Climate change and small-scale agriculture in Africa: does indigenous knowledge matter? Insights from Kenya and South Africa

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Abstract

Africa is highly vulnerable to changes in global climatic conditions due to its low adaptive capacity and sensitivity to changes in climatic variables, particularly in the agricultural sector. A key attribute of studies on climate change coping strategies and adaptation mechanisms in Africa is that they lack local specificity. Within a discourse dominated by large-scale attempts to measure the extent of climate change and its impacts with methods drawn from physical and biological sciences, there is little focus on how locally-specific knowledge and practices help communities to cope with effects of adverse environmental conditions on their agriculture at the farm level. From a sample of 115 respondents drawn from South Africa and Kenya and through interviews, discussions and interactions, this paper demonstrates that local residents deploy their indigenous knowledge in predicting seasonal weather and rainfall patterns, determining wind speed and direction, preserving grains for planting purposes and various traditional farming support systems to lessen the impacts of climate change on their agricultural activities. The paper concludes that merging local knowledge with modern science in Africa could help develop a syncretic agronomical knowledge among farmers in handling climate change.

Keywords: Climate Change, indigenous knowledge, small-scale agriculture, Kenya, South Africa.

1. Introduction

Increased concentration of greenhouse gases and atmospheric warming leading to melting glaciers, rising sea levels and changes in precipitation patterns are some of the indicators that highlight changes in global climatic conditions (IPCC, 2013). These changes have resulted in negative effects on ecosystems, agriculture, biodiversity, human health and other socio-economic indexes (IPCC, 2013). In Africa as elsewhere in the developing world, the effects of climate change on key sectors of economies are further exacerbated by complex factors like HIV/AIDS, fluctuations in market prices of oil and mineral resources, debt crisis, rising poverty levels and general food insecurity with their corresponding multiple feedback on development (Mladen and Nebo, 2020). The combination of these factors further put strains on the capacity of African governments to sustainably invest in climate change coping and adaptation programmes. It is highlighted that due to low adaptive capacity and the sensitivity nature of the agricultural sector; Africa is highly vulnerable to changes in global climatic conditions (Mafongoya and Ajayi, 2017). Experts note that as the global climate continues to warm up; the impact of such warming as a result of increasing greenhouse gases in the atmosphere is likely to affect agriculture differently from region to region and from community to community (Subhita and Babita, 2021)

Studies of climate change impacts and adaptation mechanisms in Africa are dominated by discourses of quantifying current climate change, modelling future climate change, and quantifying/modelling their impacts, using a relatively limited range of biophysical and socio-economic parameters. Despite the importance of local specificity to both characterising climate change impacts and identifying enabling adaptation strategies, it receives little attention (Nkomwa et al., 2014). IPCC assessment report chapters have included discussion on indigenous knowledge from Africa and elsewhere (most importantly Olsson et al., 2014, but also; Burkett et al., 2014; Niang et al., 2014). However, in most of these cases, material on indigenous knowledge appears in dedicated sub-sections disjunct from the main assessments of impacts and adaptation.

Some studies (for example Brenkert and Malone 2005; Maria et al., 2010; Retnowati et al., 2014) reveal that indifference to or denial of indigenous knowledge is a vulnerability factor in itself, particularly among local farmers as indigenous knowledge about local weather conditions and traditionally-established coping mechanisms is critical for the existence and survival of local residents, even though the concept of indigenous knowledge remains a contested concept in many discourses, including climate change.

Despite the positive contribution of indigenous knowledge in disaster management, including management of climate change-related impacts in some parts of the world, there is insufficient empirical documentation of the effective promotion and utilisation of indigenous knowledge by both farmers and external actors in enhancing local farmers' resilience to climate change impacts in Africa. This lack of verifiable African examples of indigenous knowledge to complement climate change adaptation strategies identified and validated by biological and physical science makes both policy and theoretical discussion on Indigenous Knowledge Systems (IKS) in Africa, in the context of climate change adaptation, hollow and incomplete. The main question is: can policies and mechanisms aimed at managing the impacts of climate change in vulnerable communities continue to ignore the idiographic richness of local ideational assets? Given this research gap, this paper assesses the role of indigenous practices, local traditions, customs, beliefs and local environmental knowledge in Kenya and South Africa in lessening the impacts of climate change relating to small-scale agriculture. The paper further looks at the mode of development and transmission of such practices, beliefs, traditions, and knowledge; as well as their 'integration' with modern scientific activities and practices among small-scale farmers in the study communities.

In this paper, small-scale agriculture or farmers is used interchangeably and refer to farmers owning small plots of land on which they grow subsistence crops and one or two cash crops relying almost exclusively on family labour and operating under structural constraints such as access to sub-optimal amounts of resources, technology and markets (Khalil et al, 2017). This category of farmers are mostly characterised by the use of simple technologies, relatively small farm sizes, seasonal labour fluctuations and low returns in their production systems (SA Gov, 2012). Thus ‘small-scale’ or ‘smallholder’ farmers is used here to denote a category of farmers who can be found on a continuum between production strictly for consumption and production for the market (Morton, 2007). This definition suits the study communities in both South Africa and Kenya. The objectives of the study are: to assess the extent to which indigenous knowledge is utilised by small-scale farmers in Kenya and South Africa to lessen the adverse effects of climate change on their farming activities; to examine the mode of transmission of indigenous knowledge in the study communities and finally analyse the extent to which indigenous knowledge is merged with formal scientific knowledge as a means of addressing agricultural related climate change impacts in the study countries.

2. Eastern and southern Africa climate change debates: synopsis

Sub-Saharan Africa is argued to be the world’s most affected region by climate change and its related events (von Soest, 2020). Similarly, most parts of East Africa, the Sahel and Southern Africa – particularly the semi-arid regions - have been classified as the most severely impacted areas by climate change with poverty and low state capability as key influential drivers of climate change impacts in such areas (Liwenga, 2017). Kenya has predominantly tropical to semi-arid climate conditions moderated by diverse topography (Kenya Meteorological Department – KMD, 2016). The highland regions in the central parts of the country, the Rift Valley area and the Lake region in the west are relatively cooler and wetter than the coastal and northern regions (McSweeney et al., 2010). As is characteristic of the East Africa sub-region as a whole, the migration of the Inter-Tropical Convergence Zone (ITCZ) is the main driver of rainfall volumes and trends in Kenya. The activities and movements of the ITCZ are further sensitive to changes in the Indian Ocean sea-surface temperatures (SSTs), particularly the El Niño Southern Oscillation (ENSO) which influences rainfall in the country and contributes to uncertainties in climate projections (McSweeney et al., 2010:1). It is indicated that the recent scarcity of traditionally long rains and wet seasons over some parts of East Africa (particularly western Kenya) could be attributed to the warming levels of the Indian Ocean (Liwenga, 2017).

