Multiple and more frequent natural hazards

The vulnerability implications for rural West African communities

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ABSTRACT

Rural, subsistence agriculture dependent communities in the West-Sudanian Savannah climate zone are dependent on a single rainy season to produce the crops that they need to sustain themselves for the following year. However, increasing variability in rainfall presents these communities with a considerable challenge, a challenge that is likely to worsen with climate change.

Seasonal variability is manifest as local level floods and dry spell droughts. These events disrupt crop growth and impact on other aspects of life such as housing and access to water. Climate change is expected to not only increase the frequency of these events but to also increase the likelihood of floods and droughts occurring in succession, in the same rainy season. Responding to gaps in the application of social vulnerability concepts to multiple hazard scenarios, this research provides an approach to account for the differential impacts and responses towards multiple and more frequent hazard events.

The research presents important insights for a future under climate change, particularly highlighting the potentially different outcomes of more frequent hazards compared to multiple (successional) hazard events where the impacts are deeper. Connecting with concepts relating to social-ecological systems and social vulnerability, the research demonstrates how thresholds of change vary based on the nature of hazard events. It finds that more frequent hazard events result in gradual erosions of assets and coping capacity that can lead to rigidity traps. In contrast, the deeper losses incurred by multiple (successional) hazard events is more likely to spark social change, however, these changes are limited by inadequate adaptation options.

The findings from this research have been generated through predominantly qualitative analysis and the application of relatively innovative methods, including a participatory game and scenarios. The focus on three case study communities in different West African countries, provides a basis for generating broader conclusions that argue for a concerted effort to address barriers to adaptation and to enhance support for affected communities.

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1 Introducing the Research

1.1 The West Sudanian Savannah and natural hazards

As a global phenomenon, climate change is anticipated to bring increasing disruption and change to climate regimes across the world. In West Africa, this disruption is likely to be manifest as seasonal variability that results in more frequent climate driven hazards such as floods and droughts. Of particular concern is the impact of this seasonal variability on the West Sudanian Savannah climate zone. As Figure 1.1 shows, this climate zone forms a band from Senegal to Nigeria and is characterised by a single rainy season, which is critical for the agriculture based communities in this area.

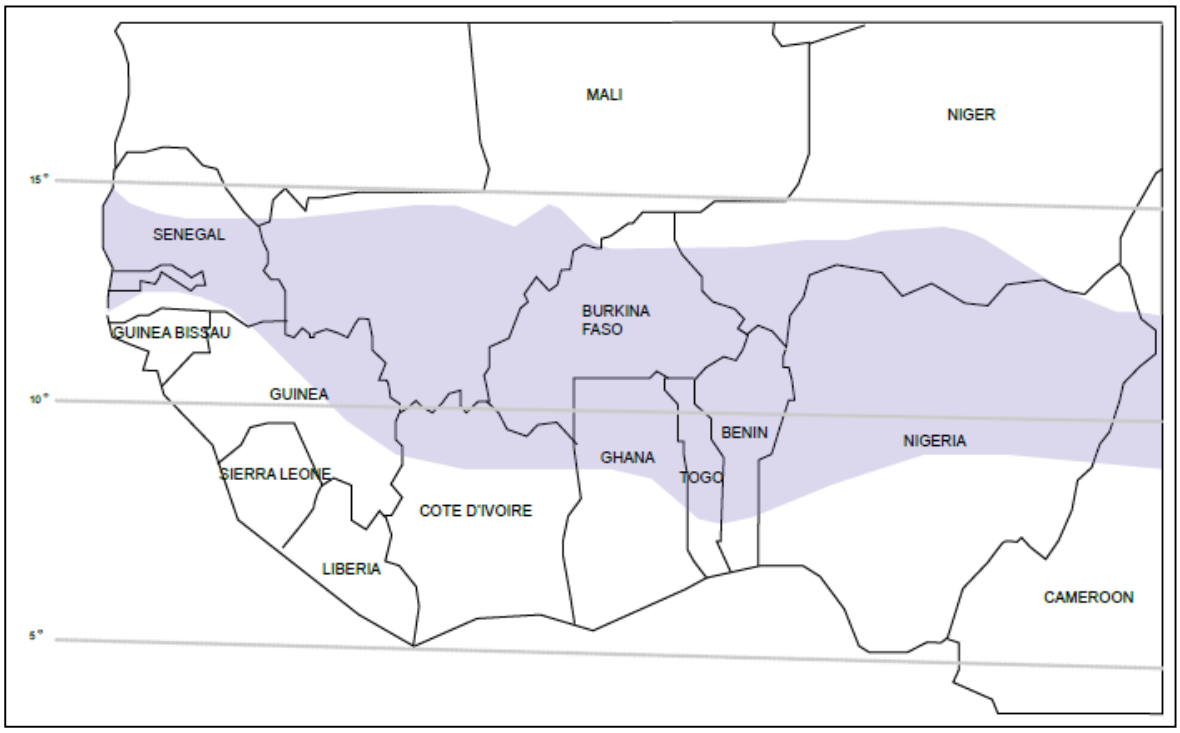


Figure 1.1 Location of West Sudanian Savannha climate zone. Own illustration based on Callo-Concha *et al.* (2013)

Rural communities in the West Sudanian Savannah depend on rain-fed agriculture for their subsistence. Many of the staple crops require the full length of the rainy season to mature but recent trends show variability in both the onset and cessation of rains which effectively reduces the growing time available to the crops. In addition to shorter growing periods, there are also trends of increasing spells of excessive and deficient rainfall which damage crops and hamper their development, resulting in diminished yields. These fluctuations in precipitation that vary from the norm are recognised as constituting floods and droughts in the local context.

Projections in precipitation for the West Sudanian Savannah zone under climate change point to increasing seasonal variability and by extension, increased flood and drought events. Not only are floods and droughts expected to occur more often, they may also occur in succession with both hazard types arising in a single rainy season, raising important questions about the outcomes of climate change for the agriculture-based communities (van der Geest, K., 2004; Bossard, 2009; Tschakert *et al.*, 2014; Mertz *et al.*, 2009).

The endemic poverty in rural West Sudanian Savannah communities combined with a dependence on climate conditions conducive to their agriculture often leads to the communities being classed as highly vulnerable. However, these communities are not passive and do have coping and adaptive capacities. As Adger *et al.* (2004) recognises, coping and adaptive capacities are not necessarily directly translated into coping and adaptation. As such, there is a need to understand the decision making processes and potential barriers and limitations that might limit the application of coping and adaptation strategies at present but which may also provide insights into coping, adaptation and by extension, vulnerability, in the future with more frequent and successional hazard events (Kelly and Adger, 2000).

By examining flood and drought impacts and responses, this research seeks to shed light on the question of whether more frequent flood and drought events, as predicted under climate change, are likely to be coped with or not. In this, the research aims to identify conditions that may lead to system collapse or adaptation, and how likely these outcomes are in a future under climate change. This is achieved by examining how current coping and adaptation strategies are applied to mitigate vulnerability and by developing and applying novel methods. Insights from the present day are built upon to explain the impacts and decision making processes under future conditions of climate change, where hazards are expected to become more frequent.

Floods and droughts are two opposite hazards and are thus mutually exclusive, however, with increasing disruptions to climate patterns, it is likely that climate change may increase the frequency of both hazards through disruptions to precipitation in the rainy season (Tschakert *et al.*, 2014; van der Geest, K., 2004). This may result in what is termed in this research as 'successional' hazards. In this West African context, successional hazards are simply floods and droughts that occur in the same rainy season. An important question is whether these successional hazard events are likely to affect different aspects of life or whether they might affect the same aspects and thus exacerbate the impacts of the first hazard and, if so, to what extent. Contributing to the emerging field of multiple

hazards risk assessment, this research examines the differences in impacts between floods and droughts and the potential multiplier effect that may occur as a result of those hazards occurring in succession. The insights from this empirical work are connected to theoretical perspectives on vulnerability, coping and adaptation, and by looking in detail at tipping points, thresholds and decision making processes to elicit information about responses that may influence the overall impacts of climate change.

The research is carried out within the West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL) programme. This programme comprises of a core research programme that is designed to develop a deeper understanding of current conditions and future trajectories under climate change. The programme has a specific focus on rural West Sudanian Savannah communities and as such has selected three potential case studies in which to conduct research on a range of climate change related topics such as the influence of climate change on hydrology, market economics and soil nutrients. The research for this study forms part of the WASCAL core research programme's work package on risk assessment and analysis and places an emphasis on understanding the social dimension of coupled social-ecological systems under climate change. The advantage of conducting this research within the WASCAL programme has been that partner institutions and colleagues have conducted research on a variety of aspects of climate change, providing important insights into related topics that are beyond the scope of this particular study. In particular, the focus on the same three case studies has provided opportunities to triangulate and verify data and information with experts in related fields. This has been particularly advantageous in enhancing the robustness of this innovative research.

The WASCAL programme selected three potential case studies that were comparable in terms of their dependence on agricultural livelihood systems and their location in the West Sudanian Savannah climate zone. The research for this thesis has been conducted in all three of these WASCAL case studies in order to provide an extended-intensive perspective (Birkenholtz, 2012) that would demonstrate the degree to which the research results, findings and recommendations might be considered applicable beyond the case studies specifically. One goal of this research has been to develop insights and recommendations that could apply more broadly to expand the scope of the impact of this research beyond simply the specific case study communities. This is an underlying goal of the WASCAL programme but is also an important feature in this specific research.

1.2 A changing West African climate

Climate change is a phenomenon shrouded in uncertainty. Observable over extremely long time scales, it is not possible to say definitely whether climate change is taking place already. However, observations of precipitation and temperature trends in the West Sudanian Savannah climate zone over the past few decades clearly show changes from the traditional climate and seasonal patterns (Bonye and Godfred, 2011; Kelly and Adger, 2000; van der Geest, K., 2004). Whether these are an early sign of actual climate change or not, these trends highlight the challenges that communities face if the trends do continue, as expected under the global and regional circulation models.

Global circulation models (GSMs) suggest that temperatures in the West Sudanian Savannah are likely to increase with global warming. The models are generally united in this finding, however, they vary considerably in their forecasts for precipitation under climate change (Barbier *et al.*, 2009; Bossard, 2009; Ibrahim *et al.*, 2014; Mertz *et al.*, 2009). Models such as HadCm2a and MIROC3.2 suggest that climate change will increase total precipitation. In contrast CM2.1 and ECHAM predict the opposite trend of decline precipitation totals (Ibrahim *et al.*, 2014). The stark contrast in model outputs can also be juxtaposed against scientific observations and recent trends which show a relatively stable quantity of precipitation, having recovered from the drier years of the 1970s and 1980s (Salack *et al.*, 2015). The recovery leads to a sense of hope that the GCMs that predict increased precipitation might be correct and that this would bring benefits to a region so dependent on rain-fed agriculture (Dong and Sutton, 2015). However, perceptions on the ground do not match this hope and do not reflect the positivity associated with increased precipitation.

When compared with the perspectives of farmers in the region, it appears that the trends observed by scientific precipitation measurements are not easily validated. Eguavoen (2013) and West *et al.* (2008) found that whilst local people do agree with scientific observations that temperatures are increasing, they disagree that precipitation has recovered and is also increasing. Indeed, Mertz *et al.* (2009) reported that local perceptions were generally negative towards trends in precipitation, perceiving a decline in recent years and decades rather than a recovery in rainfall, as demonstrated by total precipitation observations.

The reason for the differences between scientific observations and perceptions could be attributed to misperceptions by local people. However, as Eguavoen (2013), West *et al.*

(2008) and Mertz *et al.* (2009) found, local perceptions are actually highlighting nuances that reveal a greater complexity which is often masked by scientific observations. Specifically, West *et al.* (2008) found that a decrease in precipitation overall is perceived due to the apparent shortening of the rainy season and increasing frequency of prolonged dry spells.

In terms of the onset of the rainy season, this would traditionally be measured as the first, second or third rains of the year- normally occurring in April or May. These first few rainfall events would be taken as a signal to begin sowing fields as the rainy season has begun. This is the same measure of rainy season onset that is used in the GCMs. However, as West *et al.* (2008) highlights, local farmers no longer trust these first three rains as indicators of the rainy season. Experiences with prolonged dry spells that extend for one or two months shortly after the first few rains has resulted in a shift whereby some farmers wait for a prolonged dry spell to pass and then use the next rains as a guide to define the onset of the rainy season. Salack *et al.* (2015) and West *et al.* (2008) refer to this as a 'false start' to the rainy season and emphasise that extensive local experience with such false starts has led to the first rains being ignored and not classed as the onset of the rainy season.

In addition to local perceptions that indicate an effectively shorter growing season due to the delayed onset of the main part of the rainy season rains, local perceptions also indicate greater intra-seasonal variability in terms of more frequent dry spells and more intense precipitation (Roncoli *et al.*, 2001; Tschakert *et al.*, 2014). Dry spells were highlighted by Mertz *et al.*'s (2012) research on local perceptions of climate trends. They found that dry spells were increasing in both frequency and duration and this was disrupting crop growth. Where dry spells exceed two weeks, they are seen as constituting agricultural droughts as this is the point at which crops are particularly likely to be negatively affected. In addition, Salack *et al.* (2015) found increasing reports of intense rainfall events that result in flooding. When comparing these trends to the scientific observation that total precipitation remains relatively stable and has recovered from the drier period of the 70s and 80s, it becomes apparent that the rainfall in becoming condensed, falling over fewer days (as evidenced by the more frequent and longer-lasting dry spells) and thus resulting in more intense rainfall events. This conclusion is in line with the local perceptions and highlights the importance of more nuanced measures of precipitation that are currently masked by GCMs (Ibrahim *et al.*, 2014; Salack *et al.*, 2015; Bossard, 2009; Heinrigs and Trémoliéres, 2012; Eguavoen, 2013).

In order to better capture and account for the important nuances of intra-seasonal variability, regional climate models (RCMs) have been developed to examine climate factors and trends at a higher resolution. The findings of these models highlight a greater complicity with the local observations and perspective of recent trends in seasonal patterns (Ibrahim *et al.*, 2014; Salack *et al.*, 2015).

Ibrahim *et al.* (2014) examine the outputs of five RCMs for Burkina Faso. Their findings show trends from 2021 to 2050 which suggest a delay to the onset of the rainy season by one week on average, dry spells that will be 20% longer and fewer rainy days. Salack *et al.* (2015) also find a trend in increasingly frequent and prolonged dry spells. In addition, they highlight more frequent intense rainfall events. Salack *et al.* (2015) and Ibrahim *et al.* (2014) both link the increasingly disrupted intra-seasonal patterns with increasingly frequent natural hazard events. They agree that prolonged dry spells, which the RCMs predict will become more common and last longer, can be seen as droughts and the increased frequency of intense rainfall events, particularly during the month of August, will lead to floods. Based on this analysis, it appears that climate change in West Africa is likely to result in more frequent flood and drought events as a result of intra-seasonal variability. **Figure 1.2** depicts these trends compared to the traditional pattern and traditional crop needs.

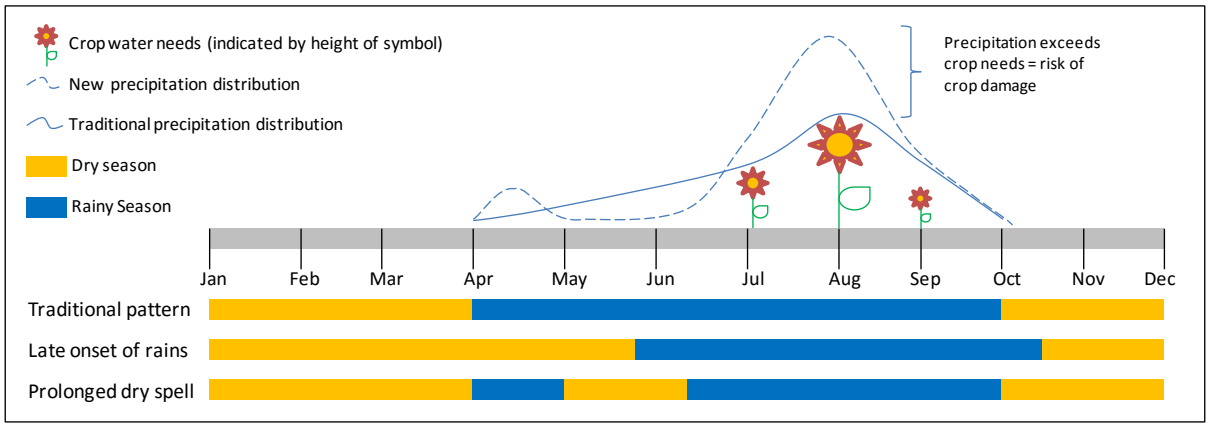


Figure 1.2 Traditional and current trends in seasonal precipitation compared to crop needs. Based on Salack et al. 2015, Ibrahim et al, 2014, own data and (FAO)

It is important to note that floods and droughts driven by intra-seasonal variability tend to be low magnitude events. As such, they tend to receive less attention than the more severe, high magnitude floods and droughts which are more impressive from an international media perspective and in order to capitalise on windows of opportunity (Birkmann *et al.*, 2010). However, despite being low magnitude events, these events are particularly damaging to the communities that depend on stable patterns of precipitation

to grow their crops in the manner that they have become adapted to. Therefore, the RCM outputs that suggest increasing seasonal variability that creates more 'hazardous' conditions (Salack *et al.*, 2015; Ibrahim *et al.*, 2014) are a considerable concern for the future viability of rural West Sudanian Savannah communities.

1.3 Vulnerability and the potential multiplier effect

As the previous section has demonstrated, regional climate models forecast increasingly variable seasonal patterns which increase the likelihood of floods and droughts due to more intense rainfall events and more frequent and prolonged dry spells. As total annual precipitation is found to remain stable, intra-seasonal variability demonstrating that fewer rainy days (which indicate dry spells) are likely to be offset by intense rainfall (which indicate flooding), the findings of the regional climate models not only demonstrate the potential for floods and droughts to become more frequent but they also highlight the increasing likelihood of both hazard events occurring in the same rainy season (Mertz *et al.*, 2009; Ibrahim *et al.*, 2014; Salack *et al.*, 2015).

Research on multiple hazards is an emerging field and as such, the approaches to assess and understand multiple hazards and their outcomes remain underdeveloped. At present, multiple hazards are often considered as cascading hazards and attention is focused on trying to understand how one hazard might trigger other hazards (Kappes *et al.*, 2012). However, in the context of the West Sudanian Savannah where floods and droughts are mutually exclusive, the main focus is on successional hazards and whether the impacts of both floods and droughts that occur in succession will be more severe than if only a flood or drought occurred, and if so, to what extent will the impacts be amplified by the second hazard? Will the impacts be doubled by the second hazard or will the first hazard cause most of the damage leaving only a small fraction left to be impacted upon by the drought? These are key outstanding questions particularly relevant to the context of this research but which could also provide important contributions to the emerging multiple hazards literature.

Central to questions on multiple hazards are the implications for people and societies. Risk encompasses both hazard exposure and vulnerability, recognising the importance of the social dimension. However, to date, multiple hazard risk assessments have focussed on understanding the potential cascades within the hazards component of risk. Although they often result in the production of multiple hazard *risk* maps, the vulnerability element

of these is often provided as a simplistic assessment on physical, rather than social, vulnerability (Kappes *et al.*, 2012; Bell and Glade, 2004a).

Representing simple measures of vulnerability as a single layer in a multiple hazard risk assessment, these assessments fail to account for the different impacts that different types of hazards may have on the social dimension. Where hazards cascade, the impacts may simply be amplified but in the context of this research where the hazards are floods and droughts, the impacts are likely to be more complex. Therefore, it is important to consider how floods and droughts might affect people differently and the degree to which this will amplify overall impacts. Given the complexity inherent in social vulnerability, it is not sufficient to simply take single hazard impacts and multiply these by the number of hazards. A more sensitive and detailed approach is required and this is one of the objectives of this research.

In addition to considering vulnerability, it is also important to acknowledge that those affected by hazards are not necessarily passive victims (Smit *et al.*, 2000). People have the capacity to respond in advance, during and after a hazard event to reduce the overall impacts and to enhance their resilience. These coping and adaptation strategies are also important aspects to consider when analysing vulnerability and whilst there have been studies on decision making processes and coping strategies, these have been applied to single hazard situations or as generic vulnerability (Mertz *et al.*, 2010). A multiple (successional) hazard event may reveal different approaches and strategies which have a differential effect on the overall outcome, however, without research focussed on this, the similarities and differences in coping and adaptation from single to multiple hazards cannot be known.

1.4 Research questions

The limited consideration of the vulnerability dimension in current approaches to multi-hazard risk assessments has been identified as an important area for further research. As such, the purpose of this study is to provide a more detailed and nuanced perspective of how social vulnerability might vary from the present day situation to a future under climate change which is expected to result in more frequent and multiple hazard events in the West Sudanian Savannah climate zone. In particular, this research is concerned with understanding how multiple (successional) hazard events might result in different vulnerabilities, coping and adaptation approaches.

In order to achieve the research goal of understanding the differential vulnerabilities, coping and adaptation approaches under climate change, the following core research questions have been developed along with sub-questions that help these core questions to be answered:

Research Question 1: How is vulnerability to natural hazards, specifically floods and droughts in rural West-Sudanian Savannah communities manifest at present?

- Sub 1.1 What are the impacts of floods and droughts on rural West-Sudanian Savannah communities?
- Sub 1.2 How do the West-Sudanian Savannah communities respond to the impacts with coping and adaptation strategies?
- Sub 1.3 To what extent are the impacts of floods and droughts recovered from in the present day?
- Sub 1.4 To what extent are the impacts and responses variable between the case study communities and what are the implications of this for drawing conclusions for a broader geographical area?

Research Questions 2: In what ways might vulnerability, coping and adaptation vary from the present day to a future under climate change with more frequent flood and drought events?

- Sub 2.1 How will more frequent hazard events strain existing coping and adaptation strategies?
- Sub 2.2 To what extent are more frequent hazard events likely to encourage changes to coping and adaptation strategies and will these be sufficient to compensate for the new hazard periodicity?
- Sub 2.3 What are the implications of the outcomes for the continuity of the social-ecological system?

Research Question 3: How might vulnerability vary from single flood or drought events to events where floods and droughts occur in succession?

- Sub 3.1 To what extent might a second, successional and different hazard event amplify the impacts of a single hazard event?
- Sub 3.2 How might coping and adaptation strategies respond to differential impacts?

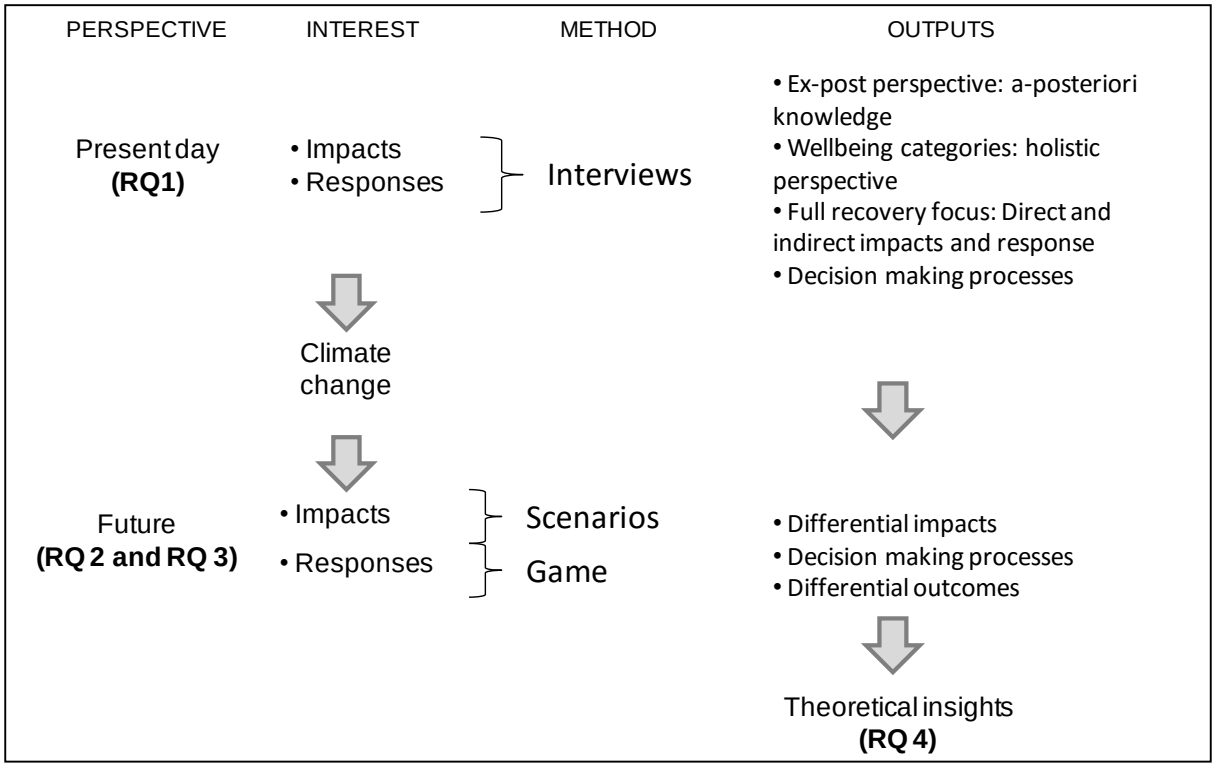
- Sub 3.3 To what extent might new coping and adaptation strategies be triggered to meet the amplified impacts of the multiple hazard situation?

