Chapter 23
Local and Indigenous Knowledge Systems in Subsistence Agriculture, Climate Risk Management, and Mitigation of Community Vulnerability in Changing Climate, Lake Victoria Basin: A Case Study of Rakai and Isingiro Districts, Uganda

Casim Umba Tolo, Enock Amos Majule and Julius Bunny Lejju

Abstract Developing countries are vulnerable to negative impacts of climate change due to over reliance on climate-sensitive sectors, mainly agriculture. Limited adaptive capacity makes them vulnerable to climate-induced hazards. However, over the years, indigenous knowledge systems (IKS) have proven effective in promoting sustainable development particularly for those in subsistence agriculture. For example, in Lake Victoria basin, local communities have coped and adapted to climate-induced hazards using traditional systems and IKS. This chapter presents findings of a cross-sectional survey on the use of IKS in subsistence agriculture to enhance climate risk management and mitigation of community vulnerability in a changing climate. Data were collected by household questionnaires, key informants' interviews, and focus group discussions. Results showed overall, significantly high community awareness levels prevail in study area, implicating climate change as the main challenge facing agricultural sector. Nevertheless, as climate change adaptation and mitigation measures, local communities use myriad of IKS to improve resilience and productivity. They use IKS in soil conservation, weather/climate forecasting, selection of planting seeds, and preservation of seeds/crops. This study, therefore, recommends incorporating IKS into scientific knowledge systems to promote climate change adaptation and mitigation among vulnerable communities dependent on climate-sensitive resources.

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23.1 Introduction

Over the years, in the absence of scientifically proven approach, indigenous knowledge systems (IKS) have proven reasonable alternatives for promoting sustainable agricultural development, especially in developing countries. However, of recent, variety of interlinked human activities coupled with climatic variability/change have continued to negatively affect local communities in subsistence agriculture, particularly those living in Lake Victoria basin, East Africa.

Lake Victoria and its basin have undergone major environmental changes over the past decades resulting in rapid reduction in its natural resources, eutrophication, and significant drop in the water levels. At present, there is increasing demand for freshwater, agriculture land, urban expansion, and industrialization in the basin as well as changes in lake's flow regime (Phoon et al. 2004). Political instability, poverty, and frequent natural disasters are often reported in the basin. Today, increased pressure from human population is reported to be the major cause of rapid deforestation and conversion of water catchment areas into open farmlands in the lake's basin (e.g., Odada et al. 2004; Andama et al. 2012; Tolo et al. 2012); and also further reported in, e.g., Verschuren et al. (2002), Sida (2004), and Lejju (2012) that the extensive deterioration of the Lake Victoria resources is attributed to human activities and climatic variability.

According to IPCC (2001), signs of impacts of climate change observed around the world include the increase in surface temperature, sea-level rise, changes in precipitation, and decrease in snow cover. However, climate change also causes changes in rainfall regime, runoff, and evaporation, which in turn affect the water availability and variability worldwide, and especially so, for lakes like Victoria which receive 80 % of its water by direct overhead precipitation and loses about the same amount by evaporation (COWI 2002). Hence, the local communities in the lake's basin face a number of negative impacts of climate variability and change.

Climate risk management, especially in subsistence agriculture, is vital in order to assess and evaluate impacts of climate variability and change on agricultural productivity. According to NEMA (2010), climate vulnerability refers to the degree to which a system or organization is susceptible to, and unable to cope with, adverse effects of climate change/variability. Vulnerability is also regarded as a function of exposure to hazards such as droughts, conflicts, or extreme price fluctuations, and also underlying socioeconomic and institutional situation (NEMA 2010). Therefore, individual vulnerability assessment under changing climate would be able to determine, for example, if members of a given community are currently at risk or not, since people's livelihoods are directly affected by extreme weather events related to climate change and variability.

Application of indigenous knowledge (IK) and IKS would provide practical solution for local communities in meeting challenges of climate change/variability. Already, increasing importance of IK and IKS in promoting sustainable development in developing countries, including Africa, has been reported (e.g., Ulluwishewa 1993; DeWalt 1994; World Bank 1998; Makara 2002; Ngulube 2002). IK and IKS are learned ways of knowing and looking at the world (McClure 1989, p. 1), and Warren (1991) refers to it as traditional and local knowledge existing within and developed around specific conditions of women and men indigenous to a particular geographic area in contrast with knowledge generated within the international systems of universities, research institutes, and private firms. IKS have evolved from years of experience and trial-and-error problem solving by groups of people working to meet the challenges they face in their local environments, drawing upon the resources they have at hand.

World Bank (1998) contends that there is a need to learn from local communities and enrich the development process. For instance, about 80 % of the world's population depends on IK to meet their medical needs, and at least half rely on IK for crops and food supplies (CSOPP 2001). Generally, IK affects the well-being of the majority of the people in developing countries (Ngulube 2002). Similarly, Warren (1991) concludes that development projects cannot offer sustainable solutions to local problems without using local knowledge, and some scholars (e.g., Brokensha et al. 1980; Schoenhoff 1993) warn that failure to incorporate IK of local community in their development projects would inevitably result in failure of such projects.

In general, IK provides problem-solving strategies for local communities, especially the poor, and it represents an important component of global knowledge in development issues (World Bank 1999; Makara 2002). IK encourages participatory decision making and formulation and effective functioning of local organizations (Flavier et al. 1995). IKS and technology are "found to be socially desirable, economically affordable, sustainable and involve minimum risk to rural farmers and producers, and above all, they are widely believed to conserve resources" (Rouse 1999). On the other hand, Vanek (1989, p. 167; cited by DeWalt 1994) emphasize among other important features of IK for sustainable development, its traits of being convenient in rational decision making, various adaptive strategies for use at times of stress (e.g., drought and famine), indigenous system of intercropping, integration with social institutions, and flexibility with considerable entrepreneurial abilities.

