

# CHAPTER SEVEN

## 7.0 Conclusions

There is a need to understand more about climate variability and consequences for the environment and society. Recently, renewed attention is being given to identifying processes and factors that shape and generate vulnerability to climate variability (e.g. extreme events such as floods, droughts and also relatively ‘normal events’). Coupled to these efforts is the aim of enhancing resilience in the face of such events and also improving adaptive capacity of the system (both socio-economic and biophysical components of the system). This research report examines the vulnerability and adaptive capacity of the people living in Shiroro Local Government Area in Niger State, Nigeria, to flood events occurring along the Kaduna River. The impacts of flood events and factors that enhance the vulnerability to flood events in the region are identified. The scope of this research initiative is summarized in the following sections:

- Causes of flooding in Shiroro LGA
- Factors increasing vulnerability to flooding
- The vulnerable groups within the communities
- Adaptive capacity and household coping strategies among the villagers.
- Impact of Shiroro dam on the communities.

## 7.1 Causes of flooding along River Kaduna

Flooding is the most frequent and widespread form of ‘natural’ disaster, affecting more human than other physical hazard in Shiroro LGA. Flood appears to be on increase in the last decade, both at the study area and globally (Fig. 2.1 and 4.7). Atmospheric phenomenon (e.g. heavy rainfall) appears to be the primary cause of flooding of the Kaduna River. Although, heavy rainfall is the main factor that causes flooding of the Kaduna River, damming of the river, for hydroelectric power generation is also an important factor. Moreover, the likelihood of these factors leading to a flood is affected by many different characteristics of the drainage basin, such as topography, drainage density, vegetation cover, and human influence often plays a role, especially by

modifying land use. But the aspect of these characteristics of the Kaduna River drainage basin is beyond the scope of this research. Therefore, only two main causes of flooding are identified along the River Kaduna, at Shiroro LGA. These include:

- Rainfall and the
- Opening of Shiroro dam gate to release water

Although, figure 4.3 shows an irregular rainfall pattern over the Kaduna River catchment areas, the graph shows a slight increase in rainfall amount. The average annual rainfall amount from 1981-1989 is 1028 mm while from 1990 –2003 is 1217 mm, therefore, there is 189 mm rainfall difference between the two decades, which is significant. About 60% of the annual rainfall total accumulates in the three heaviest rainy months of July, August and September (Fig. 4.2). The flood-peak inflow immediately following accumulated peak rainfall period may be attributed to the time lag factor between rainfall and peak flow. A slight increase in rainfall therefore, increases the amount of river runoff and discharge of flood into the Shiroro reservoir. Natural flooding by rivers, the most common type of flooding, is caused primarily by heavy rain or rapid melting of snow, which causes water in the river channel to over flow and to cover the adjacent area (Miller, 1994 and Middleton, 2003). Interestingly enough, the 1990s with abundant rainfall harvest coincide with the period of abundant flood flow in the Kaduna River System and very significant runoff into Shiroro reservoir.

This research report shows that flooding of the Shiroro communities along the Kaduna River occurs primarily in the rainy season when heavy rain increases the magnitude of discharge of flood into the Shiroro reservoir, except in 1988 when heavy rain caused the Kaduna River to overflow its bank. The 1988, 1999 and 2003 flood data (Tables 4.7, 4.8 and 4.9) show that during the month of September in those three years during the rainy season, heavy rainfall over Niger State caused extensive flooding of the Kaduna River. The floods were primarily as a result of heavy rainfall that increased the peak discharge of flood into the Shiroro reservoir. Consequently, the dam management opened the dam gate to release the excess flood in the reservoir. The release of the excess water from the dam reservoir downstream forced thousands from their homes along the floodplain of the

Kaduna River. Some countries have enough annual precipitation but get most of it at one time of the year. In India, for example, 90% of the annual precipitation falls between June and September, during the monsoon season, causing floods (Miller, 1994 and Byrne, 1997). Heavy rainfall anywhere can cause rivers and lakes to overflow and flood the surrounding land (Miller, 1994 and Byrne, 1997). Rainfall therefore, is an important factor that contributes to flooding of the Kaduna River at Shiroro communities on the floodplain.

