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Climate Change Adaptation in Rwanda through Indigenous Knowledge Practice

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ABSTRACT The research paper demonstrates the contribution of indigenous knowledge and farming practices to climate change resilience. The study involved a purposive sample of 100 indigenous knowledge holders living adjacent to the Nyungwe National Park (NNP) and Volcanoes National Park (VNP), Rwanda. The major threats to climate change included deforestation, floods, changes in volcanic activity and changes in solar radiation and the use of chemical fertilizers. The majority of local farmers (75%) perceived indigenous farming systems and practices to be effective in climate change resilience. It is cheap, relying mostly on less external inputs, local and indigenous varieties, crop residues, and cow dung and produces a significant contribution on climate change resilience and has less side effects compared to the modern farming systems and practices. It is therefore imperative to incorporate IKS into modern farming systems and practices to increase agricultural productivity without compromising on environment and nature conservation.

INTRODUCTION

Overview and Rationale of the Study

Agriculture and climate change are inextricably linked. For Rwanda in particular, intensive agriculture is done around the national parks especially around the Volcanoes and Nyungwe National parks due to favorable climatic conditions and agricultural potential in these areas. The overarching challenge is that intensive agriculture mostly relies on application of external inputs, which are often harmful or even detrimental to environment (ROR 2011; REMA 2014).

As stated by Nelson (2009), agriculture is part of the climate change problem, contributing about 13.5 percent of annual greenhouse gas emissions (with forestry contributing an additional 19%), compared with 13.1 percent from transportation. Agriculture is, however, also part of the solution, offering promising opportunities for mitigating emissions through carbon sequestration, soil and land use management, and biomass production (CIGI Special Report 2009; Ngigi 2009; AGRA 2014).

Climate change threatens agricultural production through higher and more variable temperatures, changes in precipitation patterns and increased occurrences of extreme events like droughts and floods. There are prolonged and intensified droughts in eastern Africa, unprecedented floods in western Africa, depletion of rain forests in equatorial Africa, and an increase in ocean acidity around Africa's southern coast. Vastly altered weather patterns and climate extremes threaten agricultural production and food security, health, water and energy security, which in turn undermine Africa's ability to grow and develop (GECHS 2008; ATPS 2013).

A key challenge for decision-makers, policymakers, and development partners is to understand the strategies adopted by farmers and other stakeholders in their efforts to address climate change-induced water stress. Smallholder farmers are the most vulnerable to climate change, and they have no alternative but to adapt their livelihood systems to changing climatic conditions. Fortunately, several practical options for adaptation exist and all efforts should therefore be made to refine, augment and deploy them appropriately and urgently (Ngigi 2009).

The following is a typical package for a national climate change adaptation strategy.

Technological Innovations: Include improved crop varieties, early warning systems, land and water management and integrated pest management.

Government Subsidies: In the form of agricultural subsidy among other farmers' support services to cushion famers against the impacts of climate variability.

Farm Production Practices: Include farm production, land use, land topography, irrigation, and timing of operations.

Farm Financial Management: In the form of crop insurance (in case of crop failure related to variations in weather conditions), crop shares and futures, income stabilization programs, and household income (diversification schemes).

A number of climate change adaptation strategies have been employed in Rwanda, namely, Automated Agro metrological monitoring in 10 Rwanda Agriculture Board (RAB) stations, climate remote sensing data generation and calibration against meteorological stations, capacity building of RAB staff to be champions in strategizing for climate change adaptation, climate data management and sharing with other government and non-government agencies, simulation for climate change projection and scenarios development for risk mitigation (Gahakwa et al. 2014).

According to the Government of Rwanda's development programs and priorities, particularly Vision 2020 and Economic Development Poverty Reduction Strategy (EDPRS), agriculture has evolved as the mainstay in domestic food supply, employment and cash income, foreign exchange, raw material for processing and handicraft for Rwandans. By 2020, agriculture is envisaged to contribute thirty-three percent to GDP whereas industry, including agro-processing, is expected to grow from current levels of fourteen percent to twenty-six percent of GDP. As noted by ROR (2011) and the MINAGRI Annual Report (2010-2011), agriculture continues to be a catalyst for growth and poverty reduction. However, environmental degradation and climate change are becoming major barriers to realize Rwanda's medium and long-term development aspirations considered in the economic development and poverty reduction strategy (EDPRS) and the Vision 2020, respectively.