23.1.1 IKS Use to Improve Agriculture and Natural Resource Management

Apart from its common use by rural communities in developing countries as local climate forecasting tool to guide farmers in timing planting seasons (e.g., Roncoli et al. 2002), on-farm research findings on IKS in Kentucky, USA, demonstrated that no-tillage farming resulted in greater production because it made double-cropping possible (Phillips and Young 1973; DeWalt 1994). In this case, no-tillage farming technology was a local initiative by indigenous farmers who effectively demonstrated to agricultural scientists that it was possible to plant soybeans followed by wheat while ensuring better soil moisture retention, saving in labor, less soil damage from machinery, better timing in planting and harvesting, and reduction of some weather risks (Choi and Coughenour 1979).

For local climate forecasting, IKS indicators which farmers mostly use are, e.g., fruit production of certain trees at the onset of rainy season and temperatures during dry season, intensity and direction of winds, cloud cover, behavior of birds and insects, as well as different phases of the moon throughout the year among others (e.g., Roncoli et al. 2002, 2010, 2011; Kangalawe et al. 2011). Local farmers from Burkina Faso also devised their own method of rehabilitating degraded land by improving the traditional planting pits through the application of organic matter, thereby attracting termites, which dig channels and, thus, improve the soil structure and water retention capability (Aly and Hamado 2005).

In the same way, Rubaihayo (2002) reports on peri-urban farmers around Kampala, Uganda, employing IK in producing and consuming traditional vegetables. In this practice, the farmers work back the organic indigenous plant matter into the soil after harvest and this was reported to have improved the vegetable yield in the following planting season. The farmers realized that rotating green beans (*Phaselous vulgaris*), "Ebugga" (*Amaranthus dubius*), and tomatoes (*Lycoperscum lycopersicon*) in that order makes "Ebugga" neutralize the soil after planting green beans, thereby preparing the soil for good tomato yields (Rubaihayo 2002). Similarly, Banyankole cattle keepers in Bubaare subcounty and other parts of Greater Mbarara, Uganda, have been using various indigenous herbs including, recently, *Moringa oleifera* seeds to treat water from ponds before feeding to their animals. The herbs are believed to have Molluscicide and other anti-microbial properties capable of reducing microbial load in water, hence reducing the cost of animal production and increasing milk yield. Other beneficial application of IKS in natural resources management has also been documented, e.g., among the Runa community of San José of Ecuadorian Amazon through resource enhancement practice within a shifting cultivation system (Irvine 1987). Similarly, in this chapter, we present findings of a study set to investigate and document local system and IKS used in subsistence agriculture to enhance climate risk management and mitigation of community vulnerability in a changing climate and promoting livelihoods security for vulnerable communities in Lake Victoria basin. It was guided by the following main research questions with focus on communities living in Lake Victoria basin: (1) What are the knowledge levels of local communities involved in subsistence agriculture on trends of climate variability and change? (2) Can we identify possible risks in subsistence agriculture related to climate variability and change and the strategies for the climate risk management? (3) What kinds of individual and community vulnerabilities exist in subsistence agriculture as a result of climate variability and change; and how do individuals and communities improve their resilience to changing climate? (4) Can we document local system and IKS used in subsistence agriculture to mitigate community vulnerability in a changing climate, adaptation options, and coping strategies?

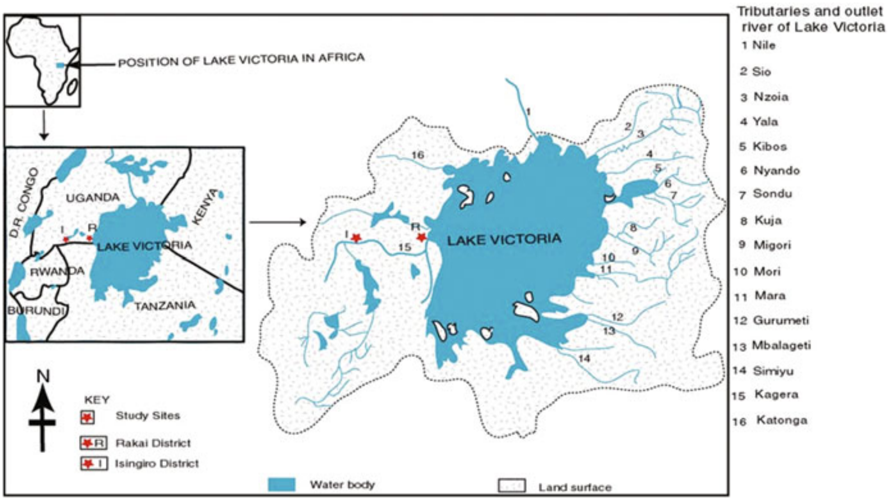

Fig. 23.1 Lake Victoria basin showing location of the two study villages of Kimbugu and Nyabuziba, Isingiro and Rakai districts, Uganda, respectively

23.2 Materials and Methods

23.2.1 Study Area

This study was conducted in the Lake Victoria basin, in Rakai and Isingiro districts, Uganda (Fig. 23.1). Lake Victoria situated in East Africa within 0° 20′ N to 3° 00′ S and 31° 39′ E to 34° 53′ E coordinates, an altitude of 1,134 m (Ssemmanda and Vincens 2002; Njiru et al. 2008) and a surface area of 68,800 km^2 (Crul 1995), is the second largest freshwater lake in the world and the largest in Africa (Crul 1995). The lake is shared by Kenya (6 % of shoreline), Uganda (43 %), and Tanzania (51 %), with a catchment area of ≈195,000 km^2 that also includes Rwanda and Burundi. Lake Victoria basin is one of the eight major subbasins identified within the Nile basin (Conway 1993). The water of the lake is a vital resource for an estimated 30 million inhabitants who are dependent on its resources for food, energy, water, building materials, and transport.

The Lake Victoria basin is covered by an extensive wetland ecosystem composed of macrophytes, papyrus, phragmites, typha, and vossia and contains more than 500 species of fish, including 300 endemic species of the haplochromine cichlids and several endemic Tilapiines (e.g., *Oreochromis esculentus* and *O. variabilis*). Introduction of exotic fish such as Nile perch (*Lates niloticus*) and Nile tilapia (*O. niloticus*) threatens this diversity and is blamed for the near extinction of more than 200 endemic species (Njiru et al. 2008). Other threats facing the resources of the lake and its basin include eutrophication, overexploitation of fisheries, catchment destruction, population pressure arising from people constantly being attracted to exploit economic potentials of the area, pollution from domestic, industrial, as well as agricultural wastes, and climate variability and change.

