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RESEARCH ARTICLE



Comparison of community-based adaptation strategies for droughts and floods in Kenya and the Central African Republic

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ABSTRACT

This paper discusses community-based adaptation strategies for droughts and floods in small watersheds in Kenya and the Central African Republic. Survey data on adaptation strategies and annual rainfall data in the watersheds were used to assess the occurrence of floods and droughts, and their impacts. In both areas, the main adaptation strategy for floods is temporary relocation. For droughts, changing livelihood activities was the main adaptation strategy, while relief-seeking applied to both droughts and floods. We recommend greater preparedness, capacity building, and the diversification of livelihoods as means of enhancing adaptation.

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Introduction

The effects of climate change on water resources are manifested through extreme events such as droughts, violent storms, and floods that impact communities dependent on these water resources. Climate change affects the quantity, variability, timing, form and intensity of precipitation, thereby affecting the availability of water (Adams & Peck, 2008). Those impacts are observed in the form of extreme events such as floods and droughts. Along the spectrum from droughts to floods, phenomena such as dry spells, water scarcity, dry riverbeds, shorter spells of rainfall, shifts in the timing of rainfall, and low infiltration of rainwater also disturb human life and activities.

According to Margat (2001), water resources are assessed based on their usefulness and accessibility. Accessibility is subject to the spatiotemporal variability of water, including both too much and too little water. In this article, droughts and floods are treated as indicators of climatic variability (Conway, 2002; Kane, 2002; Nguimalet, 2010a). Drought can be defined as an extreme event which occurs infrequently and consists of lower-than-normal rainfall, water flows, and water levels (Mosley & Pearson, 1997). According to Brekke et al. (2009), the Intergovernmental Panel on Climate Change Fifth Assessment Report defines it as ‘a period of abnormally dry weather long enough to cause a serious hydrological imbalance’. Conway (2002) analyzed two extreme rainfall events that occurred in 1961 and 1997 and generated catastrophic floods in East Africa. Kane (2002) analyzed the rising inter-

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annual variability of the Senegal River at its mouth to understand the occurrence of floods despite the persistence of drought in this region. Both droughts and floods are hydro-climatic extremes which historically have disturbed the livelihoods of communities in the watersheds in Kenya and the Central African Republic (CAR) analyzed in this article.

Floods have caused major concern through harmful water abundance that destroys harvests and houses or causes loss of life, whereas droughts cause water scarcity that impacts crops, livestock, or extra-agricultural activities, and generates conflicts around access to resources. How communities cope with the twin phenomena of floods and droughts using their endogenous skills, i.e. coping and adaptive capacities, deserves attention. According to Smit and Pilifosova (2001), *adaptation* involves adjustments to reduce communities' vulnerability to climatic change and variability. Studies of the coping and adaptation strategies adopted by communities are important for both impact assessment, to estimate adaptations which are likely to occur, and policy development, to advise on or prescribe adaptations (Smit, Burton, Klein, & Wandel, 2000). Urama and Ozor (2010) highlight the key role of adaptation in African countries in response to a range of immediate and long-term impacts of climate change on water resources such as flooding, drought, the drying up of rivers, poor water quality in surface and groundwater systems, shorter duration of rainfall, and smaller quantity of rainfall.

This article analyzes the resilience of poor and marginalized communities dependent on natural resources to the risk of extreme weather events such as floods and droughts in select watersheds in Kenya and CAR. It asks whether the adaptive capacities and adaptation strategies of communities in these areas are sufficient to face the challenges of climate change.

Overview of droughts and floods: indicators of variability and extreme climate events

Extreme events such as droughts and floods are among the most immediate impacts of climate change. Climate change effects have become increasingly evident worldwide. According to data published by the US National Aeronautics and Space Administration and National Oceanic and Atmospheric Administration, 2012 was the hottest year recorded since 1992. The Intergovernmental Panel on Climate Change reports of 2012 and 2013 confirm that climate change impacts reached the magnitude and the frequency of some climate extremes. Rising temperatures due to climate change cause heavy rains, which lead to fast runoff, resulting in floods, and long dry seasons result in various forms of drought. Extreme weather events due to climate change have received increased attention in the last few years due to the large loss of human life and exponentially increasing costs associated with them (Karl & Easterling, 1999). Floods and droughts affect a large number of people who are injured, made homeless, or forced to seek emergency assistance (Blankespoor, Dasgupta, Laplante, & Wheeler, 2010). These authors summarized that losses from flood have increased markedly since 1960 for two reasons: the *risk of loss* has increased significantly; and the *population subject to risk* has more than doubled.

State of extreme events such as droughts and floods in the studied watersheds

Droughts and floods as climate extremes have existed in the watersheds studied in Kenya and CAR, and have historically impacted communities. Under the altered climatic conditions due to the growing impacts of climate change in the watersheds, recent floods and droughts have been hazardous, resulting in unpredictable and sometimes catastrophic societal consequences. A 1200–1400 mm, the average rainfall in CAR watersheds corresponds to the wet tropical Sudano-Guinean climate variant with a monomodal regime, whereas in the Malewa watershed in Kenya, rainfall mode is bimodal, with subtropical climate in the south (average rainfall of 750–2000 mm) and semi-arid climatic conditions in the north (average rainfall of 250–1000 mm). Calculated rainfall indices help identify recorded dry and wet sequences per watershed (Nguimalet, 2010c). The Tomi and Malewa watersheds recorded a relatively dry phase before 1960, followed by a humid phase from 1961 to 1971. Thereafter, dry and wet periods alternated, confirming the absence of consistent rainfall in these watersheds. In the Gribingui River watershed, too, humid (1955–1969 and 1975–1980) and dry (1970–1974 and post-1981) spells alternated. Finally, the Fafa River watershed had a long humid spell (1960–1969), followed by a long dry spell (1970–1980). It also experienced shorter humid spells (1981–1986) and dry spells (1953–1959 and 1987–1990) as well as short sequences. The alternation of these dry and wet sequences in the studied watersheds indicate the impacts of climate change.

According to Parry, Echeverria, Dekens, and Maitima (2012), extreme climatic events such as floods and droughts have historically posed a significant problem to regions in Kenya. Major droughts occur about every 10 years, and moderate droughts or floods every three or four years. The total number of climate disaster victims increased substantially in the 1990s and 2000s, due in part to Kenya's population growth. Droughts in particular have affected a greater proportion of people and have had a big economic impact on the country. The costs due to droughts are estimated at around 8.0% of the GDP every five years. From 1964 to 2004, about 1,500,000 people were affected by each of the 11 recorded droughts, on average. In the Malewa watershed, drought severity has been caused by the shortage of rainfall or the lack of water for most farmers and pastoralists, as well as very low river flows since 1931, rarely exceeding $1 \text{ m}^3/\text{s}$. The river's critical low-water discharge is $0.04 \text{ m}^3/\text{s}$ ($0.02 \text{ L/s per km}^2$), which was recorded 6 May 1985 (2.3 years' return period) (Nguimalet, 2010a). These critical low-flow problems are more recurrent today – drought was experienced by people in 1984, 1987, 1994, 2008 and 2009, indicating a trend towards water scarcity over the past 30 years. Murphy and Tembo (2014) noted an increase in the frequency of extremely warm events between 1961 and 2008 in Kenya, suggesting the increasing incidence of dry years, with a simultaneous and significant decline in rainfall since the mid-1970s. This climatic context of dry years with a shortage of rainfall causes conflicts between pastoralists and farmers in the Malewa watershed.