Research Question 4: How useful are theoretical concepts relating to vulnerability and resilience for understanding the implications of a future under climate change?

1.5 Approach to the research

To answer the research questions, this research is divided into two key parts which look at the present day impacts and responses to floods and droughts and the future impacts and responses to more frequent and successional flood and drought events as anticipated under climate change. The focus of this research is the local, community scale. This is the scale that Eriksen and Kelly (2007) and O'Brien *et al.* (2004c) argue best enables the capture of context specific vulnerability while accounting for the complexity of interactions in coupled social-ecological systems. Applying the research approach to three case studies in the West Sudanian Savannah, insights for the broader West Sudanian Savannah region are elicited through a comparisons that highlight similarities and differences between the case studies and provide a foundation for wider reaching conclusions.

Figure 1.3 Research design overview



The first stage of fieldwork primarily aims to address Research Question 1 (RQ1) which seeks an understanding of the present day impacts and responses to floods and droughts

from an ex-post perspective. Through interviews, impacts and responses are revealed and these are categorised through the application of the conceptual and analytical framework presented in Section 3.8. The interview findings provide an a-posteriori foundation for the second phase of the research and fieldwork which aims to address Research Questions 2 and 3 (RQ2 and RQ3).

The second part of the research and fieldwork applies novel techniques adapted specifically in order to address RQ2 and RQ3 which examine the likely impacts and responses under future conditions of climate change. As the conditions of more frequent and multiple (successional) hazards are not currently experienced widely in the region, a participatory game is used to simulate these conditions in order to provide a context for participants to demonstrate their potential decision making, coping and adaptation strategies. Comparing the coping and adaptation processes undertaken in the game with those revealed by the first stage of fieldwork provides an insight into how coping and adaptation strategies might vary under climate change conditions in the future. In particular, the research approach aims to determine whether coping capacities and adaptation will compensate for the increased frequency and successional nature of hazards in the future or, if not, whether theories of collapse and transformation in systems under pressure might be validated.

In addition to understanding the responses to more frequent and multiple hazard events under climate change, scenarios are developed to provide a more in-depth examination of the potential multiplier effect of multiple hazards. Based on findings from the interviews, the scenarios focus on crops as the most critical element of present day impacts. The scenarios present flood and drought events that occur in succession, as is expected under climate change conditions and the participants then provide feedback on how they would expect the crops, under such conditions in the local community to be affected. Discussions on adaptation and coping strategies to manage such impacts are used to reveal the likely degree of damage and answer RQ3 on the degree to which there would be a multiplier effect from a second hazard event.

The entire research process is iterative and designed to be flexible enough to respond to logistical challenges and also new insights that arise through the data collection process. As a qualitatively driven approach, regularly revisiting the literature and results to enhance the analysis and reveal a greater depth of information and insights is crucial to the research process. Through this process, the empirical findings of the research can be compared with theories of vulnerability, resilience and systems under pressure in order

to validate theoretical concepts or highlight where concepts are not applicable for the research.

This research is conducted from a post-positivist perspective that emphasizes the importance of context and seeks a deeper understanding of complex processes rather than simply quantifying phenomena (Ryan, 2006). It is anticipated that the findings of this research will illuminate the importance of accounting for the social dimension in multiple hazard risk assessments. By applying a range of qualitative research methods, important details and complexities can be illuminated for better quantitative approaches to be developed to capture the important facets of social vulnerability, coping and adaptation at broader scales.

1.6 The thematic and geographical scope of the research

This research aims to examine the impacts and responses to multiple natural hazards, specifically floods and droughts, in the present and to project how those impacts and responses might vary under climate change conditions which are expected to increase the frequency of such events.

Although the research aims to shed light on how vulnerability varies from single to multiple hazards in order to contribute to the literature and knowledge on potential multiplier effects, the research will focus on just two natural hazards. The decision to examine two natural hazards is based on a desire and need to take a detailed perspective that captures the complex interactions at play in vulnerability towards natural hazards and how these might change from single to multiple hazards. With a considerable gap in the literature on a social vulnerability centred approach to multiple hazards, the focus on two hazards is designed to provide an initial insight into the potential multiplier effects and complexities that ought to be considered in other similar studies. This research utilises a range of novel and innovative approaches to elicit new information and insights. As such, the application to the two hazards in this study is designed as a means of scoping the need for other further studies on different hazards and how these might be conducted.

The selection of floods and droughts as the hazards of interest for this study developed through a scoping field visit. The scoping visit revealed a range of different natural hazards in the three case study communities but also emphasised the importance of floods and droughts as the hazards with the most significant impacts on the case study communities. These hazards are the two hazards that were present across all three case studies, whereas hazards such as strong winds were particularly important in Benin but

not in the other case studies, for example. Floods and droughts were also highlighted as climate driven hazards that are already experiencing changes in their periodicity and intensity. With climate change anticipated to exacerbate these trends, these two hazards were highlighted as critical to examine from a climate change perspective.

The scope of the research is to examine the impacts and responses to floods and droughts in the three West Sudanian Savannah case study communities. These rural, agriculture-dominant communities can be seen as a closely coupled social-ecological system whereby people are connected to their environment through agricultural activities. The social-ecological system is used as a frame for this research because it emphasises the interactions between the social and ecological dimensions, as is particularly clear in agricultural systems (Andrade *et al.*, 2011; Ostrom, 2009).

While social-ecological systems comprise feedbacks that travel in both directions between social and ecological systems, the focus of this research is particularly placed on the interactions from the ecological to the social system. The aim of this research is to determine the outcomes of environmental processes on people and therefore the social system will the focal point of the study. As such, floods and droughts are seen as external driving forces of change in the social-ecological system and in turn, climate change defines the nature of the floods and droughts that drive change. The system can be represented as shown in Figure 1.4, with climate change influencing the nature of the two hazards of interest and these hazards then being applied to the ecological dimension of the social-ecological system. The research is, interested in the interactions between the ecological and social dimensions and particularly on the outcomes for the social dimension. Although it is recognised that this may in turn influence the ecological system, various studies have already examined the influence of climate change on the environment and influences of the social system on the ecological system (An, 2012), see d'Aquino and Bah (2003) and Barton *et al.* (2012) for examples. An important gap remains in the context of this research on the influence of climate change driven ecological impacts on the social dimension and this research aims to contribute to this gap.

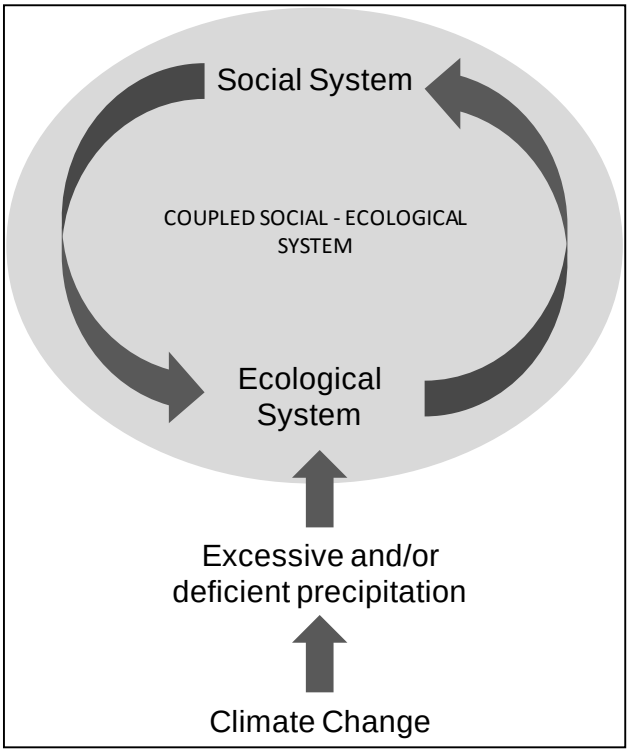


Figure 1.4 Social-ecological system with influences from climate change

1.7 Organisation of the dissertation

This dissertation is organised into eight key chapters. Beginning with a review of the key literature and concepts, Chapter 3 develops a conceptual framework that forms a foundation for the analysis of the first phase of data collection. The data collection approach and methods are detailed in Chapter 4. This chapter describes the research approach and key methods which include some novel approaches to address the core research question. Chapters 5 and 6 present the results and findings from the research, beginning with the results from the first phase of research which examines the present day impacts and responses to floods and droughts. The results from the second phase of research which examines the potential impacts and responses of a future under climate change are presented in Chapter 6. Chapter 7 provides a discussion of the results and places the findings in the context of the key literature. Finally chapter 8 concludes the dissertation by highlighting the key findings and contributions that this research makes to the literature and scientific knowledge before providing some suggestions for further research on this topic.

2 Case Study Selection and Background

The case study areas shown in Figure 1.1 were selected under the WASCAL programme with the goal being to conduct a range of research in the same three case studies in order to develop a particularly detailed picture of the complex social-ecological system and their interactions. From this, insights into the impact and outcomes of climate change can be examined.

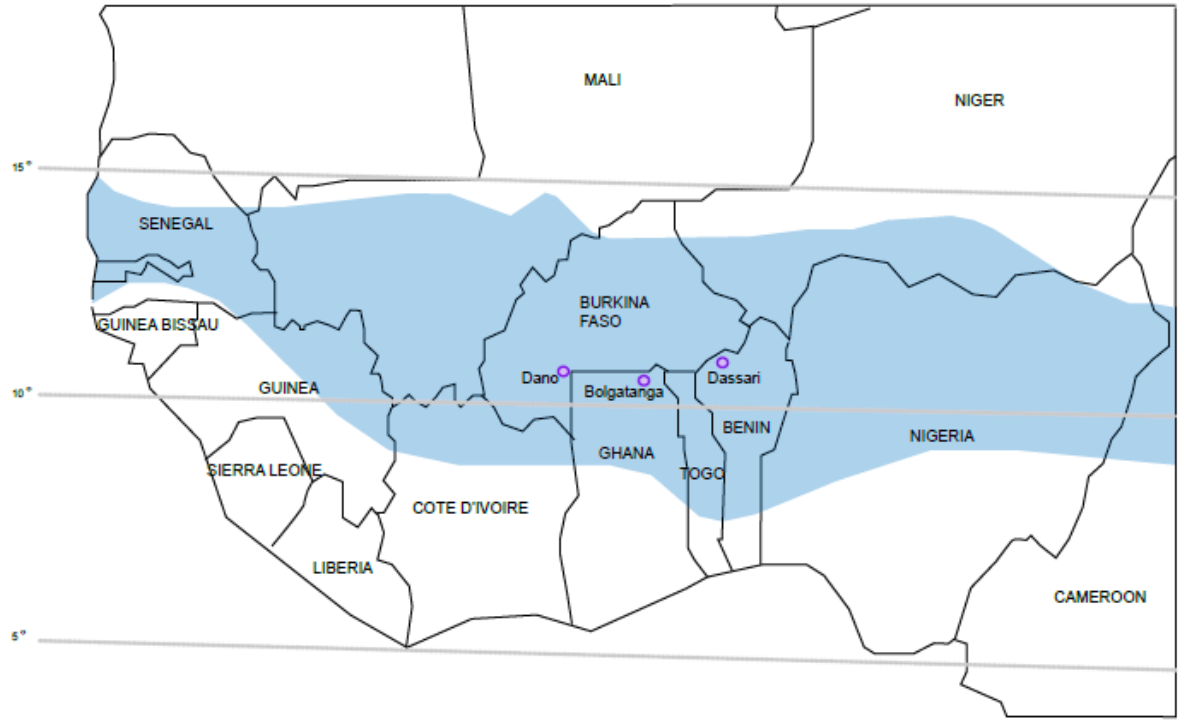


Figure 2.1 Map showing location of case study sites

The three case studies are located in neighbouring West African countries (Benin, Burkina Faso and Ghana). All three are former European colonies with Benin and Burkina Faso as former French colonies and Ghana as a former British colony. Today, Ghana is one of the more economically developed countries in the West African region, with a stronger economy than Benin and Burkina, (measured by Gross National Income (GNI)) (World Bank, 2015b, 2015a). Benin and Burkina feature among the United Nation's ten least developed countries in the world, with Benin occupying the 4th spot and Burkina Faso the 6th spot ,in 2013 (United Nations, 2013).

2.1 Socio-economic characteristics of the case study countries

According to the United Nations, Benin and Burkina Faso are classed as least developed countries, with Benin the 4th least developed county in the world and Burkina Faso ranked

in 6th place (United Nations, 2013). The classification of least developed country is related to poverty, weak human resources and economic vulnerability. In 2008, Ghana was also found to satisfy this criteria but refused to be included in the list of least developed countries, citing concerns of the validity and accuracy of the data (United Nations, 2008). Indeed, in 2013, Ghana did not satisfy the criteria for a least developed country but it is still classed as a lower-middle income country, ranked 138th out of 187 in the Human Development Index (HDI). Benin is ranked 165th in the HDI and Burkina Faso is 181st out of the 187 indexed countries (United Nations Development Programme, 2014a). Therefore, Burkina Faso and Benin can be seen as particularly economically challenged while Ghana is somewhat better off, but still classed as a lower-middle income country.

The population growth rates of all three countries are between 2 and 3%. Ghana has the lowest population growth rate of the three with a 2.1% annual increase anticipated. This would bring its population of 26 million to around 35 million by 2030. Benin has a population growth rate of 2.7% and Burkina Faso of 2.8%. The national populations of Benin and Burkina Faso are estimated at 16 million and 27 million respectively. Of these populations, in Ghana and Benin roughly half of the population is located in urban areas, with just under half in Benin and just over half in Ghana. In contrast, Burkina Faso has a considerably smaller proportion of urban dwellers (28.2%) (United Nations Development Programme, 2014b).

Rural populations in all three countries face similar challenges in access to water and sanitation, as basic services. Table 2.1 and Table 2.2 show that the proportion of people living in rural areas with access to piped and water and sanitation is particularly low, although it has improved in recent years under the millennium development goals. Notably, access to improved (although not piped) water is relatively high in all three countries. This is due to concerted efforts to provide access to water through wells, boreholes and pumps. In contrast, improved sanitation facilities remain a rare luxury for rural communities.

	Piped	Other improved	Other Unimproved	Surface water
Benin	5%	67%	25%	3%
Burkina Faso	0%	76%	19%	5%
Ghana	3%	81%	8%	8%

Table 2.1 Sources of water in rural communities. Source (World Health Organisation, 2014a, 2014b, 2014c)

	Piped	Other improved	Other Unimproved	Open
Benin	7%	10%	7%	76%

Burkina Faso	7%	10%	8%	75%
Ghana	9%	45%	12%	34%

Table 2.2 Sources of sanitation in rural communities. Source (World Health Organisation, 2014a, 2014b, 2014c)

Life expectancy in all three countries is around 60 years with 58 in Burkina Faso, 59 in Benin and 62 in Ghana. Again, this is improving over time, as are literacy rates. Adult literacy in Benin and Burkina Faso is 28.7%, whereas youth literacy is 42.4% in Benin and 39.3% in Burkina Faso. In contrast, Ghana has a considerably higher literacy rate of 71.5% amongst adults and 85.7% amongst the youth (UNESCO Institute for Statistics, 2013). Literacy rates are important for determining the approach to this research, in order to ensure that illiterate persons are able to actively participate and literacy does not become a hindrance to that.

All three countries are described as multiparty democracies. However, Burkina Faso has recently experienced a political coup d'état. The coup arose in protest against the wishes of the then President, Blaise Campaoré, to change the constitutional limit to the number of terms a president may serve. The proposed change would have enabled Compaoré to contest another election, although he had already served as President for more than 27 years. Since the coup in November 2014, an interim government has been in place to maintain the functions of the state until the election scheduled for November 2015. It is important to note that most of this research, and in particular the fieldwork, was carried out prior to the coup in Burkina Faso and thus it was carried out under, what were then, relatively stable governmental conditions with established governmental institutions.

Based on the national context of the case study areas, with low levels of literacy, access to piped water and sanitation and generally low levels of development based on the human development index, it can be argued that the context for the case studies already provides evidence of a degree of underlying vulnerability. However, this research aims to provide a more detailed view of this vulnerability but also coping and adaptive capacity to reduce the impacts of vulnerability and enhance resilience, specifically towards natural hazards and climate change

2.2 Case study community characteristics

At the local level, all three case studies are located in different climate zones and at a distance from their national capitals. The Benin and Ghana case studies are located at opposite ends of the country to their southern capitals. In Burkina Faso, the case study is located south of the capital and therefore enjoys more rainfall which makes it seen as benefitting from better conditions than the capital and other parts of the country. In

contrast, the case studies in Benin and Ghana are located in the drier parts of the country and are thus automatically seen as disadvantaged from a national perspective. These differences in the case studies compared to the national capitals serves to create a sense of distance and remoteness from centralised forces which emphasises the need for a local level perspective.

2.2.1 Village composition and characteristics

The case studies are all comprised of clusters of dwellings that form small villages with some larger villages acting as centres for a wider range of services. The Ghanaian case study, however, is slightly different to the Benin and Burkina Faso case studies as it is located in close proximity to the Upper East regional capital of Bolgatanga. This affords the community there a broader range of services and opportunities than can be found in the vicinity of the Benin and Burkina Faso case studies that do not benefit from some such larger urban centres.

Despite the differences in proximity to urban centres, the characteristics of the villages sampled demonstrate considerable similarities. The villages are dominated by scattered dwellings in the form of compounds. Compounds are traditional houses comprising a few (3-5) small huts around a central courtyard (See Figure 2.2). The huts provide shelter for members of the family as well as dedicated spaces for cooking and storage. In a compound, huts can be made uniformly or from different materials. Traditional materials for huts are mud/adobe with an increasing trend towards using brick. Concrete is particularly rare in the Burkina and Benin case studies and is also uncommon in the Ghana case study, although it can be found at wealthier households and some households accumulate concrete blocks over time as an investment and saving towards constructing a concrete room in the future.

Figure 2.2 Model of compound homestead structure.

In addition to variations in construction materials, there are also variations in roofing. Traditionally thatch was used as the roofing material but corrugated metallic sheeting has risen in popularity, becoming more prolific. There are debates regarding which is preferable with some arguing that the corrugated metallic sheeting is stronger and others preferring the traditional thatch as more conducive to keeping a dwelling cool. It is not uncommon to find compounds comprising a mix of hut types and roofing materials. This can often reflect the different preferences of older and younger members of the household with elderly relatives tending to prefer the traditional dwellings and younger relatives seeking more modern materials and construction techniques. This is also reflected in the shapes of dwellings. Round huts are the traditional style but in more recent years, square shaped huts have become popular. Again, there is a debate over which is better suited to the local conditions and again a compound may comprise a mixture of the two shapes to satisfy the different members of the household.

The huts are often connected by a surrounding wall and small animals are expected to return to be kept in the compound overnight. The land immediately surrounding the compound is often used for cropping during the rainy season and this is known as the compound farm, as shown in Figure 2.3. Crops grown here are surplus to the main fields which can be located at a greater distance the compound.

Figure 2.3 Picture of compound homestead with cropped land.

2.2.2 Agriculture in the case study communities

Agriculture is the dominant source of income/livelihood. Agriculture is rain-fed and predominantly used for individual household needs, rather than commercial sale (subsistence agriculture). The main crops that are grown are a variety of crops required for household sustenance, usually centred on cereals, in particular sorghum and millet. Both sorghum and millet are cereal grains, traditionally grown in the region. Sorghum is often red and millet produces a similar grain that is white in colour. These grains form staples of the local diet and have a traditional value. In the Ghana case study, millet is particularly prized for its use in the local dish, 'TZ', which is said to provide strength to farmers and new mothers. However, sorghum and millet are falling out of favour to the more recent addition of maize. Maize is now seen as a more desirable crop for its flavour and is increasingly cultivated in the region.

Another popular crop is rice. This is usually grown in the low lying river valleys and is often the only crop that women are permitted to cultivate for themselves. Typically women would be expected to support and provide labour for their husbands farming activities as a priority. Once they have completed these duties on their husband's fields, women may then be permitted to cultivate their own parcel of land and rice is the crop that they are normally able to grow.

In addition to key cereals and grains of sorghum, millet, rice and maize, other commonly grown crops are groundnuts which are important for producing a groundnut sauce that usually accompanies millet, maize and sorghum pastes for meals. Other commonly grown crops are various beans and in the Benin and Burkina Faso case studies, cotton is also cultivated as a cash crop.

Cotton cultivation is encouraged and supported by national level initiatives. It is seen in Burkina Faso and Benin as a source of cash income and thus as an opportunity to create produce for export in areas with limited alternatives. However, as cotton requires fertilizers and pesticides, support is provided to farmers to ensure access to these inputs. Support is often in the form of subsidies for chemical fertilisers and pesticides which are distributed through cooperatives that also organise the sale of the cotton crop.

In the Burkina Faso and Benin case studies, the subsidized process for cotton fertiliser and pesticides creates additional challenges. Farmers are normally provided the fertilizers based on the area they agree to cultivate. These fertilizers and pesticides should then be paid for from the proceeds of the harvest with remaining profits as a source of cash income. This means that a poor harvest or sudden decline in global market prices can lead to problems in repaying the loaned fertilizer and pesticides, resulting in cash debts for the farmers. Another problem is that fertiliser is also required for the cultivation of increasingly popular maize. As fertiliser is generally more difficult to access outside of the cotton cooperatives and is more expensive, farmers try to use the fertiliser intended for cotton on their maize crops, making it even harder for them to produce the cotton yield required to repay their loan (e.g. BNDab7, BNFir6, BFSor1 and BNDas13).

As many farmers have difficulty paying for the subsidised fertilisers and pesticides upon harvest, this is reflective of a wider debate regarding the suitability of cotton as a cash crop for the West-Sudanian savannah. The debate about cotton as a suitable and beneficial crop was a theme reflected in interviews with local people. A divide between those who have had success, those who struggle and those who have tried and then ceased cotton production demonstrates the varied effectiveness of cotton as a source of cash in the region. Some farmers even appear to be trapped in cotton production, arguing that they feel they have to grow cotton but would not if they did not need the fertilizer for their maize (e.g. BNDab7 and BNSet13). Indeed, several interview respondents commented that they were able to break even but do not enjoy an additional surplus from cotton production. They simply continue to cultivate cotton as it provides them with access to

discounted and more easily accessible fertilisers that they can then use for other crops such as maize.

In Ghana, cotton is particularly rare. Instead, farmers cultivate the key crops with tomatoes in the dry season (if they have access to irrigated land). Most farmers neglected to mention growing tomatoes in the interviews, indicating that this crop is not prevalent and not an important component of their harvests. A similar issue with fertilizers and pesticides is present in tomato farming there as well but is less prominent as few farmers have access to irrigated land for dry season cultivation.

Another crop of note is yams. Yams have a similar status to millet in the Benin case study with farmers growing the crop primarily for reasons of tradition. From a practical perspective, yams, like the early millet crop in the Ghana case study, are one of the first harvested crops, making their success essential to ending the hunger period that ensues during the beginning of the rainy season until around July when these early crops are harvested. However, as yams have to be planted during the dry season, they are particularly sensitive to disruptions in the early part of the rainy season.

In addition to crops, farm households also have livestock. Typical livestock include chickens, goats, pigs and sheep with households aspiring to cattle ownership. Cattle ownership is present in all three case study areas but appears more commonly in Ghana, demonstrating a greater degree of comparable wealth than the Burkina and Benin case studies, reflective of the overall higher degree of wealth nationally. Pigs are also common although, similar to rice, they tend to be reserved for women. Pork is a popular meat among non-Muslims, however, as pigs regularly suffer ASF (African Swine Fever), which occurs as an epidemic on an almost annual basis, women can often lose their entire herds during the dry season, placing them at a disadvantage over men who are able to keep a wider variety of animals (World Organisation for Animal Health). Overall, sheep are deemed particularly resilient to diseases with chickens more vulnerable.

Although agriculture is the dominant source of livelihood, other economic activities are present that provide alternative sources of income. These alternative sources of income predominantly revolve around the trade of processed farm produce such as processed rice or perennial/tree crops such as Shea nuts which are used for Shea butter. In all three case studies, Shea processing is increasingly common as Shea has become a keen source of export revenues for the region and cooperatives have been formed to help women take advantage of the export demand. Other trade products vary slightly, with the Ghana case

study specialising in basket weaving for sale in the city of Bolgatanga, as an example. The Ghana case study also has a larger proportion of rural residents who are involved in service provision such as portaging and cleaning, again this is likely to be the result of the case study villages close proximity to the main town. However, there are many alternative occupations, besides these, that are common to all three case studies. These include tailoring and hairdressing services, the production and sale of local beer and security guard services.

2.3 The West Sudanian Savannah climate and landscape

The three case study areas are all located in the West Sudanian Savannah or West African Sudanian Savannah zone. The West Sudanian Savannah climate zone covers a band of West Africa that stretches from approximately 7° to 15° north (refer to Figure 2.1). The climate zone is characterized by a uni-modal seasonal pattern that is traditionally manifest in a single rainy season that stretches from April to October/early November. The remainder of the year is dry, with limited rainfall and characterized more by fluctuations in temperature which relate to the shifts of the Inter-Tropical Convergence Zone (ITCZ) and the Harmattan winds that this generates.