Rakai and Isingiro districts both lie in the western part of Lake Victoria basin, Uganda. The two districts represent typical rural setting common to many of the districts found in the lake's basin. The population is mainly dependent on natural resources to meet their basic needs at subsistence levels, and the local communities are extremely vulnerable to negative impacts of climate variability and change.

23.2.2 Research Design

A cross-sectional survey was the design. A household questionnaire was used for data collection; in addition, two different checklists were designed to guide key informants' interviews and focus group discussions, respectively. Participants were selected among the local communities of the study area.

23.2.3 Study Population

The population comprised selected local communities of the study area from two villages purposively selected (Fig. 23.1). Study population was carefully chosen to reflect true characteristics for cross section of total population of the study area. To this study population, a comprehensive questionnaire was administered at household level, Focus Group Discussions (FGDs) at village level, and key informants' interviews at subcounty and district levels to triangulate data collection process.

23.2.4 Sample Size

For households selected to participate in the study, sample sizes were calculated from the formula for estimating population proportion that is applied for finite populations (Krejcie and Morgan 1970).

23.2.5 Sampling Procedure

The participants included in the sample size were selected applying probability and non-probability procedures (Byaruhanga 2005). For each study village, questionnaires were administered to households using random sampling method until a required sample size was attained. A questionnaire was administered to not more than one member of each household, but often to the head of the household. About 10–15 participants from local communities of the study area took part in FGDs. At least two FGDs were conducted per village. In addition, key informants' interviews were conducted with participants purposively selected (Mugenda and Mugenda 1999) from subcounty and district levels. Key informants comprised mainly district technical staff and political leaders, community elders / opinion leaders, and community-based organizations (CBOs) /nongovernmental organizations (NGOs) staff in the area. In all cases, youths, elderly, and other interest groups were incorporated in participant-selection procedure.

23.2.6 Research Instruments/Tools Used for Data Collection

Tools used included household questionnaire, key informants' interview, and focus group discussion guides. To ascertain validity and reliability, all the tools were pretested, appraised, and retooled before use for data collection.

23.2.7 Data Analysis

Appropriate analytical techniques for qualitative and quantitative data analysis were used. A total of 164 duly filled household questionnaires were included in analysis in addition to synthesis of transcribed information from focus group discussions and key informants' interviews. Thematic content analysis was mainly used to handle qualitative responses. Data were coded according to inductive category (for open-ended questions) and deductive category (for close-ended questions), focusing on issues not captured in terms of frequency and other statistics (e.g., Denzin and Lincoln 1994; Krueger 1998; Morgan 1996). Quantitative data were subjected to nonparametric tests and coefficient correlations within a computer program, statistical package for social sciences (SPSS 17.0). For simplicity, the results of the survey are herein presented in tabular and graphic forms.

23.3 Results and Discussion

Here, we present, interpret, and discuss the main results of the study. Unless otherwise stated, results presented demonstrate perspectives of local communities as they relate to the use of IKS in subsistence agriculture in a changing climate to enhance community resilience and livelihoods. Overall, summary results are presented beginning with demographic characteristics of the study population and ending with IK used in storage/preservation of seeds/crops.

23.3.1 Generalized Demographic Characteristics of the Study Population

Overall, 60.37 % ($n = 99$) of the household respondents were male against 34.14 % ($n = 56$) female with 5.49 % ($n = 9$) not mentioning any gender, reflecting patriarchal nature of the community in Lake Victoria basin where men dominate socioeconomic and environmental issues (Tolo 2010). Respondents' age distribution reflects only mature individuals, who have lived in the area for decades, took part in the study, and are believed to have accumulated, over the years, considerable IKS used in subsistence agriculture, a similar view expressed in Kangalawe et al. (2011). Majority of the respondents reported having attained only basic primary level education, representing 62.2 % ($n = 102$). As a result, most of them, 78.65 % ($n = 129$), practice subsistence farming as their main occupation and livelihood. The low level of education cannot permit majority of the local population to be gainfully employed in service industry; and, therefore, as argued in NEMA (2010), local environment and/or natural resources in the area remain their primary source of livelihoods. This, they supplement with subsistence agriculture which is also threatened by land shortage, degradation, fragmentation, and general adverse effects of climate and change/variability in the area.

The demographic characteristics of the population is also challenged by a number of land-related problems, with households citing mainly land degradation and land shortage, each representing 78 % ($n = 128$), followed by unproductive land, 75 % ($n = 134$). Other land-related problems cited include land fragmentation, landlessness, land conflicts, and soil exhaustion. **S**imilarly, participants of FGD members of key informants' interviews cited the same reasons as above. Ironically, some of the land-related problems are the same reasons that led respondents to migrate from their previous settlement places. This implies, indeed, there are both social and physical factors that promote land-related problems in the study area. However, this may lead to vicious cycle of settlement abandonment with people not having incentive investing and/or developing their land to increase productivity.

23.3.2 Awareness Levels of Local Communities on Trends of Climate Variability and Change in Lake Victoria Basin

The study established that majority, 88.41 % ($n = 145$), of the local communities in the study areas are aware of trends in climate variability and change in their area, and the level of awareness is overall significant ($P = 0.000$) in the two study districts of Isingiro and Rakai. And the awareness level of trends in climate variability and change in the two districts compared is the same ($P = 0.213$). The findings clearly indicate that local communities in Lake Victoria basin, just like elsewhere in Africa (e.g., Roncoli et al. 2010, 2011; Kangalawe et al. 2011), are aware of trends in climate variability and change in their area. However, the level of awareness does not seem to reflect communities' readiness for climate change adaptation. Most of the level of awareness revolves around unpredictable onset and ending of rains and shortened growing seasons (e.g., West et al 2008; Mpeta 2009), incidences of severe droughts, and consequent widespread famine (e.g., Reardon and Taylor 1996). The problem is that most of these perceived indicators of trends of climate variability and changes remain highly variable, changing from season to season, year after year with

Fig. 23.2 A local farmer displaying a bunch of banana from a plantation suspected to have been affected by "banana bacteria wilt (BBW)" in Nyabuziba village, Rakai district, Uganda

no definite pattern, thus making it difficult for communities to take commensurate adaptation measures.