In CAR, droughts have been analyzed by Bruel (1902), Sircoulon (1976) and Djibrine (1984a, 1984b). During the drought of 1983, severe low levels in rivers or their drying-up affected river transport and led to forest fires, as well as an extreme shortage of electrical energy (Djibrine, 1984a, 1984b). Faced with an acute shortage of water, women and children were forced to seek water from supply points 5–10 km farther away. However, few studies on the impacts of extreme climate events have been

undertaken in this country. Nguimalet and Boulvert (2006) studied the historical high water levels of the Oubangui River that caused flooding in Bangui, the capital. Studying rising flows allows us to understand the flood phenomenon in relation to its return at the disaster's origin within the city. Doing so helps us plan pathways which would help us prevent, forecast, and in turn reduce the extent of the flood's impacts on people and their property. Nguimalet (2010b) also analyzed previous risings and flood dynamics in the Tomi, Gribingui and Fafa River watersheds in relation to variations in climate to help predict their future occurrence and related management strategies.

Thus, droughts and floods are multi-scalar and seasonal, which is due to the length of time characterizing their alternating occurrence under climate change. In particular, the abnormal or uncommon dry-weather periods are taken into consideration, because of their sufficiently prolonged nature, which increases water scarcity, as evidenced by below-normal streamflow and lake levels, depletion of soil moisture, and/or the lowering of groundwater levels (Dakova, 2004). In our study, the negative impacts on communities due to such extreme weather conditions need to be seen in the context of the persistent aridification that started in the 1970s. The idea of the *threshold* determines the occurrence of these extreme events during periods of lower- or higher-than-average rainfall/flow over a prolonged period. People need to cope with or adapt to the occurrence of phenomena such as droughts and floods over space and time. The purpose of this paper is to study and characterize the perceptions of droughts and floods in the studied watersheds to analyze communities' adaptation strategies, and to propose pathways for effective adaptation.

Methods and data

The study context

The Malewa River watershed at Morendat (1,700 km²) is located between 0°8' and 0°35' south and between 36°17' and 36°43' east (Gathenya, 2007) in the Aberdare Range in the Rift Valley in Kenya and Eastern Africa (Figure 1). Its headwaters originate at an elevation of 3,700 m in the Nyandarua (Aberdare) Mountains and flow into Lake Naivasha. The watershed's rivers are relatively shallow but perennial. The highlands have dense forests and are volcanic; the Rift Valley floor is mainly covered with scrub and some bare soil. Rainfall peaks in April–June and October–November. There is intensive cultivation of food crops and cash crops. The river is threatened by deforestation and siltation, increasing diversion of water for irrigation, and pollution by fertilizers and pesticides. The population of the Malewa watershed was 515,017 in 2010 (Table 1), with a density of 303 inhabitants per km². The dense population exerts pressure on natural resources in the watershed. There is widespread poverty, and water conflicts are common. Improvements in resource management practices could abate pollution and erosion.

The watersheds studied in CAR are Tomi at Sibut (2,380 km²), Gribingui at Kaga-Bandoro (5,680 km²), and Fafa at Bouca (4,380 km²), in the Central-South and Central-North, between 5°30' and 7° north and between 18° and 19°50' east (Figure 1). The CAR watersheds adjoin river watersheds dividing Chadian (Fafa and Gribingui) and Congolese (Tomi) upper basins in the Sudano-Guinean climate variant. The upper basins are at

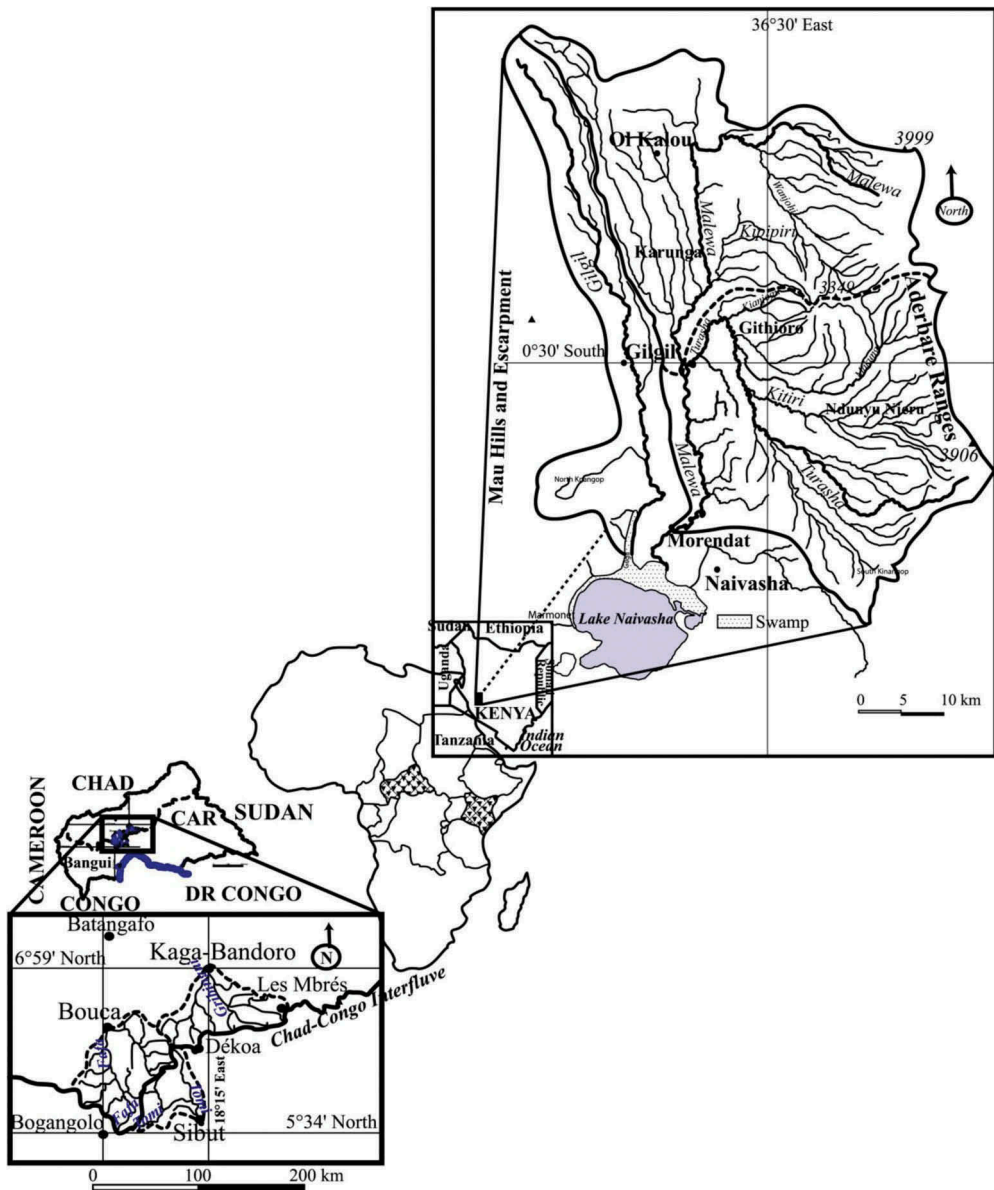


Figure 1. Study areas. Adapted from Nguimalet (2010c).