Various climate models, using decadal records on the climate conditions of the region, estimate that the coming years stand a higher chance of experiencing declines in rainfall volumes (particularly low-lying areas), increasing temperatures, and rising sea levels accompanied by droughts and a decline in agricultural productivity because of fluctuations in SST (Meehl et al., 2009). Omondi et al (2012) add that decadal oscillation evidence of the East Africa region suggests that the next three decades will mark a period of extreme variability in inter-annual patterns in temperature, precipitation and rainfall. In Kenya for instance, McSweeney et al (2010) assert that annual mean temperature has increased by 1° Celsius since the 1960s; and is projected to reach 2.8° Celsius by the 2060s with a corresponding decline in overall annual rainfall volumes if the current trend in climatic conditions continues. Thus, extreme climate-related events influenced by sea-surface temperature changes and oscillation patterns will impact negatively on agricultural production and other weather-linked economic activities of the sub-region, thereby extending the frontiers of poverty in the East Africa sub-region further (Omondi et al., 2012:140). In other words, the unpredictability of the climate conditions in the eastern Africa belt – an area whose economies and livelihoods are closely aligned to rain-dependent systems and activities – will bring serious hardships such as poverty, food and water insecurity, diseases, famines and migration (Niang et al., 2014).

Similarly, the southern Africa sub-region varies from arid in the west, semi-arid in the east, and semi-arid, humid and sub-humid in the north and central zones (SADC and UNEP, 2010; IPCC, 2013). In addition to these geophysical traits, the climate of the sub-region is largely influenced by the wind systems prevailing in the arid and semi-arid regions (Ncube and Lagardien, 2015). The sub-region is also characterised by the southeastly wind systems (which bring about rainfall from the Indian Ocean); the Inter-Tropical Convergence Zone (ITCZ) (which brings about extremely warm and cold conditions) and the sub-tropical eastern continental moist maritime winds (which are conducive for cyclones) (SADC and UNEP, 2010: 11). The IPCC (2013) reports that the sub-region has experienced an average increase in temperature of over 0.5° Celsius in the last century alone. It has also witnessed a relative decline in the volume of rainfall and recurrent isolated droughts (IPCC, 2013). Evidence and climate change prediction models suggest that the southern Africa sub-region's weather will be hotter in the years ahead than it is currently due to climate change. In addition to such increase in temperature, Kandji et al (2006) state that the annual precipitation in the region is expected to decline by approximately 10% with rising temperatures; a situation which could likely translate into a large scale crop failure due to high dependency on rain-fed crop production systems. In support of this argument, Benhin (2008: 666) asserts that, climate change resulting in higher temperatures and worsening rainfall patterns, together with the already scarce water resources in the region are expected to have significant adverse effects on various sectors. Thus, key aspects of national economies (such as agriculture, and tourism) are expected to pay a hefty toll for sustained and unfavourable climate variability.

Despite the huge contribution of agriculture to the growth and development of two of the leading economies in Africa; the agricultural sector in the continent (especially small-scale agriculture) is highly vulnerable to climate change, especially through changing rainfall patterns (IPCC, 2013). The sustainability of a productive agricultural sector in Africa therefore depends on properly managing climate change, among other critical issues. Thus, the capacity of the sub-region to effectively respond to climate change impacts is to the greater extent bound up in the ability and preparedness of its societies to act collectively and make maximum use of its resources including indigenous knowledge relating to agriculture (Ncube and Lagardien, 2015).

This notwithstanding, the dominant discourse on climate change impacts in Africa is predominantly based on modern scientific knowledge. Viewed from below, this approach looks like an imposed discourse, even though the IPCC has given some level of recognition to indigenous knowledge and practices in climate change impacts coping/adaptation strategies in its successive reports. The next section of the paper looks at indigenous knowledge and climate change coping mechanisms from a theoretical perspective.

3. Indigenous knowledge, agriculture and climate change: a theoretical engagement

The term indigenous knowledge can be seen as encompassing other terms such as 'local knowledge,' 'traditional knowledge or practices,' 'peasant knowledge' and 'traditional environmental knowledge' (Mavhura et al., 2013:39). It is used synonymously with 'traditional' and 'local knowledge' to differentiate the skills gained and developed by a given community from the international knowledge systems (Mathias-Mundy, 1993a:3-4; Gupta, 1998). Thus, indigenous knowledge refers to the knowledge of indigenous people of a defined area or community as well as knowledge gained through interaction with other people or communities (Gupta, 1998). This implies that knowledge or practice is considered indigenous if it resides in, or is possessed by, a community – either a large or a small community. It is important to again mention that indigenous knowledge can develop over time in various ways.

Despite its multiple meanings, indigenous knowledge represents a body of knowledge existing within, constructed or acquired by local people over a reasonable period of time and transferred from one generation to another. Shaw et al (2009) indicate that indigenous knowledge in most cases is locally bound, culturally rooted and context-specific. It constitutes traditional local knowledge or local know-how accumulated across generations (Agrawal, 2003). In other words, it is learned and applied within a specific locality or cultural group (Nkomwa et al., 2014). By its cultural background and local specificity, indigenous knowledge is non-formal and orally transmitted, not typically codified and closely linked to the survival and subsistence of particular local or cultural group (see Mavhura et al., 2013).