23.3.3 Effects of Climate Variability and Change on Agricultural Activities in Lake Victoria Basin

Most of the respondents in the study areas, 96.34 % ($n = 156$), reported that their agricultural activities in the past years have been affected by climate variability and change, and only a negligible number, 3.66 % ($n = 8$), could not directly attribute the losses to climatic factor. According to the local communities, some of the effects of climate variability and change on subsistence agriculture, as cited in decreasing order of severity, include decrease in crop productivity, frequent outbreak of pests/diseases (e.g., Fig. 23.2), frequent droughts, frequent floods, reduced water/pasture for livestock, and unreliable rainfall patterns among others. These have severely hampered agricultural activities in the villages, making local communities vulnerable in most cases, to the verge of famine and loss of livelihoods. Just like households, key informants and members of FGDs stressed increasing incidences of banana bacterial wilt (BBW) disease "toduura" in Luganda that keeps devastating banana plantations, and yet banana is a key income earner among the subsistence farmers in the area. Overall, climate variability and change has significantly affected local communities' agricultural activities in the two study villages ($P = 0.000$) as well as within the individual districts of Rakai ($P = 0.000$) and Isingiro ($P = 0.000$). However, the impacts experienced in the two districts compared are the same ($P = 0.340$).

Findings of the present study have revealed that climate variability and change is one of the greatest challenges facing agricultural activities in Rakai and Isingiro districts. However, on a regional and continental scale, Lake Victoria basin is not an exception. For example, Kangalawe et al. (2011) in Great Ruaha River catchment, Tanzania, also documented similar impacts. Nelson et al. (2009) report that agriculture, especially in developing countries, is extremely vulnerable to climate change, as higher temperatures lead to reduced yields of most desirable crops while encouraging weed and pest proliferation, and that overall, impacts of climate change on agriculture are negative, threatening global food security.

23.3.4 Sensitization of Local Communities on Trend of Climate Variability and Change in Lake Victoria Basin

Almost half of the local communities who took part in the study, 54.26 % ($n = 89$), admitted having been sensitized on trends of climate variability and changes. The remaining 45.74 % ($n = 75$) have never received any form of sensitization on the same. Myriad of organizations associated with the sensitization program include Millennium Development Goals (MDGs) Project termed as Millennium Village Project (MVP) which is being piloted in Isingiro district, National Agricultural Advisory Services (NAADS), media (radios and televisions), World Vision, and agricultural extension officers. On the contrary, National Environmental Management Authority (NEMA), a watchdog of environment in the country, was the least mentioned.

Nevertheless, communities still felt sensitization program falls far below expectation. To them, it is rather thin on ground and does not reach all communities and more can be done by government, NGOs, and CBOs in order to reach many citizens. Overall, the level of sensitization in the two districts compared is significant ($P = 0.000$). People seemed more sensitized in Isingiro than in Rakai district. This disparity may be attributable to the activities of United Nations Development Programme, Millennium Village Project operating in Isingiro. Lack of funding and inadequate capacity are, however, some of the common reasons cited especially by government-funded agents for not carrying out sensitizations, and for some NGOs/CBOs, climate change-related problems are simply not on their current agenda.

23.3.5 Risks in Subsistence Agriculture Due to Climate Variability and Change and Strategies for Climate Risk Management in Lake Victoria Basin

A number of risks have prominently been associated with subsistence agriculture in a changing climate. Owing to small-scale nature, lack of access to capital/finance, and relevant technologies, local farmers in the study area have become vulnerable to climate-induced risks affecting their livelihoods. In most cases, they are often made to adapt and cope with these hazards using IKS. In particular, local communities are wary of decreasing quantity of farm produce, frequent outbreak of pests/diseases, frequent droughts, insufficient amount of rainfall received per season/unpredictable

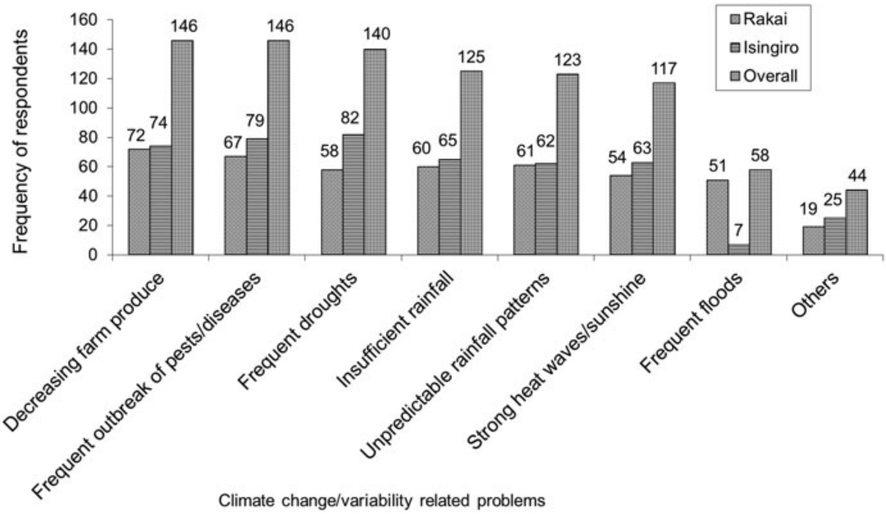

Fig. 23.3 Some of the climate change/variability-related risks on subsistence agriculture experienced in study villages of Rakai and Isingiro districts, Uganda

rainfall patterns, strong heat waves/sunshine, and frequent floods among others (Fig. 23.3). Similarly, participants of both FGDs and key informants unanimously agreed with the said risk factors. They also cited frequent famine in the area as a result of failed crops and unexpected heavy rains destroying crops, hence leading to increasing household poverty due to reduced income from produce sale. They also associate with climate change/variability, prolonged sunshine, and frequent strong winds that lead to drying of crops before maturity. Other risks relate to poor/muddy roads for transportation of produce to market, hence deteriorating the quality of produce on transit.