735 m (Kaga Yagoua) and 725 m (Kaga Mbrés) above mean sea level along the watershed line. Gribingui's source is at an elevation of 550 m, at Dékoa. Fafa and Tomi rise at 690 and 650 m, respectively (Boulvert, 1987). The rivers are generally perennial but sometimes run dry, depending on the severity of drought. Vegetation includes semi-deciduous and dense forests, savanna types, and gallery forest (Boulvert, 1986). The area is characterized by agricultural activities and extensive livestock. The total population in the three watersheds is 77,667 inhabitants spread over 12,440 km² (Table 1), with a density of 6.24 per km². To date, few pressures on natural resources have been observed.

Table 1. Physiographic and social context of the studied watersheds.

	Malewa watershed, Kenya	Central African Republic watersheds
Watersheds	1,700 km ²	12,440 km ² for the whole, divided into Tomi, 2,380 km ² ; Gribingui, 5,680 km ² ; and Fafa, 4,380 km ²
Rivers	Rivers shallow but perennial	Perennial rivers that run dry occasionally
Climates	Subtropical in the south (750–2000 mm) and semi-arid in the north (250–1000 mm), bimodal rainfall regime	Wet tropical climate Sudano-Guinean variant (1200–1400 mm on average), monomodal rainfall regime
Vegetation	Tussocky grassland with very few trees on Kinangop Plateau; many tussocky bogs in stream valleys	Semi-deciduous and dense forests; savanna types; gallery forest
Land use	Intensive cultivation of food crops and cash crops; poor land-use practices	Extensive cultivation of food crops and cash crops; settlement and activities in floodplains
Issues	Deforestation, siltation; excessive water abstraction for domestic and agricultural use; population pressure on natural resources; pollution; water scarcity	Deforestation; drying-up of rivers during severe droughts; pollution due to fertilizers; climate change
Population	515,017 in 2009	77,677 in 2009

Data collection and analytical methods

A historical approach combined with a review of the literature was used to study perceptions of the impacts of climatic change with a focus on droughts and floods, and communities' adaptation strategies. We used a combination of rainfall data from 1958 to 1996 and community surveys in both sites in Kenya and CAR.

In the Malewa watershed, annual rainfall data until 2003 were obtained from four gauging stations – Kari Naivasha, Gilgil Kwetu, North Kinangop Forest Station and Geta Forest – with the permission of the Water Resources Management Authorities. In CAR, rainfall data were obtained from six gauging stations – Bogangolo, Sibut, Dékoa, Bouca, Kaga-Bandoro and Les Mbrés (Figure 1). The data were provided by the Agence pour la Sécurité de la Navigation Aérienne en Afrique et Madagascar in Bangui, supplemented by the Institut de Recherche pour le Développement database. Given the lack of data since 1996 in CAR, we estimated annual rainfall in 1996–2003 using data from four synoptic stations surrounding these watersheds (Bangui, Bossembélé, Bossangoa and Bambari) that have similar geographical conditions. For surveys, we sampled no district in the Malewa watershed because it had no flooded districts; we sampled districts established in floodplains in the river outlets of Sibut, Kaga-Bandoro and Bouca in the CAR watersheds.

Rainfall indices allowed us to understand dry and wet years over time and obtain historical information on floods and droughts in the studied watersheds. Recorded rainfall amounts from some dry and wet periods were compared with people's perceptions of these extreme events to not only assess their experiences and management strategies to reduce the impacts of these extreme events but also to corroborate the occurrence of flood and drought events in the watersheds.

We also conducted surveys in two different sites in the Malewa watershed of Kenya (Nguimalet & Onyando, 2009) and in the CAR watersheds of Tomi at Sibut, Gribingui at Kaga-Bandoro and Fafa at Bouca (Nguimalet, 2010a, 2010b) to understand perceptions of droughts and floods and related community adaptation strategies. We obtained 227 responses for the survey and conducted 40 interviews with long-term residents of the Naivasha, Morendat, Gilgil and Olkalou areas in Kenya who had resided there for at

least 20 years and were aged 40 years or more (Figure 1). The survey instrument was pretested to rectify ambiguities and errors.

In CAR, we surveyed 330 respondents and conducted 70 interviews in Sibus, Kaga-Bandoro and Bouca, with 100 respondents per locality during the investigation phase and 10 each in pretesting. The survey aimed to identify the most recent extreme events that affected the communities, their impacts in both sites, and the respective adaptation mechanisms that the communities adopted. The survey questions recorded extreme events in the studied localities and the communities' perceptions of observed changes in the landscapes due to the most marked extreme events (floods, drought, and violent storms) and their corollaries (water shortages, very low water levels) in space and time. The community survey aimed to understand how similar extreme events affected human activities in both zones, especially their impacts on the availability of water and strategies for water management in these areas.

The survey data and information from interviews were extracted, coded and analyzed using SPSS 12.0 and Excel to understand how local residents experienced climate variability or change, particularly in relation to water availability or water management over space and time, and the adaptation strategies that they adopted to deal with changes in water availability. We studied the distribution of water-related extreme events over a period of 30 years, i.e. the average duration of residence of over two-thirds of the respondents in the study areas.

Results and discussion

Perceptions of floods and droughts: characteristics of damaging extreme events in these areas

The major extreme events in the Malewa watershed are droughts (Figure 2(a)), whereas both droughts and floods affect the studied CAR watersheds (Figure 2(b)). Water scarcity followed by low water levels has affected communities and their activities in the last few years, particularly since 1998 in the Malewa watershed, and since 1979 in the CAR ones. The shortening of the rainy season or the insertion of a dry spell into the rainy season and very low water levels explain this water scarcity phenomenon. Very low water levels are chronic in the Malewa River, which recorded a critical average discharge of less than 1 m³/s due to excessive water abstraction for multiples uses and the porosity of volcanic rocks.

In the CAR watersheds, droughts have been observed in rivers in the last few years in 1983–1984, 1987–1988 and 1990–1991. Since 2000, small rivers have also experienced severe droughts, particularly those in the headwaters (first- and second-order streams), as evidenced by their complete drying up or sporadic flows of once in two or three years. In 1990–2010, severe droughts occurred five times in Kenya: 1991–1992, 1995–1996, 1998–2000, 2004–2005 and 2009. People's recollection of droughts prior to these events is weak – they recall a few events that occurred in the 1950s and 1970s. However, the length of drought periods in recent times is suppressed by the amount of annual rainfall, which obscures its spatiotemporal distribution in the form of dry spells, and the shortening of rainfall periods.

