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ORIGINAL ARTICLE

The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel

A. Nyong · F. Adesina · B. Osman Elasha

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Abstract Past global efforts at dealing with the problem of global warming concentrated on mitigation, with the aim of reducing and possibly stabilizing greenhouse gas (GHG) concentrations in the atmosphere. With the slow progress in achieving this, adaptation was viewed as a viable option to reduce the vulnerability to the anticipated negative impacts of global warming. It is increasingly realized that mitigation and adaptation should not be pursued independent of each other but as complements. This has resulted in the recent calls for the integration of adaptation into mitigation strategies. However, integrating mitigation and adaptation into climate change concerns is not a completely new idea in the African Sahel. The region is characterized by severe and frequent droughts with records dating back into centuries. The local populations in this region, through their indigenous knowledge systems, have developed and implemented extensive mitigation and adaptation strategies that have enabled them reduce their vulnerability to past climate variability and change, which exceed those predicted by models of future climate change. However, this knowledge is rarely taken into consideration in the design and implementation of modern mitigation and adaptation strategies. This paper highlights some indigenous mitigation and adaptation strategies that have been practiced in the Sahel, and the benefits of integrating indigenous knowledge into formal climate change mitigation and adaptation strategies. Incorporating indigenous knowledge can add value to the development of sustainable climate change mitigation and adaptation strategies that are rich in local content, and planned in conjunction with local people.

A. Nyong (✉)
Climate Change Adaptation in Africa Programme,
International Development Research Centre,
P.O. Box 62084, 00200 Nairobi, Kenya
e-mail: anyong@idrc.or.ke

F. Adesina
Department of Geography, Faculty of Social Sciences, Obafemi Awolowo University, Ile-Ife, Nigeria

B. Osman Elasha
Climate Change Unit, Higher Council for Environment and Natural Resources, Khartoum, Sudan

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1 Introduction

Increase in greenhouse gas (GHG) emissions through human activities has resulted in additional warming of the earth's surface, with several anticipated disastrous impacts. Initial efforts at dealing with the problem of global warming concentrated on mitigation, with the aim of reducing and possibly stabilizing the GHG concentrations in the atmosphere (UNFCCC 1992). Even if this stabilization was achieved, sea level rise and global warming would continue to increase over centuries because of the inertia of the earth systems. Consequently, adaptation was seen as a viable option in reducing the vulnerability associated with anticipated negative impacts of climate change. It is increasingly realized that mitigation and adaptation can yield better results if both strategies are seen as complements. This is justified in the recent calls to integrate adaptation and mitigation strategies into climate change policies.

Integrating mitigation and adaptation into climate change concerns is not a completely new idea in the African Sahel. The African Sahel is characterized by recurrent droughts, the magnitude and intensity of which have been on the increase over the last 100 years and consequently in the destruction caused by it (Benson and Clay 1998; Brooks 1999). Records show that the region has experienced marked rainfall declines and droughts that exceed those predicted by models of future climate (Hulme et al. 2001). The fact that the communities in this region have survived till today with a fast population growth rate is an indication that they have developed indigenous mechanisms and strategies to cope with these droughts. Some of these actions combine elements of mitigation and adaptation. Traditional knowledge about how local populations have coped with previous droughts has the potential of providing important guide for addressing current and future climatic events.

While the importance of indigenous knowledge has been realized in the design and implementation of sustainable development projects, little has been done to incorporate this into formal climate change mitigation and adaptation strategies. Climate change cannot be divorced from sustainable development as sustainable development may be the most effective way to frame the mitigation question and a crucial dimension of climate change adaptation and impacts (Swart et al. 2003; Cohen et al. 1998). Incorporating indigenous knowledge into climate change policies can lead to the development of effective mitigation and adaptation strategies that are cost-effective, participatory, and sustainable (Robinson and Herbert 2001; Hunn 1993). However, incorporating indigenous knowledge into climate change concerns should not be done at the expense of modern/western scientific knowledge. Indigenous knowledge should complement, rather than compete with global knowledge systems.

This paper explores some of the ways in which local populations in the Sahel have integrated mitigation and adaptation into their livelihood strategies to reduce their vulnerability to droughts. Collectively, this knowledge represents a dynamic information base that has supported an immense population by adapting to constantly changing and varying climate.