However, when the impact of climate change/variability-related risks on subsistence agriculture is compared in the two districts, no significant difference exists between all the other risk factors except for frequent droughts experienced in Isingiro district ($P = 0.043$) and frequent floods experienced in Rakai district ($P = 0.000$). These findings suggest that communities in districts of Isingiro and Rakai should, as necessities, adopt two different adaptation and mitigation measures against the impact of climate change/variability-related problems, with communities in Isingiro placing more emphasis on drought mitigation and coping measures, while those in Rakai should emphasize more on flood prevention and mitigation. Drought mitigation measures such as constructing water-harvesting tanks (on small scale, e.g., from rooftops) and planting quick maturing/pest-resistant crop varieties (i.e., drought-tolerant and early-maturing crop varieties) will help those living in drought-prone areas such as those in Isingiro district to adapt to negative impacts of climate variability and change, while those in flood-prone area like those in Rakai district should engage in constructing water channels to prevent floods in their areas as adaptation measures.

Fig. 23.4 Rain water harvesting in locally constructed water tanks (on small scale, e.g., from rooftops) as drought mitigation measure in Kimbugu village, Isingiro district, Uganda

23.3.6 Strategies Put in Place by Local Communities for Climate Risk Management in Lake Victoria Basin

A number of strategies have been put in place in the study area for climate risk management, with most of them incorporating IK and IKS. Some of these strategies, in the order of importance as mentioned by respondents include tree planting/afforestation, planting quick maturing/pest-resistant crop varieties (i.e., drought-tolerant and early-maturing crop varieties), avoiding environmental degradation, adopting modern farming techniques, constructing water-harvesting tanks on small scale, e.g., from rooftops (Fig. 23.4), constructing water channels to prevent floods, and animal rearing/setting up poultry to diversify livelihoods. Others include mulching, manuring, watering crops, swamp reclamation, contouring/terracing, and planting root crops.

On the basis of these findings, it is true that a number of risks in subsistence agriculture are related to climate change/variability in Lake Victoria basin, creating sense of uncertainty and vulnerability among the local population. These uncertainties make subsistence farmers feel wary and helpless. To them, climate change-related problems are far beyond their control. This is similar to the findings of Hassan (2010) in Zanzibar Island, where most farmers were found to be planting their crops during the planting seasons simply by trial and error with future of their crop success uncertain due to unpredictable climatic seasons. However, it will be important if local communities are equipped with right adaptation and mitigation measures in order to develop appropriate strategies for climate risk management in

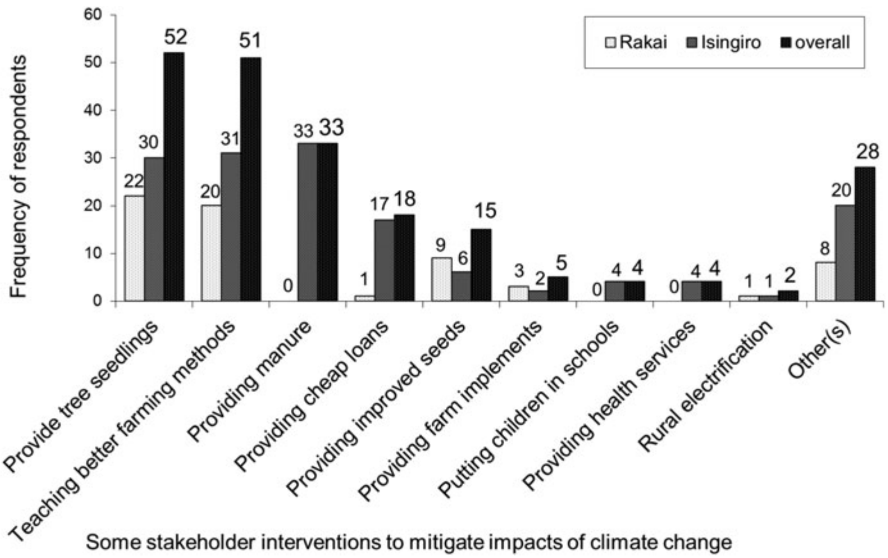

Fig. 23.5 Some interventions by different stakeholders (government, NGOs, CBOs, etc.) in addressing negative impacts of climate variability and change in the study villages of Rakai and Isingiro districts, Uganda

Lake Victoria basin. For example, farmers of the Central Plateau in Burkina Faso, after incorporating drought-mitigation adaptations into their agricultural systems, were found to view drought as "normal" (West et al. 2008). It is, therefore, important to encourage farmers in the study area to continue with strategies such as planting trees/afforestation, early planting of crops and planting of quick-maturing, pest-resistant, and drought-tolerant varieties, as well as diversification of livelihoods.

Nevertheless, there are some modest interventions (Fig. 23.5) by different stakeholders (e.g., government, NGOs, CBOs, etc.) that include providing tree seedlings, teaching better farming methods, and providing manure and cheap loans among others. However, when some of the key specific interventions by different stakeholders were compared across the two study districts, it is observed that statistical significant difference exists only in one intervention, providing cheap loans to the communities ($P = 0.000$), with local communities in Isingiro receiving much better financial services in the form of cheap loans than do those in Rakai district.

Vulnerability to climate change can vary within countries, communities, and even households, and, as such, adaptation requires context-specific activities, with strategies targeted to meet the needs of different vulnerable groups (Dazé et al. 2009). Relatedly, vulnerability to climate change has been defined as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes (Dazé et al. 2009). Therefore, vulnerability is a function of the character, magnitude, and the rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC 2001).