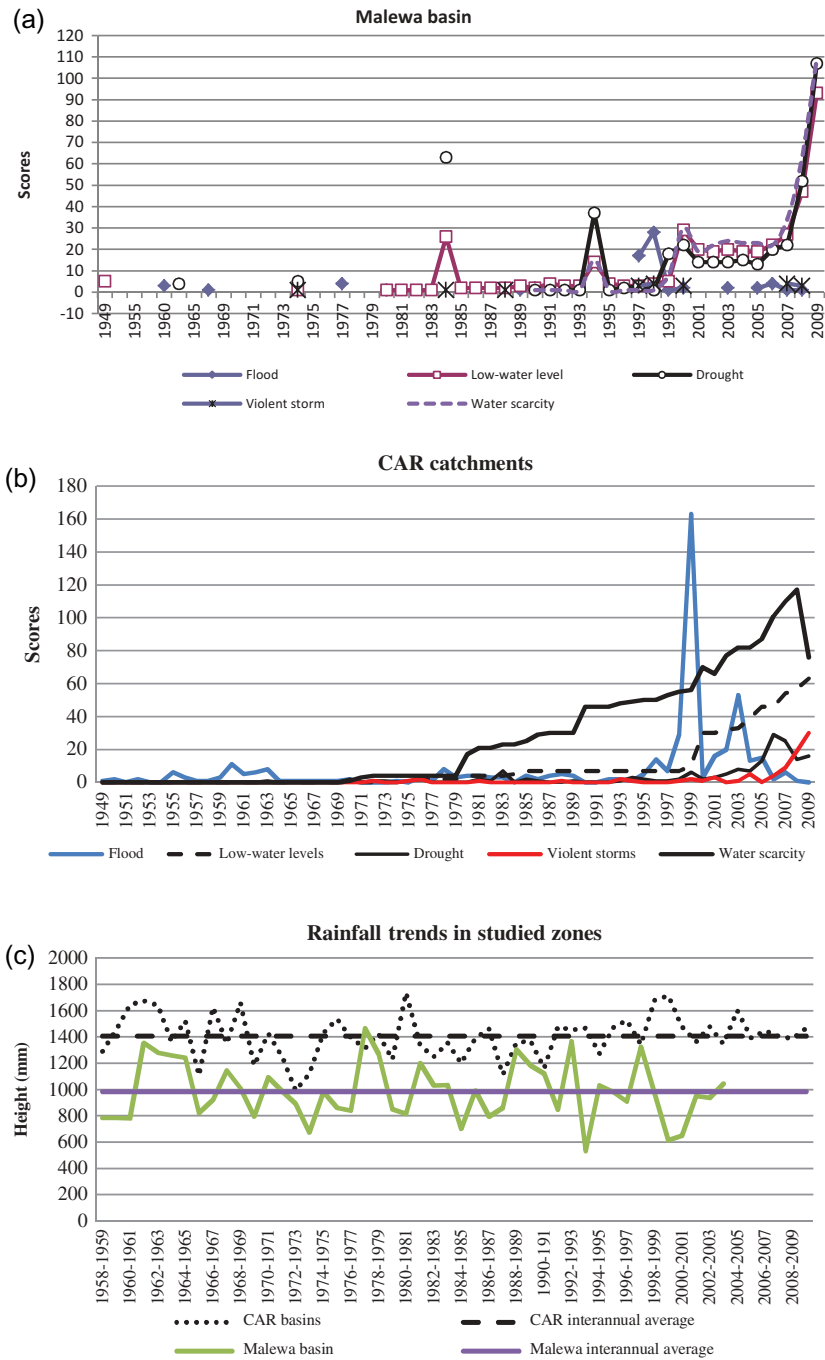


Figure 2. (a) State of the extreme events faced by local communities in the Malewa watershed. (b) State of the extreme events faced by local communities in the studied Central African Republic watersheds. (c) Comparison of rainfall trends in all watersheds.

Table 2. Average decadal rainfall (mm) in the studied zones.

	Malewa watershed	Central African Republic watersheds
1958–1967	1037	1467
1968–1977	959	1331
1978–1987	954	1349
1988–1997	1055	1389.4
1998–2007	861	1490

We note some trends in rainfall decline in the study areas in 1965–1966, 1969–1970, 1973–1974 (a year of severe drought across Africa), 1980–1981, 1984–1985, 1986–1987, and 1991–1992, which show a continental phenomenon dimension (Figure 2(c)). These trends show the evolution of inter-annual and annual rainfall as well as climatic differences in both zones: inter-annual rainfall averages 984 mm in the Malewa watershed and 1406 mm in the CAR watersheds. Also, calculations of average decadal rainfall evidence a return of rainfall in the CAR watersheds between 1978 and 2007, and over the 1988–1997 decade in the Malewa watershed (Table 2). This return in rainfall doesn't seem to reverse the persistence of ongoing drought and its likely effects on human activities. As far as floods are concerned in the CAR watersheds, they have occurred sporadically since 1970. Severe droughts were recorded in the Malewa River watershed in 1992, 1996, 1999 and 2004. Simultaneously, the CAR watersheds experienced floods during these years, with catastrophic floods in 1999 due to exceptional rainfall across the whole country (Figure 2(b)), as observed in 1955, 1960, 1961, 1962, 1964, 1969 and 1975 in the large CAR rivers. Beyond these large trends, we notice some watershed-specific trends on the rivers Tomi, Gribingui and Fafa due to local rainfall and geographical features.

Survey results also reveal that extreme events and their corollaries were more perceptible in the 2000–2009 decade in both zones (Figure 2(a,b)). According to the surveyed communities, water scarcity, which started between 1970 and 1978 in the CAR watersheds, increased after the 1980s. These perceived dates reveal that communities register some catastrophic events, but these perceptions need to be corroborated with written records of these events to confirm trends. People's perceptions that extreme events are increasing in recent years prompts us not only to assess ongoing dynamics of droughts and floods but also to conclude that human memory tends to record more recent events better. These perceptions help us fill gaps in measured data from recent years, and allow us to gain information on some historical losses. Droughts shape communities' water resources availability and accessibility in the studied watersheds. However, responses to droughts and floods vary in the different watersheds based on their social and economic environments.

Communities' adaptation strategies

Communities' adaptation responses to extreme climatic events and their corollaries (droughts, floods, low water levels and water scarcity) vary across the watersheds. Adaptation strategies against floods in the Malewa watershed include temporary displacement, construction of dams, and search for relief (Figure 3(a)). In the CAR watersheds, adaptive strategies are to move, to dig gutters to drain/absorb excess