The paper begins by reviewing the Sahelian environment, the past, present and future climatic characteristics of the region and their influence on other elements of the environment, especially vegetation, water resources, socioeconomic as well as cultural patterns. The next section reviews the concept of mitigation and adaptation and describes some indigenous mitigation and adaptation strategies the local populations in the Sahel have implemented to reduce GHG emissions as well as adapt to adverse impacts of climate variability and change. Section 4 discusses the need to integrate indigenous knowledge into mitigation and adaptation policies, and also suggests ways of doing that. The conclusion supports the need to integrate indigenous knowledge with western scientific knowledge for the design and implementation of best practices in climate change mitigation and adaptation strategies.

2 The Sahelian environment

The Sahel generally refers to the semi-arid and arid region of Africa and constitutes significant portions of Senegal, Gambia Mauritania, Mali, Burkina Faso, Niger, Chad, and the Sudan. By some definitions, the Sahel covers a wider latitudinal belt that extends roughly between 10° and 20°N into parts of the Ivory Coast, Ghana, Benin, Togo, Nigeria, Cameroon and Ethiopia. The word ''Sahel'' is derived from Arabic which means ''shore''; a shore which borders the extreme fringe of the Sahara, where the ecology and the climate make life possible again after the vast and lifeless Sahara desert. The vegetal cover is composed of annual grasses with few shrubs and stunted trees, which becomes denser as one moves towards the South. Several major rivers flow through the region, fed mostly by the wetter regions in the south. Few of these rivers are perennial. Within the region there are also ephemeral streams, which flow only during and shortly after the rainy season

The Sahel is characterized by strong climatic variations and fluctuations with a highly irregular rainfall. The region exhibits a steep gradient of decreasing rainfall from south to north, with totals ranging from 150 mm in the northern fringes to about 600 mm in the south (Brooks 1999). The rains fall during a short single wet season that lasts for about 3–4 months. Annual rainfall levels have been decreasing in the region over the course of this century, with an increase in inter-annual and spatial variability.

Drought has been a recurrent feature in this region, with early records dating back to the 1680s. The magnitude and intensity of these droughts have been on the increase over the last 100 years, and consequently in the destruction caused by it (Hulme et al. 2001; Tarhule and Lamb 2003). The most prominent of these droughts was that of the early 1970s during which 100s of 1000s of people and millions of animals died (Mortimore 1998). The Palmer Drought Severity Index shows that the Sahel is still experiencing drought conditions (Dai et al. 2004). The climatic changes observed in the Sahel are consistent with scenarios of anthropogenic enhanced greenhouse warming as described in modeling studies. Climate simulations also show a statistically significant influence of changing Sea Surface Temperature on rainfall variability over a large part of the Sahel. The warming of the tropical Atlantic by up to 2K as predicted for 2090 has a remarkable impact on the distribution of rainfall over the southern part of the Sahel: while coastal rainfall up to 10°N is increasing by almost 500 mm, the Sudan and Sahel are threatened by a deficit of precipitation amounting to 200 mm (Hulme et al. 2001).

The Sahel is characterized by a very high population growth (about 3.1%) and a rapid rate of urbanization that is estimated at about 7%. With a population of about 50 million

inhabitants, population density is often higher than in sub-humid and humid agroclimates. There is a visible north-south stratification of the livelihood systems. The northerly cultures tend towards pastoralism, while the southerly cultures largely practice sedentary arable rain-fed farming. Agriculture is the predominant livelihood system, employing more than half of the working population and contributes nearly 40% of the Gross Domestic Product. Only 8% of the land area in the Sahel is suitable for farming and irrigated agriculture currently occupies only about 5% of this land. Rain-fed agriculture is therefore the dominant practice and is only possible in areas where the length of the growing season allows crop maturation. Irrigated agriculture is only possible around the flood plains of the few perennial rivers. The lack of water, in association with high temperatures (up to 45°C at certain periods of the year), is the most limiting factor for agricultural productivity in the region. Millet, sorghum, cowpeas and maize are the dominant food crops grown in the region. Sorghum (*Sorghum*) predominates in the heavier soils and millet (*Panicum*) in the sandy soils (FAO 1998). The main cash-crops are cotton (*Gossypium*) and groundnut. Farmers are predominantly small-holders using traditional farming systems which mix food crops and cash crops on the same farming unit. The rearing of livestock is a very important aspect of life.