However, a key complexity or limitation associated with the definition of indigenous knowledge is the definition of what constitutes a 'community' within which the knowledge can be located. Various submissions on the subject tend to define 'community' as a small-scale, bounded, face-to-face, homogenous and egalitarian society (Gupta, 1998:174). This definition becomes somehow contentious as societies are more cosmopolitan in nature, which allows indigenous practices to permeate cultural and geo-political barriers. Although indigenous knowledge is classified as the knowledge of local people and that of any defined community (see Mathias-Mundy, 1993a); limiting the definition of ‘a community’ to a geographically bounded area opens the conceptualisation of indigenous knowledge system to a wide range of criticisms and contentions. In the postcolonial capitalist world we are living today, it is not easy – if not impossible – to limit a particular practice, value or custom to a specific locality or separate such values and practices from modern science due to the increased velocity in the spread of ideas and concepts over space. This means that indigenous knowledge and modern science are imbricated in climate change and development discourses as they overlay each other in practice (Gupta, 1998,).

Linking indigenous knowledge to environmental issues (climate change), indigenous environmental or local climate ‘technical’ knowledge, according to Gupta (1998) constitutes a body of information deployed by locals in the management of natural and human resources to boost agriculture and sustain livelihoods. This means that local small-scale farmers’ technical knowledge about farming environment and interpretations of their local climatic conditions can be more detailed than the global climate generalisations and standardised farming practices or techniques. Gupta (1998) further indicates that the emphases on locally-specific climate and agricultural knowledge – particularly at the small-scale level – does not in any way imply the failure of global scientific research systems on small-holder or low-resourced farmers. Instead, it is a recognition of the empirical knowledge local farmers possess and how they apply such knowledge to sustain their local farming activities in the face of changing global climatic conditions. This is what Scott (1998) refers to as *metis* or practical environmental knowledge and wisdom gained through experience. It is highlighted that *metis* ‘represents a wide range of practical skills and acquired intelligence in responding to a constantly changing natural and human environment’ (Scott, 1998:313).Thus, it is contextual and embodies personal skills and practical results. One key characteristic that qualifies indigenous knowledge as *metis* or tacit knowledge, and further differentiates it from epistemic or scientific knowledge is that, it can only with difficulty be stored, codified or taught as text. It can only be acquired or transferred through practice and experience. Adolph (2005:3) concludes that indigenous knowledge is either embodied in the skills and experiences of individuals or embedded in systems and processes or encultured in social norms and values as opposed to scientific knowledge which is embrained or encoded.

In the context of climate change and small-scale agriculture in Africa, this paper draws on the arguments of Mathias-Mundy (1993a) and Scott (1998) and sees indigenous knowledge systems as ways and means through which residents of a given community (with some degree of socio-cultural, economic, political and environmental commonalities) define and classify their natural and social environments to support their various forms of livelihoods – most importantly, agriculture. It is important to note that community, as used in this context, refers more to a socio-cultural space than a physical geographically circumscribed entity or space. Indigenous practices, traditions and customs are therefore common to people in a particular 'homogenous' socio-cultural space, although there are sometimes local specific variations. Experts argue that such idiographic nuances are informed by differences in environmental conditions, weather and climate patterns and trends. 'Indigenous agriculture' is therefore deemed to be well adapted to such local conditions because it (indigenous agriculture) depends mostly on local practices and traditional plant and animal varieties, which are efficient and productive in their local natural settings. For instance, the local classification and management of soils for crop and animal production, local technical knowledge on which animal breeds and crop varieties can be reared or grown in difficult climatic environments, traditional weather prediction skills, traditional ways of treating crop and animal diseases, and local farming support systems or mechanisms constitute the core of indigenous agricultural knowledge in Africa.

Based on the various arguments presented so far, it could be posited that indigenous knowledge constitutes not only part of human capital, but also of the social capital of rural people as it covers local rules, norms, values and practices that empower residents to cope with adverse environmental conditions. In other words, indigenous knowledge is knowledge in use that can be a useful resource in climate change coping and adaptation drive in Africa, particularly in the agriculture sector, taking into account the rich cultural diversity of the continent. Agrawal (2003) concludes that the need to preserve and merge indigenous knowledge with modern science, particularly in Africa, is informed by the fact that indigenous knowledge is an integral part of the everyday life, religion and customs of those who possess it. This implies that indigenous knowledge is not only culturally bound, but also holistic in its applications, linking agriculture and other forms of production to social organisation and culture. Arguing in favour of the positive role of indigenous knowledge in climate change coping strategies in Africa, Mavhura (2013:38) notes that ‘Indigenous knowledge has been an inherent component of traditional disaster management systems where over centuries; people have adjusted their lives and livelihoods to adapt to changing context’.

4. Methodology

This section gives details of the research methodology adopted. It first describes and justifies the choice of the study countries, sites and the local climate trends; highlights the research design and techniques adopted and finally, the sampling methods used.

4.1 Why South Africa and Kenya?

Agriculture remains critical to people’s livelihoods and national economies in Sub-Saharan Africa. In South Africa for instance, it is estimated that the entire value chain of agriculture accounts for about 12% of national Gross Domestic Product (GDP); while estimatedly 8.5 million people depend on agriculture for employment and income with approximately half of them engaged in small-scale agriculture (Gov SA, 2013:44). In the Eastern Cape Province of the country, agriculture is the most important economic activity after automobile manufacturing. This makes small–scale agriculture one of the major sources of livelihood among most rural inhabitants of the province.

In Kenya, agriculture is the largest contributor to employment – with more than 70% of the agricultural labour force engaged in small-scale rural agriculture (Republic of Kenya, 2006). The total contribution of agriculture to the GDP of Kenya is estimated at about 24%, with crop and livestock production at the forefront (Republic of Kenya, 2006). The Kisumu County is classified by both the Kenya National Bureau of Statistics (KNBS) and Kenyan Meteorological Department (KMD) as one of the highpotential agricultural areas of the country (KNBS, 2014; KMD, 2016). The agricultural significance of the two regions in the two countries makes the Kisumu County and the Eastern Cape Province appropriate sites of a study of this nature.