The landscape is characterized by grasslands interspersed with fragmented woodlands, lone trees and clusters of dwellings. Areas of uncultivated bush land remain on the outskirts of the case study communities and national parks also restrict expansion, particularly in the Benin case study where the Pendjari National park forms a natural perimeter to the case study area.

The West Sudanian Savannah climate zone features a uni-modal seasonal pattern with the year divided into a single rainy season and a dry season. Traditionally, the rainy season would begin in April and continue until the end of October with the dry season developing over November to April. The rainy season would traditionally commence with a few light rains that enable the farmers to weed out the farms and commence preparations prior to sowing seeds. A short break in the rains would allow seeds to be planted in time for the main onset of the season shortly afterwards (i.e. towards the end of May/beginning of June). Traditionally, all of the crops would be installed by the end of June, although some crops, such as millet, may be planted in two batches and thus spread over the season with an early harvest of the first batch to ease the 'hunger' period.

The rainy season typically builds up over June and July to a peak in August and September before reducing again towards the end of the season (Figure 2.4) when it falls

to 0mm per month. The dry season begins with temperatures cooling, particularly at night, with a peak in low temperatures around December and January of 15°C. As the Harmattan winds develop, they transport considerable dust from the Sahara causing dust storms/fogs which are often associated with respiratory problems. As the Harmattan winds die down, temperatures begin to rise to a peak in March and April where temperatures can exceed 40°C. With little wind, the conditions are often described as being akin to an oven that becomes increasingly warmer. As a result of these challenging conditions, social and economic activity remains particularly low during this time and residents describe the conditions as particularly difficult to manage.

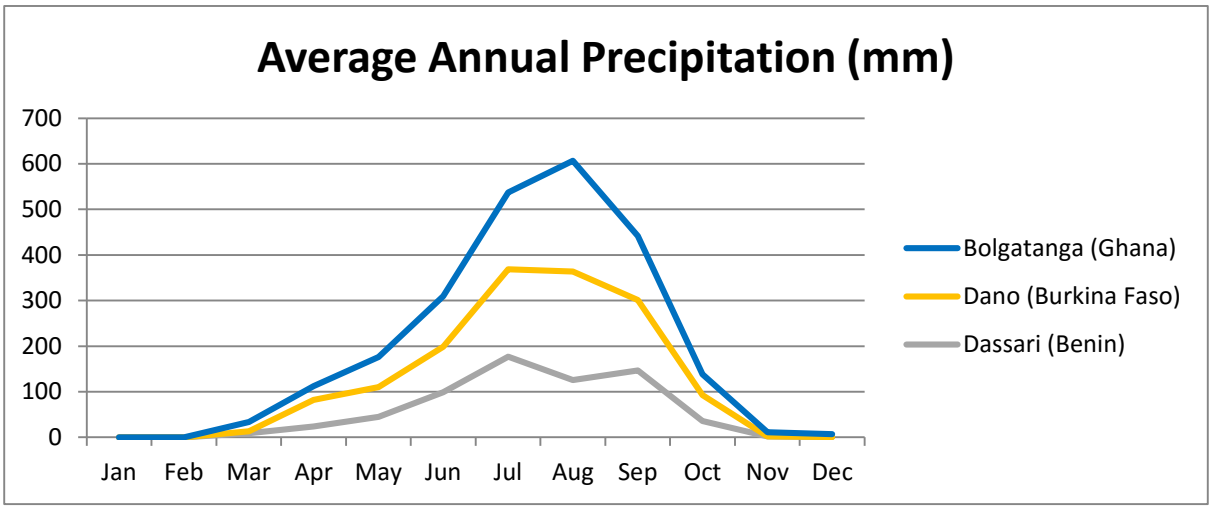


Figure 2.4 Annual average precipitation for the three case studies areas. Source (World Weather Online, 2015a, 2015b, 2015c)

The single rainy season is essential, therefore, to social-economic activities. The quality of the season determines the productivity of farms and the local economy as a whole. However, there are increasing reports that the traditional climate is changing, bringing with it increased natural hazards, particularly floods and droughts.

2.4 Local perspectives and definitions of floods and droughts

Floods and droughts are globally occurring hazards, yet there is considerable variation in the magnitude and nature of these hazards across the world. Thus, both require definition in the local context. In order to achieve this, interviews from a scoping field visit, undertaken in November 2012, provide key insights into perceptions that help define floods and droughts in the local context.

In the case study areas, floods and droughts tend to be low intensity events that result in limited loss of life but with significant impacts on other aspects of the social system. As interviewee BN2012CheDD described; “Floods are not a big problem. We have some

periods with much rain which causes rivers to flood and houses nearby collapse and farms near the river also flood" but that "the rain comes with very strong winds which damage things and causes victims". This highlights the impact of heavy rains and demonstrates that despite being low relatively low intensity events, they remain a major concern due to the disruption they cause to other aspects of life. The centrality of agriculture in the case study communities means that floods and droughts are often defined from an agricultural perspective. Essentially, they represent rainfall extremes and are often associated with precipitation patterns that vary from the traditional seasonal trends described above and upon which agriculture is so dependent.

Droughts and floods can be defined simply as insufficiencies and excesses of rainfall, respectively. However, the thresholds for these extremes are determined by variation from the traditional seasonal pattern, rather than absolute volume or intensity. Crucially, floods and droughts viewed as too much or too little rainfall for the traditional crop growth cycle, as depicted in Figure 2.5 .

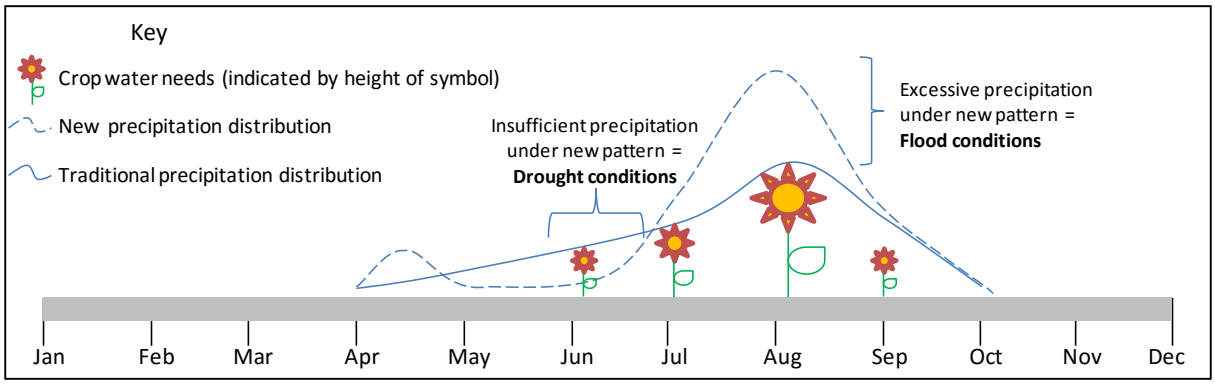


Figure 2.5 Crop water demand compared to traditional and current precipitation patterns

Insufficient rainfall during the rainy season can be manifest in two forms. The main form of drought is a prolonged break in the rains during the rainy season. A key threshold that was frequently mentioned as denoting a prolonged break in the rains was a break that exceeded two weeks (e.g. Interviews BF2012Ste and BN2012Che1). If this occurs during the rainy season, but particularly during key stages of crop growth such as in August when crop water needs are highest, this constitutes a significant challenge and is therefore classed as a drought. Such droughts are termed 'dry spell' droughts here, based on the terminology used by those interviewed.

The second type of drought that is experienced in the case study areas is a shortened rainy season. The rainy season can be shortened by a late onset of the rains and/or an early

cessation of the rains, in comparison to the traditional patterns. Shortened rainy seasons are detrimental to crops as they reduce the length of time available for the crops to mature, placing their productivity at risk. It is noteworthy that the dry season, where rainfall is virtually completely absent over approximately 6 months, is not considered a drought (West *et al.*, 2008). This is because local communities expect and are therefore are adapted to such a lack of rainfall during this period. They do not plan to grow crops at this time and therefore suffer no losses from these conditions. As Adams *et al.* (1998) highlight, in the case study region, the seasonal element is crucial in determining the severity of the hazard in the context of the social-ecological system. A hazard event that takes place outside of the rainy season is much less important or problematic to the local communities compared to a hazard event that falls within the rainy season and thus may affect livelihood activities that are the foundation for well-being. However, as interviewees such as BN2012ExpHoC highlighted, if the dry season extends beyond the traditional six month period towards, say, eight months then this would be considered a drought in the form of a prolonged dry season.

The definitions of floods and droughts are largely based on the conditions that would lead to crop damage. However, definitions and perceptions of floods differ slightly from droughts because their impacts are also felt directly on other aspects such as housing. This makes their definition less connected to agriculture and based more on a general notion of excessive water on land which causes damage. High intensity flooding can occur in the West Sudanian Savannah, particularly along major rivers such as the Pendjari and Niger Rivers that flow through the region. However, the floods commonly experienced in the case study areas are not such intense events and occur more frequently as a result of heavy rainfall. Despite a lower magnitude than some of the larger fluvial flood events, the impacts from heavy rainfall induced (pluvial) flooding are keenly felt, nonetheless.

As interviews with local residents illustrated, flooding arises in various forms across the case study villages. Some village such as Timbouni in Benin were most affected by fluvial flooding. In addition, in Burkina Faso, some interview respondents such as BF2012Flo and BF2012Dab highlighted a rising water table as their main source of flooding (i.e. groundwater flooding). Across all three case studies, pluvial sources of flooding were prevalent and despite some of the variations in additional sources of flooding, the impacts were found to be very similar.

The hazards experienced in the case study areas can, therefore, be described as low intensity but high frequency events. Such hazard magnitudes tend to be neglected in the

literature which leans towards a focus on the more dramatic, high intensity but low frequency events. However, less intense events can still have devastating effects on communities. As Roncoli *et al.* (2001) and West *et al.* (2008) highlight, in rural West African communities, the dependence on a particular pattern of precipitation in the rainy season means that disruptions in rainfall that lead to floods and droughts of low intensity can still wreak considerable impacts on people. These types of low intensity hazards are, therefore, particularly important to study in addition to the more extreme events.

2.5 Climate change and changing hazard profiles

Although floods and droughts have long been known in the case study areas, there is a sense that these events are becoming more frequent with many interviewees citing climate change as a source for these trends as they are perceived on the ground (e.g. BN2012Kia, BN2012Far, BF2012Dre).

Scientific observations show that precipitation levels appear to have recovered in the last couple of decades following the drier years of the 1970s and 1980s (Salack *et al.*, 2015). The trend in total rainfall suggests a recovery which some have cited as demonstration that climate change may influence precipitation in the region for the better (Dong and Sutton, 2015). Indeed, some global climate models (GCMs) have predicted an increase in precipitation as a result of global warming, whereas other models predict a decrease. The widespread disagreement in modelling precipitation is complicated by scientific observations and local perceptions. Scientific observations show a relatively stable annual precipitation over recent years. In contrast, local perceptions identify a decrease in total precipitation. This is confirmed through interviews carried out in this research as well as previous work by Mertz *et al.* (2012) and West *et al.* (2008). The mismatch in scientific observations and local perceptions appears to arise from differences in precipitation assessment measures. GCMs and scientific observations tend to focus on total annual precipitation which measures the sum of rainfall over the course of the entire season, beginning from the very first rain at the start of the season to the very last, at the end. However, as this research illustrates, large breaks in rainfall, particularly near the onset of the rainy season, mean that the early rainfalls are of little benefit and are increasingly disregarded (e.g. BN2012ExpHea, BF2012Tow, BF2012Cot, BFLof2, GHSum1). In addition, it transpires that whilst the rainy season is effectively being reduced by prolonged dry spells. The total rainfall is thus condensed to fall over fewer rainy days, which results in higher intensity events that cause flooding (Mertz *et al.*, 2012). This creates a reality of a highly disrupted rainy season comprising dry spell droughts and

floods from the annual precipitation being condensed over fewer days, although total precipitation remains stable, providing the scientific community with a different perception of the trends.

As Ibrahim *et al.* (2014) and Salack *et al.* (2015) highlight in their work on regional climate patterns, in the West Sudanian Savannah context, floods and droughts are related to intra-seasonal variations rather than extremes in total precipitation. Too much and too little precipitation at key points in the traditional crop growth cycle are the determinants of flood and drought hazard events. Based on this and drawing on the need to assess intra-seasonal variability, Salack *et al.* (2015) and Ibrahim *et al.* (2014)(Mertz *et al.*, 2012) use regional climate models (RCMs) to project climatic trends in the future. Unlike the coarser GCMs, the RCMs focus on measures such as the number of rainy days, the frequency of intense rainfall events and the length of dry spells. From this research, they find that the trends observed at the local level, and highlighted by local communities, are likely to be exacerbated by climate change (Ibrahim *et al.*, 2014; Salack *et al.*, 2015). Ibrahim *et al.* (2014) and Salack *et al.* (2015) reveal an increase in both the frequency of intense rainfall events combined with prolonged dry spells and a reduced number of rainy days. They conclude that this will make floods and droughts more "hazardous".

This research aims to understand the likely impacts of the trends identified by the local communities and projected to become exacerbated by climate change, according to the regional model outputs. This research is novel in considering both floods and droughts and the potentially amplified effects of both hazards occurring in the same rainy season. The research looks not only at the impacts of these hazards under climate change conditions but also analyses the response capacity of local communities that might mitigate these impacts.

2.6 Institutional support and policies for disaster management

In order to support communities in responding to and managing risks such as floods and droughts, governmental and non-governmental agencies can provide risk management support in a variety of ways. The specific structure of governmental risk management and natural hazard support arrangements vary from case study to case study, as a result of different hierarchies and approaches at national levels. However, in all case, a hierarchical process comes into play when a natural hazard event such as a flood or drought takes place. This usually involves information being fed up from the local level through the relevant governmental agencies to an appropriate higher level where a

decision is made on the degree and nature of support to be provided. In Benin the disaster management organization is the Agence National de Protection Civile (ANPC), in Burkina Faso it is the Conseil National de Secours d'Urgence et de Réhabilitation (CONASUR) and in Ghana it is the National Disaster Management Organisation (NADMO). These are the organisations that oversee disaster management in the respective case study countries.

2.6.1 Institutional arrangements for disaster management in Benin

The republic of Benin manages disasters through the Comité National pour la Protection Civile (CNPC) or the National Committee for Civil Protection under the Ministry of the Interior. The CNPC was set up in 1985 following the introduction of Decree number 85-112 entitled "Portant creation, composition, attribution et fonctionnement du comite national pour la protection civile" which can be translated as a decree on the development, composition and function of the CNPC. Under Decret 85-112, the CNPC is charged with the organization of security in the event of a disaster. As such, the CNPC is tasked with developing a plan to ensure the protection of people and property from all types of threats and natural disasters.

To support the CNPC, a Secretariat was set up to work alongside the CNPC in order to manage equipment and coordinate the efforts of different organizations and agencies. In addition, the CNPC is supported by sub agencies at the provincial, district, commune and village level. A hierarchical process is in place whereby information about disasters can feed up and down the hierarchies as necessary to reach the relevant level. The CNPC also has the authority to call on the support of any other ministry as necessary and relevant to help manage the disaster.

Under the Direction de la Prévention et de la Protection Civile (DPPC), the key objectives of the CNPC are to alert authorities and prevent loss, to develop back up plans and provide protection during a hazard event, to evaluate the needs of victims and to centralise and coordinate relief. These duties were reinforced in 1987 by the Plan National d'Organisation des Secours en cas de Catastrophe, also known as the Plan ORSEC. The goal of this Plan was to ensure greater efficiency across the different levels of the hierarchy in order to improve the functioning of the DPPC. However, as reported in the UNISDR (2005) "Document d'information sur la prevention des catastrophe au Benin", there are considerable challenges to effectively implementing the policies and objectives of the CNPC in practice. These challenges are summarised as limited financial, material and human resources. The document states that funds for disaster prevention are not

allocated in the national budget, although there are plans to change this (UNISDR, 2005). It also notes that it is particularly difficult to form and equip voluntary teams in order to carry out prevention activities such as raising awareness and that the country appears less able to prevent disasters and focuses instead on providing assistance in the aftermath. As a result of the challenges outlined, Benin depends on external support from Non-Governmental Organisations (NGOs) and UN agencies to manage disasters and provide support in preventative measures. In the past, UN OCHA has provided support, including via cash grants (UN OCHA). At the more local level, NGOs such as Plan Benin and the Red Cross (Croix Rouge, Benin) effectively have a permanent presence in the case study area to provide support in the event of a disaster.

2.6.2 Institutional arrangements for disaster management in Burkina Faso

With foundations that stem from 1973 under the name of the Sous Comité de Lutte Contre les Effets de la Sécheresse (Sub/Under Committee of the fights against the effects of droughts), the Conseil National de Secours d'Urgence et de Réhabilitation (CONASUR) has evolved to broaden its remit and to cover a multitude of different hazards, beyond its original focus on droughts. Evolving into CONASUR but with the Co standing for "Comité", Decree No. 2004-624/PRES/PM/MASSN saw the Co become Conseil, reflecting a greater emphasis on the importance of addressing hazards and security.

CONASUR is broadly tasked with three principal domains of action: prevention, management during a crisis and recovery in the aftermath of a crisis. CONASUR is responsible for coordinating information and mobilizing resources on the ground. It operates through a hierarchical system with CORESUR at the Régional level, COPROSUR at the Provincial level, CODESUR at the Département level and COVISUR at the village level. In addition, CONASUR depends on the support of a wide range of non-governmental organizations, bilateral and multilateral agencies as well as other governmental departments. In particular, CONASUR works closely with Action Sociale who operate at the local level to provide reports of disaster events to CONASUR who then mobilize resources for Action Sociale to distribute to groups and individuals defined as vulnerable.

In terms of multiple hazards risks, the government of Burkina Faso developed the 2009 "Plan national multirisque de preparation et de reponse aux catastrophe" which aimed to clarify responsibilities, improve coordination between sectors, identify and reduce the most probable risks as well as develop a framework for the consideration of all risks,

generally. Another goal was to reduce delays in intervention and to reduce the number of fatalities caused by disasters.

Despite a long history of concerns with natural hazards and an increasing awareness of multiple hazard risks, CONASUR recognizes and emphasizes that it is unable to achieve all of its goals due to funding challenges. Despite a long and serious history of major hazard events, particularly droughts and floods[1], the Burkina Faso government does not regularly allocate a budget for disaster management activities. CONASUR therefore states that although prevention measures are highly desirable and important to prevent future damages and lives being lost, the lack of national funding means that CONASUR is dependent on the support of external organizations. However, the high costs and long term nature of developing prevention measures is seen as a key obstacle.

2.6.3 Institutional arrangements for disaster management in Ghana

Disaster management in Ghana is coordinated by the National Disaster Management Organisation (NADMO). The organization was established in 1996 by Act 571 and falls under the responsibility of the Ministry of the Interior (National Disaster Management Organisation). NADMO is generally tasked with the coordination of efforts to manage disasters which includes activities to raise awareness and preparedness such as education and early warning systems, as well as hazard and vulnerability assessment and the provision of relief and support in the aftermath of a disaster. NADMO's remit covers a broad range of potential disasters including disease epidemics and man-made disasters. Floods and droughts are also included as part of the hydro-meteorological disasters that NADMO responds.

The organization of NADMO is based on decentralization with the headquarters at the national level, under the Ministry of the Interior and regional, district and then zonal offices. There are 10 regional offices, 140 district offices and 900 zonal offices, all responsible for disaster management activities at their level.

In addition to NADMO, Ghana has incorporated disaster management objectives into several plans and policies with the support of external agencies such as the World Bank, UNDP and UN OCHA. Some of the more prominent policies and plans are the National Disaster Risk Reduction Policy (2011-2015) which advocates the consideration of disaster risk reduction in organizational planning, budget and operations. The UNDP supported

[1] Major flood and drought events include a severe drought in 1983/1984 and more recently flooding in 2008

the development of the Ghana Plan of Action for Disaster Risk Reduction which deals with assessment and forecasting and UN OCHA helped develop Disaster Management Plans in the three northern regions. Further to these plans, hazard maps of the White Volta were developed in 2010 following the flood events of 2007/2008. These maps are intended to support the identification of disaster risk reduction measures, investment in hydrological and meteorological services and the provision of early warning systems.

In practice, NADMO struggles to achieve its objectives due to a lack of funding and limited enforcement capacity. The national progress report on the implementation of the Hyogo Framework for Action (2009-2011) highlighted ineffective bye-laws at the district level and a lack of systematic policy and institutional commitment. The 2013 NADMO report on major activities also pointed to budgetary issues that restricted core activities, mentioning specifically insufficient stores of relief items, insufficient warehousing space for relief items and insufficient vehicles to transport relief items to communities in need. The lack of sufficient funding is a sentiment echoed by interviews with local community members as well as officials from the key disaster and water management organisations. Although, relief was provided to some experiencing hazard events, NADMO aims to work on disasters at three levels: preparedness before a disaster occurs, action during a disaster and relief and reconstruction after a disaster. According to interviews, efforts on preparedness were particularly hampered by financial constraints. As such, and similarly to the case in Benin and Burkina Faso, the focus is instead placed on post-hazard response rather than pre-hazard planning and preparedness.

Essentially, Ghana has produced several policies and plans, with the support of other agencies, to address disasters in line with international efforts through the UN decade for disasters. However, in practice NADMO struggles to implement these plans and policies effectively and a disaster management action remains predominantly within the realm of local communities and volunteers.

2.6.4 A comparative summary of institutional arrangements and support for disaster management

All three countries have institutions at the national level that are responsible for disaster management. These institutions also all have a mandate to take action prior to disasters through prevention activities, during disaster events to mitigate damage and following disaster events in order to support those most affected and facilitate a recovery. Yet, despite the emphasis on the importance of these activities, all three highlight budget

challenges and a lack of sufficient funding to enable the full scope of hazard management activities to be carried out.

Other similarities between the case study countries are the decentralised approaches to disaster management with several interim layers between the national down and local, village level. Staffing and financing of these different levels is clearly a challenge and the hierarchical process takes time to work through in order to mobilize support. A slight difference can be seen in the number of layers with Ghana and Benin having four levels but Burkina Faso having five. Other differences are the dates of inception of the disaster management organisations with Ghana as the most recent in 1996 and Benin in 1985 but Burkina Faso's CONASUR has its roots in the 1970s with CONASUR being named in 1993 and re-named in 2004. All three national organisations have connections to the UN decade for prevention of natural disasters which seems to have catalysed the enhancement and development of the respective national organizations, however, practical application of hazard management and disaster reduction activity remains limited.

2.7 The role of non-governmental organisations (NGOs)

Where funding is insufficient, preventative activities are often the most neglected aspect of disaster management, with efforts concentrated on providing support during and after a hazard event. Due to a lack of sufficient funds, the institutions are dependent on external support and consequently work closely with various international agencies, such as Plan, the Red Cross, CARE, the World Bank and various UN agencies.

In all three case studies, a host of temporary and more permanent NGOs are and have been engaged in various forms of disaster management support. NGOs aim to improve local conditions through the construction of wells or through programmes to support women to improve their livelihood options etc. These organizations are all involved in various projects in a largely uncoordinated manner. Some of the main and more permanently engaged NGOs are Plan and the Red Cross. In Burkina Faso, the presence of the Dreyer Foundation for scientific research provides the Burkina Faso case study with a unique connection to ongoing, high quality research and investment in improving the local agricultural conditions. The influence of the Dreyer Foundation is visible in the results and findings of this research and serves to illustrate what can be achieved with sustained dedication. Equally, the gaps that remain serve to demonstrate the reality of limitations in the Dreyer Foundations' reach and highlight the comparability and

similarities of the results and how they connect to the Benin and Ghana case studies. The difference between those households that benefit from the Dreyer Foundation activities and those that are not engaged in such endeavours highlights the similarities of the underlying conditions and how comparable the three case studies generally are.

Due to the lack of institutional capacity and limited reach of NGO and UN agency activities, practical support for natural hazards is often limited and thus there is a need for local communities to support themselves. Focussing on the local level, the capacities and approaches utilised by the case study communities will demonstrate the degree to which they are successful and how climate change might affect the longer term success and suitability of these capacities.

2.8 Comparison of the case studies characteristics

The three case studies bear considerable commonalities across all aspects of daily life and hazard exposure. Subtle differences are present which influence the overall experiences and outcomes of hazards, coping and adaptation processes and these will not only be taken into account but may provide a useful insight into alternative approaches from which the other case studies can learn lessons. Table 2.3 outlines some of the key differences among the case studies, as revealed in the preliminary, scoping visit.

Theme	Differences BF	Differences BN	Differences GH
Hazards	Groundwater flooding	Fluvial flooding	Fluvial flooding
Farming	Cotton	Cotton Yams	Differentiation between early and late millet
Organisational support	Cotton cooperatives Dreyer Foundation	Cotton cooperatives	
Dwellings	Mud and brick	Mud and brick	Concrete buildings more prevalent
Alternative occupations	Mostly self-employed	Mostly self-employed	Mostly employed
Migration	Migration to Ivory Coast and Ghana	Migration to Nigeria	Migration within Ghana

Table 2.3 Differences between the case studies

The selection of the three case studies is founded on the premise that all three comprise rural communities with considerable dependence on agriculture, particularly rain-fed agriculture. They are all located in the same climate zone, receiving similar annual rainfall totals, and subject to the same traditional climate with a single rainy season. As such, all three are susceptible to seasonal variability which has been observed and noted by some as a recent but evident trend across the case studies and wider West Sudanian

Savannah, potentially linked to climate change. The three case studies lack notable support from national institutions based on the limited resources of these institutions. Instead, NGO presence and projects provide the main input of ideas and support for development and vulnerability reduction. Although different NGOs are active in the different case studies, the projects are often similar in their targets and operation.