As one of the coping strategies for climate change, the Government of Rwanda (GOR) has acknowledged the need to incorporate indigenous knowledge into economic advancement strategies such as indigenous farming systems and practices with modern and scientific farming practices as a way to enhance climate change adaptation and mitigation for sustainable agricultural development (ROR 2013). Despite their advantages, indigenous knowledge systems and practices in Rwandan farming have not been fully exploited. The introduction of modern farming systems and practices in the country had some negative impact on flora and fauna including human beings (ROR 2011; ROR 2013). The rationale of this study is to examine the adapted strategies used to enhance climate change resilience, focusing on indigenous knowledge systems and practices by smallholder farmers in Rwanda.

Problem Statement

Most of the rural people depend on indigenous knowledge for their livelihoods (Charles 2007; Chika 2014). Accordingly, for the development process, indigenous knowledge is of particular relevance for the following sectors and strategies, including agriculture, animal husbandry and ethnic veterinary medicine, use and management of natural resources, primary health care, preventive medicine and psychosocial care, saving and lending, community development and poverty alleviation.

Unfortunately, many indigenous knowledge systems are at risk of becoming extinct because of rapidly changing natural environments and fast pacing economic, political, and cultural changes on a global scale (Sambo 2014). Practices vanish, as they become inappropriate for new challenges or because they adapt too slowly. However, many practices disappear only because of the intrusion of foreign technologies or development concepts that promise short-term gains or solutions to problems without being capable of sustaining them. The tragedy of the impending disappearance of indigenous knowledge is most obvious to those who have developed it and make a living through it (Lin et al. 2008; Sambo 2014). Nonetheless, the implication for others can be detrimental as well, when skills, technologies, artifacts, problem solving strategies and expertise are lost.

Despite the inherent incompatibilities or "constraints" between indigenous or traditional knowledge systems and that of the modern or scientific knowledge system, an important challenge is to find innovative mechanisms that serve to integrate both systems for mutual benefit (that is, ecologically sound, sustainable development).

As noted by CDKN (2013), an understanding of indigenous knowledge and customs can help the development planner establish a more flexible position to suggest project alternatives or innovative mitigation measures, in order to avoid inadvertent damage to the ecosystem or culture. Indigenous knowledge plays an important role in the way communities interact with their climate in Rwanda. It plays a significant role in the lives of the rural poor particularly in agrarian economies (Gahakwa 2014; Chika 2014).

Consideration to indigenous knowledge systems and practices in farming would not only enhance climate change resilience but is expected to boost the farmers' livelihood through incomes from food production, markets and the overall economy. According to Chika (2014), indigenous knowledge in Rwanda has been recently given attention in government programs. Rwanda has promoted IKS through the Girinka program (providing one cow to every poor family), Gacaca (traditional courts through which local conflicts are resolved) and Umuganda (community work). Although these programs have registered success towards improving the socioeconomic conditions of the rural poor, there are gaps to be filled in managing environmental challenges and climate change effects using such neglected but valuable IKS. Incorporating IKS in the farming systems of Rwanda would thus be beneficial to smallholder farmers and other actors or stakeholders in the food and agricultural value chain and more importantly in enhancing climate change resilience.

This study will therefore be very essential in identifying indigenous knowledge systems and indigenous farming practices that contribute to climate change adaption in Rwanda.

Objectives of the Study

The main objective in this research was to find out how indigenous knowledge systems and indigenous farming practices contribute to climate change resilience in Rwanda. Specifically, the study has the following objectives:

- To establish the indigenous knowledge systems.
- To investigate farmers' perceptions towards indigenous farming practices and climate change adaptation.
- To determine the effectiveness of indigenous knowledge systems on farming and climate change adaptation.
- To find out the factors affecting the adoption and sustainability of indigenous farming practices.

Hypotheses of the Study

In this research, three hypotheses were stated, as follows:

- Indigenous knowledge has contributed to the livelihoods of rural farmers in Rwanda.
- Indigenous knowledge practices in farming have played a critical role in building farmers' resilience and climate change adaptation.
- Incorporating traditional knowledge in modern scientific knowledge would better enhance climate change adaptation.