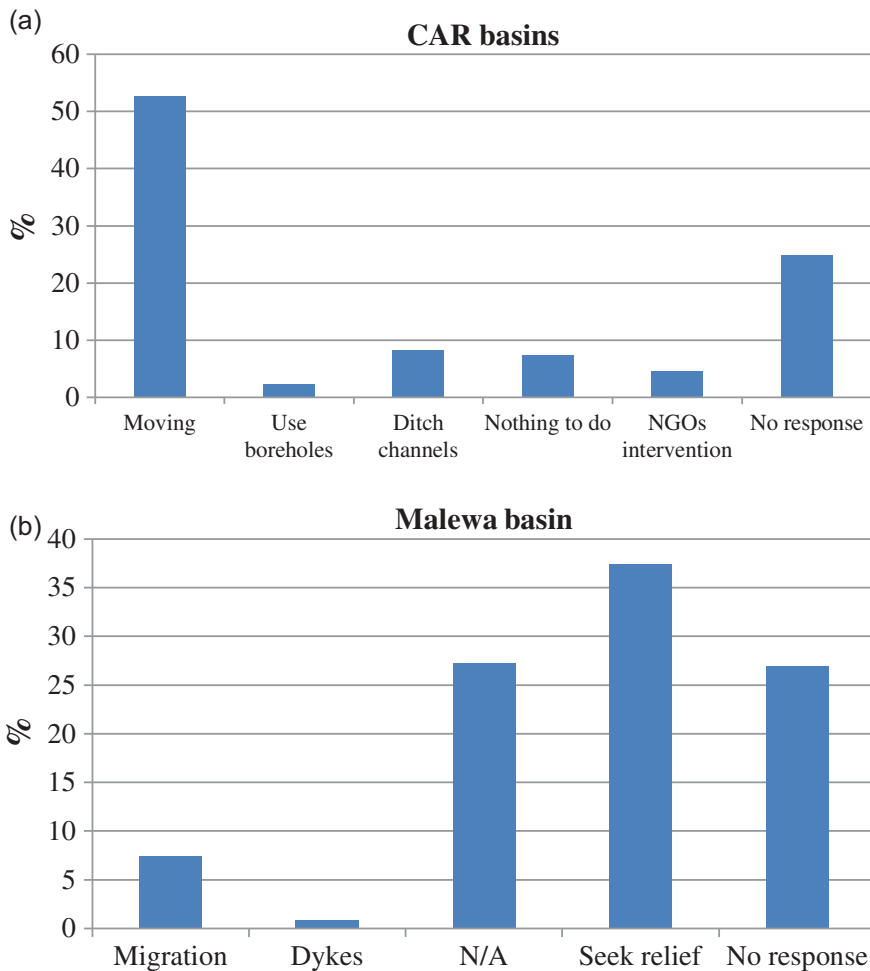


Figure 3. Communities' adaptation strategies for floods in (a) Central African Republic, (b) Kenya.

water, to use borewell water for drinking, and aid or relief from NGOs (Figure 3(b)). To adapt to droughts in CAR, communities change their activities, sink wells near the river, purchase water, use borewell water, or move elsewhere (Figure 4(a)). On the other hand, the communities' adaptation strategies to droughts in the Malewa watershed are construction of boreholes, purchase of food, search for relief, and water from traditional wells (Figure 4(b)). These adaptation strategies are functional, but communities have limited resources; they do not hold themselves responsible, because their issues are linked to climate-related risks.

We find the simultaneous adoption of similar adaptation strategies like migration, changing activity, and relief-seeking in both zones. For instance, migration or going elsewhere is a strategy against floods in both zones (Figure 3(a,b)). Migration has been a human response to climatic conditions, as evinced by progressive settlement in different parts of the world. In developing countries, people emigrate to seek welfare/jobs in developed countries. Thus, different types of insecurity, including the impacts of

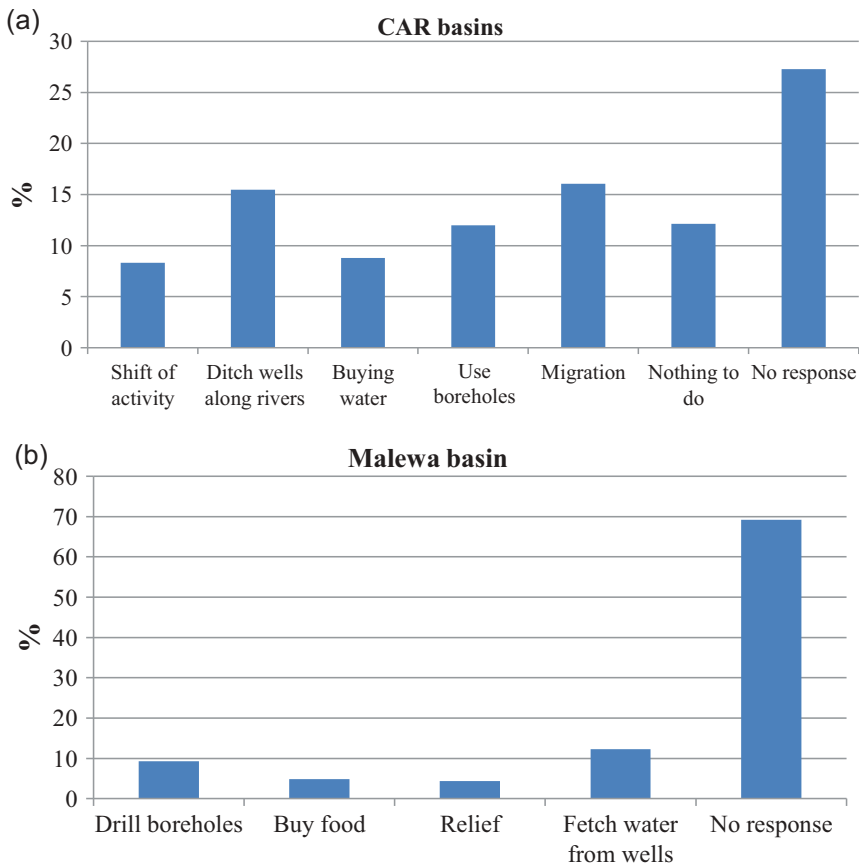


Figure 4. Communities' adaptation strategies for droughts in (a) Central African Republic, (b) Kenya.

climate change, cause communities to migrate. A case study by Maina-Ababa (2012) shows that the 1982–83 drought significantly reduced the cattle of Peulh communities in Bocaranga (north-west CAR). About 80% of the people lost all their cattle, and they migrated to the region around the dam on the Mbali River at Boali in central-south CAR. In this region, they developed some extra-pastoralist activities such as fishery (50% of Peulh), farming or other activities (30%), and trade (20%). In Kenya, too, prolonged droughts, receding lake levels, and drying of rivers and other wetlands led to the displacement of communities and the migration of pastoralists into and out of the country due to recent conflicts over natural resources (GoK, 2013). These findings reveal pathways for adaptation to the impacts of climate change, and people's experiences with moving and/or changing their activities.

Seeking relief is an adaptation strategy against both floods and droughts in the Malewa watershed, and against floods in CAR. In CAR, international NGOs, UN agencies and their representatives, and some Bangui-based foreign embassies often intervene with relief for disaster victims. Such assistance has prompted people to frequently rely on relief and assistance from NGOs after disasters occur because the government has neither the policy, the willingness, nor the financial means for disaster

Table 3. Socio-professional categories in the studied zones, according to surveys.

	Central African Republic watersheds (%)	Malewa watershed (%)
Farmer	75.5	36.6
Trader	7.3	14.1
Craftsman	3.3	4.4
Employee/salaried	8.5	29.1
Employer	0.3	4
Student	–	2.2
Unemployed	1.90	7.5
Other	3.20	2.2
Total	100	100

recovery. So far, its interventions in the area of disaster relief have been random. Kenya does not have a comprehensive disaster management framework or strategies that are guided by appropriate policy and legislative provisions. Strategies evolve in response to disaster events with much support from the international community (GoK, 2009). Communities also depend more on relief supplies. This could be because droughts are slow-onset events that give people more time to adjust than floods do. The speed of onset of extreme events determines the level of damage as well as the need for external help. Thus, communities depend on relief from governments with a high degree of external support as an adaptation measure.

Changing activity as an adaptation strategy varies across the two zones. According to the survey, the different socio-professional categories are farmer, employee/salaried, trader and craftsman (Table 3). As 75.5% of the surveyed people in the CAR watersheds are farmers compared to 36.6% in the Malewa watershed, we can assume that pressures on natural resources must be weaker in the Malewa watershed than in the CAR ones. Furthermore, global trends beyond farming, and the development of craft skills will create the opportunity to shift from one activity to another, if extreme climate events affect activities over the long term. In this way, a shift to activities or livelihoods which do not directly depend on natural resources that come under pressure from climate change is a possible adaptation strategy for communities.