By and large, and in the context of the findings of this study, local communities' perceived individual and community vulnerability has mainly been their inability to cope with the negative impacts of climate change/variability that directly affect their livelihoods. In their view, both rich and poor are vulnerable to the negative impacts of climate change/variability, although with varying degrees of vulnerability. This is consistent with the views expressed by Dazé et al. (2009) which recognizes that communities are not homogenous, so particular households or individuals within communities may have differing degrees of vulnerability.

The communities in the study area are dependent on rainfed agriculture, and, as such, most of their vulnerability stem from the way how climate variability and change affect their way of production. Their control over resources, particularly natural (mainly reliable water source and productive land), financial (diversified income sources), and human (knowledge of climate risks, conservation agriculture skills, and enthusiastic labor force), are all minimal, to say the least. In general, most of the vulnerabilities are weather related and, therefore, climate induced. Given that subsistence agriculture is the main form of livelihood in the area, their way of production is impacted heavily by vagaries of weather. It is, therefore, prudent to help local communities get access to information and enhance their adaptive capacity. One of the most important factors shaping the adaptive capacity of individuals, households, and communities is their access to and control over natural, human, social, physical, and financial resources (Dazé et al. 2009). IPCC (2007) defines adaptation as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

A well-adapted community becomes resilient to negative impacts of climate change/variability. Resilience has been defined as the ability of a community to resist, absorb, and recover from the effects of hazards in a timely and efficient manner, preserving or restoring its essential basic structure, functions, and identity (e.g., IISD 2007; UNISDR 2009). On the other hand, hazard is defined as a dangerous phenomenon, substance, human activity, or condition that may cause loss of life, injury, or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (UNISDR 2009). However, just as adaptive capacity, resilience varies greatly for different groups within a community depending on access and control over critical resources. A resilient community is well placed to manage hazards to minimize their effects and/or to recover quickly from any negative impacts, resulting in a similar or improved state as compared to before the hazard occurred (Dazé et al. 2009).

Similarly, from the results of this study, climate-related hazards have mainly been shocks, such as droughts and floods (characterized by rapid onset in nature), and stresses, such as changing rainfall patterns and rising temperatures (characterized by slow onset in nature). However, some of the effects of both climate-related shocks and stresses such as frequent famine, failed crops, low productivity/low income, high poverty levels, degraded farm lands/declining soil fertility, water scarcity, livestock deaths, and increased crop pests/diseases are widespread in the study area and, hence, communities must be helped to build resilience against them to sustain livelihoods.

23.3.7 Local/traditional IKS Used in Subsistence Agriculture in Mitigating Community Vulnerability in a Changing Climate and as Adaptation Options in Lake Victoria Basin

This study established that local communities use myriad of IK and IKS in subsistence agriculture. The use is multifaceted aimed at not only increasing productivity in terms of quantity but also enhancing quality. IK and IKS are, for instance, used in soil conservation, climate/weather forecasting in order to correctly time planting seasons, selecting suitable planting seeds, and storage/preservation of seeds and crops in a changing climate. Further still, the local communities have convincing rationale/reasons for use of each IK as summarized in Table 23.1.

Indigenous communities world over have had a well-developed traditional IKS for managing issues affecting their livelihoods in cost-effective, participatory, and sustainable manner since time immemorial. For example, in Africa, application of IKS in sustainable agriculture, including the practice of improving soil conservation and fertility (e.g., Rubaihayo 2002; Aly and Hamado 2005), have been documented. Similar practices have also been demonstrated elsewhere in the world with tremendous results (e.g., Phillips and Young 1973; DeWalt 1994). In the same way, the present study has also documented a rich array of IKS that relate to its use in subsistence agriculture with some positive aspects that can augment scientific knowledge as has been argued by DeWalt (1994).

Apparently, from the perspectives of the local communities, IKS appears to be universal and, hence, applicable in every sphere of life including its use in weather forecasting among others. For example, local communities in Lake Victoria basin are well versed with seasonality of weather in their area based on IK. They often use a number of indicators in predicting suitable planting seasons in a changing climate including knowledge of onset of rainy season (normally in the study areas expected to be the months of March and September, and also August and December of every year), knowledge of changes in particular wind movements/directions signifying onset of wet/dry seasons, knowledge of changes in ambient temperature associated with onset of wet/dry seasons, knowledge of flowering period of shrubs ("ehongwa") signifying onset of dry season, knowledge based on observation of specific cloud cover types in the sky associated with onset of wet/dry seasons. Others include knowledge of swarming of butterflies and bees associated with onset of wet/dry seasons, health status of an individual (e.g., ear blockage and excessive seating at night, feeling backache and general body weakness signifying onset of wet season), knowledge of specific birds' singing signifying onset of wet/dry seasons, and knowledge based on the presence of red ant colonies which indicates a ripe season specifically for panting onions. Also, the movement of group of birds and following of specific religious days/calendar, as well as blossoming of coffee plantation, are examples of all IKS indicators used in forecasting weather by local communities in the study area (Table 23.1).

The use of IKS as local indicators documented by this study for climate forecasting is consistent and agrees with its widespread use in most parts of Africa. For instance,

Table 23.1 Some of the local/traditional and indigenous knowledge systems used in subsistence agriculture in mitigating community vulnerability in a changing climate, Lake Victoria basin, Uganda. (Source: Field data 2012)

(a) IK for soil conservation in a changing climate in Rakai and Isingiro districts, Lake Victoria basin, Uganda

Local/traditional and indigenous knowledge	*Rationale/reasons for the indigenous knowledge*
Crop rotation	Usually for the soil to regain its fertility and avoid pests/diseases recurring
Mulching using banana leaves/grass/maize stems	Soil to retain moisture and improve soil conditions
Land/bush fallowing	To allow land regain its fertility and avoid pests/diseases recurring
Terracing/strip cropping/contour plowing	Stop or combat soil erosion/soil conservation
Application of cow dung as fertilizer	Improve on soil fertility
Tree planting in gardens	To prevent soil erosion and act as wind breakers
Construct water channels/trenches	Mitigate floods
Avoiding bush burning	Maintain soil cover and mitigate soil erosion
Growing cover crops, e.g., beans, cow peas	Mitigate soil erosion and improve soil fertility
Mixed cropping/farming	Maintain soil fertility
Burying weeds in composite pits	To be used as organic manure
Application of urine in farmlands	Enhances soil fertility