The main difference between the case studies is Ghana's relatively higher wealth. However, as illustrated in this chapter, at the local level, the case studies reflect little variation between them, with the relatively higher level of development in Ghana as a whole not reflected at the local level of the case study. As such, the three case studies are designed to enable a deeper understanding of the trends and processes related to natural hazards and climate change in the future with a focus on the West-Sudanian Savannah climate zone. The comparability of these case studies will be revealed in the results chapter and the degree to which these findings can be considered representative of the wider West-Sudanian Savannah climate zone will be evaluated in Chapters 5 and 6.

3 Theory and Conceptual Approaches

3.1 Vulnerability in multiple hazard risk assessments

In 1990, Diana Liverman stated that "we need to know how to deal with multiple vulnerabilities to multiple threats" and that "we need to decide whether studying the existing pattern and degree of vulnerability to drought and other conditions is an accurate guide to future vulnerability" (Liverman, 1990, p. 39). Despite this call, efforts to understand and assess vulnerability to multiple hazards are only at an embryonic stage. As the following Chapter demonstrates, this is due to a lack of adequate consideration of the complexities of vulnerability. This chapter outlines key conceptual and theoretical perspectives that contribute to a stronger approach to account for multiple and more frequent hazard events as anticipated under climate change. To conclude the chapter, a framework is developed based on the key concepts. This framework is both a conceptual and analytical framework to support the empirical analysis.

Interest in multiple hazard risks has been particularly sparked by the recent tsunami events that were preceded by earthquakes. The catastrophic 2004 Indian Ocean Tsunami and 2011 Tohoku earthquake that also led to a tsunami have both highlighted the potential for natural hazards to occur in deadly cascades. The Tohoku earthquake and subsequent tsunami, in particular, brought to the fore the importance of not only understanding the potential for cascading hazards but also the impacts of their interactions on people and infrastructure. In response, there are increasing attempts to assess multiple hazard risks but as a relatively new field of enquiry, key gaps remain outstanding.

Adger (2006) identifies a trend that current research is moving towards addressing multiple stressors and pathways of vulnerability. Although several authors, such as Schroeter *et al.* (2005), O'Brien *et al.* (2004b), Eakin and Luers (2006) and Tschakert (2007), acknowledge the role of multiple stressors, these stressors are often broader than multiple natural hazard sources of stress. For example, O'Brien *et al.* (2004b) and Tschakert (2007) use the example of climate change and globalisation to illustrate the concept of being 'doubly exposed'. As such a gap remains for studies in vulnerability to multiple natural hazard type stressors.

Where multiple natural hazards are considered, the multiple hazard risk assessment approaches that are applied often address vulnerability in a superficial manner because

these assessments are designed to better understand the potential for cascading hazards (Bell and Glade, 2004b; Nadim and Liu, 2013; Thierry *et al.*, 2008; Wipulanusat *et al;* Greiving, 2006). The emphasis appears to be placed on the hazards element of the risk equation, with the goal being to identify where hazard exposures overlap and thus where potential hazard interactions may occur that may affect the probability of a multi-hazard event (Delomonaco *et al.*, 2007; Kappes *et al.*, 2012). Although multiple hazard risk assessments are often focussed on cascading multiple hazards, there are other ways in which different hazards might interact. Malet *et al.* (2010) describe different types of multiple hazard interactions. Based on this, it is possible to develop a typology of multiple hazard interactions (Table 3.1). Bell and Glade (2004a) and Malet *et al.* (2010) describe cascading hazards as hazards that may trigger or increase the probability of a second (different) type of hazard occurring. An example of this is a flood that increases the probability of a landslide, such as might occur in a mountainous area, or another example is an earthquake that might trigger a landslide. These can be classed as cascading hazards and are central to several practical attempts at multiple hazard risk assessments (Bell and Glade, 2004b; Thierry *et al.*, 2008).

Different to cascading hazards, a multiple hazard event may comprise two hazard events that could occur individually but can also occur simultaneously as a "combined" hazard. An example of this might be a storm that brings strong winds and heavy rainfall which floods the land and damages property. Such types of multiple hazards can be considered "combined hazards". A third type of multiple hazard can be seen as "coincidental" hazards. These are hazard events that have no connections or interactions that influence their manifestation at that the same time. Instead they may occur simultaneously by coincidence. An example of this might be high tides combined with heavy rainfall that cause flooding. Finally, Pelling *et al.* (2002, p. 285) describes multiple hazards events that occur in succession. These could be mutually exclusive hazards such as a drought and a flood, but by occurring in succession they may potentially result in exacerbated impacts.

The example of "successional" type multiple hazards, is particularly relevant to this research as the subject of interest is the potential for floods and droughts that occur in succession to exacerbate impacts on social-ecological systems. However, this is one type of multiple hazard risk that is especially neglected in the multi-hazard risk literature to date. Due to the nature of the Indian Ocean Tsunami and Tohoku disaster, attention is focussed mostly on cascading type hazards. These hazards are often examined by mapping exposure in order to identify where multiple hazards may overlap (Delomonaco *et al.*,

2007; Thierry *et al.*, 2008; Kappes *et al.*, 2012; Bell and Glade, 2004b). Whilst this approach can be helpful for planners and those who wish to identify risk free land (Delomonaco *et al.*, 2007), this leads to an emphasis and focus in the multiple hazards literature on exposure with the potential effects on vulnerability habitually overlooked.

	Description	Hazards influenced by each other	Example
Cascading Hazards	Hazard 1 triggers hazard 2	Yes	Flood that triggers landslide
Combined Hazards	Hazards 1 and 2 occur at the same time	Yes	Hurricane that brings strong winds and flooding
Coincidental Hazards	Hazards 1 and 2 occur at the same time	No	High tides and heavy rainfall that both cause flooding
Successional Hazards	Hazard 1 is followed by Hazard 2	No	Flood followed by a drought

Table 3.1 Types of multiple hazards.

Risk is comprised of both hazard exposure and vulnerability (Wisner, 2004). Therefore, to present multi-hazard maps as *risk* maps, vulnerability must also be included (Delomonaco *et al.*, 2007; Kappes *et al.*, 2012). The approaches presented by Levy *et al.* (2010), Garcin *et al.* (2008) and Bell and Glade (2004b), for example, do include vulnerability, however, they include vulnerability as a separate, single and simplified layer. This indicates that such assessments are not hazard specific, yet as Kumpulainen (2006, p. 73) notes, "each hazard poses a different threat to different aspects of human life and the environment". A similar perspective of vulnerability as hazard specific is advocated by Adger and Kelly (1999) and Birkmann (2007).

Furthermore, a single layer of vulnerability also raises the question of how the values of the vulnerability layer should be adjusted (if at all) to account for more than one hazard. Adams *et al.* (1998, p. 266) suggest that multiple hazard events, whether occurring simultaneously or successively, can have "cumulative effects on household resilience" (Adams *et al.*, 1998, p. 266). From the multi-hazard risk assessments presented in the literature to date, it is not clear whether the values in the vulnerability layer are adjusted or not to account for multiple hazards and whether they should be. At present, it appears that the layers predominantly map potential lives lost and physical assets potentially at risk (Levy *et al.*, 2010; Dilley *et al.*, 2005; Bell and Glade, 2004a), giving these a value but not varying that value to reflect the additional hazards. A question is clearly outstanding as to whether these figures should be adjusted. Should they, for instance, be doubled to account for two hazards, and trebled for three? Should they be kept equal regardless of

the number of hazards, based on the assumption that one hazard may cause all of the damage and thus a second hazard event would have no additional impact? Or, bearing in mind the fundamental call that vulnerability is hazard specific, is vulnerability more complex?

Ironically, the current approaches to vulnerability in multiple hazard risk maps are reflective of old approaches to single hazard assessments and this reveals a distinct gap between the progress on vulnerability in natural hazard risk research for multiple hazards compared to current approaches to single hazards, which is considerably more advanced. As the following section demonstrates, vulnerability has developed over time to become a prominent component of hazard risk assessments. It is argued here that the multiple hazard risk assessment approaches should draw on the progress in the vulnerability literature to build important lessons from this into multiple hazard risk assessments in order to better account for the complexity of risk and implications on people and communities such as those in the West Sudanian Savannah climate zone.

3.2 The rise of the social dimension in risk

Up until around the 1970's, hazards research was predominantly focussed on hazard exposure, in particular, understanding the spatial distribution of hazards at various magnitudes. At that time, hazard magnitude was implicitly linked to hazard impact. However, with seminal articles and books such as Hewitt (1983) and O'Keefe *et al.* (1976), the role of the social dimension became increasingly recognised as a determining factor in natural hazard impacts and disaster. As O'Keefe *et al.* (1976) and Hewitt (1983) argue, natural hazards themselves are not natural disasters. Natural hazards should be seen instead as natural processes and, rather, that a disaster occurs when the impacts of a natural hazard infringe upon and are severely detrimental to people (Lindell *et al.*, 2006). Natural disasters are therefore combinations of natural hazards and social conditions and processes. Comparing natural disasters where the hazard events are of similar magnitude but result in widely different impacts, highlights the importance of the social dimension in determining the overall hazard outcome.

The increasing recognition of the role of social conditions and processes in determining natural hazard impacts and outcomes has resulted in considerable attention being paid to understanding the social dimension of risk. This has given rise the prominence of the concept of vulnerability in the risk literature, reflecting an anthropocentric view that hazards are of interest because they affect people (Buckle, 1999, p. 21; Liverman, 1990).

However, the theory and literature relating to vulnerability has developed substantially over recent decades to emphasise how social conditions and processes are significant in determining the overall impact of hazard events, beyond simply that they affect people.

Vulnerability theory now emphasises the role of underlying conditions such as poverty and limited access to resources as factors that contribute to the propensity to harm and help to explain differences in impacts when a hazard event occurs (Hufschmidt, 2011; Romieu *et al.*, 2010). In this respect, the literature and conceptualisation of vulnerability have benefitted from research conducted on famines by Watts and Bohle (1993) and Sen (1979). In particular, Sen's (1979) development of an 'Exchange of Entitlements' theory emphasises the role of power in determining access to resources which consequently affects the propensity to harm. Blaikie *et al.*'s (1994) Pressure and Release (PAR) model illustrates how these underlying conditions can lead to natural hazard disasters.

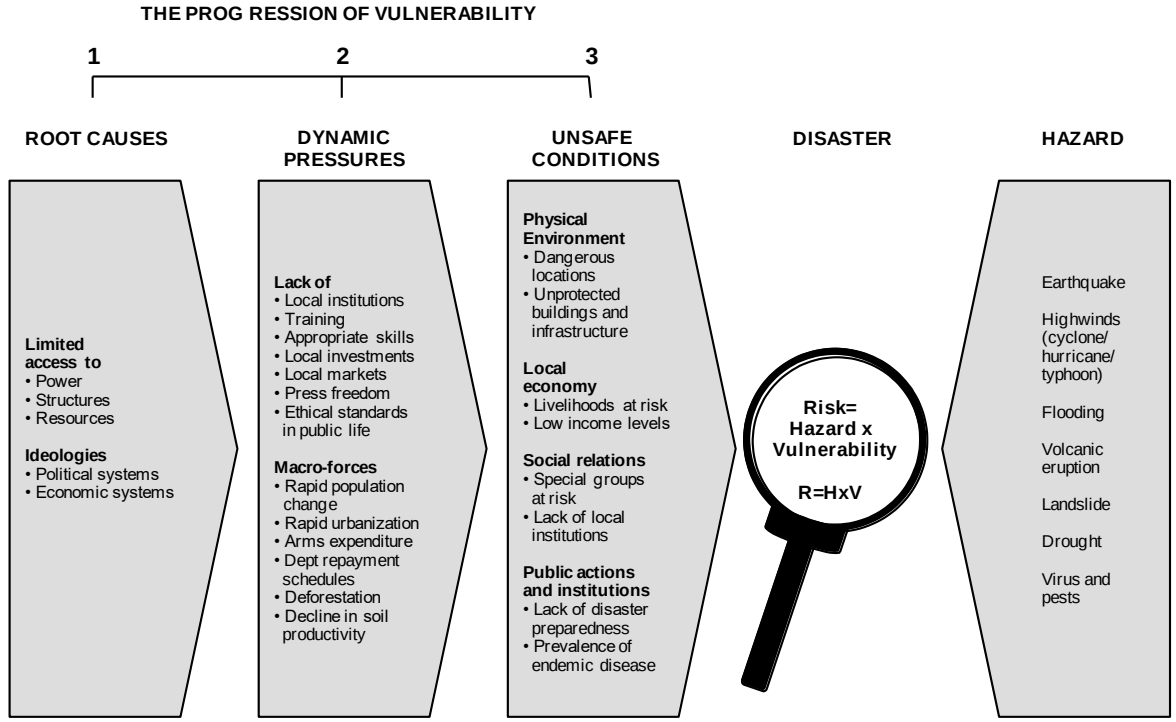


Figure 3.1 Pressure and Release (PAR) model. Source: Blaikie *et al.* (1994)

The PAR Model depicts disasters as derived from unsafe conditions which stem from root causes and dynamic pressures. The Model emphasises the role of root causes or underlying conditions and processes that lead to unsafe conditions or propensity to harm (vulnerability). The authors (Blaikie *et al.*, 1994) highlight that a disaster occurs when these unsafe conditions are coupled with a hazard event. As such, the PAR model demonstrates that vulnerability is a combination of root causes and dynamic pressures

that lead to unsafe conditions and that risk arises when this vulnerability is combined with hazard exposure. The equation at the heart of the disaster section of the model is widely cited throughout the literature, and places particular emphasis that risk should take both hazard and vulnerability elements into account.

Risk = Hazard exposure x Vulnerability

Although the risk equation highlights the role of both exposure and vulnerability in determining overall hazard risk, work that examines the spatial patterns of hazard exposure finds that exposure can be correlated with spatial distributions of vulnerability. As such, it is possible that there may be a causal relationship between hazard exposure and vulnerability and thus the two components of the risk equation may not be independent of each other (Kumpulainen, 2006; Lewis and Kelman, 2010). However a causal relationship has not been proven and there remains a debate about whether it would be vulnerability that influences the likelihood of being more highly exposed to hazards or if hazard exposure influences vulnerability. As such, the two elements are considered distinct here but it is noted that there may be factors that influence vulnerability which also influence exposure.

The PAR model advocates that as vulnerability is determined by root causes and dynamic processes, therefore, to effectively address vulnerability, it is necessary to focus on these factors. Kelly and Adger (2000) and O'Brien *et al.* (2004a) describe approaches focussed on root causes as the 'starting point' perspective and this is contrasted to what they term the 'end point' perspective.

The starting-point perspective reflects the view that vulnerability is related to underlying conditions (as advocated above) whereas the end-point perspective reflects the view that vulnerability is the harm experienced following a hazard event. This perspective takes coping and adaptation actions into account to view vulnerability as the 'residual' harm (Kelly and Adger, 2000). Both perspectives receive criticism. The starting-point is criticised as focussing on the underlying conditions so substantially that assessments overlook the role of the hazard context and present an impression that the vulnerable are passive victims (O'Brien *et al.*, 2004a; Prowse, 2003; Brooks *et al.*, 2005). In contrast, the end point perspective sees vulnerability as the harm that arises from a hazard event, therefore placing more emphasis on the hazard context. In addition, the end-point perspective emphasises the consideration of coping and adaptation as actions that reduce the overall harm, resulting in a view of vulnerability as the residual harm arising from a

hazard event after the application of coping and adaptation. For the end-point perspective, the main criticism revolves around the neglect of underlying conditions and factors that influence the likelihood of harm. By neglecting to consider these factors, opportunities to address and reduce vulnerability might be overlooked.

Vulnerability remains a contested concept, particularly in the literature that aims at a conceptualisation of vulnerability that can be practically applied. Calls for universal definitions and approaches remain unanswered as various definitions continue to evolve (Hufschmidt, 2011, p. 623; Cutter, 1996, p. 529; Adger *et al.*, 2004, p. 28). However, these definitions, although varied, do tend to converge around the notion of vulnerability as a propensity to harm (Adger, 2006) or loss (Buckle, 1999; Cutter *et al.*, 2003). The conceptualisation of vulnerability as the propensity to harm reflects the rise the weighting given to underlying conditions in vulnerability assessment as propensity implies a tendency and pre-condition that contributes to an increased likelihood of a negative outcome when a hazard or other stress is applied. Ultimately, this is a broad conceptualisation which Timmerman (1981) and Liverman (1990) argue is too broad to be practically useful.

The argument in favour of a universal definition and universal approaches to assessing vulnerability stems from the desire to compare regions and countries globally. In such assessments, a standardised approach to vulnerability can aid the identifications of general patterns of vulnerability and key hotspots. However, to understand the more detailed underlying causes and processes of vulnerability at a local level, for policy intervention and recommendations, a different approach is needed in order to account for the context specific elements of vulnerability (Adger *et al.*, 2004; Kelly and Adger, 2000; Brooks *et al.*, 2005). Indeed Cutter (1996) and Cutter *et al.* (2003) argue for a place-based approach to local level vulnerability assessments that develops proxies and indicators that take into account the local context and hazards to develop a more locally-specific approach.

3.3 The Social-Ecological Systems perspective

The over-emphasis of underlying social conditions in vulnerability assessments that leads to a lack of accounting for environmental factors, and the hazard itself, can be addressed by taking a social-ecological systems perspective.

The social-ecological systems perspective is grounded in systems theory. Systems theory essentially opposes the reductionist approach of traditional scientific experimentation

which is driven by a desire to test the nature and strength of a relationship between two isolated variables (Walker *et al.*, 2006). This approach sees scientific knowledge as developed through a compilation of these relationships between numerous pairing of variables. As Bertalanffy (1969) and Gallopín (2006) advocate, systems theoryargues, instead, that the world is comprised of more complex interactions and that the relationships and interactions between variables are not necessarily linear but may comprise circular or multi-linear connections (Folke *et al.*, 2002; McLaughlin and Dietz, 2008). Such complex interactions cannot be properly understood by separating out the individual variables and testing them one at a time. Instead, a more holistic approach is required (Walby, 2003; Walker *et al.*, 2006; Hodgson, 2012; Folke *et al.*, 2010).

Reflecting both the holistic perspective of systems theory and the paradigm shift towards a greater consideration of the social dimension in risk, Andrade *et al.* (2011) argue that a social ecological systems perspective provides a mechanism for examining the interdependencies and interconnections between social and ecological components of risk that are otherwise neglected. Anderies *et al.* (2004, p. 3) emphasises the connection by defining a social-ecological system as "an ecological system intricately linked with and affected by one or more social systems". Indeed, Jahn *et al.* (2009) and Ostrom (2009) argue that it is these connections between both elements of the social-ecological system that is critical to understanding, analysing and assessing vulnerability and risk.

Underpinning the desire to account for both social and ecological components of systems is an understanding that the processes inherent in ecological systems are driven by nature and can be examined through natural science approaches. In contrast, the social components are governed by human agency and structures that are subject to human consciousness and perspectives which make this element particularly difficult to analyse and forecast (McLaughlin and Dietz, 2008; Mertz *et al.*, 2009). Yet, the interactions and processes of and between both the social and ecological dimensions are critical to examinations of natural hazards which fundamentally connect the social sphere to the ecological (Pelling and High, 2005). This reflects the understanding that risk comprises the social and ecological dimensions but places a greater emphasis on the interactions and feedbacks between the two spheres.

In practice, applying the frame of social-ecological systems is complicated by the extensive networks and interactions of system components. Social-ecological systems, therefore, cannot be clearly defined and bounded at any scale below the global scale, as interactions cross scales and geographical spaces. However, for practical research it is necessary to

demarcate some boundaries to focus the study. Gallopín (2006, p. 294) states that this is possible as social-ecological systems "can be specified for any scale".

In the case of this research, the social-ecological system is examined at the local scale, where the impacts and responses are likely to be starkest (Levin, 1992; O'Brien *et al.*, 2004c). The social-ecological system of interest is communities in the West-Sudanian Savannah climate zone. More specifically, the social dimension is taken as the communities located in the research area and the ecological system is the natural environment within which the communities are located. The key connection between the social and ecological dimensions arises through agriculture where around 80% of the communities are directly engaged in agricultural activities. This direct connection constitutes what (Adger, 2007, p.84) refers to as a "tightly coupled" social-ecological system and thus provides an interesting subject for examining the impacts of climate change influenced natural hazard events.

It is important to highlight that the social-ecological system defined here is seen as comprising interconnections under 'normal' conditions. As such, natural hazards are seen as external to the social-ecological system in order to examine the effect of these perturbations on the social-ecological system as defined above. Hazards and climate change are not necessarily always seen as external to the social-ecological system. Indeed, natural hazards can be seen as natural events and thus comprise part of the ecological dimension. Whilst natural hazards do occur occasionally as part of the normal conditions in the West Sudanian Savannah, this research finds it more helpful to separate the hazards from the social-ecological system interactions in order to test the influence of the hazards on the web of connections. This perspective reflects Bohle's (2001) 'double structure' of vulnerability which views vulnerability as comprising an internal side concerned with coping and an external side concerned with the hazard. Whilst the hazard is recognised as central to determining vulnerability, it is also separated out in order to aid analysis. By examining the impact of climate change as a driving force on such a tightly coupled social-ecological system, it may be possible to illustrate the potential impacts and implications more clearly and to better emphasise the roles of both hazards and coping in determining vulnerability outcomes.

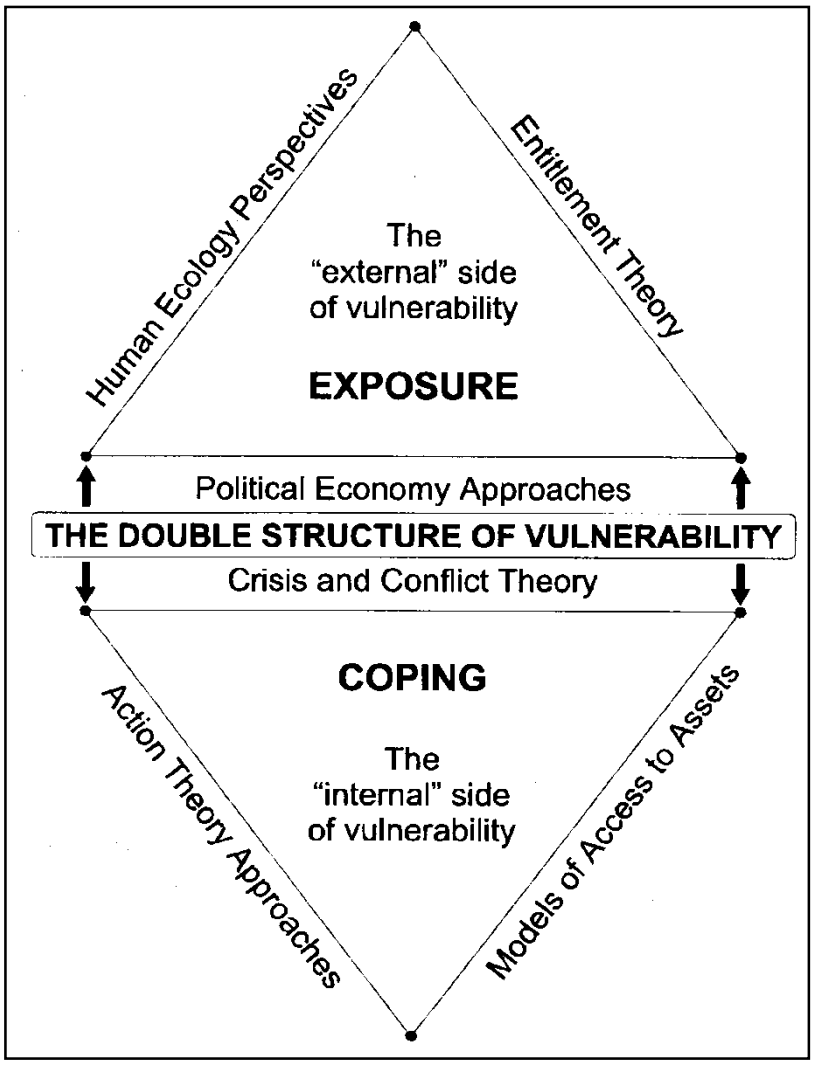


Figure 3.2 The 'double structure' of vulnerability. Source: Bohle, 20012

A further caveat to the demarcation of the social-ecological system of interest to this research is that the interactions and influences from other scales and communities outside the research focus areas may be influential and therefore important to account for. As Timmerman (1981) highlights, social-ecological systems are relatively open. Thus, the research approach will remain considerate of the potential for influences that stem from beyond the social-ecological system boundary and account for them where they arise as important factors.

3.4 Systems under pressure

Climate change is expected to bring unprecedented changes to environmental conditions. One of these changes is an expectation that climate-driven natural hazards, such as floods and droughts, will become more common and more intense as a result of changes to climate and seasonal patterns. Much of the research on climate change is concerned with the persistence of social-ecological systems under these changing conditions.