4.2 Study sites and climate trends

The study areas falls within Latitude 0'092 – 0'37; 32'45 – 33'13 degrees S and longitude 26'71 – 27'86; 34'77- 35'82 degrees E – an area which covers from East London to Grahamstown in the Eastern Cape of South Africa and the Kisumu county of Kenya (SAWS, 2016; KNBS, 2014). The study communities were Agoro, Kabura, Karemo and Nganyi Locations in Kenya; while Kwelera, Mxumbu, Dikidikana and Ndlambe villages were selected from South Africa. The Kenyan communities are inhabited by members of the Luo ethnic group, except Nganyi, whose inhabitants are Luhya. The South African communities are inhabited by members of the Xhosa ethnic group. The major crops grown in the study communities are; maize, potato, beans, millet, sorghum, cassava, pigeon pea, cabbage, spinach, carrot, water melon and pumpkin. Animal farming in the communities is predominantly livestock. Farming lands are owned by individual households and clans. Apart from agriculture, residents of the study communities support their livelihoods with remittances from their migrant relatives in the major cities and abroad. As indicated earlier, despite the significant contribution of agriculture to the growth and development of the two countries, the sector is highly vulnerable to climate change because of the relationship between climate variability and rainfall distributions and patterns (IPCC, 2013). This implies that a productive agriculture sector in the study communities greatly depends on how farmers utilise all forms of resources to manage local climate change trends, among other critical factors.

Records show that the maximum average temperature recorded in the last two generations of the 20th century and the first decade of the 21st century depicts a steady increase in temperature in the Kisumu County over the years. The total annual rainfall received within the same period in the area depicts a steady decline. This trend is projected to continue in the years ahead (KMD, 2016). Similarly, the

Eastern Cape climate situation (temperature and rainfall) corroborates that of Kisumu SAWS, 2016

The net effect of the continuous increase in maximum annual temperature and a corresponding decrease in annual rainfall volumes in the study areas is the increase in evapotranspiration; a scenario that would subsequently lead to reduced soil moisture and fertility resulting in low levels of crop yield. The need to harness local resources including indigenous knowledge to salvage small-scale agriculture in the affected areas, boost productivity and sustain livelihoods in the study communities is necessary.

4.3 Sampling, data collection and data analysis procedure

For every scientific study, the approach to the study is determined by the aim and objectives of the study. In this particular study, a qualitative study approach was adopted. Drawing on phenomenology as a paradigm which sees human behaviour as a process of making sense of their world by continuously creating, defining, interpreting, justifying, rationalising and giving meaning to actions or words (Babbie, 2014); a qualitative approach enabled the researcher to define and interpret some of the local traditions and agricultural practices of residents and give them meaning in the context of climate change. Again, in-depth interaction with the people – which is an integral part of a qualitative research – enabled the researcher to adequately assess the kind of meanings and values local residents attach to certain agricultural related indigenous practices and norms which have been helpful to them over the years in sustaining good agricultural yield in the context of changing global climatic conditions. In the next section, the sampling methods used in selecting the respondents are explained.

4.3.1 Sampling procedure

Research experts indicate that a carefully selected sample provides a group of respondents whose characteristics may be taken to reflect those of the larger population (Babbie, 2014). Given the specialised nature of indigenous ecological knowledge, non-probability sampling (purposive sampling) was used to select a total of 115 respondents from South (56) and Kenya (59) based on their years of experience and specialised knowledge in environmental issues. The respondents were made up of officials from the South African Weather Services (SAWS), the Kenyan Meteorological Department (KMD), traditional weather forecasters (Kenya), community/traditional leaders and other community members above 45 years of age. The table below gives a breakdown of the respondents.

Table 1 Breakdown of respondents

Type of respondents	Number interviewed (South Africa)	Number interviewed (Kenya)	Total respondents
Meteorological services	3	3	6
Community/traditional leaders	4	4	8
Traditional weather forecasters ('rain makers')	0	2	2
Community members above 45 years old	49	50	99
TOTAL	***56***	***59***	**115**

Source: fieldwork.

4.3.2 Data collection procedures

The fieldwork was conducted in English, isiXhosa and Dhuluo with the help of research assistants from the Universities of Fort Hare and Nairobi and officials from KMD and SAWS who assisted the researchers with translations. Key informant interviews, semi-structured in-depth interviews, focus group discussions (FGDs), visual sociology and field observations were adopted to collect data from the various categories of respondents mentioned in the section 4.3.1. Responses from the various interview sessions were recorded with an audio recorder and later on transcribed and translated for analysis purposes. The combination of these data collection techniques accorded the researchers the opportunity to measure the availability and utilisation of various aspects of agro-ecological indigenous knowledge in lessening the impacts of climate change on small-scale agriculture in the study communities. Thus, through verbal narratives, visual observations and the principle of serendipity, the researchers were able to follow leads and explore in details the study variables to compressively answer the research questions. After working with a total of 115 respondents, theoretical saturation was reached. Strauss and Corbin (1998:212) argue that theoretical saturation occurs when the researcher establishes that no new or relevant data seems to be emerging from the respondents, and that enough applicable information has been gathered to satisfactorily answer all the research questions.

4.3.3 Data analysis

To properly analyse the data collected, all the audio recordings from the various interviews were first transcribed. Responses given in isiXhosa and Dhuluo were translated into English and added to the field notes taken. This gave the research team an opportunity to identify the key themes emerging. The emerged themes were used to generate findings to give meaning to the study according to the research objectives. From the explanation given above, the traditional/manual method was used in the data analysis process and not a software. The study validated the data obtained through a methodological triangulation (the use of multiple qualitative and/or quantitative methods in the same study). This was done by comparing and integrating the data collected through various methods to confirm the validity and trustworthiness of the results. The findings of the study are presented in the next section. The first part of the findings covers the application of various aspects of indigenous knowledge and practices by small-scale farmers in their daily agricultural activities and how such practices have helped to minimise the impact of climate change on their yields. This is followed by findings on the development and transmission of local knowledge in the study communities and finally, the level of integration between local knowledge and modern science in coping with adverse climate change impacts on small-scale agriculture.

5. Results

The study found a wide range of traditional/indigenous agricultural practices, customs, belief systems and skills in the two study countries which local residents apply in various forms to boost their agricultural activities in the face of changing global and local climatic conditions. It is important to highlight here that, despite the fact that the study was conducted in two different countries from two different sub-regions in the continent; it was not necessarily a comparative study in nature. The two countries were however chosen to demonstrate to readers the widespread and commonality nature of African indigenous knowledge systems and their application thereof despite the socio-cultural diversities between various societies in the continent. As a result, even though the findings are not presented on country-by-country basis, where necessary, names of countries or places are mentioned for purposes of clarity. The findings are presented under the following headings: rainfall and seasonal weather predictions; land preparation and planting systems; grain preservation systems; intra- and inter-community support systems, traditional medicine practices, knowledge development and transmission and integration between local knowledge and modern science.