It is anticipated that climate variability and change in the Sahel will have overwhelming impacts on agriculture and landuse, ecosystem and biodiversity, human settlements, diseases and health, and hydrology and water resources. With respect to agriculture and landuse, climate change will likely elicit a significant change in agricultural production both in terms of the quantum of products as well as the location or area of production. For example, the change is expected to lead, among other things, to a shift in rainfall belts. Since agriculture is largely rain-fed in the Sahel, this will be accompanied by a shift in the traditional areas of production of certain crops with all the possible negative consequences that this may bring to the local people. The southward movement of the isohyets has also resulted in the southward migration of pastoralists into lands formerly occupied by sedentary farmers. This has been a major source of conflicts in the region leading to widespread destruction of farmlands and cattle, with adverse implications for food security in the region.

Temperature increases and decline in rainfall for example, will cause ecological stresses that could impair the functioning of ecological systems particularly in terms of plant growth and development. Settlements will similarly be affected as difficult conditions force people to move to marginal lands. The impacts of such diseases that luxuriate under high temperatures may in all probability be amplified under a changing climate driven by increased temperature. For example, it is anticipated that there will be a marked increase in the scourge of malaria across the Sahel. Water resources will be similarly affected. As surface and ground water depend on moisture from precipitation, reduced precipitation will lead to decline in local water supply in many areas. The magnitude of these impacts in the various human systems will be influenced by the level of their vulnerability to climate change.

While climate variability and change are a major problem in the Sahel, vulnerability is not only caused by weather/climate changes. Other stresses have led to severe land degradation in the region, thereby increasing the vulnerability of the already vulnerable Sahelians. For instance, the degradation of the semi-arid ecosystems has been linked to migrations that may have displaced 3% of the population of Africa since the 1960s (Westing 1994). Global economic activity may well have contributed significantly to the recent environmental changes that have occurred in the Sahel, and which have been associated with widespread human suffering and societal disruption via drought and

famine. Several scientists and researchers lay the blame for climatic and environmental change in the Sahel at the door of indigenous land-use practices, despite the fact that such methods have been employed successfully for millennia.

3 Mitigation and adaptation in the Sahel and the role of indigenous knowledge

3.1 Mitigation and adaptation

It is generally known that Africa is a minor contributor of global GHG emissions. Its share of carbon emissions, which is by far the most important GHG, is only 3.2% of the world's total in 1992. Its share of methane emission is also small, only 7.7% of the world's total in 1991 (Davidson 1998). Agriculture and land use sectors dominate GHG emissions in Africa, accounting for 57%, with the energy sector accounting for 32%. Emission from gas flaring is increasing but still accounts for a very small share.

Two lines of actions are articulated in the literature for dealing with the adverse conditions that are expected to attend climate change. These are mitigation and adaptation strategies. Mitigation strategies are procedures or activities that help prevent or minimize the process of climate change. According to Swart et al. (2003), mitigation strategies can be grouped into two categories: some represent mainly technological solutions; others involve changes in economic structure, societal organization, or individual behavior. In the African Sahel, mitigation activities are traditionally employed as natural resources conservation measures, but they generally serve the dual purposes of reducing the emission of GHG from anthropogenetic sources, and enhancing carbon ''sink''. Strategies aimed at reducing GHG emission emphasize cutbacks in the burning of fossil fuel through improved energy-efficiency, use of clean energy sources particularly solar and discontinuation of gas flaring. Carbon sink enhancement generally involves forestry programmes that protect the forest and encourage afforestation in marginal areas including range lands (Adesina et al. 1999).

Adaptation methods are those strategies that enable the individual or the community to cope with or adjust to the impacts of the climate in the local areas. Such strategies will include the adoption of efficient environmental resources management practices such as the planting of early maturing crops, adoption of hardy varieties of crops and selective keeping of livestock in areas where rainfall declined. They also include the use of technological products that enable the individual to function in the ''new'' condition. Obviously, adaptation strategies are expected to be many, and their combinations in various ways will be required in any given location.