In the literature, persistence is often described as resilience. Resilience is a complex concept that has been interpreted in various ways by different researchers and research paradigms. Alexander (2013) traces the etymology roots of the concept back to the Classical time and illustrates that from this period, resilience is likely to have been related to notions of rebound and return to a previous position. Alexander (2013) highlights that this concept of returning to a previous position historically carried negative connotations. However, in recent decades, resilience developed in both engineering and psychology disciplines to carry more positive connotations of robustness and the ability to withstand stress (Alexander, 2013). Central to these conceptualisations is flexibility and the ability to alter under stress and return to a previous state when the stress has subsided. Flexibility and the role of stability and equilibrium in systems are central to the development of resilience in the ecological literature, particularly propelled by C.S. Holling.

Holling (1973, p.17) defines resilience as determining "the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist" (Holling, 1973, p.17). This definition incorporates the notion of persistence under stress through the absorption of change and is then extended to demonstrate the value of flexibility in systems as enhancing their capacity to absorb and rebound (Holling, 1973).

Based on these perspectives of resilience, persistence under stress is associated with flexibility, absorptive and rebound capacity which is derived from the components and connections in social-ecological systems. Stresses such as climate change raise important questions about these capacities but also about how the limits to absorptive and rebound capacity might be revealed and what the outcomes of exceeding these limits might be. Of particular concern is the potential for social-ecological systems to collapse.

3.4.1 The nexus of collapse and transformation

There are different views on what constitutes a collapse. Collapse can be seen essentially as the breakdown in key connections between system components (Gunderson and Holling, 2002). This might result in the loss of a key component to the system and/or fundamental changes in the system's outputs. From an anthropocentric perspective, the concern regarding climate change is that if it does provide conditions that lead a system to collapse, this collapse may result in the loss of the social dimension. In contrast to these concerns, Gunderson and Holling (2002) and Holling (1973) have a more positive view of instability and even collapse, seeing it as an opportunity for a system to reconfigure and

potentially reconfigure into a stronger, more desirable state. This introduces the notion of transformation.

Although interpretations and definitions of transformations vary, a transformation (or regime shift (Abel *et al.*, 2006; Scheffer *et al.*, 2002; Kinzig *et al.*, 2006; Abel *et al.*, 2006)) can be seen to occur as a result of "the capacity to create a fundamentally new system when ecological, economic, or social (including political) conditions make the existing system untenable" (Walker *et al.*, 2004, p.3). Transformations are often connected to the notion of regime shifts, with transformations describing the capacity and process through which a system changes from one configuration to another, and thus from one regime to another. Although it is often considered one of the three themes of resilience, transformation can also be seen as the opposite of resilience (Brown, 2014) or a failure of resilience, since a transformation refers to a new system configuration or regime (Kinzig *et al.*, 2006).

Walker and Meyers (2004) highlight that transformations can occur suddenly or gradually as the result of micro level processes that cause small changes which cascade until a transformation is achieved (Walby, 2003; Kinzig *et al.*, 2006; Lenton *et al.*, 2008; Gitz and Meybeck, 2012). Furthermore, from a social-ecological systems perspective, change in one part of the coupled system, for example change in the ecological system, may cascade into impacts and further changes to other parts (i.e. the social dimension) of the system. In the discussion on transformation, thresholds and tipping points are important related concepts. As Folke *et al.* (2010, p.3) describe, thresholds refer to "a level or amount of controlling", the threshold can therefore be seen as a line of resistance which once crossed leads to a new system. Tipping points refer to the specific moment that the line of resistance is crossed.

Thresholds and tipping points can be seen as forming the boundary between stable states (Kinzig *et al.*, 2006; Walker and Meyers, 2004). Similarly, Lenton *et al.* (2008) describes tipping points as a critical point "at which the future state of the system is qualitatively altered" (Lenton *et al.*, 2008, p.1786). The literature on tipping points and thresholds is particularly focussed on transformation as a negative outcome. Kinzig *et al.* (2006, p.5) describe new regimes as "frequently less desirable than the original regime". However, Cote and Nightingale (2012) and Weichselgartner and Kelman (2014) highlight the perspective perpetuated by Holling (1973) and Gunderson and Holling (2002) that regime shifts can lead to better systems. The concern regarding transformations stems from the theoretical arguments that thresholds and tipping points are often irreversible as they

tend to result in new regimes that are highly resilient (Kinzig *et al.*, 2006; Adger, 2000). However, Lenton (2011) emphasises that the exceedence of tipping points can be reversible.

Hodgson (2010, p.6) describes transformations as requiring the accumulation of a surplus in order to "make a leap" to a new state. This may be a leap to a better or worse state but the important message it that this accumulation of surplus is seen to push a system over a tipping point to a new configuration because the tipping point exhibits a degree of resistance that makes it particularly difficult to reverse. As Lenton *et al.* (2008) and Lenton (2011) argue, a reversal may be possible but is extremely unlikely to be achieved due to the need for an accumulation of resources to return over the threshold. Figure 3.3 illustrates the perception that crossing thresholds creates a new configuration that cannot be readily undone. In the context of climate change, the new climatic conditions are particularly likely to prevent a return to a previous state, therefore, Renaud *et al.* (2010) argue that there is a need to understand where thresholds and tipping points lie and whether these tipping points and thresholds would lead to sudden or gradual transformations in order to better understand how and when climate impacts may occur. However, the dynamic nature of thresholds make this a formidable challenge (Walker and Meyers, 2004).

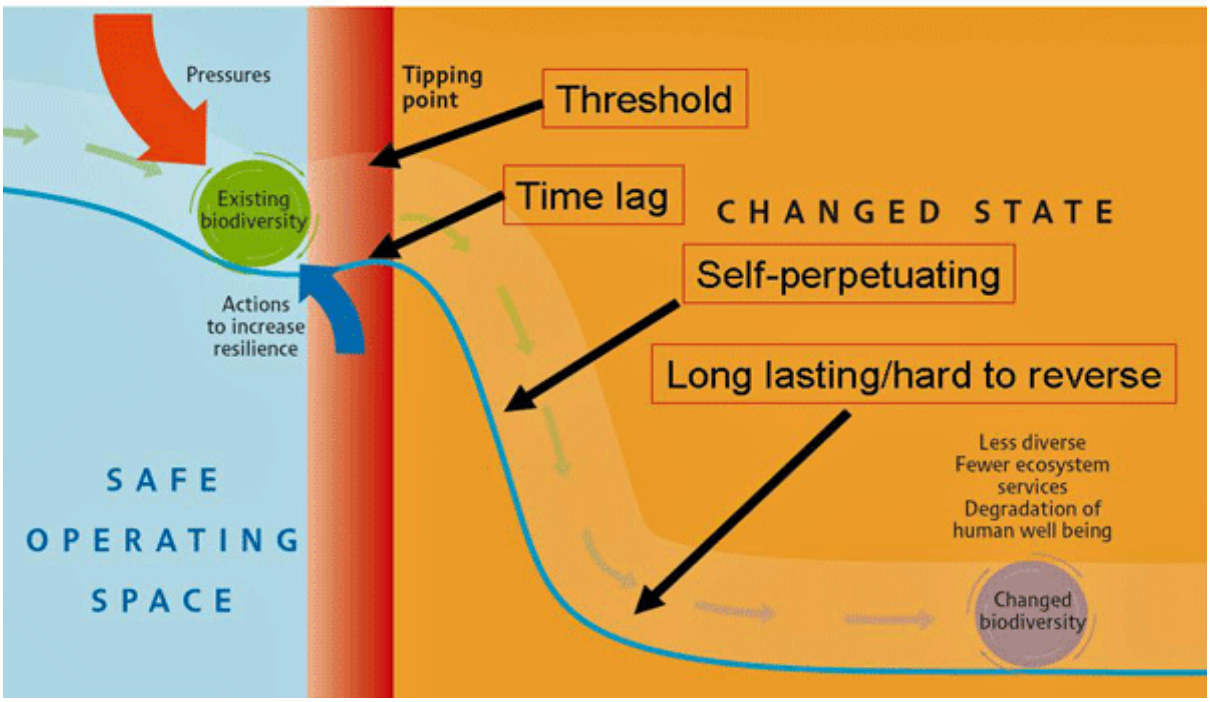


Figure 3.3 Thresholds and regimen shifts. Source: Secretariat of the Convention on Biological Diversity (2010).

3.4.2 Living with the pressure: coping and Adaptation

Whilst climate change places a pressure on systems that may cause them to transform or even collapse, there are possibilities for systems to adjust and absorb the stress in order to avoid reaching crucial thresholds and tipping points. These capacities that enable a system to persist under pressure and perturbation are often described as coping capacity and adaptive capacity.

Coping and adaptive capacity are sometime confused due to their similar foundation in the concepts as absorbing and adjusting to perturbations and stress. However, the two are fundamentally different concepts and this difference is important to make explicit. As Eriksen and Kelly (2007) and Berkes and Jolly (2001) both highlight, the main difference between the two concepts is the time scale on which they operate but this also has implications for the different processes that are enacted in coping and adaptation. Coping is seen as a short term and temporary adjustment made to manage a stress such as a hazard event as it arises. The resilience literature positions coping as a degree of flexibility in the fabric of the social-ecological system. In contrast adaptation reflects a longer term, permanent shift to accommodate the stress and therefore enhance resilience (Eriksen and Kelly, 2007; Berkes and Jolly, 2001; Gallopín, 2006; Hufschmidt, 2011; Adams *et al.*, 1998; Moser, 1998). As such, adaptation is often associated with a positive adjustment that capitalises on opportunities to strengthen the social-ecological system in the face of perturbation (Smit *et al.*, 1999). Of course, as Berkes and Jolly (2001) and Eriksen and Kelly (2007) highlight, coping strategies can become adaptation strategies if they are adopted on a more permanent basis after being enacted initially as a temporary response.

Heltberg *et al.* (2009), Berkes and Jolly (2001) and Smit *et al.* (2000) view adaptation as a deliberate action in response to an ongoing or future change. From this perspective, adaptation is a pre-meditated, purposeful response to a particular threat in order to increase the security and resilience of a social-ecological system. This purposeful adaptation may occur either in anticipation of a potential perturbation or in response to previous experience of a perturbation, such as a hazard event, and an expectation that this perturbation may arise again (Smit and Wandel, 2006; Smit *et al.*, 2000).

Kates (2000) argues that adaptation can be conscious or unconscious. Indeed, Adger and Kelly (1999) find that adaptation may not necessarily be deliberate but may, instead, occur coincidentally or as a positive side effect of other changes. Adger and Kelly (1999) thus describe adaptation as being involuntary or spontaneous, in addition to taking place

deliberately. This research recognises the arguments of all three perspectives and takes the view that adaptation can be positive or deliberate and can take place in response towards or anticipation of a perturbation.

It is important to note that adaptation is largely used with positive connotations and with the term 'mal-adaptation' being coined to denote adaptation that has taken place but has not been able to increase the resilience towards the perturbation (Smit *et al.*, 2000; Adger *et al.*, 2004). Again, this research is aware of the potential for mal-adaptation and finds it beneficial to differentiate between the adaptation and mal-adptation.

Coping can also be seen as a deliberate response and reaction to a perturbation as well as a passive response achieved through the inherent flexibility of a social-ecological system. The resilience literature roots coping in an engineering perspective, whereby the inherent flexibility of a system results in its ability to withstand certain degrees of stress. In the vulnerability literature, coping is seen as mitigating and reducing vulnerability by applying strategies that reduce the impacts of a stress on the social-ecological system (Turner *et al.*, 2003). Under the traditional resilience perspective, coping is passive, whereas, the vulnerability perspective presents coping as more conscious and deliberate. However, the vulnerability literature emphasises that coping capacity is constrained by social and ecological conditions (Cutter, 1996).

The literature on resilience provides a particularly helpful set of concepts to examine the potential outcomes of a lack of coping capacity in more detail. In this body of literature, coping capacity is viewed as system flexibility. Borrowing from the engineering roots of resilience (Alexander, 2013) , a lack of flexibility in a social-ecological system can be seen as translating into a brittle and inherently fragile system which is thus susceptible to collapse under stress. Gunderson and Holling (2002) and Holling (1973) argue that societies can often favour stability and thus aim to stabilise their social-ecological system in a manner that reduces their flexibility. The resulting rigidity leads to what Nelson *et al.* (2012) and Pelling and Manuel-Navarrete (2011) refer to as rigidity traps and what Walker *et al.* (2010) refer to as being 'locked in'. Nelson *et al.* (2012) and Pelling and Manuel-Navarrete (2011) argue that rigidity traps are likely to lead to collapse and transformation due to the brittleness of an inflexible system. In order to avoid reaching this point, it is necessary to foster a flexible and adaptable system and these are, therefore, key characteristics of resilient systems (Holling, 1973).

Coping and adaptive capacity represent the potential flexibility that reduces rigidity and brittleness. However, adaptation and coping capacities in social-ecological systems do not necessarily translate directly into actual flexibility. This is because a key factor that determines the translation of coping and adaptive capacity into actual coping and adaptation in social-ecological systems are human decisions and actions (McGinnis and Ostrom, 2014).

Human agency and conscious decision making are important factors that can determine the trajectory of a social-ecological system (McGinnis and Ostrom, 2014; McLaughlin and Dietz, 2008). However, decision making processes are constrained by limitations to knowledge, information, beliefs and tradeoffs (Heltberg *et al.*, 2009; Schoon and Cox, 2012; Baron, 2008). These are often internal processes that can be invisible at the level of the assessor and thus coping capacity assessments are often not reflective of the actual coping that would be enacted to face a stress such as a natural hazard event. Pelling and High (2005), therefore, recognise the importance of accounting for behaviour and decision making processes. Heeding Pelling and High's call, this research aims to develop an understanding of the decision making processes in the context of rural West Sudanian Savannah communities in order to better account for actual coping and adaptation. The following section examines the role of decision making and local perspectives on coping and adaptation to illustrate how important, but also challenging, accounting for these elements is in determining the likely responses and outcomes of climate change driven natural hazard events in the context of this research.

3.5 Decision making and local perspectives

As highlighted above, the social system differs fundamentally from the ecological system in that it is driven by human agency rather than natural laws and processes. Human agency carries the potential for different directions to be embarked on based on decisions made by people (McLaughlin and Dietz, 2008; Mertz *et al.*, 2009). Such decisions can drive processes of adaptation and this research aims to understand how such decisions might be made, particularly given the constraints of limited knowledge, beliefs and perceptions, uncertainty and previous experience (Risbey *et al.*, 1999; Baron, 2008).

It is sometimes taken for granted and assumed that rational humans weigh up options and select the most rational choice. However, in practice, people rarely have access to complete information and knowledge (Hayek, 1945). As such, in the case of decisions made

in the face of natural hazard events which are inherently unpredictable, such decision making is particularly challenging and likely to vary from person to person.

Efforts to illuminate decision making processes in relations to the application of coping and adaptation strategies, particularly towards natural hazards, have revealed that complex tradeoffs are central to decision making in practice (Adams *et al.*, 1998; McLaughlin and Dietz, 2008; Quinn *et al.*, 2011). These complex tradeoffs often have to balance immediate needs with longer term livelihood objectives (Quinn *et al.*, 2011). In addition, beliefs and perceptions of the decision and options can also influence the choice made. These are aspects that are particularly difficult to reveal and therefore account for scientifically. However, these elements help determine the processes of decision making that lead to the application of coping and/or adaptation strategies and are, therefore, particularly important to account for (Cannon and Müller-Mahn, 2010).

Eguavoen (2013) takes the view of the importance of beliefs and perceptions further, to demonstrate the role of interpretations and blame in decision making. Eguavoen (2013) argues that the way local people interpret their circumstances is critical to understanding their reactions. In other words, where they place blame is related to the actions and responses that they will take. As Adams *et al.* (1998) highlight, decisions may appear illogical and irrational to the outside observer (e.g. a researcher), but this does not reflect an actual irrationality. Adams *et al.* (1998) demonstrate that by examining the decision making process and understanding the complex tradeoffs, a logic can be revealed. This emphasises the need to understand local perspectives and decision making processes but it is equally important to also recognise that individuals make individual choices. Thus, choices and tradeoffs can vary from person to person, household to household.

Ultimately, decisions balance a range of competing goals and objectives (Quinn *et al.*, 2011). Decision makers estimate the likelihood or probability of a range of outcomes and make their choices based on the (limited) knowledge available, their beliefs and preferences as well as how the decision is presented to them. It is important to recognise the heterogeneity of actors and account for this in the analysis. The decisions may be grouped into typologies providing that it is understood that is it highly unlikely that a single decision making strategy will apply universally.

This research aims to develop a picture of likely responses to climate change, taking the complexity of decision making at the individual level into account. The scale of this research focuses on the community level by analysing processes at the local level. In this

way, the research seeks to retain the heterogeneity, recognising that there will be diverse strands and approaches within and between the case studies which will inform an understanding of the trends that are likely to develop over the larger, community, scale.

In the case of climate change, the conditions and decisions facing individuals and households are likely to be different to the present day. To understand decision making in the future, there is a need to unpick decision making processes, choices and tradeoffs before testing these under simulated conditions of climate change.

3.6 A community scale of analysis

As highlighted above in Section 3.3, one of the main challenges in research on social-ecological systems is determining the scale of the study. Systems function across scales with patterns emerging at higher scales to provide overall insights but local level dynamics are also important in determining the causal process behind these emergent patterns.

Eriksen and Kelly (2007) and Levin (1992) argue that vulnerability is most visible at the local scale and case study research focussing on specific examples and individuals helps to reveal the abundance of complex factors at play in determining vulnerability and hazard outcomes in those cases. For this research, the objective is to understand the processes behind disaster impacts and recoveries, as key to revealing vulnerability and to consider how these might vary in the future under climate change. As such, the research recognises that the social-ecological system at the local level comprises individual and heterogeneous agents who make up a community.

The concept of a community is heavily debated in the literature. Adams *et al.* (1998, p.274) define community as "groups of individuals or households with shared rules, beliefs and goals, among whom material and non-material resources are accessed controlled and exchanged". Blaikie (2006), drawing on Agrawal and Gibson (2001), argues that community can be viewed in three ways: a spatial unity, a distinct social structure and a set of shared norms. Cleaver (1999), however, argues that communities cannot be clearly demarcated as they do not comprise defined units. Rather, communities have permeable, overlapping borders and are part of networks that extend to other places. Similar to the concept of a social-ecological system, Cleaver's argument about communities is that they are not clearly demarcated entities and are subject to connections that span scales and place. Furthermore, Cannon (2008) and Cleaver (1999) both argue that the notion of community is often connected with positive connotations, as an idealised sphere for

participation and action at the local level. However, communities as inherently heterogeneous may comprise networks and connections that both aid and improve efficiency and efficacy but also integrate conflicts and clashes.

In this research, a community is viewed as a diverse set of individuals that form a cluster of interconnections that have developed through their close physical proximity to each other in daily life. In the rural West African context, communities develop in a largely place-based manner. Communities can be seen as delineated by their location, which Cannon (2008) argues is the only factor that determines a community that is otherwise heterogeneous. Maguire and Cartwright (2008, p.2) refer to this as "communities of place". Recognising the arguments of Cleaver and Cannon (2008) and Eriksen and Kelly (2007), it is important to make explicit the recognition that communities are comprised of diverse and heterogeneous actors who are also connected to external networks in other places and at other scales. Community in this research, therefore, comprises a general term to define the collections of people found in villages that would normally, but not always, have close connections with each other. These close connections are seen as stemming from regular engagement that arises due to the close proximities of their dwellings. These 'communities' form the diverse array of agents that make up the social component of the closely connected social-ecological system. Not only can they be seen as closely connected with each other, but these agents are also closely connected and dependent on the ecological system/ environment of their village and nearby surrounds. Thus community is used in this research to refer to the social dimension of the social-ecological system. The nature of the connections between these actors and their environments allows a spatial demarcation to be established as the basis, seeing villages as the spatial location of the communities. However, it is also recognised that these communities are permeable and connected with other communities and actors at different scales and in different places. The community is therefore taken as a general term to describe an array agents and actors in the specific social-ecological system of interest, rather than a strictly defined unit.

3.7 Synthesis of theoretical and conceptual approaches

The emerging interest in multiple hazard risks demonstrates a throwback to the 1970s when the natural hazards literature was predominantly concerned with hazard exposure, overlooking the role that social dimensions played in risk. In recent decades, vulnerability has become a key concept in the natural hazards literature. Vulnerability encourages a greater consideration of conditions and processes that operate in the social domain which can influence the outcome of a hazard event. The theoretical literature on local level

vulnerability emphasises the need to account for both hazard and social context and the need to look beyond the superficial proxies of physical vulnerability in order to address the influential elements of social vulnerability.

Despite the strength of the vulnerability concept in single hazard risk assessments and analysis, the current approach to multiple hazard risk assessments is severely lacking a consideration of these elements. This research demonstrates that there is a need to better understand the shifts in vulnerability, coping and adaptation in relation to more complex and multiple hazard situations. In this research a social-ecological systems perspective is used to emphasise the interactions between the social and ecological dimensions to expand the consideration of hazard impacts beyond a superficial level in order to generate a more holistic understanding of hazard impacts. Considering interconnections and feedbacks, the social-ecological systems perspective provides a platform for considering systems under pressure and raises questions about capacities to absorb, withstand, buffer and adapt to natural hazards that might become more frequent in the future.

The systems literature highlights collapse and transformation as possible outcomes from pressures such as natural hazards that exceed the coping and adaptive capacities of the system are to be considered (Pelling and Manuel-Navarrete, 2011). Examining themes of flexibility and rigidity, the systems literature highlights important attributes of more resilient and more vulnerable systems that will guide the approach taken in this research. A key question that this research aims to address is whether coping and adaptive capacities will be sufficient for a climate change future of more frequent and multiple hazard events or will thresholds be exceeded and lead to collapse and/or transformation? The focus of this research is to understand the flexibility and resilience of the present day situation by analysing actual coping and adaptation processes, paying particular attention to decision making processes. From this point, the additional pressure of more frequent but also multiple successional hazards will be addressed in order to reveal how coping and adaptation is likely to manage these impacts and where thresholds are crossed, what the likely outcome of that will be. An important objective of this research will be to illuminate the role of the social dimension in multiple hazard risk assessments, demonstrating that multiple hazards results in different impacts and outcomes.

Returning to Liverman's comment in 1990 (p.39) that there is a need to know "how to deal with multiple vulnerabilities to multiple threats" and "to decide whether studying the existing pattern and degree of vulnerability to drought and other conditions is an accurate guide to future vulnerability", it is clear that this need has not yet been fully addressed.

Multiple threats are increasingly being addressed as attention on these is amplified by high profile recent multiple hazard events, however, multiple vulnerabilities or even simply vulnerability to these threats has been addressed to a very limited extent with key gaps in consideration of how the different vulnerabilities to different hazards might interact under multiple hazard conditions. With regards to considering the future, it is widely acknowledged that snapshots and even historical trends in vulnerability indicators are not sufficient for considering a future under climate change which will present different conditions to those experienced today. However, it is understood through a focus on processes and feedbacks such as through the study of social-ecological systems, the mechanisms that influence vulnerability are being revealed and better understood. More effort to understand the process at play will provide a better foundation for projecting vulnerability into the future.

3.8 Towards a conceptual and analytical framework for multiple hazard vulnerability analysis

The key research questions guiding this study are concerned with a detailed understanding of social vulnerability at present and in a future under climate change. The focus is on hazard events as external pressures on a coupled social-ecological system. Taking into consideration the potential for cascades and feedbacks, the research aims to understand how coping and adaptation strategies mitigate vulnerability at present and how the strategies, their application and success might vary under climate change conditions that bring more frequent and multiple (successional) hazard events.

The conceptual framework developed here illustrates the lessons and insights gained from the research which are built into a framework that also serves as an analytical tool. As such, the framework provides a framing of the theoretical concepts that is designed to aid the analytical process to reveal vulnerability, coping and adaptation in the present day.

3.8.1 Revealing vulnerability

As discussed in Section 3.2 above, Kelly and Adger (2000) argue that vulnerability can be viewed from a starting or end-point perspective. Acknowledging the criticisms of these perspectives, the starting and end-point differentiation does highlight a difference between viewing vulnerability as the propensity to harm or viewing vulnerability as actual harm. Pelling and High (2005) and Garschagen (2014) have highlighted that in the discussion on coping and adaptation, that coping and adaptation capacities do not necessarily directly translate into actual coping and adaptation. Drawing on this and

Birkmann (2007), the view that vulnerability can be seen as either the propensity towards or actual harm, a similar argument can be made that vulnerability from a starting-point perspective does not necessarily directly translate into actual harm.

Research on climate change is founded on an inherent uncertainty. In order to minimise this uncertainty, it is important to base projections on the best evidence of present day conditions and their historical trajectories as possible. In other words, to develop effective approaches to examine an uncertain and unknown climate change future, it is helpful to base the projections on a-posteriori knowledge (knowledge derived from experience) that centres on a good understanding of the dynamics and processes that underpin the interactions in social-ecological systems (Jahn *et al.*, 2009; Kelly and Adger, 2000). As such, this research will take an ex-post perspective to understanding the present day conditions as a foundation of a-posteriori knowledge that can be used to illuminate the likely outcomes of a different future under climate change. In line with this approach, it is necessary to then see coping, adaptation, but also vulnerability, as actual and realised rather than capacities or propensities. The framework presented below will, therefore, provide a platform for assessing outcomes of hazard events as coping, adaptation, vulnerability and also resilience (i.e. where there is no evident impact).