5.1 Rainfall and seasonal weather predictions

The study found that through social, bio-physical and ecological indicators, locals are able to predict rainfall and changes in seasons and further give warnings of climate disasters. This skill of predicting rainfall and the onset of planting season resides mostly among the elderly and a special group of people known as rain-makers – in the case of Nganyi village, Kenya. It was noted that residents are able to predict rain and seasonal changes through observing changes in the behavioural patterns of birds, insects, reptiles, amphibians and different plant species. Such observations also include wind systems. The Nganyi rain-makers (*Abachimba* in Luhya) also combine the observation of the same objects with their 'supernatural powers' to predict and give weather and farming advice to their 'subjects'. At the Nganyi village of Kenya and in one of the 'shrines' (a sacred grove in the village where the Abachimba operate from), the lead rain-maker at the centre had this to tell the research team:

> “Apart from using the spiritual powers I inherited from my grandparents which I am also training my son to acquire to predict rain and other weather conditions; I also use my knowledge in the appearance and behaviour of animals like frogs, certain species of birds, butterflies, snakes and the rest to determine variations in local weather conditions and the commencement of new farming seasons. This may look strange to you (referring to the research team) because of your exposure to western education and modern technology; but this is what we use here in the village to sustain our farming activities”.

The Nganyi rain-makers are traditionally trained rain and weather forecasters with both skills and perceived supernatural powers and abilities to forecast changes in atmospheric and weather conditions including events like storms, floods and extended dry spells. According to local narratives, the special skill of traditional weather and climate forecasting dates back in history within a particular small clan or lineage called the Abasiekwe of the Banyore tribe in the Nganyi community. They are called the ‘rain-makers’ because their ‘subjects’ believe that they do not only have the powers to predict weather and climate patterns, but that they can also conjure rains when rain is least expected (this study could not however ascertain the potency and veracity of such powers). Transfer of the skills and powers of predicting rains and seasons is hereditary and reserved for only male children from the Abasiekwe lineage.

On the contrary, even though an organised body of local climate and weather experts was not found in the South African study communities like the ‘Nganyi rain-makers’ in Kenya, it emerged that elderly individuals in various households have the knowledge and skills of traditionally predicting rains and seasons like their Kenyan counterparts. In both Kenya and South Africa, it was found that local farmers trust the traditional weather experts and their predictions and therefore combine such predictions and climate advice with modern science to structure their farming calendar so as to lessen the adverse impacts of climate change on their farming activities. The next section looks at how residents use animals and various ecological objects as indicators to predict rains and seasons in the study communities.

5.1.1 Plants

Different wild plant species and their behaviours play a very important role in determining atmospheric changes and agricultural seasons among local farmers. The knowledge surrounding the use of plants to predict weather conditions and farming seasons was found to be common among residents in both study countries and plays a significant role in small-scale agriculture. A 50-year old man in Agoro (Kenya) mentioned that:

> "The use of plants to predict changes in climatic conditions and weather patterns is as old as our history as people. I do not know when it started and I do not know when it will end. What I can tell you is that it helps us a lot in understanding changes in weather conditions and the onset or cessation of the planting season, especially those of us who do not understand English".

This expression was supported by 46 other respondents – from both Kenya and South Africa – in different occasions who indicated that most scientific climate and weather forecast are given in English which makes it difficult for the uneducated ones to understand. They therefore depend on the behavioural pattern of plant species like *Onera – Terminalia brownii* (Combretaceae); *Ober – Albizia coriaria* (Leguminosae); *Ngou – Ficus vallis-choudae (*Moraceae); *Yago – Kigelia africana* (Bignoniaceae) and *Umnga – Acacia karoo-hayne* (Fabaceae) (Kokwaro and Johns, 1998; Afolayan et al., 2014) to predict weather and agricultural seasons and patterns.

5.1.2 Animals

Similarly, residents use different types of birds, frogs, snakes, lizards, butterflies and insects to predict rains and local planting seasons. Residents indicated that the behaviour of some of these animals (including procreation) is closely related to changes in local climatic and atmospheric conditions (especially temperature and humidity). For instances, the appearance or migration of certain species of birds like *Magungu – open-billed stork (Anastomus lamelligerus* – Ciconiidae*); Kaku (scientific name unknown); Okok* – cattle egret *(Ardrea ibis)*, and also reptiles and amphibians like *Obongo – Agama lizard (*Agama agama) and *Majola snake* – blind snake (*Indotyphlops braminus*) (Kokwaro and Johns, 1998; Afolayan et al., 2014).

Butterflies and safari ants are also used as indicators to predict the commencement of new agricultural season. Consequently, the early or late appearance of such animals marks good and bad farming seasons respectively. A 61-year old woman in Ndlambe (South Africa) indicated that:

> "By the nature of our culture, traditions and practices, we value our natural environment so much as it gives us so many indicators and signs to plan our farming activities here in the villages. For instance, without even listening to the radio for weather report, we can use the appearance or disappearance of some specific species of birds, butterflies and even snakes to predict the farming seasons and start preparing our farmlands accordingly".

As many as 86 different respondents from both countries mentioned that they combine the appearance and behaviour of different animals with other traditional indicators to plan and execute their farming activities.

5.1.3 Wind speed and direction

It was found that the pattern, direction and speed of the wind are used by traditional weather and climate experts to forecast local weather trends and farming seasons. The elders specifically indicated that they use wind speed and direction to predict farming seasons. A 69 years old community leader (male) in Kwelera village of South Africa said:

> "I use the movement and speed of the wind to determine whether there would be more or less rains in a particular season. I again use the same strategy to determine the onset of the rainy season, when to start preparing the farmlands and which type of crops to plant first in that particular year. I learnt this skill from my grandfather here in the village. My father was working in the mines at Johannesburg so I did not get the opportunity to stay with him. It was my grandfather who taught me farming and all the other skills that come with it before he died".