Until recently, mitigation and adaptation were seen as two mutually exclusive strategies. Nevertheless, there are strong linkages between the two and it is increasingly recognized that integration of both strategies may not only provide new opportunities, but may even be a prerequisite for successfully addressing both issues. According to Klein et al. (2003), integration connects mitigation and adaptation with natural resource management, biodiversity conservation and measures to combat desertification. While the intellectual argument for integration has been strongly made, its realization in the policy realm has been less successful. Mitigation and adaptation should not all be about the implementation of options; successful implementation depends on the availability of various types of resources to create an enabling environment for mitigation and adaptation, including the capacity to adapt and mitigate (Klein and Smith 2003). Poverty and limited technical capacity have been identified as the major impediments to integrating mitigation and

adaptation in developing countries, particularly in Africa (Michaelowa 2001; Yohe 2001; Wilbanks et al. 2003). Because the poor are considered the most vulnerable to climate change impacts, it is often believed that financial capital is the most important indicator of adaptive capacity. According to the 1998/1999 World Development Report, knowledge, not financial capital, is the key to sustainable social and economic development. Building on local knowledge, the basic component of any region's knowledge system, is the first step to mobilize such capital (Phillips and Titilola 1995).

Studies have shown that local communities in the Sahel had successfully achieved some level of sustainable livelihoods by adapting continuously in their farming, livestock-keeping, and other income-earning activities (Mortimore 2000). Therefore, any meaningful attempt at implementing or integrating mitigation and adaptation strategies to reduce the vulnerability of the people in the Sahel to the impacts of future climate change should start by examining how the communities in the region had successfully reduced their vulnerabilities and coped with past impacts, the magnitude of which had exceeded what has been predicted by models of future climate change. Building on the indigenous knowledge systems of the region offers great prospects for effective integration of mitigation and adaptation strategies that will be attractive enough to the vast majority of small-scale farmers who are expected to use them.

3.2 Indigenous knowledge in climate change mitigation and adaptation

Indigenous knowledge has been defined as institutionalized local knowledge that has been built upon and passed on from one generation to the other by word of mouth (Osunade 1994; Warren 1992). It is the basis for local-level decision-making in many rural communities. Indigenous knowledge has value not only for the culture in which it evolves, but also for scientists and planners striving to improve conditions in rural localities (Mundy and Compton 1991). The knowledge set is influenced by the previous generations' observations and experiment and provides an inherent connection to one's surroundings and environment. Therefore Indigenous Knowledge is not transferable but provides relationships that connect people directly to their environments and the changes that occur within it, including climate change (Woodley 1991).

Indigenous knowledge has been directly applied in the Sahel in climate change mitigation through emission reduction, C sequestration and carbon substitution. In the area of adaptation, indigenous knowledge systems have been applied in weather forecasting, vulnerability assessment and implementation of adaptation strategies. Considering that agriculture and landuse changes are identified as the two main sources of GHG in Africa, we will review indigenous knowledge systems that have been applied in mitigation and adaptation within these two sectors.

Local farmers in the Sahel have been known to conserve C in soils through the use of zero tilling practices in cultivation, mulching and other soil management techniques (Schafer 1989; Osunade 1994). Natural mulches moderate soil temperatures and extremes, suppress diseases and harmful pests, and conserve soil moisture. Before the advent of chemical fertilizers, local farmers largely depended on organic farming, which also is capable of reducing GHG emissions.

It is widely recognized that forests play an important role in the global carbon cycle by sequestering and storing C (Karjalainen et al. 1994; Stainback and Alavalapati 2002). Local farmers are known to have practiced the fallow system of cultivation, which encouraged the development of forests. It may be argued that with the growth in

population, lengths of fallow have been reduced to the extent that the practice no longer exists in certain areas. However, one must not forget that the importance of forests have been recognized by traditional institutions to the extent that communal forest reserves were very common in traditional societies. Besides the fact that these well managed forests provided food and timber resources to the community, they also served as C sinks. It is recognition of the role of forests in climate change that has influenced participants of the Kyoto Protocol to allow countries to include carbon sequestered in forests in a country's emission requirements.