Secondly, opening the gates of the Shiroro hydroelectric dam to release water has contributed significantly to the flooding of the communities along the Kaduna River, inundating their farmlands. The 1994, 1998, 1999, 2003 flood events were attributed to opening of the dam gates to release the excess water in the reservoir as a result of heavy rainfall. The flood event of the year 1988 occurred before the Shiroro dam started its operation in 1990, which was caused by torrential rainfall. The Shiroro dam, therefore, makes the floodwater accumulate so much that when water is released, the magnitude of the flood flow into the surrounding communities on the floodplain very high, causing greater damages.

## **7.2 Factors that act to influence vulnerability and adaptive capacity to flooding along Kaduna River**

This research identified some of the factors increasing vulnerability of Shiroro communities to flooding along the Kaduna River in Niger State of Nigeria. The factors include:

- Poverty
- Lack of technology and infrastructure
- Lack of information and skills
- Household dependent on only agriculture

Poverty is one of the most important factors increasing vulnerability of the villagers along the River Kaduna floodplain. This is because the inhabitant's standard of living in the study area is very low. This research revealed that the inhabitants on the floodplain cannot afford good shelters (Fig. 5.3). Adger *et al.*, 2004, states that poverty is also likely

to be associated with poor quality housing that is easily damaged by flood or storms. Moreover, Shiroro communities on the floodplain only depend on agriculture with a very low income that is not enough to invest in the farm inputs necessary for diversification. These communities also lack the means to transport their produce to market as a result of poverty. The inhabitants, therefore, carry their agricultural products on their heads to sell at the market that is located 20 km away from their homes (Plate 5.6). These villages along the Kaduna River floodplain in Niger State, however, lack the financial resources for adaptation. The adaptive capacities of the villagers along the Kaduna River are very low, since the means to acquire good structures (such as good housing, hospital facilities, good road networks etc) to cope with the increasing flood events are not available. Watson *et al.*, 1998, state that the vulnerability of a region depends to a great extent on its wealth, and that poverty severely limits adaptive capacities. Poverty, therefore, acts to influence vulnerability and the capacity of people of Shiroro communities to adapt to flood events.

Shiroro Local Government Area, lack the technology and infrastructure, for example, flood control measures, warning systems, and protective structures to cope with the current flood hazards occurring along the Kaduna River. Lack of technology has the potential to seriously impede a nation's ability to implement adaptation options by limiting the range of possible responses (Scheraga and Grambsch, 1998). Also, adaptive capacity is likely to vary, depending on availability and access to technology at various levels (i.e., from local to national) and in all sectors (Burton, 1996). Therefore, a community's current level of technology and its ability to develop technologies are important determinants of adaptive capacity (IPCC, 2001). The 'technological' adaptive capacity of villages along the River Kaduna floodplain is very low. This is because the local technology applied by the communities living on the floodplain to cope with the flood is not good enough to reduce the flood impacts on their livelihood. The adaptive capacity of Shiroro villages on the floodplain to flood events is low, therefore, increasing their vulnerability to flood hazards.

The interviews conducted among the households in Shiroro communities show that the communities on the floodplain lack both information technology and skills necessary to

adapt to flood hazards. Although none of the household members living on the floodplain has a formal education, the local knowledge that exists among the communities is what gives the communities the adaptive capacity to remain on the floodplain. The coping capacity is weak because of lack of access to information technology and skilled personnel, thereby reducing their ability to implement a strong and reliable adaptation options. Shiroro communities, however, lack access information to these weather hazards, which make them more prone to flood disasters. Lack of skilled personnel can limit a nation's ability to implement adaptation options (Scheraga and Grambsch, 1998). Successful adaptation also requires recognition of the necessity to adapt, knowledge about available options, the capacity to assess them, and the ability to implement the most suitable ones (Frankhauser and Tol, 1997). In general, countries with higher levels of stores of human knowledge are considered to have greater adaptive capacity than developing nations and those in transition (Smith and Lenhart, 1996). It is important, to ensure that systems are in place for the dissemination of climate change and adaptive information nationally, regionally and down to community level. Lack of access to information technology and skilled personnel, are therefore, are strong determinants of low adaptive capacity among the villages along the Kaduna River.