The direction and speed of the wind, according to the local expert, is measured by either throwing dust into the air at certain time intervals to establish a trend or from the movement of smoke from burning fields. For instance, a northerly wind indicates an impending dry spell according to the local experts; while southerly wind indicates an impending wet spell.

From an outsider perspective, one could be tempted to associate the skills and knowledge of rain and season predictions with mere environmental observations and mythology. However, a careful study and analysis of some of the practices show that the knowledge and skills surrounding local weather and climate patterns are gained through years of experience and in-depth wisdom about the behavioural patterns of salient ecological objects and therefore deserve some level of recognition in climate change discussions as residents rely heavily on their indigenous knowledge to plan their agriculture activities to avoid crop failures in the face of climate variability.

5.2 Land preparation, crop choices and planting systems

To support good crop yields against changes in local climatic conditions, the study again noted that farmers prepare their farm lands with locally prepared compost to boost soil fertility, choose specific crops to match soil types and adopt planting systems that can withstand the prevailing weather and climatic conditions. A 62-year old widow in Dikidikana village of South Africa indicated at an FGD session that:

> "As a widow with young children and grandchildren to take care of, I don't have money to buy fertilizers from the market like other people do. Again, I have a small parcel of land to farm on so I don't have the luxury of practicing shifting cultivation which most people do in this village because they have bigger land sizes. I solely rely on things like sawdust, cow and poultry droppings and non-plastic household refuse to prepare my own manure to fertilize my garden. It has been working for me very well since my husband died about 13years ago" [sic].

As mentioned by the respondent quoted above, the study found that local compost is prepared from household refuse, cow dung, poultry droppings, sawdust and post-harvest residues from the gardens. Crops like millet and sorghum are grown on relatively less moist and fertile lands because they require less water; while crops like maize, cassava and potato are grown on comparatively more fertile and moist lands due to their water requirements. Additionally, farmers indicated that they intercrop maize in particular, with different types of beans not only to maximise land utility, but also as cover crops. They argued that intercropping (particularly leguminous crops) helps in sequestering soil nutrients to boost yield and also to control soil and crop erosions.

It was found that farmers use intercropping to sustain their agricultural activities in the face of changing local climatic conditions. What was found to be more interesting was the farmers' traditional ability and skills of classifying soils (based on fertility and moisture levels) and the determination of the kind of crops to be grown on different soil types without any scientific guidance. Through years of farming experience and the knowledge gained thereof, farmers are able to determine both the quality of soils and properties of crops to suggest the best course of agricultural action on a piece of land under varying climate and weather conditions. For example, crops like maize, beans, water melons, potatoes and pumpkins are mixed and grown on relatively moist and fertile lands; while millet, sorghum and pigeon peas are grown on less moist and fertile lands based on – according to the farmers – the differences in water and soil nutrient requirements of the various crops, among other factors.

5.3 Grain preservation and farming support systems

The study again found that farmers have traditional ways of preserving grains, which is called *Bukho* (Dhuluo) or *Isiwenye* (isiXhosa), for the next planting season. *Bukho* or *Isiwenye* involves the hanging of cobs in smoky areas or mixing grains with ash and keep them in a pot sealed with cow dung. This practice, according to local narratives, provides a protective layer to the grains and defends the kernels of the grains from weevils, which further enhances germination rates. When planted, traditionally preserved grains are able to withstand hot weather conditions without rotting as compared to exotic breeds. At an FGD session in Karemo village of Kenya, a 72-year old retired police officer now a full time crop and livestock farmer said:

> "Given the continuous changes in global climatic conditions and the appearance of strange pests in our farms lately; it is very difficult to keep local species of the various crops we grow in our farms. We use what is called *Bukho* to preserve the best quality of grains harvested for

> planting purposes in the next farming season. This method involves either hanging of grains in a smoky area (kitchen), or mixing them with ash and keeps them in a pot sealed with cow dung. I know this method would look strange to you because you think we always buy our seedlings from agro-chemical shops. This is not always the case. We have our own traditional ways of preserving the grains for planting purposes and that is what I have explained to you".

Again, farmers have their own traditional intra- and inter-community agricultural support systems. To minimise the adverse impacts of climate variability – particularly shifts in the rainfall calendar and extended dry spells – residents have traditional group-labour system called *Saga* (Dholuo) or *Lima* (isiXhosa). It is an intra-community traditional support system found in both South Africa and Kenya where a number of farmers come together to form a special working group which works on the farms of its members on rotational basis. The system saves time and allows farmers to prepare their farmlands fast to meet the planting season and avoid late planting and subsequent crop failures. It is also educative as it provides platform for famers to share knowledge on farming activities while working together. To highlight the significance of this method to the local people, the headman (local chief) of Mxumbu village in South Africa said:

> "You see, this your so-called civilisation has destroyed a lot of things relating to African culture and traditions. When we were young like you (referring to the research team), *Lima* was a common practice in this village. Even though it is still practised in the village, its practise is not widespread like it used to be in the olden days because people see it as an old-fashioned practice. It is very helpful because it gives you as group members the opportunity to share more ideas when working together".

Another equally important local agricultural practice identified was loaning of livestock and seedlings. During adverse weather conditions such as severe droughts; certain crops and animal species or breeds are loaned to farmers in neighbouring villages with relatively favourable farming conditions or resources with no monetary compensation attached. This practice is called *Imbo* (Dholuo) or *Inkomo Yenqoma* (isiXhosa). The system helps to prevent a particular breed of livestock or crop variety from becoming extinct in the event of a natural or climate change induced disaster. It again helps to resuscitate the livelihoods of the ‘poor,’ ‘needy’ and climate disaster victims.

5.4 Indigenous knowledge development and transmission

The study found that generally, the proper development and transmission of this rich aspect of African culture and traditions are constrained by a number of issues. Among such issues are; the association of modernity with science, the modern education system and urbanisation. Collectively, these factors either keep the younger generation away from their indigenous culture and traditions or make them perceive such traditions as outmoded – a situation which strongly blocks the prospects of development and transmission of indigenous knowledge in the study communities. This is further exacerbated by the observation made in the communities that indigenous knowledge is mostly held by the elderly and uneducated residents who have little or no capacity at all to document it. This implies that death or memory loss – due to old age – of such standard bearers of indigenous knowledge contributes to loss of a rich aspect of African culture and traditions in local communities.