Significance of the Study

Although Rwandan agriculture has registered significant improvement in the recent years, the overarching concern is the high dependence on the use of chemical fertilizers and external inputs to increase agricultural productivity as emphasized in modern agricultural technologies despite its consequences on the environment. Much application and dependency on chemical fertilizers has resulted in environmental degradation and climate change effects. In the emerging global knowledge economy a country's ability to build and mobilize knowledge capital, is equally essential for sustainable development as the availability of social, physical and financial capital (Chambers et al. 1989; World Development Report 1997). In this regard, this study highlights the importance of indigenous knowledge systems (IKS) and indigenous farming practices (IFP) on climate change adaptation.

The green revolution has performed well in well-endowed areas with a stable climate, adequate water supply and access to inputs and cheap energy. However, the necessary fertilizers, pesticides, farm equipment and fuel are derived from dwindling and expensive fossil fuels. At the same time, climatic extremes are becoming more frequent and intensive agricultural systems show a lower resistance and higher vulnerability to such fluctuations. Fortunately, there are alternatives that enhance resilience and ensure high yields. Based on this evidence, various experts have suggested that reviving tradi-

tional and indigenous knowledge management systems, combined with the use of agro-ecological principles, may represent the only viable and robust path to increasing the productivity, sustainability and resilience of agricultural production. Hence, identifying, validating and documenting indigenous knowledge systems (IKS hereafter) and practices, and the factors that contribute to climate change adaptation and mitigation is of paramount importance in Rwanda.

Literature Review

This section presents related past research and other literature sources as a guide to the conceptual and methodological discussions handled in this paper. Various concepts used in the paper are also defined:

Definition of Key Concepts

i. Adaptation

According to Scheraga and Grambsch (1998), adaptation is an important approach for protecting human health, ecosystems, and economic systems from the risks posed by climate variability and change, and for exploiting beneficial opportunities provided by a changing climate. Adaptation can be defined as adjustments of a system to reduce vulnerability and to increase the resilience of system to change, in this case in the climate system. Adaptation occurs at a range of interlinking scales, and can either occur in anticipation of change (anticipatory adaptation), or be a response to those changes (reactive adaptation).

In other words, adaptation may refer to the efforts by the society or ecosystems to prepare for or adjust to future climate change. These adjustments can be protective (that is, guarding against negative impacts of climate change), or opportunistic (that is, taking advantage of any beneficial effects of climate change).

ii. Climate Change

Climate change refers to long-term change in the statistical distribution of weather patterns over periods of time that range from decades to millions of years. It may be a change in the average weather conditions or a change in the distribution of weather events with respect to an average, for example, greater or fewer extreme weather events (Centre for International Governance Innovation 2009).

iii. Indigenous Knowledge (IK)

Indigenous knowledge is an emerging area of study that focuses on the ways of knowing, seeing, and thinking that are passed down orally from generation to generation. Indigenous knowledge may be defined as an ancient, communal, holistic and spiritual knowledge that encompasses every aspect of human existence (Brascoupé and Mann 2001).

Brascoupé and Mann further indicate that IK may include such major areas as, agriculture and horticulture, astronomy, forestry, human health, traditional medicines and healing, knowledge of animals, fish and ecological systems, sustainable use of natural resources and the environment, traditional classification systems for living and other resources, learning systems and oral traditions, spirituality, symbols, traditional arts and culture. The researchers further argued that artwork, designs, scientific and ecological methods, crafts, music, dance, songs, stories, foods, medicines and wellness (or disease-prevention) products would draw from indigenous knowledge systems.

Indigenous Knowledge and Climate Change Adaptation: A Global Perspective

Western climate science uses the knowledge of the physics of the atmosphere to predict the most probable future weather and climate scenarios. On the other hand, most communities in Asia and Africa use IK as a critical knowledge base and survival tool for adapting to extreme climate events and other natural hazards. They have developed techniques and strategies for forecasting, and managing climate variability including coping mechanisms to respond to both normal and harsh conditions of their local environments. This forecasting depends on observation of the natural environment including flora, fauna and the stars. Although IKS have been considered as a foundation for decision-making especially in developing countries, several parameters would have to be examined before choosing the approach to address climate change in any given region or area.