Lastly, the only source of livelihood in Shiroro communities living along the Kaduna River is subsistence agriculture. This research shows that the 1999 and 2003 flood events along the Kaduna River in Shiroro communities were the worst floods that have occurred. The floods impacted negatively on the agricultural outputs of these communities and also converted most of the farmlands to river course (Plate 5.8, 5.10 and 5.11). Interviews conducted with some farmers show that, there is a severe contraction in farm output since the 1980s. Large contraction in GDP is only one indicator of impacts associated with extreme events. Moreover, the pervasive consequences of climate stress include losses in farm labour opportunities and general loss of livelihoods (Vogel, 2005). This contraction in farm outputs has led to household food insecurity among the villages on the floodplain. Agriculture in Shiroro communities on the floodplain is currently constrained by biophysical and socio-economic problems including flooding, poor infrastructure, lack of access to market, and information. As a result of these constraints, farmers hardly

produce enough food for family use for the past two decades. Failures in harvest therefore, will certainly undermine household food security, hence increasing their vulnerability to malnutrition and reduces their coping capacity to other health problems.

The most direct implications of climate changes and variability, including periods of climate stress e.g. floods, for food security are through its impacts on food production (Devereux and Edwards, 2004). Changes in rainfall intensity and extreme weather events that increase the scale of flooding and soil erosion can therefore, seriously damage agricultural capacity (Lewsey *et al.*, 2004). It is argued that, that the households and countries that stand to lose food production due to climate change and variability are also those that depend most on agriculture and have fewest alternative sources of income (Devereux and Edwards, 2004). This is because the most food secure individuals buy the food they eat instead of growing it (Devereux and Edwards, 2004). Dependent on agriculture by the Shiroro communities on the floodplain therefore, is an important factor increasing their vulnerability to climate variability and extreme (flood) and also reducing the community's adaptive capacity to other climate stress.

### **7.3 The vulnerable group(s) within the communities**

There are three vulnerable groups identified within the communities along the Kaduna River floodplain. These include the poor. The vulnerable population in Shiroro communities are identified among the poor. This, group is classified as the poor because their income per household is very low (below 45 USD per household). The group identified as the poor in the communities lack access to good water, health facilities, schools, information systems, and lack good housing structures and road networks. Several studies such as Mbithi and Wister, (1973); Kamau *et al.*, (1989); Reardon and Matlon (1989); Cutter (1996); FIVIMS (2000); FEWSNET (2000) have identified the poor as the population groups most likely to experience the adverse effects of extreme events such as flood, drought and other natural hazards or stresses induced by conflict or other social, economic or political forces.

Secondly, those populations residing on the floodplain are identified as being vulnerable. This population living on the floodplain is exposed to annual flooding because they are residing on a lowland area of river basin that is prone to flooding. This group is also highly marginalized. This is because the Shiroro village is housing one of the largest, Hydro-Electric Power Dam in Nigeria, but has no electricity, good road, good drinking water and school. Whenever, water is released from the dam (opening of dam gate), those residing on the floodplain are usually affected by the floodwaters. Although, the dam management claim to be informing the communities living on the floodplain on the days and time water are released, these communities do not have access to information system. Adger *et al.*, (2004) and Brooks *et al.*, (2004) state that high levels of inequality are likely to result in the formation of highly vulnerable groups that are financially and socially marginalized. This group on the floodplain is highly vulnerable to flood hazards occurring along the Kaduna River, and has a very low adaptive capacity because they lack access to facilities necessary to adapt to flood events.

Lastly, the vulnerable groups are those that depend only on agriculture. The chronology of the agricultural output of the communities along the Kaduna River at Shiroro LGA, as discussed in chapter five, shows a declining harvest since 1990s. This group in Shiroro LGA has agriculture as their only means of livelihood. The flooding of the Kaduna River has become destructive to lives and property especially in the year 1988, 1999 and 2003, inundating farmland and structures, for example, buildings. The persistent flood events have undoubtedly caused a lot of damages to agricultural outputs, by inundating of the farmland along the River Kaduna floodplain. The impact of the flood events on the population that are dependent on agriculture is highly pronounced, because they only have agriculture as their main source of income. Vogel (2005) and Devereux and Edwards (2004), state that the impact of climate stress is more pervasive on general well being, particularly on those dependent on agriculture with fewest alternative source of income. This research therefore, identifies the population in Shiroro communities that depend mainly on agriculture, as one of the vulnerable groups.

These three groups identified as vulnerable to flood events, have some certain characteristics in common, for instance they lack accesses to social amenities like electricity, good water, roads, health facilities and schools. These vulnerable groups also lack good shelters and are found mainly in Group C. Other households that are not classified as vulnerable to flood events have access to, good shelters, electricity, good water, roads, health facilities and schools. The group identified as not vulnerable to flood events are located outside the floodplain and are mainly found in groups A and B. This group outside the floodplain, engages in other economic activities like trading, transportation and civil service, and earn a steady income. During the time of extreme events that affect agriculture, these groups (groups A and B) do not really feel much impacts on their livelihoods. Therefore those households, which had a steady source of income, either through formal and informal means, are less vulnerable than those households whose sources of entitlement fails during times of economic shock.