Based on an examination of communities' adaptation strategies, we recommend that these strategies be augmented through a focus on training and/or capacity-building, and diversification of livelihoods. A preparedness programme that includes forecasting of extreme events, information on adaptation strategies, and building human resilience would help communities deal with the impacts of extreme climate events. According to Blankespoor et al. (2010), communities will adapt to climate change as best they can in developing countries, where part of the cost will be absorbed by households, and part by the public sector. But surveys reveal that communities have weak socio-economic adaptation capacity, as their average annual incomes range from USD 66 to USD 222 (Figures 5 and 6). Although Kenya is an economically developed country compared to CAR, surveyed communities' incomes in the Malewa watershed seem to be less than those in CAR. This paradox underscores the question of a minimum threshold for

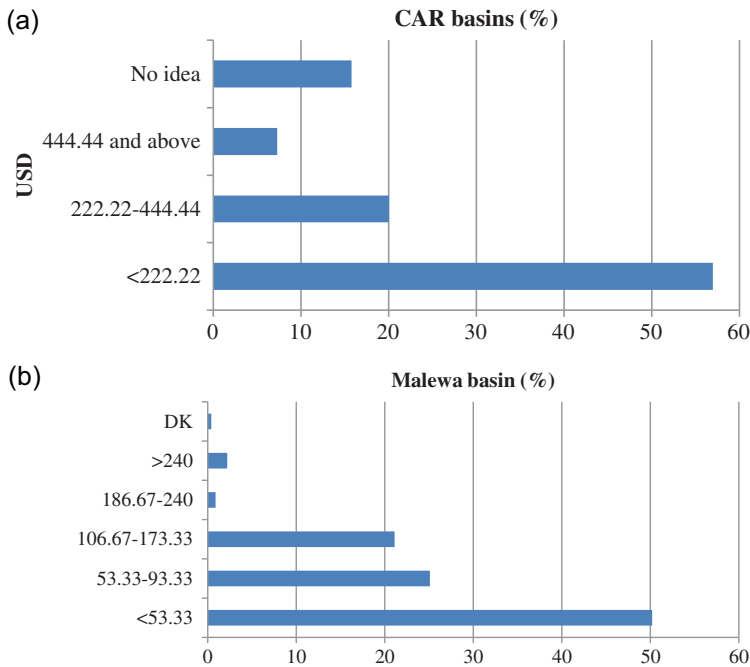


Figure 5. Expected monthly mean incomes in (a) Central African Republic watersheds, (b) Malewa watershed.

development in Africa whereby an individual can face droughts or floods without exterior support.

These different income levels in Africa translate to restricted livelihoods or household pauperization, which results in incapacity to adapt during natural disasters. This statement will help options for some strategic pathways which maybe would convene at these identified income levels in terms of struggle against extreme events. According to Parry et al. (2012), Kenya's weak economic performance is reflected in the fact that nearly half of its people (46.9%) lived below the national poverty line in 2006. The average annual income per capita increased from USD 650 in 2006 to USD 992 in 2012. In CAR, 62% lived in poverty and earned less than USD 530 in 2008. Today, this is around USD 200–300 due to the conflict in the country.

Over-adaptation mechanisms of communities in both areas

Adaptation may at first be the spontaneous response of people facing an event. This response may be enhanced over time depending on the duration of the event, and its persistence or magnitude in the area. According to modern disaster risk reduction measures to cope with hazards, some steps recommended for adapting to climate extreme events and building resilience include those for protecting (preparedness, mitigation, prediction and early warning) and for recovering (impact assessment, response, recovery and reconstruction). Communities' perceptions of adaptation pathways in this study appear ambitious in both sites. In the Malewa watershed

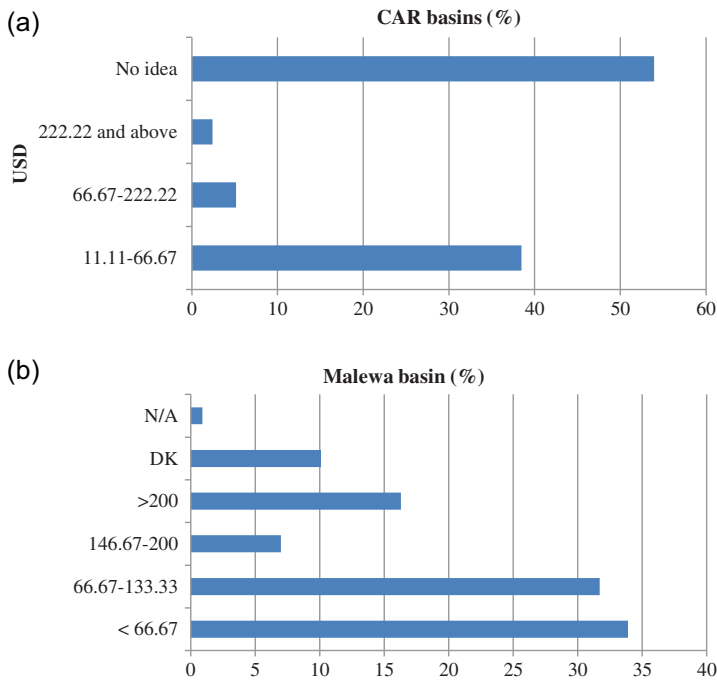


Figure 6. Estimation of mean annual incomes in (a) Central African Republic watersheds, (b) Malewa watershed.

(Figure 7(a)), communities have planned irrigation to reduce water shortages, afforestation, information campaigns on climate change and its impacts, environmental protection, and water purification.

In the CAR watersheds, most communities suggest increasing the number of boreholes for water, sensitizing and training on climate change, financial support for farmers, installation of traditional wells, protection of water and forests against bushfires, and the revision of agricultural calendars as pathways to improve communities' adaptation strategies (Figure 7(b)). The survey reveals gaps in the communities' perceptions of the fight against climate change impacts. This is because of the high rate of illiteracy in the surveyed communities, and their poor understanding of the drivers of African climate and their complex interactions (Conway, 2009). Their beliefs and habits run counter to new appraisals for the management of extreme events. For instance, Wanyonyi, Musuya, and Nguimalet (2012) conducted an experiment on rainwater harvesting for crop production in the semi-arid area of Marigat, Kenya, which is inhabited by semi-nomadic pastoralists of the Njemps Tugen, Turkana and Pokot ethnic groups. Their experiment proposed the establishment of water and soil conservation structures to fight aridification and improve communities' livelihoods. Although the results were technically promising, they were not adopted by the communities, as the strategies were alien to their own experiences or culture.