As noted by Scheraga et al. (1998), nine fundamental principles should be considered when designing adaptation policy, namely:

- The effects of climate change vary by region
- The effects of climate change may vary across demographic groups
- Climate change poses risks and opportunities
- The effects of climate change must be considered in the context of multiple stressors and factors, which may be as important to the design of adaptive responses as the sensitivity to change
- Adaptation comes at a cost
- Adaptive responses vary in effectiveness, as demonstrated by current efforts to cope with climate variability
- The systemic nature of climate impacts complicates the development of adaptation policy
- Maladaptation can result in negative effects that are as serious as the climate-induced effects being avoided
- Many opportunities for adaptation make sense whether or not the effects of climate change are realized

Scheraga et al. (1998) also noted that adaptation is particularly important in developing countries since those countries are predicted to bear the brunt of the effects of global warming. That is, the capacity and potential for humans to adapt (called adaptive capacity) is unevenly distributed across different regions and populations, and developing countries generally have less capacity to adapt (Schneider et al. 2007). Adaptive capacity is closely linked to social and economic development (IPCC 2007).

Building on the arguments from Scheraga et al. (1998) and Brascoupé and Mann (2001), IKS and practices would further be considered in efforts to adapt and mitigate climate change effects especially in developing countries where Western climate science is expensive and sometimes not relevant to the causes of climate change in the region.

The term 'indigenous knowledge' is used to describe the knowledge systems developed by a community as opposed to the scientific knowledge that is generally referred to as 'modern' knowledge (Sambo 2014). Indigenous knowledge is the basis for local level decision-making in many rural communities. It has value not only for the culture in which it evolves, but also for scientists and planners striving to improve conditions in rural localities. Incorporating indigenous knowledge into climate change policies can lead to the development of effective adaptation strategies that are cost-effective, participatory and sustainable (ATPS 2013; AGRA 2014).

According to Nakashima et al. (2012), indigenous or traditional knowledge refers to the knowledge and know-how accumulated across generations, and renewed by each new generation, which guide human societies in their innumerable interactions with their surrounding environment. The researchers further noted that indigenous knowledge is not only important for climate change adaptation but would also contribute to other fields such as agro-forestry, traditional medicine, biodiversity conservation, customary resource management, applied anthropology, impact assessment, and natural disaster preparedness and response among others.

IKS and practices are thus becoming recognized for their importance in climate change adaptation and mitigation in developed and developing countries and in this regard it has attracted attention from both academia and development researchers. Wisner et al. (2004) observed that the efforts to mitigate impacts of climate change tend to focus on infrastructure development such as building high sea walls, or on high-tech solutions such as sophisticated early warning systems based on scientific data and modeling. These technical and scientific solutions save lives when hazards strike, however, they need to be complemented by actions to address risks surrounding the hazard and the underlying components of vulnerability the interrelated human, social and cultural factors that influence risk, which can contribute to turning a hazard into a disaster and this justifies the importance of local and indigenous knowledge in increasing the resilience of communities and also contributing to climate change resilience.

Indigenous Knowledge Systems in Africa

Many African communities through accumulated indigenous knowledge (IK) gained from generation to generation, knew the patterns of weather, could easily predict how and when local natural disasters would likely occur and they would therefore plan to cope with their impacts on the natural environment, livelihoods, and lives.

Indigenous knowledge systems in Africa (as similar to other indigenous societies around the

world) are traditionally applied in harmony with the natural and spiritual world (Charles 2007; Chika 2014; Sambo 2014). These traditional or cultural practices are ingeniously designed to address local ecological limitations by maintaining a sustainable utilization and protection of commonly shared natural resources. This "ecosystem view" of many indigenous or traditional societies throughout Africa, appears to be in contrast to the modern (scientific) knowledge systems.

Agro-ecological approaches to enhance resilience to climate change in sub-Saharan Africa. Diversity is the norm in African farming systems with a farmer typically growing ten or more species and varieties of crops in their home gardens and fields (FAO 2011). Africa has a relatively homogenous environment because of the broad vegetation belts, desert, savannah and forests that stretch from the Atlantic coast on the west to the Red Sea and Indian Ocean coast on the east. As observed by White (1993), this superficial uniformity actually encompasses vegetation types that are complex and rich in biodiversity, comprising a greater diversity of ecosystems than for any other equivalent area of land in the world. The traditional farming systems of Ethiopia, for example, use over 100 different crop species (Edwards 1991). Worth noting however, is the attitude of ignoring or underestimating the role of African women farmers. Ignoring the role of Africa's women and the lack of appreciation of the diversity in both genetic resources and its accompanying traditional knowledge as well as lack of investment in infrastructure and appropriate research and development (R&D) are the main reasons why Africa's agriculture has not developed sufficiently.