(b) IK for forecasting planting seasons in a changing climate in Rakai and Isingiro districts, Lake Victoria basin, Uganda

Local/traditional and indigenous knowledge indicators of climate	*Starting/ending of rainfall season*
Months of March and September; and also August and December every year	Known rainfall months in local calendar every year. So farmers prepare their gardens and plant their crops/seeds
Swarming of butterflies	Signifies starting of dry season. Hence, no planting of crops/seeds
Swarming of bees	Signifies onset of rain season. Hence, farmers prepare their gardens and plant their crops/seeds
Movement of groups of birds "Ebiranganseneme," literally meaning "announcing arrival of grass hoppers" (Lunyankole)	Signifies onset of rain season. Hence, farmers prepare their gardens and plant their crops/seeds
West–east direction of wind movement	When the wind blows from west to east, it signifies onset of rain season. Hence, farmers prepare their gardens and plant their crops/seeds
Presence of "red ant" colonies "Empazi" (Lunyankole) and "Ensanafu" (Luganda)	Specifically signifying planting season for onions. Hence, farmers prepare their gardens and plant onions
Blossoming shrub "Ehongwa" (Lunyankole)	Signifies onset of dry season. Hence no planting of crops/seeds
Singing of specific birds, e.g., a bird known as "Ekishamututu" (Lunyankole)	Usually the songs of this bird signify rains are soon coming (rainfall season approaching). Hence, farmers prepare their gardens and plant their crops/seeds
Specific religious days, e.g., Easter and Ascension day, August 15 of every year	These religious calendar days are associated with rainfall, ideal for planting crops/seeds
Blossoming of coffee plants	Associated with rain season. Hence, farmers prepare their gardens and plant their crops/seeds

Table 23.1 (continued)

Local/traditional and indigenous knowledge indicators of climate	*Starting/ending of rainfall season*
Specific health status of an individual experienced, e.g., ear blockage (at night), excessive sweating (at night), backache, and general body weakness	The local communities associate these health conditions with onset of rainfall. Hence, farmers prepare their gardens and plant their crops/seeds

(c) IK for selecting suitable planting seeds in a changing climate in Rakai and Isingiro districts, Lake Victoria basin, Uganda

Local/traditional and indigenous knowledge (features/mode of selection)	*Indigenous knowledge and planting seed selection criteria*
Damaged vs. undamaged seeds	Undamaged seeds only are always selected for planting
Healthy vs. unhealthy seeds	Healthy seeds only are always selected for planting
Attractive vs. unattractive seeds	Attractive, mostly brightly colored seeds are selected for planting
Water soaking seeds	Only denser seeds as opposed to floating ones are selected for planting
Weevil infested vs. uninfected	Only weevil-free seeds are selected for planting
Disease resistance of the varieties	Only seeds from disease-resistant strains are selected for planting
Size of the seeds	Usually big-sized seeds are selected for planting
Maturity of the seeds	Only mature seeds are selected for planting
Number of cotyledons	For dicotyledonous seeds, e.g., beans, only those with two dicots are selected for planting
Seeds with or without embryo	Only those seeds with embryo are selected for planting

(d) IK for storage/preservation of seeds/crops in a changing climate in Rakai and Isingiro districts, Lake Victoria basin, Uganda

Local/traditional and indigenous knowledge	*Rationale/reasons for the indigenous knowledge*
Storing in cool/dry place	To avoid fungal attacks, eliminate moisture accumulation
Storing in granary Accumulation	To ensure fresh air circulation eliminate moisture
Mixing seeds with ash	To prevent weevil/fungal attacks
Smoke treatment of seeds	To prevent weevil/fungal attacks
Smearing seeds with mud obtained from anthill soils	To prevent weevil/fungal attacks
Storing in big calabashes	To prevent weevil/pest attacks
Inserting a "bone from unused meat" in stored seeds	To scare away weevils/pests
Brick-dusting seeds	To prevent weevil/fungal attacks
Herbal treatment of seeds (e.g., mixing with leaves from tobacco, red pepper, "Karwenda and Kanuka" in Lunyankole)	To prevent weevil/pest/fungal attacks
Hanging seeds/crops on house ceilings, usually near fire places	To prevent weevil/pest attacks
Partial harvesting of root crops (e.g., cassava, potatoes, yams etc.), i.e., leaving some in gardens	To avoid pest attack and rotting in storage areas
Storing in big baskets "Kyagi" (Luganda), sacs, and open jerricans	To prevent direct pest attacks
Treating seeds with a mixture of ash from cow dung and dry juicy banana leaves	To prevent weevil/pest/fungal attacks

Kangalawe et al. (2011) in the Great Ruaha River catchment area (GRRCA) Tanzania documented similar use of IK in seasonal climate forecasting: Here, he reports of the use of “Mipalamba” trees among the Wasangu. Usually, these trees produce flowers during the dry season, and if they do not produce sufficient fruits, it indicates that the following season will have little rains, while the reverse is true when it produces many fruits. The early sprouting of “Mihango” trees also indicates an early onset of rains. The Wanji (another major ethnic group in the Usangu plains) use birds known as “Njigu,” also known as “Sangual nyanzala” (Nyakyusa). When these birds fly very high in the sky and start singing, they are locally used to indicate that the following seasons will have good rains. Similarly, when “Dudumizi” and “Kolekyaka” (birds) start singing, they are locally interpreted to mean the rains are near. Further still, to other community members in their areas the sprouting of Acacia trees (locally known as “Mipogoro”) in the dry season indicates a good rainy season thereafter, while to others flowering of Christmas trees (*Delonix sp*) indicates that rains are approaching. Also, the use of IK in rainfall forecasting has been documented in Burkina Faso (e.g., Roncoli et al. 2002).