Agroforestry is another practice that has been very effective in carbon sequestration. Agroforestry is a rational land-use planning system that tries to find some balance in the raising of food crops and forests (Adesina et al. 1999; Floyd 1969). A practice similar to this has been described in a part of south western part of Nigeria to raise shade tolerant crops such as *Dioscorea* spp and cocoyam in essentially a permanent forest setting (Adesina 1988). In addition to the fact that agroforestry techniques can be perfected to cope with the new conditions that are anticipated under a drier condition and a higher population density, they lead to an increase in the amount of organic matter in the soil thereby improving agricultural productivity and reducing the pressure exerted on forests. Traditional knowledge of plants is very useful in agroforestry projects. Scientists have tended to limit plants' trials for forestry and agroforestry to known species that have performed well in other parts of the world. In the drier parts of the Sahel, the significance of the baobab (*Adansonia digitata*) and acacia (*Acacia*) trees is just being realized by researchers as a valuable tree especially during the hot and dry parts of the year. Local people certainly know other trees that perform well under different ecological conditions. The integration of such candidates into the pool of suitable agroforestry trees will provide opportunities for the farmers to make choices.

Local knowledge is vital for preserving bio-diversity, which is considered a very successful mitigation strategy. Through the World Bank, gene banks have been established to preserve genetic information of local varieties or indigenous species. Genetic traits of these species and the knowledge of cultivators may prove instrumental in future breeding programs to introduce resistance against pests or diseases or endurance for harsh climatic conditions. A major criticism of this initiative is that preserving genetic traits without preserving the knowledge of their husbandry may prove futile as the seeds and clones stored in seed banks do not carry the instructions on how to grow them (Warren 1991). Hence, these gene banks should cooperate with farmers and communities who still cultivate local varieties to preserve such essential knowledge and skills in situ.

In the Sahel, local farmers have developed several adaptation measures that have enabled them to reduce their vulnerability to climate variability and extremes. One important step in reducing the vulnerability of a climatic hazard is the development of an early warning system for the prediction or forecast of the event (Ajibade and Shokemi 2003). There is a wealth of local knowledge based on predicting weather and climate. A study of weather knowledge in various parts of the Sahel reveals the wealth of knowledge that farmers possess. These farmers have developed intricate systems of gathering, prediction, interpretation and decision-making in relation to weather. To a very great extent, these systems of climate forecasts have been very helpful to the farmers in managing their vulnerability. Farmers are known to make decisions on cropping patterns based on local predictions of climate, and decisions on planting dates based on complex cultural models of weather.

Adaptation strategies that are applied among the pastoralists include the use of emergency fodder in times of droughts, multi-species composition of herds to survive climate

extremes, and culling of weak livestock for food during periods of drought. During drought periods, pastoralists and agro-pastoralists change from cattle (*Bos*) to sheep (*Capra*) and goat (*Capra*) husbandry as the feed requirements of the later is less than the former (Oba 1997). Pastoralists' nomadic mobility reduces the pressure on low carrying capacity grazing areas through the circular movement from the dry northern areas to the wetter southern areas of the Sahel. This system of seasonal movement represents a local type of traditional ranching management system of range resources.

4 Integrating indigenous knowledge into formal mitigation and adaptation strategies

4.1 Benefits of indigenous knowledge in climate change mitigation and adaptation

Developmental projects are known to have been created, funded and managed by outside resources and introduced into rural communities with the hopes and promises of impacting their lives. These projects did not take into consideration the culture of the people and resulted in low participation and success rates (Howes 1980; Woodley 1991; Nyong and Kanaroglou 1999). As a result of these failures, there was a growing interest in the incorporation of local knowledge and traditions to increase project participation rate and provide environmentally sound approaches to development. Although research is gradually recognizing the importance of indigenous knowledge systems in developmental studies, the value of indigenous knowledge in climate change studies has received little attention. Climate change mitigation and adaptation projects can learn from the experiences of other developmental projects by recognizing the value of indigenous knowledge systems. Two major problems that can be identified as obstacles to integrating indigenous knowledge into formal climate change mitigation and adaptation strategies are: recognizing the need to, and how to actually integrate indigenous knowledge into formal western science.