Despite these general challenges, it was noted that Kenya has a comparatively better systems of indigenous knowledge development and transmission than South Africa. The acquisition of the knowledge of rain and season prediction under the traditions of the rain-makers in Kenya for instance, is through a traditionally ‘institutionalised’ apprenticeship where recruitment into such an institution or ‘training school’ is based purely on kinship ties. Male children from a particular lineage or kinship are selected and trained to inherit their parents and grandparents in the practice. This somewhat allows for a smooth transmission of knowledge from one generation to the other in the said lineage. Even though individual elders in South Africa were found to possess similar skills of predicting rains and seasons, the study did not however come across any kind of ‘institutionalised’ form of knowledge transmission as it is done in Kenya. This makes the smooth transfer of local agricultural knowledge and practices from one generation to another slow in South Africa as compared to Kenya.

5.5 *Integration between indigenous knowledge and modern science*

Merging modern scientific farming methods with indigenous farming practices was found at two levels in the study communities – individual and institutional levels. It emerged that individual farmers in both countries combine the use of modern farming equipment and inputs like tractors and their supporting implements, hybrid seeds, inorganic fertilizers and tube wells with locally prepared compost, traditional crop varieties and other local farming practices and knowledge to sustain yield in the face of changing climatic conditions. Institutionally, Kenya was found to have better integration of the knowledge systems as compared to South Africa. Probably, the political history and the relative level of development of South Africa could explain why there is low level of integration between indigenous knowledge and modern science. South Africa is arguably more developed than Kenya and therefore has more advanced and modern farming technologies and equipment than Kenya, hence the lesser deployment of indigenous knowledge by small-scale farmers in South Africa as compared to Kenya. Under the Agricultural Sector Development Programme (ASDP), both national and county governments in Kenya aim among many other things, at alleviating poverty and improving livelihoods of small-scale farmers through the mobilisation of local resources, particularly indigenous knowledge. The Kenyan government therefore holds indigenous knowledge in a high esteem under the ASDP, a practice that could clearly not be found in South Africa. Again, under the Radio Africa Network (RANET) initiative, the Kenyan government in collaboration with the Kenyan Meteorological Department (KMD) has established local radio stations to educate and inform farmers on climate change and agricultural issues in local languages. The broadcasting content of these local radio stations is based on the combination of modern science and indigenous knowledge of the people with experts drawn from various government departments and the rain-makers fraternity. Again, this was not found in South Africa. This initiative gives local farmers an opportunity to blend traditional farming practices with modernity in Kenya than in South Africa.

The evidence given above are some of the socio-cultural practices farmers deploy to supplement modern agricultural technologies in minimising the impacts of climate change on small-scale agriculture in Kenya and South Africa, as well as the development and transmission of such practices as found by the study.

6. Discussion

To make reading easy and for a coherent presentation of discussion of the findings, this section is divided into sub-sections following the specific objectives of the study namely: the role of indigenous practices, local traditions, customs, beliefs and local environmental knowledge in lessening the impacts of climate change relating to small-scale agriculture; the mode of development and transmission of such practices, beliefs, traditions and the 'integration' between modern scientific activities and local practices among small-scale farmers in the study communities.

6.1 The role of indigenous practices in lessening the impacts of climate change relating to small-scale agriculture

Based on the findings presented, the study shows how indigenous agricultural concepts, local knowledge and traditional skills of agronomy still dominate both the discourse and practice of farming among rural residents in Kenya and South Africa with the study communities as examples. This is not to say or imply that bio-scientific concepts and practices are totally absent. Thus, local farmers continually combine hybrid seeds and bio-chemical inputs with indigenous agricultural practices and norms to boost their farming activities and sustain livelihoods. The study demonstrates the coexistence of modern science and indigenous knowledge small-scale farmers in the study communities in handling climate change. This cements Mafongoya and Ajayi (2017) argument that with little or no scientific guidance at all, Africans are able to predict weather patterns using traditional indicators to ameliorate the impact of climate change on their livelihood systems. Although over time, the value of some of such indicators would become threatened or declined due to climate change itself; currently, their usefulness is still paramount to the African rural residents. Farmers with inadequate resources to buy seedlings and or properly irrigate and fertilize their farms resort to traditionally preserved seeds and local compost to sustain their farming activities. Similarly, those with relatively good financial resources and who can afford some level of modern farming inputs and technologies equally compliment such inputs with local practices. All these indicate that there is an enormous repertoire of indigenous knowledge in rural communities in both countries – and by extension Africa – which is vital in managing climate variability and its corresponding adverse impacts on livelihoods, particularly agriculture. Again, it fills the void created by inadequacy or unavailability of financial resources and agricultural extension services.

Synchronising indigenous knowledge of rain and season prediction with climate science for instance; it could be argued that probably the behaviour of some of the plant species is a result of their close affinity with moisture or humidity. Thus, the flowering and the production of new leaves of plants are indications of an enhanced increase in atmospheric moisture, hence the onset of rainfall season (Ouma et al., 2013). Additionally, Ogallo (2000) argues that some of these plants by their nature are able to sense the decrease in water supply (something which indicates the end of the rainy season) and shedding their leaves or folding up for example, is a natural way of conserving water and energy. Moreover, some of the observed animals (birds and butterflies) use the monsoonal winds – which carry moisture and bring rainfall within and around the inter-tropical convergence zone – as their carriers to migrate; while most reptiles and amphibians by nature react to changes in atmospheric temperature (Ogallo, 2000; Ouma et al., 2013; Mapfumo et al., 2015). Finally, insects and ants presumably appear to gather and store enough food underground to avoid being washed away by runoff water. Hence, the coincidence of the appearance and migration of some of these animals with the beginning of rainfall seasons in the study areas (Elia, et al., 2014).