#### **7.4 Household coping strategies among the communities**

Households at Shiroro LGA employed various coping strategies to survive the flooding occurring along the River Kaduna. These strategies include:

- Building of the storage facilities by each household to enable them store farm produce for a longer period since they do not have access to market or financial institution.
- Using stones to raise each storage tank high above the ground to avoid floodwater destroying them since each silo is made from clay soil.
- Every household, sand fills their compound regularly to raise the ground level higher than the riverbank. The females in the villages carry out this activity.
- The pattern of fixing doors on every house also is an adaptive measure to prevent floodwater entering into the houses. Doors are raised above 50 to 60 centimetres from the ground.



- Each household contributes some seeds or foodstuff to help any member or members of the community who have problems of low or insufficient harvest during harvesting period, or who has been affected by flooding or locusts attack.

These adaptive strategies adopted by the Shiroro communities appear to be successful to some extent since the inhabitants are able to remain in such environment, but have some limitations. Adaptation reduces vulnerability to an extent that depends greatly on adaptive capacity of a region or socio-economic group (IPCC, 2001). This research, however, shows that the adaptive capacity of the Shiroro communities in Niger State of Nigeria is being severely compromised by factors such as poverty, poor infrastructure, weakening social networks, environmental degradation etc. Many factors (e.g. wealth, technology, information, skills, infrastructure, institutions, equity, empowerment, and ability to spread risk) will determine a system's capacity to adapt to a variety of existing or anticipated hazards (IPCC, 2001). Moreover, the adaptive capacity of communities is determined by their socio-economic characteristics (Adger *et al.*, 2004). Enhancement of adaptive capacity, therefore, represents a practical means of coping with changes and uncertainties in climate, including variability and extremes (Brooks, 2003). The adaptive capacity of the Shiroro communities to flood events on the floodplain is therefore, very low because of poverty and lack of access to social amenities.

### **7.5 Impacts of flood and Shiroro dam on the communities**

This study has highlighted the environmental as well as human impacts of the Shiroro hydroelectric power dam on the communities in Shiroro Local Government Area. The environmental impact is in the form of Macro and Microclimate change and hydrological response of the River Kaduna. This research report shows that opening of the dam gate to release excess floodwater from the dam reservoir has caused inundation of large agricultural farmland. A lot of residential and public structures were destroyed, killing humans and their domesticated animals. For, example, in the year 1988 about 30,000 hectares of farmland were flooded, in the year 1999, over nine hundred hectares of farmland were flooded and in the year 2003, 177,600 hectares of farmland were flooded

and property worth of 2, 570,000 destroyed. Some secondary roads and footpaths have been submerged as a result of the flooding making transportation very difficult. There were reported cases of outbreak of diseases such as malaria, typhoid, diarrhoea and gastroenteritis in Shiroro communities on the floodplain. These communities on the floodplain are always cut-off from their neighbours between August to September as a result of the Kaduna River over flooding its bank arising from the backwash of water from the reservoir. Similar cases have occurred both in United States of America (USA) and Bangladesh. In USA, the 1993 flood event along the Mississippi River washed over an area of about four million hectares, destroying more than 40 000 buildings (Williams, 1994 and Swiss Re, 1994). The cost of the total damage is estimated to amount to US\$12 billion, with a total of 45 people killed (Williams, 1994 and Swiss Re, 1994). In Bangladesh, the year 1987 and 1988 flood events occurred, inundating 40% and 57% of the county respectively (Rashid and Pramanik, 1990). The flooding of the Kaduna River, therefore, has become destructive to lives and property. This research report therefore, shows that Shiroro communities, especially those living on the River Kaduna floodplain are highly vulnerable to the flood events. Moreover, the adaptive capacity of these communities on the floodplain is being severely compromised by factors such as poverty, poor infrastructure, weakening social networks, lack of information technology and skilled personnel, and environmental degradation.

## **7.6 Recommendations**

The River Kaduna flow has contributed positively to both Shiroro communities and the country in general. The Kaduna River serves as source of water for irrigation to the communities on the floodplain and also serves as source of water for hydroelectric power generation. Considering these benefits derived from the Kaduna River, there is need to maximise the use of water for irrigation and for hydropower generation into National Grid for overall economic development of Nigeria, and for the sustainable development of communities along the river basin. The following recommendations are therefore, put forward for consideration and possible implementation by the Federal Department of Water Resources that coordinates all water related activities in Nigeria, the National

Electric Power Authority (NEPA) that owns, manages and operates Shiroro dam, and the government that formulates and implement water resources policies.