Similarly, Roncoli et al. (2010, 2011) found that the people of Rakai, southern Uganda, most of them long settled in their territory, have a collective memory of weather patterns that extends into the past. They share a strong sense of the climatology or characteristics of the seasons. Local people give different names to the two rainy seasons and are familiar with a number of attributes. They know the typical timing and duration of the seasons. The first rainy season (“toggo” in Luganda) is expected to run from March through May; the second season (“ddumbi” in Luganda) runs from September through December. Though they do not describe amounts in millimeters of precipitation, farmers distinguish the quantity of rain that has fallen during each season by scraping soil away with their hands, or digging with hoes to examine soil moisture content after rains.

However, comparing the data of present study with those of previous scholars, the main problem still remaining is how to standardize their meanings to cater across all cultural boundaries to mean the same thing. In most cases, all the local IK indicators, e.g., singing of a bird in one area does not necessarily mean the same thing in another. Also, the name of one bird or an insect, important as local climatic indicator, may vary from one ethnic language to another and, hence, its associated climatic indicator. In the same way, Roncoli et al. (2010, 2011) contend that the question of accuracy often arises in discussions of IK, particularly in cases of relatively arbitrary or symbolic signs such as those presented above. Similarly, work elsewhere, for example, has linked shifts in the flowering patterns of trees to El Nio events (Curran et al. 1999) and also it has been shown that migratory birds often use the movements of fronts to provide them with tailwinds (Liechti 2006). Obviously, IKS finds it difficult explaining how such phenomena can be linked to local conditions and only confined to a specific indigenous group. Roncoli et al. (2010) also found significant variation in the language that farmers use to discuss their weather observations especially in regard to appearance of clouds in the sky and other signs. In the case of clouds associated with arrival of rains, some local people simply refer to them as “black clouds,” while others employ more figurative language, such as “thick huge clouds,”

clouds looking mature holding water, clouds that are still heavy holding rains, and other local farmers use the term “nimbus,” referring to them as “rain-bearing clouds.”

Relatedly, the present study found a number of IKS used in both selecting planting seeds and storage/preservation. Their relevance notwithstanding, IKS used for selecting suitable planting seeds as well as those used for storing/preservation of seeds/crops harvested are diverse and also suffer from issues of standardization. Most of them, however, seem to be relevant and confined to this area. Therefore, unlike scientific knowledge, IK is not transferable across time, space, and social setting (DeWalt 1994), and, as it is very rich in contextual detail, it is immobile, having little utility outside particular places (Kloppenburg 1991, p. 531). And this can be seen as the main weakness of the IK in the context of main findings as documented by the present study.

The issue of adaptation and coping strategies to a changing climate is also a pressing one to most rural communities, especially those living in developing countries. As such, most local communities do employ IKS to enhance their adaptation and coping strategies. However, some of these strategies can be counterproductive. Some are simply reactive and carried out for survival purposes only. They deplete resource base of the community and are, therefore, not sustainable in long term in enhancing livelihoods security. For example, coping strategies such as opening up virgin lands for crop production each planting season and cultivating in wetlands to get adequate soil moisture for crops are just crisis-driven actions aimed at survival. Such practices are unsustainable, and they deplete resource base of the very community. Similarly, purportedly “punishing rain makers” in case of delayed rainfall in a given season can be equated to, in my opinion, “extra judiciary killing” and a “mob justice” motivated merely by superstitious beliefs. Such practices should never be allowed to recur in a modern society.

The “rich” and the “poor” in a community also tend to vary in their approaches of embracing a given form of a livelihood under a changing climate, primarily depending on access to and control over resources. These approaches may unfortunately involve adaptation or just coping strategies or both. It should be noted, however, that most often times, “adaptation” and “coping” in the study of climate variability and change have been used interchangeably, yet the two mean different things. And because of frequent confusion associated with use of the two terms Dazé et al. (2009) outline the following to illustrate fundamental characteristics between the two: Coping is generally short term and immediate, oriented towards survival, not continuous, motivated by crisis and is reactive, often degrades resource base, and is prompted by a lack of alternatives. On the other hand, adaptation is oriented towards longer term livelihoods security, a continuous process where results are sustained, involves planning, combines old and new strategies and knowledge, and is focused on finding alternatives. By and large, findings of this study revealed that local communities actually use both “adaptation” and “coping” strategies in reducing their vulnerability to climate change. However, community members endowed with reasonable resource bases tended to adopt adaptation measures much more than those without access to and control over resources within the same community. Such individual, therefore, resort to short-term, crisis management approach, hence depleting even further, the little resource base they may have. Therefore, it is extremely important to have interventions that will cater for the less privileged communities, especially emphasizing need for adaptations to changing climate in order to lessen their vulnerability in a long-term basis.

23.4 Conclusions

This study has revealed in depth, a wealth of local system and IKS that exist in subsistence agriculture to enhance climate risk management and mitigation of community vulnerability in a changing climate. The study has also revealed that climate variability and change has had severe impacts on local communities in Lake Victoria basin, but they seem to use rich stock of IKS to promote livelihoods security and mitigate vulnerability to climate variability and change. Generally, people are aware of trends in climate variability and change in Lake Victoria basin. The study has identified climate variability and change as one of the greatest risks facing agricultural activities in the area, a threat to local communities' livelihoods. However, as much as communities seem to have high awareness levels on trends of climate variability and change, their readiness to climate change adaptations remains wanting. Unfortunately, lack of funding and inadequate capacity are frequently cited as reasons for this and seem to be hampering better adaptation and mitigation measures. Nevertheless, communities in the area have also acted in their capacity to improve resilience and mitigate the negative impacts of climate variability and change mainly by use of IK and IKS in almost all aspects of their lives. Notwithstanding its inherent weakness to have meanings that cater across all cultural boundaries, IKS still remains a source of wisdom readily available to most rural subsistence farmers who continue to achieve tremendous results from its use in enhancing livelihoods security. It may, therefore, be important to incorporate IKS into scientific knowledge systems in an attempt to promote climate change adaptation and mitigation measures among vulnerable communities dependent on climate-sensitive resources.

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