Indigenous knowledge by its disposition and application is neither conservative nor static. This means that it continually adopts or borrows from other cultures and knowledge bases – particularly from modern biotechnology – to accommodate the changing trends of climate events (see Gupta, 1998; Mavhura et al., 2013). As farmers' most important experience of climate change over the short and medium term will be through increased climate variability and extreme events, local environmental knowledge can be considered an important resource in managing the impacts of climate change in Africa. This partly explains why small-scale farmers combine their traditional practices with exotic seeds, chemical fertilizers, pesticides and irrigation facilities in the study communities to boost their yields. Moreover, what gives indigenous knowledge on agronomy some level of significance in coping with climate change impacts on small-scale agriculture – particularly in Africa – is that it represents, to some extent, culturally constituted solutions to various environmental challenges in local settings as reported in countries like Uganda, Tanzania, Zimbabwe, Malawi, Bostwana Burkina Faso and Mali by other researchers (for instances Mapfumo, et al., 2015; Mafongoya and Ajayi, 2017; Liwenga, 2017; Subhita and Babita, 2021).

6.2 The development and transmission of indigenous knowledge

The importance and value of indigenous knowledge in the management of environmental and natural resources has been ignored and not adequately developed and integrated into modern science or formal education systems in Africa (Mafongoya and Ajayi, 2017:138). This assertion is confirmed by the current study as it was noted that the development and transmission of indigenous knowledge, particularly an aspect relating to farming is constrained by a number of factors. This is despite the fact that since time immemorial indigenous knowledge has been one of the key resources on which rural communities have relied upon for food security and income generation (von Soest, 2020). Literature and empirical evidence from this study show that there is a real threat to the development of indigenous knowledge systems in Africa as a whole due to the advent of modern religions, urbanisation and western education systems in the continent. These factors have made people to perceive indigenous knowledge as primitive, pagan and unchristian. Assessing the situation from a different perspective, one could say that the total neglect of traditional African knowledge on environment and agriculture because of western impositions is the beginning of the demise of African identity and its social capital.

However, there is a glimpse of hope in developing and preserving indigenous knowledge systems in Africa as Kenya was found to have a little bit of knowledge development and transmission structures among the Nganyi group which other Africa communities can emulate. Even though there was no system like that in the study communities of South Africa, a similar system can be instituted to preserve this rich aspect of African culture and even in other African countries not mentioned in this study.

6.3 Integration between modern science and local practices

This study demonstrates that merging modern technologies of farming with traditional and culturally inherited agricultural practices can help cushion local farmers against the adverse impacts of changing global climatic conditions on their farming activities.

This comparative account of indigenous knowledge in two countries is intended to move contestation around the potency of local and African climate change adaptation strategies onto an empirical footing. Integrating or merging indigenous knowledge with modern climate change policies and intervention programmes could help in designing efficient and effective adaptation strategies relating to agriculture, particularly small-scale agriculture. The incorporation of traditional African understandings of local weather patterns and the local meanings attached to ecological indicators into global climate change adaptation strategies can help small-scale farmers in Africa to easily understand and accept the implementation of various climate change adaptation policies. This notion is borne out of the fact that the contextualisation of climate change impacts and tackling such impacts from an indigenous knowledge perspective would be more than relevant, as local understanding and interpretation of climate change and climate events influence local residents' preparedness to accept or reject certain adaptation strategies. Arguing in favour of this view, Retnowati et al., 2014 states that integrating indigenous knowledge with main stream scientific knowledge through research is essential as it can contribute to the generation of new co-produced knowledge relevant for effective adaptation strategies and actions at local levels. This could again provide an insight into short and long term climate change adaptation in Africa relating specifically to the agriculture sector and further strengthen the links between policies, local practices, and climate change impacts mitigation in Africa.

7. Conclusion

This paper has presented a congeries of ethno-agricultural practices from the two study countries to demonstrate that indigenous knowledge is culturally bound and forms part of the socio-economic lifestyle of the people who possess it. It is of a different nature from scientific knowledge, being knowledge in use, *metis*, or tacit knowledge. Traditional practices are common to people with similar or common socio-cultural practices and values across borders and regions. The paper further highlights that a hybridized small-scale agriculture (a mixture of local and modern farming practices) in Africa could help develop a syncretic agronomical knowledge among local farmers in handling climate change impacts. Thus, complementing modern and scientific agricultural methods with saliences in indigenous agricultural practices in Africa could help small-scale farmers to strengthen their buffers against the negative effects of climate change on their farming activities. The local practices discussed in this paper are not necessarily indigenous to the study areas; indeed, most of the local practices/customs are prevalent across African communities, and in communities outside the continent. The crucial point is that they form part of the veritable assets around which the practising African communities build resilience against socio-environmental hazards.

Using evidence from two different countries in this paper helps to demonstrate how widespread the application of indigenous knowledge is in coping with climate change impacts in the agricultural sector; and again highlight the strength and weakness in the development, transmission and integration process of indigenous knowledge systems with modern science across nations and cultures in Africa. There are systemic differences between Kenya and South Africa in the amount of knowledge that is current, the extent to which it is being transmitted across generations, and the ways in which it is being integrated with scientific knowledge. In conclusion, one could mention that policies and mechanisms aimed at managing the impacts of climate change in vulnerable communities in Africa should not ignore the richness of local and indigenous knowledge.

8. Policy implications

Further to the above conclusion, the findings of the study could have the following policy implications in Africa:

- The paper could lead to policy revisions that would promote an increased investment in further research into indigenous knowledge systems and its relevance to agriculture in Africa in the face of changes in global climatic conditions. This would give farmers accurate and relevant data on which aspects of local traditions and practices relating to agriculture to be reinforced and those to be discontinued.
- Again, it could enhance the promotion of the conservation of certain plant and animal species in the rural settings of Africa for the purposes of using them as indicators for predicting weather conditions and farming seasons.
- The paper could further add more voice to the call for the development and promotion of indigenous knowledge in Africa in order to increase its recognition and value in African farming systems. This would allow the younger generation to draw closer to the few custodians of the knowledge for the purposes of learning and preserving it.
- The paper could finally prompt policy makers and research funders to support research bodies and institutions of higher learning to document the salient aspects of indigenous knowledge in order to save it from going extinct. The preservation of African indigenous knowledge could serve as a pacesetter for the development of what some scholars refer to as ‘African science’ for African consumption.

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