It is important to note that in line with a holistic approach to understanding the impacts of hazards at present and in the future, the work on the present day hazard outcomes will focus on the full recovery process. Often, impact assessments and in particular, ex-ante assessments, tend to focus on the most direct impacts and coping or adaptation strategies. For example, an ex-ante vulnerability and coping assessment might assess the resources that a household has available with which to pay for repairs to a flooded house. This approach struggles to account for the indirect impacts that might occur if the resources measured really are used for repairs: will that prevent school fees from being paid? Furthermore, this approach implies that the application of the resources to the problem will achieve a recovery. At a superficial level, that may be the case as the damage to the house is repaired, for example. However, the sale of the resources leaves the household with fewer resources and thus, still in a worse off position than prior to the hazard event. Heltberg *et al.* (2009) indicates research that highlights slow recoveries and debt accumulation as long lasting impacts from hazard events. As such, this research argues that when addressing the challenge of a future with more frequent and more intense (multiple) hazard events, it is important to consider the recovery process holistically in order to account for cascading impacts and to understand the extent to which a full

recovery is achieved rapidly. An ex-post perspective that considers the full recovery process from the onset of recovery to a complete return to the pre-hazard conditions is essential to demonstrate vulnerability, resilience, coping and adaptation in practice and to show the extent to which recoveries can be achieved before the next hazard event occurs.

3.8.2 A continuum of vulnerability and resilience: The framework

The objective of the continuum presented in Figure 3.4 is to demonstrate that hazard outcomes are more complex and diverse than simply resilience, vulnerability, coping and adaptation. With sub-concepts, this diversity can be illuminated and by placing the sub-concepts on a continuum, the framework demonstrates a recognition that in reality, hazard outcomes and impacts vary from household to household. The framework is designed to assist the analysis by providing practically applicable conceptualisations of the key concepts and useful perspectives on these from the literature. The sub-concepts are simply markers along a continuum of more or less vulnerable or resilient. Additional sub-concepts may be added and unnecessary sub-concepts may be removed. The continuum is designed to be flexible in order to best reflect the reality experienced on the ground.

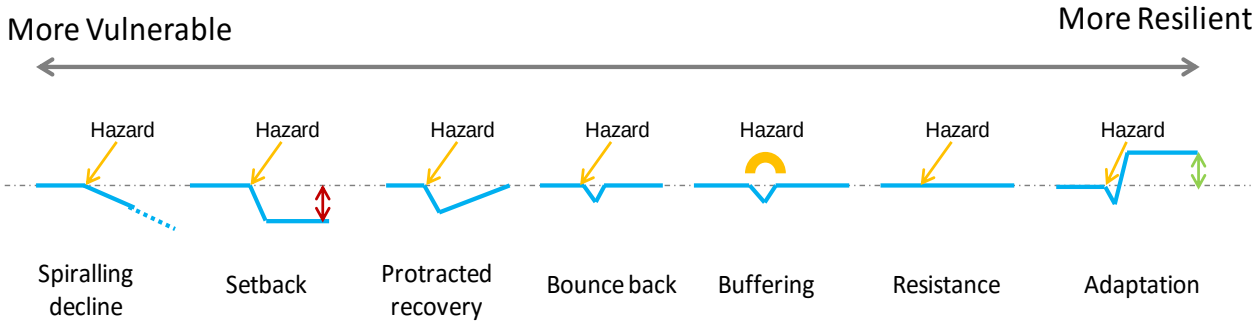


Figure 3.4 Conceptual and analytical framework showing sub-categories of vulnerability and resilience

The framework presented above in Figure 3.4, depicts a continuum ranging from more vulnerable to more resilient. Placing vulnerability and resilience at opposite ends of the continuum implies that these concepts are opposites. In the literature, this is a contested view. Adger (2000, p.348) advocates that resilience can be seen as a "loose antonym for vulnerability" and Speranza (2013) equates resilience with vulnerability reduction. However, Ostrom (2009) and Gallopín (2006) argue that vulnerability and resilience are fundamentally different concepts having developed from different fields which are founded on fundamentally different ideologies that underpin their conceptualisations and thus make them effectively incompatible. A similar perspective underpins Maguire and

Cartwright's argument (2008) that "a community can be resilient and vulnerable at the same time" (Maguire and Cartwright, 2008, p.7), thus implying that the concepts cannot represent polar opposites. However, this perspective is based on an analysis at the community level where communities are comprised of many different components, some of which may be resilient and others that may be vulnerable (Buckle, 1999). As Weichselgartner and Kelman (2014) comment, everything has a combination of vulnerability and resilience but that vulnerability and resilience are essentially "different manifestations of a variety of response processes to changes" (Weichselgartner and Kelman, 2014, p.5).

It is argued here, that vulnerability and resilience represent different degrees of impacts and outcomes with vulnerability representing greater (negative) impacts and resilience representing lesser impacts and a more positive outcome. Thus, they are placed at opposite ends of the continuum to apply the connotations of greater and lesser harm to guide the sub concepts that populate the continuum. Indeed, Hufschmidt (2011, p.631) agrees that the 'flipside' of vulnerability could comprise "notions of resistance or robustness" if these are placed "along a continuum of potential damage", as is the case in the framework presented here. O'Brien *et al.* (2004c) also state that vulnerability and resilience can be placed at opposite ends of a multidimensional continuum. The O'Brien *et al.* (2004c, p.196-197) continuum is not presented visually but described as encompassing "flexible axes that characterise the biophysical properties of a system". Although also based on a continuum with vulnerability and resilience at either end, the framework presented here is simpler than this and focussed instead on describing outcomes of hazard events.

The literature repeatedly emphasises that vulnerability and resilience are broad concepts with imprecise definitions that have resulted in a complicated and confused literature. As Timmerman (1981) commented, vulnerability is a concept too broad to be practically useful. Timmerman (1981), therefore advocates that vulnerability could be placed on a scale, reflecting different degrees of vulnerability. Based on this perception of vulnerability as a broad and vague concept, this research argues that vulnerability and resilience can be seen as overarching concepts where vulnerability represents factors that increase damage or harm and resilience represents factors that decrease damage or harm. In this way they the two concepts can be seen as located at opposite ends of the continuum but with a recognition that the two concepts are not perfect 'flip-sides' of each other but rather they are partners (Buckle, 1999).

Viewing vulnerability and resilience as overarching concepts, the goal of the framework is to examine the different ways in which greater and lesser vulnerability or resilience may be manifest. The framework presents various sub-concepts which are placed along the continuum to demonstrate hypothesised manifestations of different degrees of vulnerability and resilience that might be revealed at the local level. The following sub-sections of this chapter describe the sub-concepts in detail.

3.8.3 Spiralling decline and set-backs

In line with the recommendation of Timmerman (1981) that vulnerability could be viewed as comprising different degrees, the framework presents two sub-categories of vulnerability. Beginning from these sub-categories at the 'more vulnerable' end of the continuum, spiralling decline and set-back are the first two sub concepts that populate the continuum. These sub concepts represent different types of vulnerability but they both show a lack of any recovery of the damages and losses. The difference between the two categories is that spiralling decline represents a situation where the losses incurred from a hazard event trigger cascades that lead to a continued decline. With no coping strategies applied, the decline perpetuates until a threshold is reached. In contrast, set-back represents damages or losses that are incurred and sustained due to a lack of coping but these losses do not trigger further cascading losses. Set-backs can be expected to arise where the household feels the damage and losses are unnecessary to replace or where the tradeoffs required to replace the items would be unfavourable and outweigh the value of the recovery.

3.8.4 Protracted recovery, bounce-backs and buffers

Adams *et al.* (1998) suggest that coping strategies can be placed on a continuum to denote different degree of coping. Drawing on this notion, the three sub-categories in the middle of the diagram have been developed to represent different degrees of coping. The three sub-categories have been defined based on the needs of this research with protracted recovery resulting in a slow recovery that implies a greater vulnerability to further hazard events. Bounce-back recovery, represents a recovery process that is relatively rapid and buffering represents adjustments made during a hazard event to accommodate the hazard, resulting in a return to normal conditions shortly after the hazard passes.

Buffering is perhaps the best resemblance of flexibility in a resilient system as it reflects adjustments made during a hazard event. However, this is not complete resilience as the adjustments are noticeable and inflict a degree of hardship or unpleasantness, albeit it

temporary. Thus, buffering is seen as the closest to resilience but still represents a small degree of impact.

In contrast to buffering, bounce-back and protracted recovery represent recovery processes that take place following the hazard event. The three categories are distinguished for the specific purposes of their operationalisation in this research. Specifically, the key difference between bounce-back and protracted recovery is the time taken to complete the recovery. Bounce-back reflects a relatively rapid return to pre-hazard conditions, unlike protracted recovery which results in a longer recovery process. Although bounce-back implies a relatively rapid, almost instantaneous recovery, in this research the key boundary between the two sub categories is twelve months. This is because, in the case study context of this research, if a recovery processes exceeds twelve months, the recovery process is then deemed to be a protracted recovery.

The twelve month cut-off point is context specific and has been determined for this research specifically. As this research is interested in understanding how vulnerability, coping and adaptation are manifest in the present day in order to address the extent to which these capacities are likely to fare under climate change conditions of more frequent hazards, the research needs to identify where recovery processes are and are not achieved before the next hazard event may occur. The twelve month cut-off point is particularly relevant for the research question on more frequent hazards as this considers the potential for hazards to occur on an annual basis. Therefore, if recovery has not been fully completed by the next rainy season when the hazard event may re-occur, this may have a compounding impact on the losses. Thus, twelve months is used as a crude cut-off point to elicit this understanding. It can, therefore, be assumed that recovery processes which are completed before the next rainy season, i.e. within the twelve months, these are not likely to be affected by more frequent hazard events.

The twelve month cut-off point is crude but also relatively flexible because essentially, twelve months is used as a rough indication of the next rainy season, however, if the first hazard event occurs at the end of the rainy season and the next year the hazard event occurs at the beginning, the actual recovery time available is closer to seven months than twelve. Thus, the cut-off point was not applied strictly and, in questioning, the respondents were asked when they had fully recovered and if it was before the next rainy season.

3.8.5 Resistance and adaptation

The final two sub-categories on the continuum are resistance and adaptation. Resistance is provided as an indicator of a lack of impact from a hazard event, defined by Smit *et al.* (2000, p.238) as the "degree to which a system opposes or prevents an effect of a stimulus". This is where the hazard event is not felt and does not affect the household. In contrast, adaptation represents a degree of impact but where the recovery process leads to a permanent shift or change that results in a greater degree of resilience in towards hazard events in the future. In this framework, adaptation is seen as reactive although it is acknowledged that adaptation may also be anticipatory (Smit *et al.*, 2000; Smit and Wandel, 2006). As the research approach is ex-post and focussed on understanding the outcomes of hazard events that have occurred, it is anticipated that adaptation processes will be revealed as reactionary, after suffering a loss. However, it is acknowledged that examples of anticipatory adaptation may also be revealed during the data collection process. The data collection process will be designed to be sensitive to this potential and will incorporate any examples of proactive/anticipatory adaptation into the findings, if they arise.

3.8.6 A flexible framework design

The sub categories of the conceptual and analytical framework have been designed to reflect practically applicable versions of the key concepts of vulnerability, coping, adaptation and resilience. The sub categories are designed to be applied to label responses and recovery processes towards flood and drought events in a manner that reveals examples of greater and lesser resilience. Where lesser resilience (or greater vulnerability, as it may also be viewed through the continuum perspective), is found, this highlights a potential challenge for a future of more frequent and multiple hazard events under climate change. With a particular focus on examples of protracted recovery which illustrate coping under current conditions, the research questions how additional hazard events that occur before that recovery is complete might affect the recovery trajectory. These questions are illustrated in Figure 3.5 and Figure 3.6, where Figure 3.5 represents the question on more frequent hazard events and Figure 3.6 represents the question on multiple (successional) hazard events.

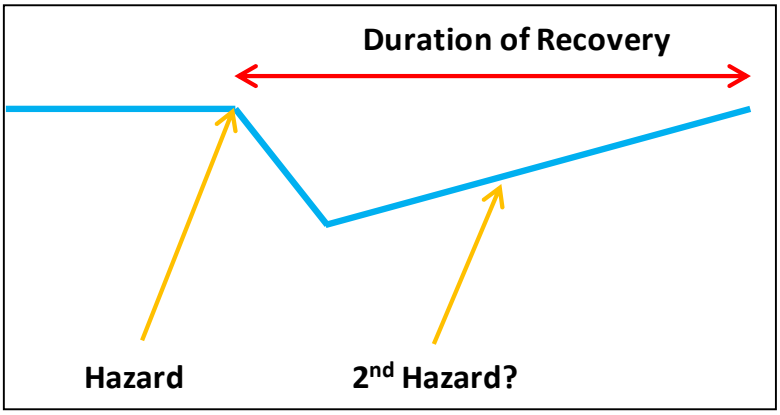


Figure 3.5 Depiction of the question on the trajectory that might arise if a second hazard event occurs during the recovery phase

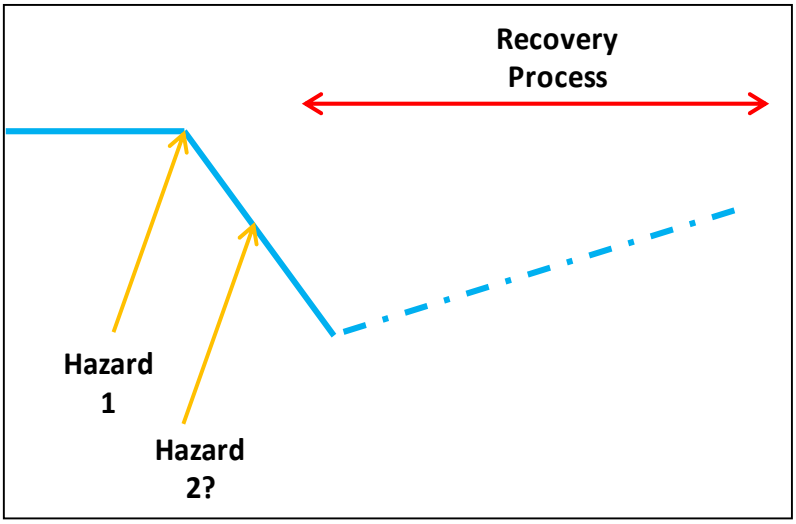


Figure 3.6 Depiction of the question on the trajectory that might arise if a second hazard event occurs shortly after the first

The framework, therefore, provides a foundation for analysing the present day vulnerability and resilience situation. Combining this analysis with approaches to examine future conditions of more frequent and multiple hazard events, new insights on recovery trajectories can be developed that demonstrate the extent to which responses under future conditions are likely to exhibit vulnerability, resilience and crucially, whether different coping and adaptation strategies are likely to be triggered, changing the vulnerability and resilience profiles of the communities, potentially for the better.

The framework is designed to be flexible, representing anticipated manifestations of greater or lesser vulnerability and resilience along a continuum. The framework is intended to be applied to the case studies in the format presented above, however, following the application of the framework, the categories will be reviewed based on an evaluation of the effectiveness of the approach for analysing and characterising

vulnerability, coping, adaptation and resilience. As such, new categories may be added and redundant categories removed in order to reflect the findings of the research.

The following chapter (4) on methodological approaches will further elaborate on the application of the framework and how this informs the analysis of the future conditions of more frequent and multiple hazards under climate change.

4 Methodological Approaches to Revealing the Impacts and Responses towards Hazards Events at Present and the Future

4.1 A post-positivist epistemology for systems research

The natural sciences are dominated by the positivist epistemology that sees truths as existing independently of the observer and is based on the assumption that knowledge of these truths may be gained by objective experimentation. Such perspectives have led to reductionist methodologies that isolate variables in order to test for a relationship between them, relying on numerical data and measurements to provide an 'objectivity' and replicability that reveal genuine truths. However, these approaches are designed for revealing linear relationships between variables. In contrast Glaser *et al.* (2008) and Hodgson (2012) argue that variables may be subject to non-linear relationships. Indeed relationships could be circular, for example variable A may affect variable B which in turn affects variable A. In addition, linear relationships may vary if other variables are present in the system. For example, variable A may affect variable B but variable C may also affect variable B. Therefore, the state of variable B would be different if both A and C are present and this state may not simply be a sum of the influence of A and C. As these examples illustrate, a positivist would be less likely to reveal and account for such circular and complex interactions between numerous variables. This view is emphasised by systems theory which argues that the sum of linear interactions may not necessarily be equal to the whole due complex interactions and feedbacks which reflect non-linear interactions and externalities (Mason, 2006; Eakin and Luers, 2006; Wisner n.d.). In line with systems theory and concepts of complexity that are recognised in the study of coupled social-ecological systems, this research is founded on a post-positivist epistemology.

The post-positivist epistemology recognises the importance of context, complexity and holistic perspectives (Ryan, 2006). The post-positivist epistemology is concerned with understanding how and why patterns develop with an emphasis on the interconnections and feedbacks processes. Post-positivism therefore moves beyond quantifying and qualifying linear relationships, towards more holistic qualitative or mixed quantitative and qualitative approaches (Levin, 1992; Ryan, 2006). Qualitative methodologies are particularly favoured for being able to account for context and complexity. However, the post-positivist epistemology recognises that such approaches can be criticised for facilitating biases and subjectivity that may skew the generation of objective truths. Post-positivism recognises that a degree of subjective interpretation is inevitable but aims to

control for this and to be explicit about any limitations in order to retain the capacity to reveal truths within these clearly recognised limits (Ryan, 2006).

As the following sections illustrate, standard approaches to vulnerability assessment tend towards a middle ground where numerous quantitative indicators are employed in order to capture the various and complex facets of vulnerability. However, as the following sections argue, such approaches carry considerable limitations for eliciting knowledge of vulnerability, coping and adaptation due to the difficulties in accounting for circular feedbacks and cascades. In particular, the derivation of indicators for vulnerability assessment based on either deductive analysis or expert judgement are based on present day proxies of vulnerability, coping and adaptation. When considering a future under climate change, where the different environmental conditions may give rise to new processes of vulnerability, coping and adaptation, the present day assessment approaches may not be reliable. Therefore, following a review of standard, present day, approaches to vulnerability, coping and adaptation assessments, this chapter demonstrates how a qualitative centred, post-positivist research approach can be used to provide a different approach to assessing vulnerability, coping and adaptation in the future under climate change conditions.

4.2 Approaches to vulnerability assessment

Standard approaches to vulnerability assessments that are frequently utilised today are based on the use of proxies that reflect the underlying factors expected to increase propensity to harm. Some of these proxies are derived through deductive approaches which examine ex-post data and reveal correlations through linear regressions. In order to achieve these regressions, harm (as the ex-post or realised version of vulnerability) must be defined as the key variable against which other variables may be tested to reveal correlations. Deductive approaches reported in the literature often centre on two key variables that denote harm; victims and economic damages, where victims may be fatalities or a broader definition of fatalities and those seriously injured (Pelling, 2013; Dilley *et al.*, 2005). For the value of damages, this is often based on insurance claims or estimates of the costs of repair and replacement of buildings and infrastructure.

Whilst the deductive approach can reveal correlations that imply or hint at causality and provide proxies of vulnerability based on an ex-post perspective, the foundation of victims and value of damages particularly emphasises high intensity hazards and focuses on a specific nature of outcome. Therefore, such approaches are especially useful for larger

scale national, regional or global level assessments to determine hotspots, but for the context of this research in the rural West-Sudanian Savannah, they bear considerable limitations.

In the rural West-Sudanian Savannah climate zone, endemic poverty results in limited high value infrastructure and buildings. As such, an assessment that centres on financial and economic costs of hazards is likely to place a higher weight on wealthier countries with more valuable exposed infrastructure. Cardona and Carreno (2013) emphasised this in their IDB-IDEA approach where they incorporated a broader range of measures such as poverty, population growth and availability of healthcare facilities to demonstrate a more nuanced picture that provided a clearer direction for policy makers. In addition to physical infrastructure and buildings, the basis of deductive approaches that derive proxies from lives lost or injuries leads to an emphasis on higher intensity events. As a result of this, the vulnerability assessment literature tends towards case studies in areas with high intensity hazard risks. In the context of this research, the hazards of interest in the rural West-Sudanian Savannah are lower intensity hazards which result in limited lives lost.

Whilst it is understandable that governments and non-governmental aid agencies may wish to target those areas with the most serious risks to lives and valuable property, the impacts of low intensity hazards on the rural West-Sudanian Savannah communities are also important and deserve attention. In particular, the impacts on these communities of low intensity hazards can have serious implications for food security. These rural communities are important sources of agricultural productivity and floods and droughts of low intensity can still result in significant disruption to the community's productivity, resulting in wider food security impacts. Therefore, while this research recognises the value of larger scale assessments that focus on harm in terms of victims, economic and financial costs, this research advocates that in the context of the rural West-Sudanian Savannah communities, a different approach to vulnerability assessment is required in order to better capture the factors that influence harm in this context.

Alternative approaches to deductive vulnerability assessment that are also commonly adopted are the derivation of proxies of vulnerability through expert judgement. Expert judgement involves the selection of indicators based on an in-depth understanding of the vulnerability context in question. At the local level, indicators are often developed in conjunction with experts situated within the local community such as key service workers and even local residents. Indicators are then selected by these 'experts' based on their

knowledge and perception of the factors that contribute to higher and lower vulnerability. In this manner, expert-selected indicators are highly context specific, however, they are subject to prejudices and subjectivity. In particular, a key limitation of indicators selection through expert selection is that the indicators tend to be numerous, raising the potential for double counting, and therefore difficult to weight. The indicators could be based largely on anecdotal evidence or be based on perceptions of proxies that have developed from pre-conceptions rather than evidence.

Another limitation of standard approaches to vulnerability assessments are that expert-judged indicators and proxies tend to be derived based on conceptions of inherent system weaknesses. Factors such as poverty and infirmity or ill health are often highlighted and whilst these certainly can influence vulnerability, these factors tend to resemble general weaknesses regardless of the specific hazard. As highlighted in Section 3.2, the focus on general social factors of weakness tend towards the starting point perspective and as such can bear limited connection to the specific hazard type and nature. A key feature of this research is the notion that vulnerability may be hazard specific and therefore, the vulnerability indicators developed should reflect this. Hazard specific vulnerability indicators are particularly important to this research so that when examining multiple hazards, the social vulnerability component reflects the differential impacts of two or more different hazard types, rather than simply reflecting generic social conditions of weakness.

Vulnerability assessments often result in outputs that reveal a spatial distribution of vulnerability that helps to identify the specific locations most in need of support to increase their resilience. In this research, the objective is different. Although these assessments might imply causality, most focus on illustrating a spatial distribution that highlights hotspots for more detailed research to reveal underlying processes. In contrast, this work is focussed specifically on determining the processes that influence vulnerability, coping and adaptation in the present day and to consider how this might change with a different environment under climate change.

Recognising the limitations of standard approaches to vulnerability assessments, particularly in the context of this study where impacts are potentially subtle and wider reaching than lives lost and financial damage and where hazard specific vulnerability is of central importance, a different approach is proposed that does not depend on pre-defined indicators and proxies. The alternative approach that this research attempts is based on a desire to account for complexity and cascades specific to the rural West-

Sudanian Savannah communities. Aiming to capture vulnerability holistically and openly, without preconceptions of potential indicators, the research methods are based instead on qualitative approaches.

4.3 The devil in the detail: Qualitative methods

Qualitative approaches are valued for providing detail and depth in a more holistic, post-positivist perspective (Marshall, 1996; Ryan, 2006). Qualitative approaches focus on context and thus provide specific insights that help to explain phenomenon that provide insights into causality which can then be used to help to identify the specific problems and potential areas for intervention to reduce vulnerability (Eriksen and Kelly, 2007; Eakin and Luers, 2006). In this research, the research questions are all "how" questions, which as Marshall (1996) states, preference a qualitative approach that focuses on root causes and complex processes and interactions to elicit knowledge. Qualitative approaches are therefore useful for research questions that require rich, context specific data whereas quantitative approaches are better suited to "what" questions (Marshall, 1996).

Despite their suitability for considering complex social-ecological systems from a holistic perspective (Mason, 2006) and in order to strengthen understanding and knowledge through context specific detail, qualitative approaches are often criticised as being too subjective and not 'scientific'. These approaches are seen by other scientists as too focussed on the perspectives of the subjects which are a reflection of reality filtered through the subjects and thus potentially distorted. Questions of validity remain a key criticism of qualitative approaches despite the post-positivist stance that advocates for careful consideration, accountability and control of subjective potential biases.

As a compromise and a means to enhance the validity of qualitative (and potentially also quantitative research), mixed methods approaches can be used to combine both qualitative and quantitative data to provide validation and strengthen the trustworthiness of the research. The mixed methods approach is based on an idea similar to Hayek's (1945) view that different types of knowledge are held by different groups. Therefore, to gain a complete perspective, it is necessary to interrogate different sources and perspectives of knowledge. Recognising the value of different epistemologies and aiming for a 'best of both worlds' approach, mixed methods approaches have become commonplace in social science research, particularly in research concerned with coupled social-ecological systems (SES). In coupled SES, quantitative methods can be applied to

features of the natural, ecological system with qualitative approaches being applied to social system features and connections drawn between the two in the analysis stage. Other approaches to mixed methods include the use of two different sources of information in order to verify insights through triangulation (Moran-Ellis, 2006; Tellis, 1997). Such approaches are particularly useful for overcoming the key criticisms of qualitative research as being too subjective.