Many studies have revealed that small-scale farmers who follow agro-ecological practices cope with, and even prepare for, climate change, thus minimizing crop failure. Results from various studies also suggest that these practices provide a higher resistance to climate events reduce vulnerability and make farms more sustainable in the long-term. Strategies to enhance the ecological resilience of farming systems are essential, but in themselves are not enough to achieve sustainability. Social resilience, defined as the ability of groups or communities to adapt to external social, political, or environmental stresses, must go hand in hand with ecological resilience.

According to Tompkins et al. (2004), rural societies must have the ability to buffer disturbance with agro-ecological methods adopted and disseminated through self-organization and collective action. Reducing social vulnerability through the extension and consolidation of social networks, both locally and at regional scales, can further increase the resilience of agro-ecosystems. The vulnerability of farming communities depends on the development of the natural and social capital that gives farmers and their systems resilience against climatic (and other) shocks. This adaptive capacity resides in a set of social and agro-ecological conditions that influence the ability of individuals or groups, and their farms, to respond to climate change in a resilient manner (Tompkins et al. 2004; Lin et al. 2008).

Implication of Indigenous Knowledge as a Strategy for Climate Change Adaptation and Mitigation in East African Community (EAC)

Climate change represents a new threat and challenge to Africa because many households, social groups and regions have a limited capacity to adapt to climate variability and change. Eastern and Southern Africa's vulnerability to climate change is shaped by the complex interaction of social, political, economic, cultural and environmental factors, all of which are likely to be affected by the projected impacts of climate change (GECHS 2008).

Climate change has attracted a lot of attention not only from the developed countries but also in the developing economies due to its global consequences on biodiversity and to humans. Several interventions have been designed, and both adaptation and mitigation policies have been developed to address climate change challenges in EAC. Another policy response to climate change, known as climate change mitigation (Verbruggen 2007) focuses on reduction of greenhouse gas (GHG) emissions and/or enhancing the removal of these gases from the atmosphere (through carbon sinks). Even the most effective reductions in emissions, however, would not prevent further climate change impacts, making the need for adaptation unavoidable (Klein et al. 2007).

The researchers also asserted with very high confidence that in the absence of mitigation efforts, the effects of climate change would reach

such a magnitude as to make adaptation impossible for some natural ecosystems. For human systems, the economic and social costs of unmitigated climate change would be very high. In the EAC, the necessary legal and regulatory frameworks have been put in place such as, the treaty for establishment of the EAC, the Protocol on the establishment of the EAC common market, the Lake Victoria Basin Commission, Protocol on environment and Natural resources management, the EAC climate change policy, EAC climate strategy, EAC climate master plan, and the fourth EAC development strategy (2011-2012-2015-2016).

- Referring to the content of the treaty, the five member countries of EAC agree on the promotion of sustainable utilization of the natural resources of the partner states.

- The protocol agrees to implement the principles of environmental and natural resource management that will prevent environmental degradation.

- The EAC has identified The Lake Victoria Basin as an area for common interest and a zone for regional economic development.

- The protocol on environment and natural resource management promotes and enhances cooperation in conservation and management of environment and natural resources among member countries. The main focus areas of the protocol are transboundary natural resource, biological diversity and genetic resources, forestry, wildlife, water, wetland, coastal and marine fishers, minerals, energy, mountainous ecosystems, and tourism.

- *The EAC climate change policy insures a more strategic and cooperative approach among member states to respond to the impact of climate change.*
- *The EAC climate change strategy guides the implementation of the EACCCP over a five-year period from 2011 until 2015.*
- *The EAC climate master plan provides a long-term vision for operationalizing actions for climate change adaptation and mitigation in the EAC.*
- *The fourth EAC development strategy (2011/2012-2015/2016) highlights the achievements and challenges in environmental management.*

As articulated in the National Adaptation Program Actions (NAPA), key interventions for climate change and environmental protection include conservation and protection of lands against erosion and floods, installations, rehabilitation of hydrological and meteorological stations, monitoring round irrigation perimeters from water flows, plan and implement conservation measures and water storage (Viljoen 2013). The Rwanda Environmental Management Agency (REMA) has launched a fresh bid to promote green growth and mitigate climate change effects by 2030 (Nkurunziza). It will involve costing of government strategic activities. The costing study was undertaken by consultants under the support of African Development Bank (AfDB) and the United Nations Development Program (UNDP). The study aimed at implementing the Green Growth and Climate Resilience Strategy (GGCRS) approved by the government in 2011.