The adaptation strategies proposed by communities do not consider the 'anticipation, survey, and forecasting' dimensions as well as preventive measures, such as long

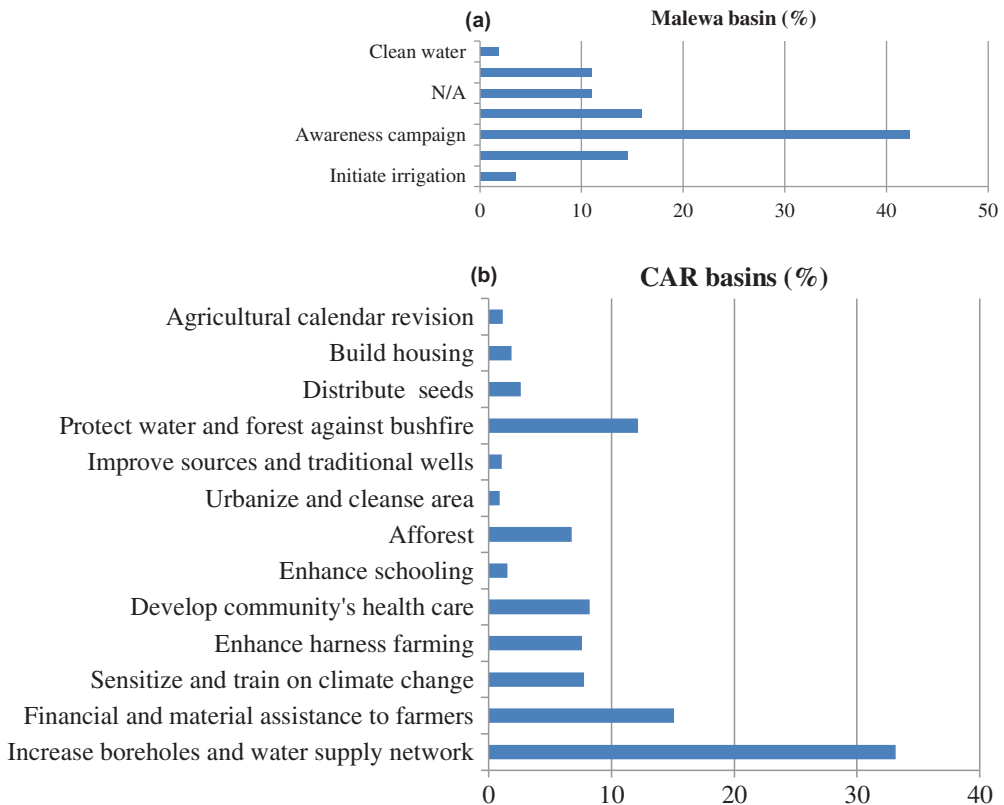


Figure 7. Surveys' expected outputs in (a) Malewa basin, (b) Central African Republic basins.

time scale in the case of earthquakes and tsunamis (Conway, 2009). Surveyed communities' strategies refer more to restoration and recovery after the phenomena occur. Communities can produce smaller-scale surveys to help them plan for swift response to local floods and other hazards. Anticipation also includes producing long-range weather forecasts, which are then used to put adaptive measures in place. For Conway (2009), it is the poorest countries, and especially the poorest people in them, who are the most vulnerable to climate change. African countries are particularly exposed to risk for a variety of reasons. We found two major constraints that prevent effective adaptation to droughts and floods in the studied watersheds (Figures 8 and 9). First, the weaknesses of local community-based organizations or associations in efficiently assisting or rescuing drought and/or flood victims are justified by the chronic lack of material, financial and logistical means (Figure 8(a,b)). Thus, the lack of willingness by responsible organizations or their managers to test or try out improved strategies for adaptation is an obstacle for local efforts to combat these climate-related extreme events.

Second, random approaches to policies for adapting to extreme events in the watersheds characterizes a framework with a lack of functional management plans, financial means to support drought and flood victims, or the expertise to do so (Figure 9(a,b)). Research findings reveal that supply of relief is the government's main adaptation

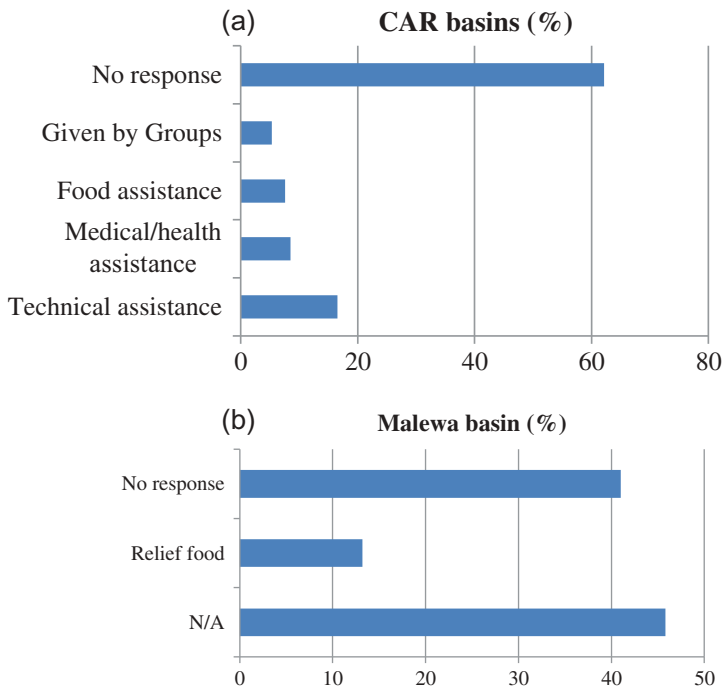


Figure 8. Specific activities of local organizations or associations while supporting extreme event victims in (a) Central African Republic watersheds, (b) Malewa watershed.

strategy. This governmental attitude is shaped by the absence of a deep commitment to managing risks and disasters sustainably, and a lack of initiative on behalf of the agencies who are responsible for predicting the occurrence of disasters. Although the frequency of extreme events has increased in the last decade, it hasn't raised awareness among those who govern the national framework for disaster prevention or make plans for disaster management. This is probably due to the unexpected occurrence of these catastrophic events. For example, CAR farmers lost nearly three-quarters of their peanut crop in 2009 at the peak of this phenomenon. Both Kenyan pastoralists and farmers respectively lost about 40% of their livestock, and maize or other harvest. The state did not provide assistance to these disaster victims. Adaptation responses by the government should depend on the scope and magnitude of the disaster events in both zones. For example, in the Malewa watershed, conservation and food stores could form a part of long-term adaptation and preparedness strategies, in contrast to CAR, which mostly relies on response.

Adaptation is both an individual and an institutional activity. However, in both sites, the institutional side of adaptation is poor, and government interventions are scarce, depending on the severity of the disasters. The strategic efficiency can be described by the improving degrees that will help in facing more severe, catastrophic phenomena, the sustainable strategies, and their trans-boundary aspects/roles. An improvement in institutional responses, particularly national or transnational preparedness, will be