Although mixed methods approaches are commonly used and can provide advantages over qualitative or quantitative only approaches, criticisms regarding the mechanisms through which the methods are combined present some challenges to the robustness of the methodologies (Mason, 2006). Indeed, Mason (2006) and Creswell and Plano Clark, (2006) question whether methods can be considered mixed if they are conducted separately and only integrated in the discussion. Bryman (2007) and Moran-Ellis (2006) also point out that although the objective of mixed methods approaches are often to triangulate and thus validate each approach/technique, the two approaches may actually measure different aspects of a phenomenon rather than the same aspect through different tools, thus not effectively triangulating data for knowledge on the same feature. As such, Mason (2006) argues that mixed methods are useful but that care must be taken to ensure that the mixed methods approaches are suitable and able to achieve the mixed methods objectives.

Essentially, there is a consensus that the qualitative, quantitative and mixed methods approaches all have their merits and drawbacks. More crucially, each approach draws on different epistemologies and ideologies. Thus, it is the research questions that should guide the approach to be taken. The Research Questions for this research, shown in Figure 4.1 Research Questions, demonstrate the need to consider qualitative approaches, in line with the recommendations of Marshall (1996) and the focus on more detail and depth.

Research Questions
RQ 1: How is vulnerability to natural hazards, specifically floods and droughts in rural West-Sudanian Savannah communities manifest at present?
RQ 2: In what ways might vulnerability, coping and adaptation vary from the present day to a future under climate change with more frequent flood and drought events?
RQ 3: How might vulnerability vary from single flood or drought events to events where floods and droughts occur in succession?

RQ 4: How useful are theoretical concepts relating to vulnerability and resilience for understanding the implications of a future under climate change?

Figure 4.1 Research Questions

The overall objective of this research is a more detailed understanding of present day hazard impacts and response from which to consider the outcomes of a future under climate change. A holistic approach that embraces complexity is suited to the post-positive epistemology and the research questions which clearly target a qualitative approach that seeks rich information to provide a detailed understanding of the complex system. Methods are required that allow for the subtle and complex dimensions of vulnerability to be revealed and data centric (quantitative methods) are not suited to such approaches (Eakin and Luers, 2006).

The centrality of qualitative methods will be complemented by secondary quantitative data and findings from other studies in order to triangulate and validate the insights and perceptions from the local level/participants. However, as this will be done to a lesser extent and will be driven by the gaps that emerge from the qualitative research, this does not constitute a truly mixed methods approach. It is important to note that the use of secondary and quantitative data will be applied with caution. Quantitative data from experts in the case study areas is particularly limited in availability but also in terms of accuracy. Deriving accurate quantitative data is particularly difficult given the unwillingness and inability of many members of the local community to provide accurate figures for aspects such as their livestock herd sizes. Even ages of household members can be difficult to obtain as people either do not know or are not willing to provide an accurate age. As such, where quantitative data is to be used, this will be limited and subject to the caveats elaborated here.

4.4 Back to the future: Research design and approach

In order to answer the research questions defined in Chapter 1 and repeated in Figure 4.1, above, the research takes a two part approach. As Figure 4.2 demonstrates, the first part of the research is designed to provide answers to the first Research Question (RQ1). This question aims to examine vulnerability, coping and adaptation towards the two selected hazards of floods and droughts in the present day. The second part of the research, as shown in Figure 4.2, is designed to answer the second and third research questions (RQ2 and RQ3). These questions require a future perspective, examining

themes of vulnerability, coping, adaptation and resilience within the context of climate change manifest as more frequent and multiple hazard events.

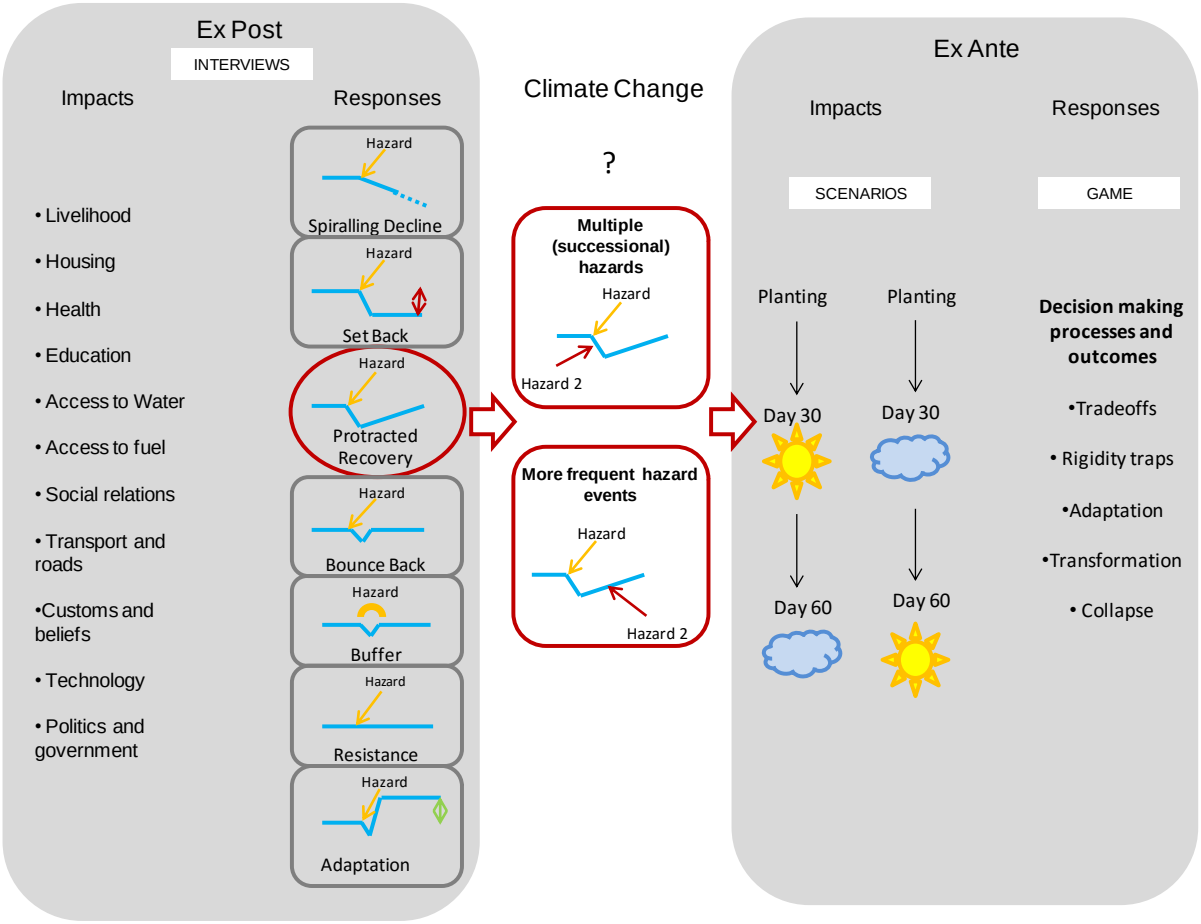


Figure 4.2 Research design showing first phase (Ex Post study via Interviews) and second phase (Ex Ante study via scenarios and game)

4.4.1 The present day, ex-post perspective

Research Question 1 requires an understanding of the present day situation and, specifically, how vulnerability, coping and adaptation are manifest in relation to floods and droughts. Recognising that coping and adaptation capacities are not necessarily directly translated into coping and adaptation during and following a hazard event, the research takes an ex-post approach perspective to reveal actual vulnerability, coping and adaptation. This is intended to provide a strong foundation of a-posteriori knowledge (i.e. knowledge derived from experience) from which to then examine the future under conditions of climate change.

The ex-post perspective is particularly helpful for revealing realised vulnerability but also for taking actual coping and adaptation responses into account. As Turner *et al.* (2003) argue, vulnerability can be seen as the propensity to harm but this can be mediated by

resilience features such as coping and adaptation. Ex-ante studies of vulnerability rely on estimates of coping capacity and adaptive capacity, however, as Smit *et al.* (2000), Garschagen (2014) and Pelling and High (2005) highlight, the capacities to cope and adapt may not be implemented fully or as anticipated. Insights from Adams *et al.* (1998) and Schoon and Cox (2012), emphasise the role of tradeoffs and complexity in decision making processes surrounding the application of coping and adaptive capacity, therefore, estimates of coping and adaptation can be particularly challenging. In contrast, an ex-post perspective enables actual coping and adaptation to be revealed which Smit *et al.* (2000) argue is important to provide an understanding of how decisions may be made in response to climate change and how adaptive capacity is translated into adaptation more generally.

As Figure 4.2 demonstrates, the research aims to take a deeper and more detailed approach to examine vulnerability, coping and adaptation. This is achieved by considering a broader, holistic range of potential impacts beyond simply lives lost and financial damages. In order to achieve this holistic perspective, a range of 'wellbeing' categories have been developed to guide the interviews as detailed in section 4.8.1, below. These wellbeing categories are designed to cover a more holistic range of potential areas of impacts in order to account for both direct and indirect or cascading impacts.

In addition to considering the impacts, the research is also designed to examine the responses. As discussed in the Theory and Conceptual Approaches Chapter (Chapter 3), vulnerability is viewed as the residual harm that remains after coping strategies and adaptation strategies have been implemented, therefore, an examination of the recovery process is central to achieving this. This research aims to reveal the complete recovery process beyond the superficial layers of recovery to understand whether a full recovery is completed and if so, how rapidly. As Figure 4.2 shows, the recovery process is analysed with the use of the conceptual and analytical framework. The application of the framework is designed to demonstrate where the recovery process currently presents a risk for more frequent and multiple hazards under climate change.

Although the examples of all recovery processes from spiralling decline to protracted recovery represent responses that may be inadequate under more frequent and multiple hazard events, the interest in this research is particularly on examples where protracted recovery ensues. This is because protracted recovery was the most frequently revealed outcome of flood and drought responses and importantly, this outcome is an example of a recovery process that currently exemplifies a degree of coping capability but where the

length of recovery time required places such examples at risk of potentially not being able to cope under climate change conditions. Therefore, protracted recovery became the basis for the examination of the future impacts and responses under climate change.

4.4.2 The future under climate change

The original approach of this research was to undertake interviews to examine the impacts and responses to natural hazards under present conditions and then under future conditions of more frequent and multiple hazard events. This was intended to enable a direct comparison between the past and future. However, upon trialling the interviews for the future conditions, it was found that interviews were unable to reveal the potential impacts and responses. The reasons for the inadequacy of the interview technique were three-fold. Firstly, respondents commented that they had very limited experience of multiple (successional) hazard events, in particular, and as such would not be able to provide a general account of impacts and responses. Secondly, respondents felt unable to comment on a hypothetical multiple or more frequent hazard scenario as they argued that their responses to hazards are taken at the time of the impacts and based on the resources that they have available and the full nature of the impacts. They felt unable to provide an accurate account without a very specific and detailed scenario being presented to them. Finally, respondents were particularly unwilling to answer questions on a future that would be worse than the present. They commented that they did not like to think of worse conditions in the future and preferred to focus on a more positive outlook for the future (e.g. BNFir5), despite a recognition that the trends of hazards over recent years did not necessarily provide reassurance that the future will be better. As such, a different approach was necessary and the research design was adapted to accommodate this.

The modified research approach retained the objective of collecting information on the impacts and responses for a future under climate change, however, the tools developed to facilitate this data collection were scenarios and a participatory game. As Figure 4.2 details, the scenarios were developed to provide more detailed information on the impacts of multiple hazard events. More frequent hazard event impacts can be seen as a duplication of the impacts under the present day conditions, but multiple (successional) hazard events carry the potential for different impacts. A key element of the research was to determine how the present day impacts might vary under multiple hazard conditions in order to understand where a potential multiplier effect may arise. Following the insights from the present day impacts, crops damages were highlighted as the key area of focus for a potential multiplier effect to be examined. Responding to this, scenarios were

developed to investigate how damages might vary from single flood or drought events to a second event of a different nature. The two scenarios developed were a flood followed by a drought and a drought followed by a flood. The development and implementation of these scenarios are described in greater depth in section 4.10 below.

From an investigation of the differential impacts of multiple (successional) hazard events compared to single hazard events as in the present day, the research also examined how responses might vary under more frequent and multiple hazards as expected with climate change. To achieve this, a participatory game was developed as a simplified model of the social-ecological system. The key elements included in the game were determined based on the insights of the key social-ecological system components and interactions that were revealed by the interviews for the present day impacts and responses. Details on the development and design of the participatory game are provided in Section 4.9, below, however, it is highlighted here that crops, houses and livestock were deemed the key features to represent.

The objective of the game was to reveal how responses might evolve in situations of more frequent and multiple hazard events. In particular, the game was designed to answer Research Questions 2 and 3 which aimed to understand whether different coping and adaptation responses might be triggered under climate change conditions or if the responses might remain the same as in the present day situation and if so, what that might imply for the sustainability of the current social-ecological system. The game was particularly suitable for eliciting these insights as, compared to the interviews, the game placed the respondents in the future situation with sufficiently complex information to enable them to evaluate their situations and make decisions based on tradeoffs that are reflective of their decision making processes in reality. Specifically, the game provided the participants with the information that they required on the composition of their yields and livestock. Analysis of their actions and decisions elicited information on the extent to which decision making processes and outcomes might vary compared to the present day.

Finally, the research is designed to analyse and compare the impacts and responses under the present day and future conditions under climate change. Crucially, the analysis aims to also compare the impacts and responses between the two types of climate change conditions (i.e. more frequent and multiple (successional) hazard events), to reveal any potential differences in these two manifestations of climate change. Comparing the results and findings from this data collection with the theoretical conceptualisations of systems under pressure, as detailed in Chapter 3, the research is then able to answer the fourth

research question: How useful are theoretical concepts relating to vulnerability and resilience for understanding the implications of a future under climate change?

4.5 Case study approaches

Case studies are useful qualitative methods as they allow for context and place specific analysis that is particularly relevant to assessing vulnerability in order to understand causality and complexity which is often lacking in comparative assessment approaches (Eakin and Luers, 2006; Cutter *et al.*, 2000; Berkes and Jolly, 2001). In terms of studies on complex social-ecological systems, Walker *et al.* (2006) and Máñez Costa, *et al.* (2011) highlight case studies as particularly suitable due to the detailed contextual information that they can provide. Furthermore, case studies allow a wide range of variables and system components to be examined holistically. Eakin and Luers (2006) also argue that case studies that look at individuals or population groups are more likely to reflect the "fluid and diverse natures of human activity and social relations in particular places" (p.374), taking a more holistic and context specific perspective. The consequence of this, however, is that the findings are then specific to the case study making them difficult to upscale and generalise beyond the case study itself (Birkenholtz, 2012; Mason, 2006).

Ostrom and Cox (2010) argue that models should not be too general or too precise to the point that they cannot be applied anywhere or elsewhere. In terms of case studies, a similar argument can be made. Birkenholtz (2012) highlights that single case studies can be criticised as providing information that is so detailed that findings are only applicable to the case study itself. Carmel (1999) also highlights the limited wider lessons that can be drawn from a single case study. Whilst this level of detail might provide some insights on a particular phenomenon it can only do so in the context of the specific case study because the specific factors in play are unlikely to occur in the same configuration elsewhere and a basis upon which to apply the findings elsewhere cannot be deduced from such a single case study. Further study of other cases would be necessary to determine whether the processes of the phenomenon play out in the same way so that the insights might be applied to other case studies. In contrast, larger scale assessments, such as those which operate at the global level, often have to take a more superficial perspective so as to enable comparisons across all of the cases. Birkenholtz (2012) calls this the extensive approach and argues that it fails to provide sufficient detail for more local level action as it fails to account for different contexts and thus, once again, further study at a more local scale would be necessary before interventions to improve the situation can be confidently adopted.

The challenge of case study scale is reflective of the broader debates that surround qualitative research. The debate epitomises the dichotomy between global level quantitative vulnerability assessments that enable comparisons but fail to provide specific detail for action and policy and on the other hand, the highly detailed, case study approach that is too specific and lacking in guidance on how to apply the findings more broadly that the insights are treated as only valid for that particular case and thus also restrictive to broader action and policy. Birkenholtz (2012), however, presents an argument in favour of a compromise between the single case study approach and more extensive comparative studies that typically lack detail from which to base policy decisions and interventions on. The compromise that Birkenholtz (2012) presents is a combination of intensive (single case study) and extensive (comparative assessment) approaches which is achieved by 'extending the intensive'. In other words, Birkenholtz (2012) argues that a smaller sample of multiple, select, case studies can help to derive the extent to which lessons may be more widely applicable whilst simultaneously retaining the more detailed, qualitative perspective that provides insights on causality in complex social-ecological systems. This approach is complementary to the 'hazards-of-place' approach advocated by Cutter *et al.* (2003). Cutter *et al.* (2003) advise conducting vulnerability assessments across places with a similar foundation. Their argument is based on the notion that vulnerability assessments should take social and geographical context into account and be tailored to capture place-relevant vulnerability as a result. Thus, they argue in favour of conducting comparative cases studies but across a more focussed geographic area to enhance their specificity.

The criteria upon which the multiple case studies are selected provide a platform for the identification of other places to which the findings and insights might be extended. Responding to Birkenholtz (2012) and Cutter *et al.* (2003) arguments, the approach in this research is to examine three case studies with a common basis in the dominance of agriculture and similar climatic conditions. More specifically, the three case study communities are all comprised of rural agriculture dependent communities in the West Sudanian Savannah climate zone. However, they are located in different country contexts which subject them to different policies and institutional influences. Thus, any commonalities between the case studies can be taken as likely to represent similar findings in other places and the in depth understanding of institutional influences and differences in the case studies will help to determine the extent to which the findings can be deemed relevant and applicable beyond the case study areas. This forms the foundation for generalisation where comparable findings are revealed.

The case study approach in this research differs from that of Cutter *et al.* (2003) in that this research focuses on a small number of case studies and is not based on pre-determined proxies of vulnerability. Instead, the research aims to develop a deeper understanding of the processes at play at the local level, rather than to examine the spatial distribution of vulnerability as intended by the hazards-of-place model (Cutter *et al.*, 2000). The objective of this research is to identify factors that increase vulnerability, coping and adaptive capacity and where tipping points and thresholds may lie in order to draw conclusions for the wider West-Sudanian Savannah region under future conditions of climate change. The degree to which the case studies are similar will provide a basis for considering the applicability of the findings more broadly.

4.6 Case study selection

The case study locations were pre-selected as part of the WASCAL project. The WASCAL project criteria for selecting the case studies is based on the location of the case studies within the same climate zone. All three case studies are located in the West Sudanian Savannah climate zone and are located on a similar line of latitude (ca. 11 degrees North). Additional criteria for the selection of the case studies was proximity of communities to key river basins and experience of climatic variability with expectations of worsening conditions under climate change in the future. The final selection of case studies for the project was Dano in the Ioba province in south west of Burkina Faso, Dassari in the Materi District of Atacora in North West Benin and Bolgatanga in the upper East region of Ghana (See Figure 2.1).

The WASCAL case study selection process is in line with the objectives and approach of this study which has the following criteria for case study selection:

- Case studies within the same climate zone and with experiences of similar natural hazards (floods and droughts)
- Rural communities with dominance of subsistence agriculture
- Households clustered in or around small villages

The objective of this approach is to illustrate the extent to which the findings can be applied to other rural, agriculture dependent communities exposed to similarly natured floods and droughts in the West Sudanian Savannah zone. The focus of the research is on local level interactions with the environment, taking the close SES connection as central to the research objective and assuming that institutional support arrangements are limited, based on scoping fieldwork evidence. As such, limited institutional support allows

the case studies to demonstrate their 'natural' vulnerability, coping and adaptation, allowing space for policy interventions and institutional support to consider how best to contribute to and support these communities in the future.

In terms of generalising these results, it can be expected in the three case studies, which are part of three different countries where the communities are subject to different national policies and institutional regimes, that if the results are similar, that this would demonstrate the limited influence of policy and institutional regimes and provide a foundation for generalisation based on the community rather than the national policy characteristics. Indeed, it is hypothesised that institutional and policy influences are particularly limited in the case study communities, given their remoteness (geographically but also climatologically) from the country capitals and an understanding that high levels or endemic poverty would limit the capacity of the institutions and policy to be implemented. This assumption was based on the policy analysis carried out in the scoping phase of the research and detailed in Chapter 2 on the case study background. Strong similarities in findings across the three case studies would provide evidence for the value of such a basis for generalising applying the findings to other rural agricultural communities in the same climate zone and with similarly low levels of policy and institutional influence/intervention.

4.7 Sampling the case study communities

Sampling in qualitative research tends towards the local level as this is the level at which detailed interactions and complexity can be revealed and understood. Several authors such as Levin (1992) and Prowse (2003) also advocate that the local level is most appropriate for assessing and understanding vulnerability as the local level is where vulnerability is particularly visible and prominent. O'Brien et al (2004) find that the local level is where processes such as climate change are really experienced. Eakin and Luers (2006) comment that local scales of assessment are appropriate because individuals are not bounded by particular sectors and thus reflect the fluidity and diversity of human activity. Although vulnerability can be considered at other scales, for the purpose of this approach, the detail required for a holistic understanding makes the local level of a case study particularly well-suited to explore the research questions on how vulnerability is currently manifest and how it might vary under climate change conditions in the future. The focus of this study is therefore at the community level with data collection at the individual or household level to populate the community perspective.

In order to conduct the research in three different case study areas, a clearly organised and structured research process is required. Based on Onwuegbuzie and Leech (2007)'s parallel sampling approach, this research takes a similar approach to multiple case study assessment by carrying out the same process in each location.

The broad case study areas are determined by the three WASCAL case study areas that are centred on the local watersheds. The focus of the sampling is on individuals as household representatives in the smaller villages in order to maintain the rural nature of the research focus. The villages formed the basis from which individuals were invited to participate. To ensure that a cross section of villages were sampled a range proximities to the main rivers and towns were sampled. The objective of the village selection was to cover a geographical spread across the catchment. Figure 4.3 shows the villages selected in Dassari (Benin), Figure 4.4 shows the villages selected in Dano (Burkina Faso) and Figure 4.5 shows the villages selected in Bolgatanga (Ghana).

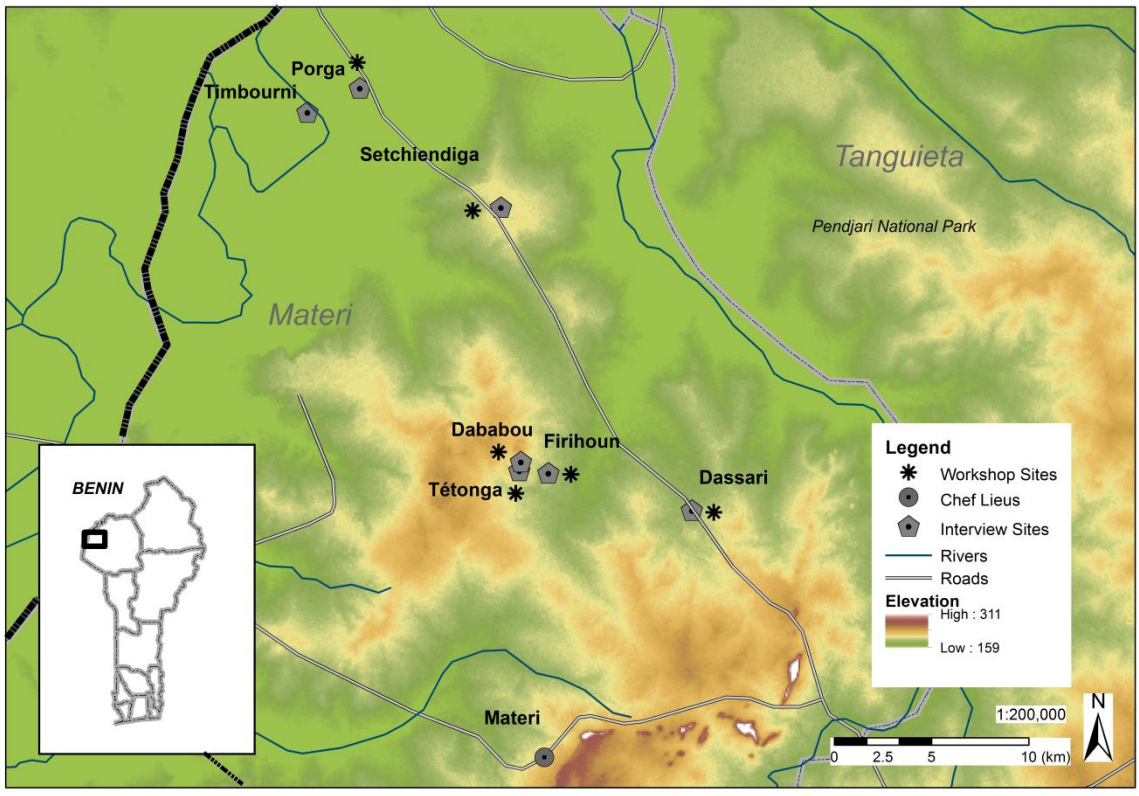


Figure 4.3 Map of case study villages in Dassari, Benin. Map produced by Susanne Haas.