Indigenous knowledge adds value to climate change studies in the following ways. First, indigenous knowledge systems create a moral economy. It identifies a person within a cultural context, therefore providing decision-making processes or rules of thumb to be followed based on observed indicators or relationships within events (Adugna 1996; Woodley 1991). Members of communities act within these rules of thumb to maintain security and assurance, or risk isolation from their community. In an uncertain and biased world these rules of thumb provide people with a sense of community, belonging and stability. Second, indigenous knowledge is increasingly exhibiting a resemblance with scientific methods as many ideas in indigenous knowledge that were once regarded as primitive and misguided, are now seen as appropriate and sophisticated. Third, indigenous knowledge systems provide mechanisms for participatory approaches. A major requirement for the sustainability of any project is that the local population must be seen as partners in the project, with joint ownership. This is best achieved when the communities effectively participate in the design and implementation of such projects. Fourth, indigenous knowledge systems share the same guiding principles with sustainable development framework with 3E concerns—Economy, Equity, and Environment (Davies and Ebbe 1995). The essence of most climate change projects is to reduce poverty and ensure sustainable development. This can be facilitated by the integration of indigenous knowledge into climate change policy. Fifth, indigenous knowledge systems can facilitate understanding and effective communication and increase the rate of dissemination and utilization of climate change mitigation and adaptation options.

4.2 Steps to integrate indigenous knowledge into mitigation and adaptation strategies

In order to integrate indigenous knowledge into formal climate change mitigation and adaptation studies, certain steps must be taken. The first step is to acknowledge that indigenous knowledge has provided communities with the capability of dealing with past and present vulnerabilities to climatic extremes and other stresses. Second, one must adopt the bottom–up participatory approach that encourages the highest level of local participation. The benefits of this are that (i) provides valuable insight into how communities and households interact and share ideas, and (ii) it allows the intended beneficiaries to develop the skills and practices necessary to forge their own path and sustain the projects. Third, the local communities should be seen as equal partners in the development process. It is basically an internal process, which only may be enhanced by outside assistance. Local actors should progressively take the lead while external partners back their efforts to assume greater responsibility for their development. Reducing vulnerability entails the strengthening of adaptive capacities of vulnerable individuals and groups. Capacity building should emphasize the need to build on what exists, to utilize and strengthen existing capacities. Indigenous knowledge plays a significant role in the sum total of what exists in a local community. Fourth, inasmuch as we acknowledge the importance of indigenous practices in climate change mitigation and adaptation, they should not be developed as substitutes of modern techniques. It is important that the two are complements and learn from each other in order to produce ''best practices'' for mitigation and adaptation (Adugna 1996). A Best Practice is the result of articulating indigenous knowledge with modern techniques—a mix that proves more valuable than either one on its own. The interaction between the two different systems of knowledge can also create a mechanism of dialogue between local populations and climate change professionals, which can be meaningful for the design of projects that reflect people's real aspirations and actively involve communities.

However, it is important to note that not all indigenous practices are beneficial to the sustainable development of a local community; and not all indigenous knowledge can a priori provide the right solution for a given problem. Therefore, before adopting indigenous knowledge, integrating it into development programs, or even disseminating it, practices need to be scrutinized for their appropriateness just as any other technology. In addition to scientific proof, local evidence and the sociocultural background in which the practices are embedded also need consideration in the process of validation and evaluation.

5 Conclusion

The highly populated West African Sahel has historically been prone to long and severe droughts. The most recent began in 1968 and relatively dry conditions have persisted since then. While the problems of the Sahel are not only caused by weather/climate changes, other stresses have led to severe land degradation in the region, thereby increasing the vulnerability of the already vulnerable Sahelians. Global economic activity may well have contributed significantly to the recent environmental changes that have occurred in the Sahel, and which have been associated with widespread human suffering and societal disruption via drought and famine. There has been a tendency for Western researchers to lay the blame for climatic and environmental change in the Sahel at the door of indigenous land-use practices, despite the fact that such methods have been employed successfully for millennia. Arguments that traditional methods of land management are no longer

appropriate because of population pressure and climatic fluctuations are tenuous; on a local scale changes in population density and climatic conditions are unlikely to be a feature solely of the late 20th century. In this paper, we have argued that the inhabitants of the Sahel have, over the years, adapted to climatic extremes that exceed those predicted by some of the IPCC models. They have accumulated sufficient knowledge of the ways in which the adverse impacts of droughts may be reduced through both mitigation and adaptation, but that knowledge has not been and is not being applied in an effective manner. There is the need therefore to integrate this local knowledge into formal mitigation and adaptation policies.

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