resources for survival.

As such there is need for long-lasting efforts to enhance the adaptability and resilience in Lesotho. IKS in climate change adaptation and mitigation have been neglected in climate change observation, planning, implementation, monitoring and evaluation and policy formulation and have not been taken up in the climate change discourse. The study examined the existence and the utility of the Machobane Farming System (MFS) an indigenous farming system that is integral in promoting climate resilience in Lesotho. However, the study highlighted the inherent weaknesses and shortcomings of IKS and scientific knowledge in dealing with the impacts of climate change. As such the study recommended the fusion, synchronisation, amalgamation and integration of IKS and scientific knowledge systems. There is need to promote collaboration of research and action between IK holders and scientists. There is thus need for dialogue and exchanges between indigenous people and scientists with the support of IK experts. The study was therefore based on the notion that incorporating IK into climate change policies and interventions can lead to the development of adaptation strategies that are cost effective, participatory, locally relevant and sustainable.

REFERENCES

Adger, W.N., Barnett, J., Chapin, F.S. and Ellemor, H. 2011. 'This must be the place: underrepresentation of identity and meaning in climate change decision-making.' *Global Environmental Politics* 11 (2): 1–8.

Berkes, F. 2012. *Sacred Ecology*. Third Edition. Routledge: New York.

Busby, D. 2017. *Rural Development and Climate Change*. Longman, London.

Chilunjika, A. and Gumede, N. 2021. Climate Change and Human Security in Sub-Saharan Africa. *African Renaissance*. Special Issue on Climate Change and Strategy Management, 13-37.

Chilunjika, A. and Uwizeyimana, D.E. 2015. Contextualising Climate Change: Theoretical Considerations. *Administracio Publica.* 23(4), 202-220.

Huntington, H. H., S. Fox, F. Berkes, I. Krupnik, A. Whiting, M. Zacharof, G. McGlashan, and M. Brubaker. 2005. The changing Arctic: indigenous perspectives. ACIA. Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK, chap. 3: 61–98.

Intergovernmental Panel on Climate Change (IPCC). 2014. *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. IPCC WGII AR5 Summary for Policymakers.

Kaphengst, T. and Smith, L. 2013. *The Impact of Biotechnology on Developing Countries*. Berlin: Ecological Institute of Berlin.

Kolawole, O.D., Wolski, P., Ngwenya, B. and Mmopelwa, G. 2014. 'Ethno-meteorology and scientific weather forecasting: Small farmers and scientists' perspectives on climate variability in the Okavango Delta, Botswana.' *Climate Risk Management* 4/5: 43–58.

Lesotho Climate Change Portal. 2017. *National Climate Change Implementation Strategy*. Maseru: Wade Publications.

Lesotho National Communication. 2021. *Lesotho Climate Change Baseline and Trend Analysis Report.* Maseru: Government Publishers.

Machobane, J.J. and Robert, B. 2004. *Drive out hunger: The story of J.J. Machobane of Lesotho*. Jacana: Johannesburg.

Mafongoya, P.L. and Ajayi, O.C. *Indigenous Knowledge Systems and Climate Change Management in Africa*. CTA, Wageningen.

Malephane, L. 2022. *Climate Change- A Little Known in Reality in Lesotho*. AD524.

Masterson, V. 2024. *Climate Action: Six Technologies to Help the World to Adapt to Climate Change*. World Economic Forum.

Mekbib, S.B., Olaleye, A.O., Johane, M. and Wondimu, T. 2017. IKS to address the challenges of climate change: Case of Machobane Farming System in Lesotho. In Mafongoya, P.L. and Ajayi, O.C. *Indigenous Knowledge Systems and Climate Change Management in Africa*. CTA, Wageningen.

Messer, E. 2010. *Climate Change and Violent Conflict: A Critical Review*. Oxfam.

Ministry of Energy and Meteorology. 2015. *Lesotho's Intended Nationally Determined Contributions (INDC)*. Ministry of Energy and Meteorology, Maseru.

National Academies of Sciences, Engineering, and Medicine (NASEM). 2010. Advancing the Science of Climate Change. Washington, DC: The National Academies Press.

National Climate Change Policy. 2017. Lesotho's Second National Communication to the Conference of Parties of the UNFCCC. https://unfccc.int/sites/default/files/resource/LESOTHO.

Narayanan, Z. and Glick, B.R. 2023. Biologically Engineered Plants. *Biology*. 12(4), 1234-53.

Nkomwa, E.C., Joshua, M.K., Ngongondo, C., Monjerezi, M. and Chipungu, F. 2014. 'Assessing indigenous knowledge systems and climate change adaptation strategies in agriculture: A case study of Chagaka Village, Chikhwawa, southern Malawi.' *Physics and Chemistry of the Earth, Parts A/B/C* 67/69: 164–172.

Notre Dame Global Adaptation Initiative (ND-GAIN). 2021. Notre Dame Global Adaptation Initiative. https://gain.nd.edu/our-work/country-index/

Nyong, A., Adesina, F., and Elasha, O.B. 2007. 'The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel.' *Mitigation and Adaptation Strategies in Global Change* 12: 787–797.

Pandey, K. 2019. 195% more Africans affected due to extreme weather events in 2019. https://www.downtoearth.com.

Phamotse, M. 2022. Interviewed by Alouis Chilunjika. 15 September 2022, Roma.

Popp, J., Jahn, M., Matlock, M., and N. Kempter, N. (eds). 2012. *The Role of biotechnology in a sustainable food supply*. Cambridge: Cambridge University Press.

Prevention Web. 2022. Climate Risk Country Profile: Lesotho. https://www.preventionweb.net/publication/climate-risk-country-profile. [Accessed on 16 October 2022].

Rankoana, S.A. 2022. Indigenous Knowledge and Innovative Practices to Cope with Impacts of Climate Change on Small Scale Farming in the Limpopo Province, South Africa. *International Journal of Climate Change Strategies and Management* 8:135-169.

Roncoli, C., Jost, C., Kirshen, P., Sanon, M., Ingram, K.T., Woodin, M and Hoogenboom, G. 2009. 'From accessing to assessing forecasts: an end-to-end study of participatory climate forecast dissemination in Burkina Faso (West Africa).' *Climatic Change* 92: 433-460.

The National Academies of Engineering, Medicine, and Sciences. 2010. *The advancement of climate change science*. The National Academies Press, Washington, DC.

United Nations Development Programme (UNDP). 2021. Climate Change in Lesotho. UNDP. https://www.adaptation-undp.org/explore/africa/lesotho. [Accessed 14 October 2022].

Wilkinson, E. Kirbyshire, A. Mayhew, L. Batra, P. and Milan, A. 2016. *Climate-induced migration and displacement: closing the policy gap*. Overseas Development Institute, London.

World Bank. 2011. Climate Change Overview. https://climatechangeportal.worldbank.org/country/lesotho. [Accessed 10 October 2022].

World Bank Group (2021) Climate Knowledge Portal. https://climateknowledgeportal.worldbank.org/country/lesotho/climate-data-historical.

World Intellectual Property Organisation (n.d.) *Understanding Indigenous Knowledge Systems (IKS)*. NY: WIPO Press.

Zara, S. 2023. *The Potential of Biotechnology in Combating Global Challenges like Climate Change and Resource Scarcity*. Tamil Nadu: KARPAGAM Academy of Higher Education.