Referring to the literature above, highlighting the evidence from Rwanda and also from the EAC region, several development interventions and regulatory frameworks have been put in place to address climate change effects. However, all interventions indicate lack of a major parameter, which is integration or incorporation of IKS and practices from the local community including the smallholder farmers. This lack of incorporation of IKS constitutes the major gap especially resulting in the lack of ownership of all interventions in the area in view that the interventions are not often implemented in a consultative and participatory approach. Incorporation of IKS and practices would thus add value if all interventions were blended or integrated. Some of the IKS and practices to consider include the nature of farming, soil conservation, varieties grown, seeds for planting, planting materials, water harvesting and storage, pre-harvest, harvest, post-harvest handling and storage of agricultural products and fishing methods.

Indigenous Knowledge Systems and Climate Change Adaptation in Rwanda

Impacts of climate change include but are not limited to making streams too warm to support animals and plants, alteration in rainfall patterns, causing runoff, causing soils and vegetation to become drier, increasing the frequency and intensity of forest fires, changing forest composition, changing the spatial and temporal occurrence of new assemblages of species, increasing the spread of invasive species, altering

the quantity and quality of wildlife habitat, and predator/prey relationships, and increasing the area covered by early succession of ecosystems in response to more outbreaks, flooding, and fire (ATPS 2013).

The availability of potential adaptation measures has been envisaged through different lenses, including both traditional and modern knowledge systems (Yamoah 1987). Adaptation can mitigate the adverse impacts of climate change, but it will incur costs and will not prevent all damages. Extremes, variability, and rates of change are all key features in addressing vulnerability and adaptation to climate change, and not simply change in average climate conditions. Planned adaptation can supplement autonomous adaptation, though there are more options and greater possibilities for offering incentives in the case of adaptation of human systems than in the case of adaptation to protect natural systems. In Rwanda, indigenous knowledge in agriculture has been considered as one of the potential areas that will help mitigate, and also contribute to climate change adaptation (Republic of Rwanda 2011; Climate and Development Knowledge Network 2013; International Fund for Agricultural Development 2014).

RESEARCH METHODOLOGY

This section presents the methodology, which was employed in the study.

Description of the Study Area

This study was conducted from December 2014 to January 2015 within the communities living adjacent to the National Parks of Rwanda, namely, the Volcanoes National Park (VNP) in the Northern Province and Nyungwe National Park (NNP) in the South-Western Province. The two areas are highly populated as a result of the prevailing favorable climate, soil fertility and higher rainfall amounts compared to other areas. Due to these factors, there is a high population density in these areas, which consequently exert a lot of pressure to the parks and especially on biodiversity. There are competing claims from the conservation angle and agricultural development.

A total of 100 respondents were purposively selected from the population. These were mainly seasoned farmers, local leaders and opinion leaders. The criteria for selecting respondents mainly included age and experience on indigenous knowledge systems and indigenous farming practices. Snowball sampling was applied to identify the seasoned farmers with relevant indigenous knowledge practices in the two study areas. Snowball sampling is often used to find and recruit groups not easily accessible to researchers through other sampling strategies. The distribution of respondents was proportional (that is, 50 respondents) selected from each community and the respondents were selected purposively. Sample size determination followed

Cochran's formula: . $n_0 = \frac{(z_\alpha)^2 \, p \, q}{e^2}$

Where, n_0 is the sample size of the unknown population, z_α is the standard normal deviation (1.96), alpha is the level of significance (5%), **p** is the probability of success (50%), q is the probability of failure (50%), and **e** is the margin of error (10%).

Pertinent questions revolved around the importance of traditional knowledge on climate change resilience through indigenous farming practices. Questionnaires and interviews were the key research instruments. Secondary data sources were consulted especially national policy documents, procedures and strategic plans.

RESULTS AND DISCUSSION

This section emphasized on the key objectives of the study, namely, identifying the indigenous knowledge systems and indigenous farming practices, investigating farmers' perceptions on the effectiveness of IKS, contribution of IKS to climate change adaptation as well as determining the factors affecting the adoption and sustainability of indigenous knowledge practices in Rwandan agriculture.