The flood management plan on Hydropower Producing Areas Development Commission (HYPPADEC) currently being worked on should be legislated to ensure efficient implementation at a time of flood. Short and long term procedures should be designed to deal with flood effectively. This will help to reduce the vulnerability and impact of flood disaster on the communities living on the floodplain to flood events. In the plan, it is important to have clear communication between the government, NEPA and communities. The community leaders should be actively involved in the whole plan, especially concerning relocation and distribution of relief packages. There is need to improve the infrastructure, such as roads, water supply, electricity, health centres and schools. Good access road and electricity will surely help in opening up and diversifying economic activities in these communities instead of depending on agriculture alone. Also, provision of schools and communication facilities will reduce illiteracy level and increase environmental awareness among the communities. These will help improve the welfare of the communities and reduce their vulnerability to flood events.

A well-designed flood management plan will contribute largely in curbing adverse flood effects. It is also important to revisit some cultural norms and assess how a better understanding of these can be used to positively reduce vulnerability to extreme climate conditions. Socio-economic factors must also be addressed to boost the adaptive capacity of the communities. Risk reduction through mitigation is also very important. Physical factors enhancing vulnerability must be addressed to further prepare the community for extreme conditions. Coping strategies at household level must also be acknowledged and well understood. This is because adaptation strategies will have to be built upon successful present coping strategies. Understanding the findings from this research report therefore, should enable appropriate adaptation strategies for these communities.

There is need to invest in data gathering programmes, to improve the understanding of hydrological changes resulting from global climate change and climate variability. Moreover, the sensitivities of water availability and need to manage water from river flows is increasing, for example, building of dams for irrigation, hydropower generation and flood control. There is, therefore the need for those concerned to invest in data gathering programmes to also include all major lateral feeder rivers of the River Kaduna. In this way, hydrological changes will be effectively monitored on the Kaduna River basin.

To summarise this research report, the key conclusions are made to give a better understanding of the research findings. A case study on vulnerability and adaptation to floods in Shiroro LGA in Niger State of Nigeria has been conducted. Meteorological data, from the year 1981-2000, was selected and participatory rural appraisal was used. Moreover, household interviews were conducted among the twelve communities, to investigate the environmental and socio-economic consequences of climate variability and extreme (flood).

The following are the key findings of this research report:

- During times of climate stress, e.g. flood periods, large losses have occurred. These have been shown to be coupled to vulnerability to flood events. Factors such as poverty, lack of technology and infrastructure, lack of information and skills and household dependent only on agriculture have been identified as increasing vulnerability to flooding along the Kaduna River at Shiroro LGA in Niger State of Nigeria.
- Three vulnerable groups are also identified within the communities in Shiroro LGA. These vulnerable groups include the poor, the population residing on the floodplain and those populations that depend only on agriculture. Vulnerability and adaptive capacities have, however, been shown to vary across groups. In groups A and B, the vulnerability of the population is low, with high adaptive capacity. This is because the population consists mainly of civil servants and traders, with low level of dependency on working group. Moreover, the communities have access to social amenities such as electricity, piped water, good roads, hospitals and schools.
- The social networks in groups A and B are strong as result of their flexible culture that allows interactions with the external communities. While in Group C, the vulnerability of the population is high, with low adaptive capacity. This is because the population depend only on agriculture as their source of livelihood, with high levels of dependency on those members of the household who have off-farm employment. Moreover, the communities do not have access to social amenities such as electricity, piped water, good roads, hospitals and schools. This group also do not have access to good housing. Having outlined the key findings of this research report, the next paragraph brings the entire report to a conclusion.

The analysis of rainfall and flood flow into the Kaduna River System shows that there appears to be an increase of floods along the River Kaduna for the past two decades. Floods have impacted negatively on the life of the people living on the floodplain resulting in food insecurity, poverty and vulnerability including, malnutrition and other health problems among the communities in Shiroro Local Government Area. Moreover, this research shows that the adaptive capacity of the communities along the River Kaduna floodplain in Niger State of Nigeria is very low and is being severely compromised by factors such as poverty, poor infrastructure, lack of technology, lack of information and skill, weakening social networks and environmental degradation.