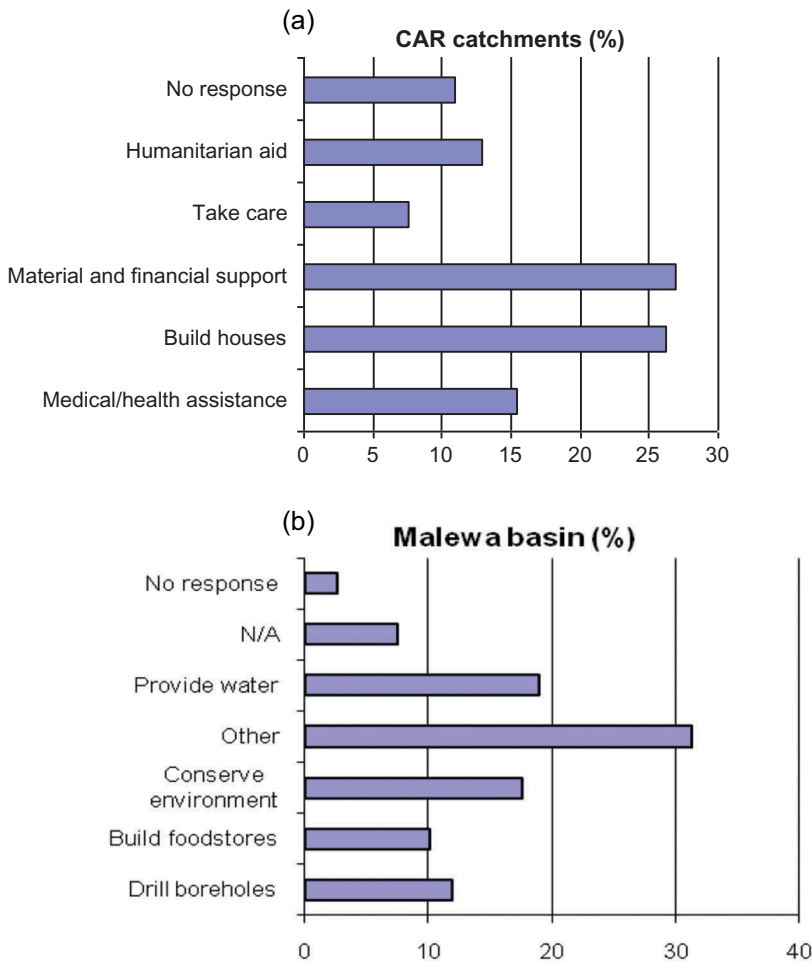


Figure 9. Opinions on the government's intervention efforts in (a) the Central African Republic, (b) Kenya.

necessary to strengthen communities' adaptation responses to the extreme events in their watersheds.

Importance of disaster planning and management

Climate change influences the rate of occurrence and the intensity of disasters and exacerbates their impacts. Investments in disaster risk reduction can play an important role in supporting communities' adaptation to the impacts of climate change. Environmental disasters are unanticipated but can be tackled with careful planning and execution of contingency measures (Al-Amin, 2013). Droughts and floods also demand research on the relief measures available to communities as well as their skills to mitigate the impacts of these extreme events. Adaptation strategies should include local strategies elaborated by communities as well as national policy

frameworks. Policy dimensions should strengthen local initiatives through a legal framework. An effective water management system depends to a large extent on a well-functioning institutional framework (Stakhiv, 1998). The possible consequences of climate change over the recent past and the next 50 years underscore the importance of preparedness, which includes mitigation, adaptation and development policies. Preparedness conceptually requires decentralized decision making and effective engagement of local governance (Habib-Mintz, 2008). Development policies refer to policies and mandates to enact mitigation or adaptation such as changing building codes, traffic regulations, etc. According to Taylor (2005), the great success of Cuba's programme of disaster preparedness is based on the development of a culture of safety: instruction in disaster preparedness that begins in grade school; civil defence training for all adults; and an elaborate system of neighbourhood organizations that are trained to mobilize people and pass on information at the street level. Kenya and CAR should apply a similar approach to fight the impacts of droughts and floods on communities.

According to Goulden, Conway, and Persechino (2009), impacts and responses to extreme events can be transboundary. They show how far local strategies are appropriate and whether there are opportunities to use another strategy in similar conditions. In general, the magnitude of the disaster's impact on communities dictates interventions from humanitarian NGOs, governments, or others. According to Conway (2005, p. 2), 'Adaptive actions can be implemented across all levels of society at local, national, and international scales; but in all cases, actions related to climate variability or change occur within a decision-making framework that encompasses wider socio-economic and political considerations.' Also, according to Kabat, Schulze, Hellmuth, and Veraart (2002) (as quoted in Goulden et al., 2009), examples of adaptations to climate change in the water sector in developing countries are less documented, perhaps because developing countries have many other pressing issues to tackle and few resources to invest in researching water issues or solutions for improved water management. To be effective, adaptation should fit with the existing management systems and objectives. Goulden et al. (2009) have shown that climate change impacts and other stresses on water resources and changes to flooding risks in future will require adaptation on the behalf of water resource management institutions and water users. This implies that policy makers in both study sites should support local strategies for adaptation. In addition, improvements in climate projections and long-term weather forecasts offer potential for reducing economic losses (or increasing economic gains) associated with climate change. More specifically, improvements in the ability to use such forecasts to inform management strategies would enhance water users' confidence in regional forecasts, and their ability to efficiently prepare for and adapt to water resource management challenges in future (Adams & Peck, 2008).

Conclusions

This study has shown communities' exposure and vulnerability to droughts and floods. The surveyed communities are not well prepared to face the devastating effects of droughts and floods due to a chronic lack of material means in both sites. Downing, Ringius, Hume, and Waughray (1997) suggested that 'most strategies to adapt to

climate change in Africa are likely to reduce vulnerability and to enhance the broad spectrum of capacity in responding to environmental, resource and economic perturbations’.

Taken together, the main adaptation strategies for droughts and floods across the study areas have some similarities and differences. They include migration or moving elsewhere to avoid droughts and floods in both zones, and also against droughts in the Malewa watershed only. However, this strategy is not unique to climate extremes but has been used by people in the region for a long time. In CAR, people migrate seasonally to extract diamond or gold from riverbeds and floodplains in the dry season; temporary villages and campsites are created that disappear after the discovery of diamond deposits. Migration increases with the exacerbation of climate change effects in Kenya, where 85% of the land is semi-arid or arid. It also causes communities to change activity due to the socioeconomic perturbations created by climate change impacts, such as loss of livelihood or possible displacement. Beyond these local strategies, measures should include building the capacity of communities, and support to diversify livelihoods and develop coping mechanisms.

We emphasize preparedness, implying not only forecasting data, information on climate extremes, and building human resilience as an adaptation to climate change, but also decentralized decision making and effective engagement of local governance systems. But we also emphasize the need for national policy frameworks in each country. Kenya has a draft national policy for disaster management, which outlines its preparedness process. However, there is no policy in CAR. Hence, we recommend the installation of a water management policy framework that integrates drought and flood (i.e. water scarcity or water excess) management based on the experiences of communities. While relocating communities who are flooding victims or live in floodplains is a viable strategy, it is important to ask whether they will be relocated to a place with sufficient access to water and other activities that are linked to water availability. Adaptation to droughts and floods is not possible when hydraulic options such as dam-building are overseen. Are existing and proposed facilities enough to reduce the effects of recurring droughts and floods? What are the levels of preparedness to face climate change impacts in the watersheds? These are some issues that policy makers have to deal with for communities’ adaptation to the impacts of floods and droughts.

There may be socio-political barriers to adaptation, such as stakeholders’ attitudes towards proposed options, and the limited capacity of water management institutions to promote adaptive measures (Arnell & Charlton, 2009). These limitations can be overcome. For example, Penning-Rowsell, Johnson, and Tunstall (2006) found that flooding events can create windows of opportunity for policy change. Similarly, Arnell and Delaney (2006) found that extreme events triggered better awareness of climate change, which provided incentives for building adaptive capacity for public water supply in the UK. Unfortunately, global institutional adaptive capacity has been relatively weak in helping populations adapt to the impacts of extreme events in the studied watersheds. Our analysis of communities’ adaptation strategies also shows some gaps in government investment in adaptation due to which communities depend on the supply of relief. There is a lack of commitment from governments in the form of a national policy for disaster prevention and preparedness, as shown by their ad hoc interventions at the time of disasters. This is especially true in many African countries. Faced with

such ad hoc approaches to disaster risk management, communities tend to depend on relief supply from external agencies through government claims. Thus, governments need to change their strategies and invest in risk management, particularly in preparedness. Such a shift could enhance communities' adaptive capacity in affected watersheds such as those surveyed here.

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