Causes and Consequences of Climate Change in Rwanda

Several factors have contributed to climate change in Rwanda and these include but are not limited to destroying of swamps, deforestation, and changes in volcanic activities and solar radiation.

The consequences of climate change have been reported in the form of floods, unpredictable seasonal changes, droughts and loss of biodiversity among others.

Identified Indigenous Knowledge Farming Systems and Practices

Over the years, Rwandan farmers have depended on traditional farming systems and practices such as mixed farming mixed cropping, crop rotation, mulching, bush fallowing and cultivation following seasonal rainfall patterns, however, some these farming practices have of late been confronted by several factors. Due to increasing population density, new technological developments in agriculture, and changing food demands both locally and globally, there are competing claims on the systems of farming that would be more efficient and effective to respond to the local, regional and global economic development challenges.

As perceived by local farmers, these systems are still practiced despite the influence of new technologies and policies in Rwandan agriculture. Of major importance is cultivation following rainfall patterns and mixed farming. These are necessary due to their contribution to risk management regarding agricultural risks such as droughts, food insecurities, hunger and famine. Mixed farming not only contributes through agriculture and livestock production but also through inputs such as cow dung and crop residues for mulching.

Perceptions of Farmers on the Effectiveness of Indigenous Knowledge in Agriculture

Majority of the farmers in the survey perceived IKS to be more effective compared to modern farming especially with regard to production costs, simplicity of the technologies involved, easy to replicate, encouraging mixed cropping and serving as a source of traditional medicine. Local farmers (59.02%) emphasize that IKS do not require high investment and is manageable for the low-income earners. Apart from that, IKS employs technologies that farmers are more familiar with compared to the modern technologies, which involves advanced and complicated technologies.

Contribution of Indigenous Farming Systems and Practices on Climate Change Adaptation

Local farmers perceive IKS as an effective way of contributing to climate change adaptation in agriculture. A number of farming practices have been adapted through IKS and these include mulching, bush fallowing, mixed cropping, no tillage, cover cropping, tree planting and construction of progressive terraces. Local farmers still emphasize on the importance of traditional ways of addressing the impacts of climate change through IKS. For example, the farmers' livelihood is improved through multiple benefits from agro-forestry species and the local farmers gain from cultivation of crops and livestock production. This therefore confirms the 1st and 2nd hypotheses. Major farming practices recommended include agro-forestry, crop rotation, and mixed farming and mixed cropping. The farming practices applied indicate that local farmers are incorporating both indigenous knowledge and modern farming practices to enhance climate change resilience in their areas. This is in accordance with the current Rwandan agricultural policy to promote farming practices that increase land productivity using friendly-farming practices, thus verifying the 3rd hypothesis.

Impact of Replacing IKS with Modern Farming Practices

Due to pressure for increasing food production in Rwanda, there has been growing awareness to apply modern farming practices that mainly focus on increased yields and productivity. The major consequences of modern farming practices in Rwanda include loss of genetic resistance (65.3%), soil degradation (16.8%), and loss of biodiversity as well as loss of traditional knowledge systems that have been valuable over the years.

CONCLUSION

Findings from the study indicate that about 50.5 percent of the respondents have lived in these areas for over 40 years. This therefore implies that the information provided by respondents is reliable and can be used to inform policy and make decisions on climate change adaptation and mitigation. The major threats identified in relation to climate change included deforestation, floods, changes in volcanic activity and changes in solar radiation and the use of chemical fertilizers. Over 75 percent of the respondents still perceive indigenous farming practices as an effective way to enhance climate change resilience in Rwanda. However, indigenous farm-

ing practices have continued to be neglected in favor of the modern farming practices, which are usually associated with higher yields and increased productivity.

Although indigenous farming practices would not be considered as a panacea, local farmers still regard such practices as more resilient and more effective to climate change. Some of the indigenous farming practices include crop rotation and mixed cropping especially with (sorghum, millet, beans, peas, groundnuts).

RECOMMENDATIONS

Organic farming, which is mostly associated with IKS, should thus be promoted especially in these study areas. It is cheap, relying mostly on less external inputs such as the application of indigenous varieties, crop residues, and cow dung and produces a significant contribution on climate change resilience and has no side effects compared to the modern farming practices.

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