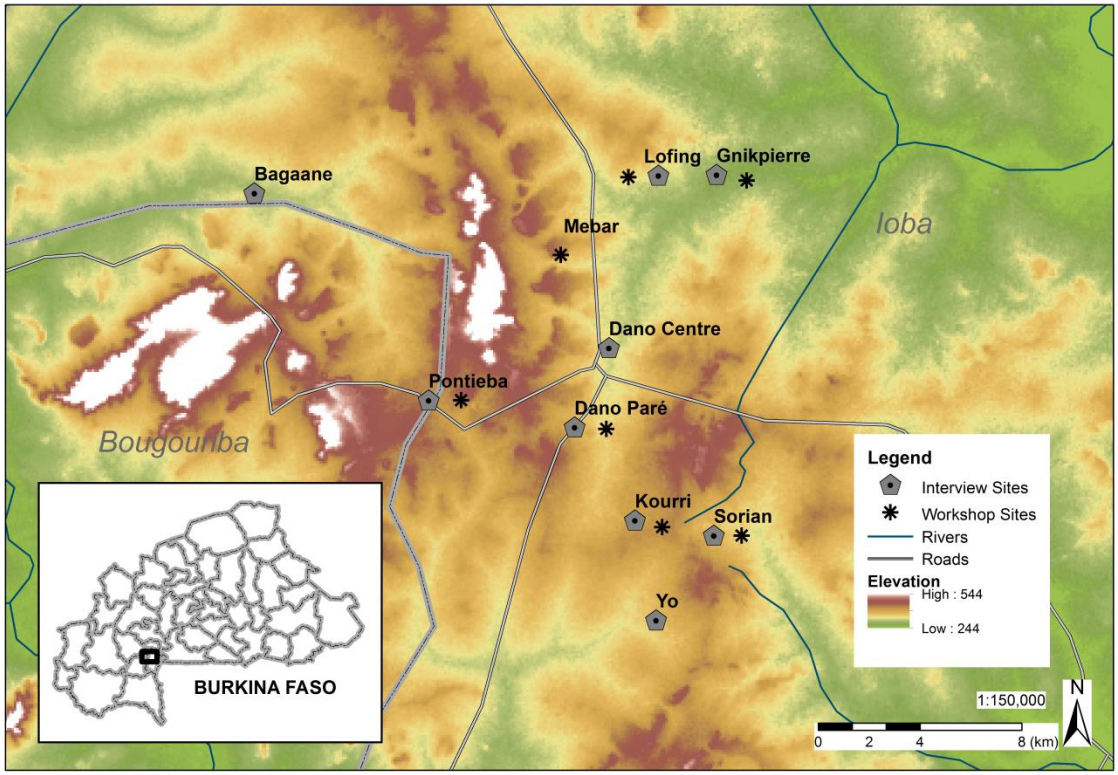


Figure 4.4 Map of case study villages in Dano, Burkina Faso. Map produced by Susanne Haas

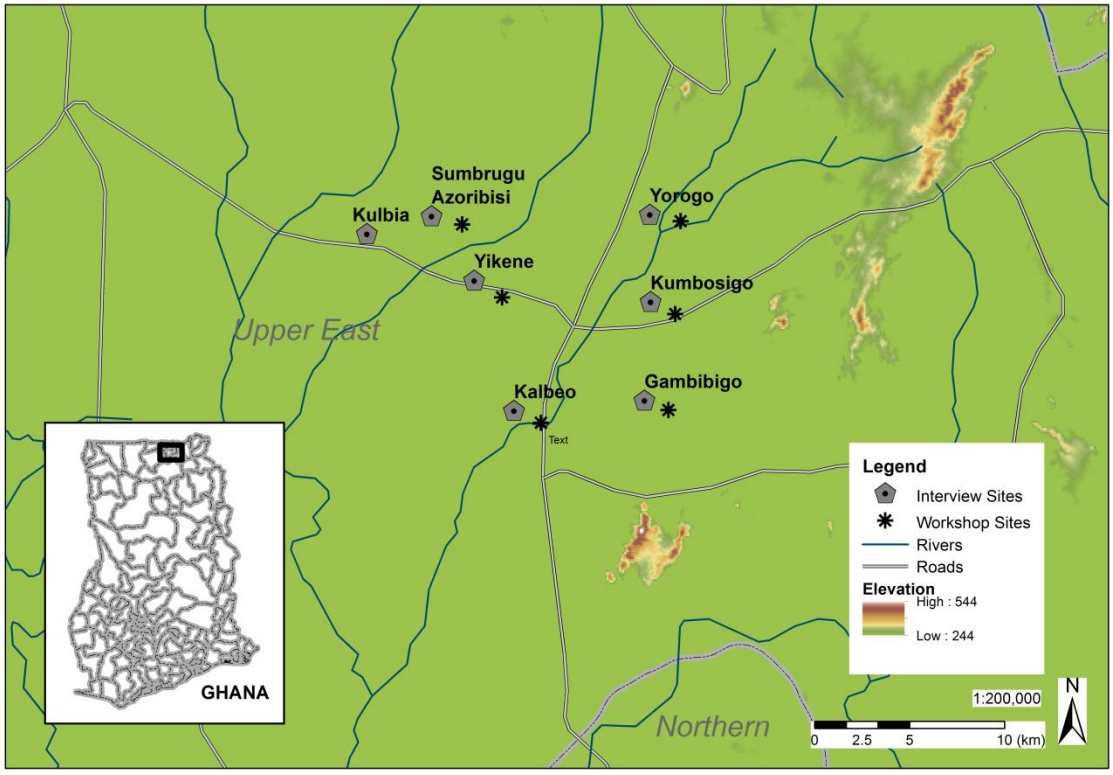


Figure 4.5 Map of case study villages in Ghana. Map produced by Susanne Haas

Within each case study area, 6-8 villages were selected (See Figure 4.3, Figure 4.4 and Figure 4.5). The number of villages sampled was greater in Benin as this was the first area sampled for the interviews and as such it was not clear how many villages would need to be sampled to reach saturation. As the process continued it became clearer that saturation had been reached earlier and as such 8 villages were sampled in the Benin case study, 7 in the Burkina case study and the final case study visited in Ghana included 6 villages.

At each stage of the research, the same villages were sampled, however, this did not necessarily include the same individuals each time. As the objective was to develop findings for the community level, a broad participation was desired. In this respect it was beneficial to expand participation to those not previously sampled as well as those sampled to verify that the knowledge gained was accurately represented by the researcher and applicable to the wider community of that village. The village focus, however, was crucial as it was necessary to understand that each village comprised different characteristics with some being more prone to fluvial flooding where others were prone to groundwater flooding. Different soil types and different degrees of access to other services were represented and thus it was important to re-visit the same villages to ensure that the general characteristics remained consistent. In addition, due to the participatory nature of the research, it was particularly important to demonstrate continued engagement and provide feedback on the information and insights previously learned. Returning to the same villages was sufficient for this as even if the people interviewed were not present for the second visit, word would spread to the participants that the research team had returned. As such, individuals were sought for participation in the interviews, game and scenario activities based on their residency within the village.

Sampling at the village level involved some logistical challenges, in particular, obtaining permission from the authoritative figures. In advance of each visit to the villages, contact would be made with the village chief or a key resident with authority such as an assemblyman/woman. These focal point individuals were contacted firstly to obtain permission to undertake the research in their village and secondly to advise the local residents of the research and invite them to avail themselves to the sampling in the following or proceeding days. Where contact was sought more than one day in advance of the sampling, a phone call would be made to the focal point contact to remind them of our arrival on the day of the fieldwork. This approach was highly successful in that all villages

selected were able to be visited. However, it was found that in two cases, village chiefs had sought to exploit or manipulate the research.

Due to the large number of villages sampled over the course of the research and the local insights that the translators were able to provide, instances of attempted manipulation were particularly clear on the few occasions when they arose. The two villages and a small number of single individuals sampled that appeared to be attempting to manipulate the research were quickly identified as doing so either through the observations of the researcher and in particular the translators or through the answers provided to questions which were either too consistent with all other respondents (suggesting the participants had been briefed beforehand) or were trying to take the questions in a different direction to suit the individual's agenda. Where such instances occurred at the village level, the interviews were cut short and the village was not included in the follow up field visits. Instead, alternative villages were identified and these acted as an additional check on the validity of the insights for the wider area/other villages. Where instances of individuals attempting to manipulate the research occurred, again interviews were terminated as quickly as possible and marked as being unreliable. However, it was not possible to instantly terminate such interviews as this would raise alarm and potentially offend the interviewee. As such, a degree of subtlety was required and the interviews were completed but subsequently labelled unreliable and discarded from the results.

The following sections elaborate on the specific research methods in more detail, beginning with the interviews undertaken to reveal the impacts and responses of floods and droughts in the present day, followed by details on the novel methods developed to examine the future under climate change.

4.8 Qualitative methods for understanding the present day

4.8.1 Interviews

Interviews are a commonly applied qualitative research method favoured for their ability to gather rich and detailed information in a flexible, non-prescriptive manner that allows the researcher to tailor the questions to follow the most relevant lines of enquiry (Bernard, 2011). This flexibility is particularly beneficial when examining a phenomenon through an inductive rather than deductive approach. Interviews may be structured, semi-structured or completely open but emphasis is placed on gathering rich data from detailed oral descriptions (Bernard, 2011).

Based on this, interviews are a particularly suitable method to apply to Research Question 1 which seeks to understand how vulnerability is manifest in West Africa through an inductive approach where the researcher does not apply preconceived ideas of what vulnerability might be (Bernard, 2011). However, as the research is grounded in specific research questions and has explicit goals, a degree of structure is required to guide the interview and maintain the research focus.

In order to ensure that the interviews were structured to elicit data relevant to the research question but not so structured as to centre on preconceptions of vulnerability, semi-structured interviews were designed based on broad categories of enquiry. The categories of enquiry aimed to provide a guide to ensure that impacts to all aspects of life would be covered in order to reveal where harm actually occurs as a result of floods and drought in line with recommendations from Cannon (2000) and Tschakert (2007).

In devising the categories, the well-being literature was particularly useful. Well-being is currently prized as an alternative measure of 'success' to economic centred measures such as GDP (Curtis and Oven, 2012). Well-being is valued as including broader measures of quality of life such as happiness and security (Curtis and Oven, 2012) and is referred to in some of the literature on vulnerability and resilience (e.g. Adger, 2006, 2007). As the objective is to capture aspects beyond economic factors, the goal of wellbeing indicators is similar to this research in aiming to consider a full range of lifestyle factors, based on the notion that society values more than simply economic success (O'Brien et al, 2004). Thus, the well-being literature and related measures of well-being formed a basis for the development of the categories for the semi-structured interviews in this research.

Based on a comprehensive literature survey, well-being categories were collected from various sources and compared in order to develop a comprehensive yet broad list of categories to guide the interviews (See Appendix 10.1 summary table of literature review). These categories were then validated against vulnerability indicators used in a wide range of other studies to ensure that the broad categories would be able to capture all of these aspects of vulnerability as well as others potentially overlooked. The final selection of 'well-being' categories is as follows:

- Livelihoods
- Access to essential resources (i.e. fuel and water)
- Housing
- Health

- Education
- Transportation
- Social relations
- Happiness
- Politics and Governance
- Technology
- Beliefs and customs

Minor adjustments were made to these categories. In particular, access to resources was divided into access fuel and access to water. This was done because access to fuel and access to water are notable aspects of potential but very different impacts. Thus, in order to ensure that both access to fuel and water were covered, these were separated into two distinct categories as a prompt for the interviews.

These categories provided the structure to the interviews. The aim was to ask interviewees about the impacts of floods and droughts across the range of categories to ensure that the full range of impacts were taken into account. This approach was used to elicit information on impacts from an ex-post perspective in order to generate a-posteriori information that could be used as a platform for assessing the impact of climate change in the future. Taking an ex-post perspective would allow the reality of harm caused by floods and droughts to be illustrated, rather than relying on speculation. Importantly, it would also enable the consideration of vulnerability reducing coping and adaptation strategies. Again, by taking an ex-post perspective, actual coping and adaptation could be measured rather than speculative coping capacity and adaptive capacity. This was important as the literature highlighted discussed in Chapter 3 demonstrate that the role of tradeoffs and complex decision making processes that influence the degree to which coping and adaptive capacities are actually enacted during and after a hazard event, something that is not otherwise easily predicted. The ex-post perspective diminishes uncertainty by providing a-posteriori knowledge.

4.8.2 Sampling approach for the interviews

As the interviews take an ex-post perspective, it was essential that those interviewed had experience of the hazards in question. As such, a key criterion for the interviews was experience with either flood, drought (dry spell and/or prolonged dry season) or both. As the interviews had many categories to cover but recognizing that the interviews had to be limited in time so as not to overburden the participant, it was accepted that some

interviews would concentrate on a flood experience where others concentrated on a drought experience. Therefore, there was a degree of flexibility with regards to whether participants had experienced both types of hazards or only one. As the overall sample size was large for qualitative research (n=188), sampling a range of flood and drought experienced residents was easily achieved.

Further adjustments to account for time pressures and limitations included a realization that it was unlikely that all categories could be covered in every interview but also that not all categories might necessarily be relevant as aspects of life that experience impacts from flood or drought events. As such, it was understood that over time, the most relevant categories would emerge as priorities for the interviews and that these should be the focus of the detailed questions, but to ensure that the holistic nature was retained, every category would be covered at least once in every village in each case study. Where respondents repeatedly stated that no impact was experienced for a particular category for the hazard, this category would decrease in priority for the next interviews and those that received greatest frequency of impacts would increase in priority but every topic would be covered in every village to ensure that all impacts, even if rare, could still be captured but that the interviews focussed on eliciting the most detail from the more important areas of impact.

Table 4.1 shows the priority order that emerged from the interviews. The table highlights that politics and governance as well as technology became redundant categories, with no impacts reported despite being questioned in each village. In contrast, livelihoods, housing, health and access to water became the categories most frequently discussed.

Priority Group 1	Priority Group 2	Priority Group 3
Livelihoods	Transport	Customs and beliefs
Housing	Education	Technology
Access to water	Access to fuel	Politics and governance
Health	Social relations	

Table 4.1 Interview topics grouped by emerged priority

The sampling approach was driven by the goals of maximum variation which seeks to elicit as many different responses as possible and ceases when saturation is reached (Marshall, 1996; Onwuegbuzie and Collins, 2007; Sandelowski). Based on the scoping visit undertaken before the first phase of fieldwork, it was estimated that one month per case study would provide sufficient time to sample a large enough proportion of the community to satisfy the requirements for maximum variation and saturation, with the potential to extend the visit if more time was needed. In line with this, the initial sample size target

for the interviews was 100 per case study, that is 10 per village. However, in practice saturation was reached before 100 samples had been collected and with the benefit of experience in the first and then second case studies, it was easier to recognize the achievement of saturation in the second and third case studies respectively, hence a decrease in the total number of samples collected per case study over time. In total, 75 interviews were conducted in Benin, 65 in Burkina and 55 in Benin.

During this fieldwork, each case study was visited for a period of approximately one month. The field visits were designed with the intention of being present to witness the rainy season and thus observe, first-hand, any incidents of droughts or flooding that might occur that year. As such, the peak of the rainy season was used to determine the order in which the case studies were visited during the 3-4 month period. As the rainy season peaks in the Benin case study slightly earlier, this was selected as the first site for the field visit. In addition, the strong facilitation facilities also provided this case study with advantages as the first case study to test the approach. As such, a slightly longer period of time was required to be spent in Benin to allow for testing and refinement of the approach in the case study context. Burkina Faso was selected as the second case study to be visited as the peak of the rainy season in Dano is August and the Ghana case study was selected to be visited last as the most likely period for flooding in Ghana is September. Time was allowed for travel between the case studies and to establish translation support facilities.

4.8.3 The case study sampling regime

Interviewees were selected randomly within each village but with an objective to obtain maximum variation. In Benin, a local facilitator visited the village one or two days in advance to request permission from the village chief and to canvass the village for willing participants. In Burkina Faso, local focal points were found in each village and asked to inform neighbours of the research and invite participants to attend the interviews. In Ghana, the researcher and translator visited each village in advance to meet with the chief directly in order to seek permission and invite participants. Participants were selected at random but efforts were made to ensure that a range of male and female participants of varying ages (young, old and middle aged) were represented. It should be noted that it was not possible to capture specific ages as participants often did not know their age, being born before birth certificates were issued. In addition, participants, particularly in Ghana, were reluctant to provide their age and almost certainly would not provide their accurate age when asked. As such, it was deemed sufficient to note if a

participant is old, young or average aged and how this might relate to their ability to respond to a hazard event. Often a difference of one or two years is not relevant and as most studies delineate by working age, this study aimed to look at young, middle age and elderly adults of retirement age. Understanding that men and women have different roles in a household and based on a wealth of literature which details the different impacts, experiences and capacities to respond to hazards of men and women, it was decided that this would also be important to capture for the analysis.

Other demographic information such as household size and education level were deemed less useful as the objective was not to undertake simple regressions to add to a wealth of existing knowledge on the role of education and response capacities, nor was it within the scope of the study to examine the labour resources versus demand capacities of households based on their size. Instead the focus was on the assets that households had and how these were used to recover from the impacts of a flood and/or drought. As such, the basic information collected per interview were the animals (quantity, where possible as a guide) and the types of crops grown.

4.8.4 Interview Process

For each interview, the basic information as highlighted above was collected before proceeding to ask about experience with floods or droughts (either dry spells, prolonged dry season or both). Once experience with one or both hazards had been established, the participants were asked to describe how the hazard had affected them and what the impacts were. The categories were used to guide the discussion to ensure that a range of impacts were covered with participants being asked "how did the flood/drought affect your livelihood/housing/children's education", for example. The impacts were recorded on a standard pro forma in note form and also by voice recorder which was then transcribed to provide a source for more detailed analysis (see Appendix10.4 for sample).

After the impacts for a category were described, the interviewees were then asked how they managed and responded to the impacts. This was important to reveal the coping and adaptation strategies that were used to reduce the harm and thus provide information on the residual vulnerability. This recovery process was covered in detail to understand to what extent and how a recovery took place and how rapidly a full recovery (that is a return to the same situation as prior to the hazard event, including with the same resources) was achieved, if at all. In this respect, interviews were an excellent tool, enabling the researcher to delve deeper into the recovery process to reveal the cascades of impacts.

The researcher conducted all of the interviews personally and without research assistants in order to ensure that the same process was conducted across all three of the case studies. In addition, by conducting the research in person, it was possible to guide the semi-structured interviews based on the underlying goals of the research. Whilst undertaking the interviews, which were often carried out at the interviewees homesteads or farm, additional observations could be gathered to supplement the insights from the main methods.

4.9 The application of participatory games

The second and third research questions are concerned with building on the knowledge of the existing vulnerability situation to examine how vulnerability, coping and adaptation strategies might vary with more frequent flood and drought events as expected under climate change.

The standard approach of asking people directly in an interview or question was not appropriate for this case as people were reluctant to comment or even consider how they might be affected and manage worse conditions. Participants commented in trials that they did not want to think about negative potential futures. They, instead, preferred to retain a positive outlook, hoping for a better situation (e.g. BNFir5), despite recognising a trend of worsening conditions. As such, and in order to understand how people might be affected by and respond to more challenging conditions with more frequent hazard events, it was necessary to find a tool that would allow this future to be explored hypothetically, removing the emotional element and vagueness of the hypothetical. For this purpose, a game as a simplified model of the key features of the social-ecological system was developed to simulate climate change and reveal response strategies and decision making processes through the 'safer' environment of game play.

Games are already used in research to investigate and improve participation, understanding and cooperation in the context of managing common pool resources (Lerner, 2013; d'Aquino and Bah, 2003; d'Aquino and Bah, 2014). In such circumstances, games are used as participatory tools with the objective being to bring together stakeholders with different or competing interests to work through a complex problem (Tschakert and Dietrich, 2010). Commonly applied to common resource pool problems, in this manner games can function as educational tools as well as providing opportunities to reveal and understand competing pressures and the different perspectives of different stakeholders. Role playing games (RPGs) are also often applied to questions of managing

common resource pools and these games help educate and inform stakeholders not only about the different perspectives and competing needs of other stakeholders but also of the need to find a way to effectively manage the resources before the pool disappears (d'Aquino and Bah, 2003; Lerner, 2013; d'Aquino and Bah, 2014).

Lessons from role playing and common resource pool games show the value of games for engaging stakeholders, enhancing participation and educating participants. RPGs are also commonly used to explore conflicts and develop understanding between different stakeholders about the different and competing needs of different stakeholders that lead to or contribute to conflicts (d'Aquino and Bah, 2003). Essentially, games bring people together and have the power to train or educate them (Michael and Chen, 2005). Games can be motivational and thus encourage people to engage in discussions that they would be otherwise reluctant to contribute their time to (Poplin, 2012). As such they are often used to increase participation and participatory involvement in decision making (Lerner, 2013) and are thus considered 'serious games'. But games are not always used first and foremost for imparting information, knowledge or teaching a lesson. Games may also be useful for gaining information as a researcher or policy developer about behaviour under different conditions. In this respect, games are becoming increasingly adopted as a tool for input into Agent Based Models (ABMs).

Agent Based Models (ABMs) aim to investigate the impacts of changes on coupled social ecological systems by modelling both natural and human systems, processes and the interactions between them (Nay *et al.*, 2014; Saqalli *et al.*, 2013). However, in practice ABMs are most commonly used to investigate the impacts of human actions on ecological systems with a degree of interest in the feedback of such changes on the social system in turn. For this research, the interest is in the other direction, namely looking at the influence of ecological change on changes in human behaviour, or in other words, human responses to ecological change. Although an ABM could be developed to serve such a purpose, ABMs that incorporate human behaviour and decision making tend to rely on classifications of behaviour developed in theory or based on observations in the current system (Lamarque *et al.*, 2013). Lamarque *et al.* (2013) comments that this produces overly linear interactions which over-simplify and universalise behaviour and decision making. They tend to rely on correlations which fail to enlighten causal explanations of social processes (Elsenbroich, 2012). As this research aims to investigate behaviour under circumstances that do not currently exist, such models are not appropriate. As such, the alternative approach adopted here is to use a particular game as a simplified version of

an ABM in order to elicit insights into the potential responses of local individuals towards the anticipated climate change conditions.

The game developed for this research aimed to explore the complex social-ecological system by presenting a simplified model of the current livelihood system and recovery mechanisms as were revealed by the interviews as central to vulnerability and coping. Based on feedback from the participants, the game setting was found to closely represent the context that the participants were familiar with (e.g. BN2014Dababou, BN2014Firihoun, BF2014Gnikpierre, BN2014Pare, GH2014Yikene).

4.9.1 Description of the game

The game was developed as a simplified model of the social-ecological system. Board games require simplification and thus the goal was to focus on the key interconnecting components of the system that would allow the research question of how people might be affected by and respond to climate change to be answered. The key parts of the system to be included were the crops, livestock, housing and climatic conditions as it was the interactions between these that was of interest.

Based on the results of the interviews that showed the centrality of impacts to livelihoods and housing combined with the role of livestock resources in coping, to answer the second and third research question, it was of critical importance to understand how people might use their assets (livestock and crops) to manage losses in crops and housing from the new climatic conditions (floods and dry spells/droughts). Another goal was to understand how people might use their assets to anticipate manage risk as the potential for losses and whether any asset management strategies would be implemented specifically for this purpose. The research approach sought to reveal if particular adaptation strategies might be triggered under future hazard conditions. As livestock assets are often undermined by diseases, this was another important element to include in order to determine whether the sale of particular animals might be influenced by the likelihood or prevalence of diseases for that species. This was an important consideration to help understand which animals would be sold and why to recover losses.

In order to examine these questions, the game was designed to be comprised of the key components: livestock assets, key crops, housing and climatic events. All of these components were represented by images and colour coded game pieces. Images were important as large proportions of the communities have limited or no literacy skills. The use of images prevented illiteracy from becoming a prohibitive factor to participation,

ensuring an inclusive approach could be achieved. The images used for the cards had to be selected bearing in mind that cultural connotations and conceptions between the researcher and participants might vary. A sun was used to depict drought and a cloud with rain to depict flooding, with the French or English words 'drought' or 'flood' to accompany this. A normal climatic season card was depicted by a smiling face and the phrase 'normal'. For the animals, simple pictures were selected. Cartoons were used but for some animals, such as sheep, the traditional western cartoon sheep was not appropriate as local sheep do not have thick wool coats and may not, therefore, be easily recognised. As such, silhouette or outline animals were used specifically searching for 'African' sheep to ensure that the sheep was recognisable. Again, the words for each of the animals were provided on the cards in English or French, depending on the case study. At the beginning of the game, the translators provided an explanation of the game components and how the game functions, providing the goal or objective as simply to do better than their opponent. During this explanation, the translators introduced each of the different cards, to familiarise the participants with the images in case they were not able to read the accompanying text descriptor on the card.

For the crops, these were represented by different coloured Lego bricks (see Figure 4.6), as described for the scenarios. Each brick colour represented a different crop and the brick colours were selected deliberately to make it easier for participants to remember. For example, white bricks were used to represent cotton as cotton is seen as a white product and yellow used for maize and maize is often called 'yellow sorghum'. The same colours were used to represent the same crops for both the game and scenario activities. It became clear that the participants were often able to very quickly memorise which colour represented which crop but the facilitators (translator and researcher) were able to remind them and reinforce this when necessary.

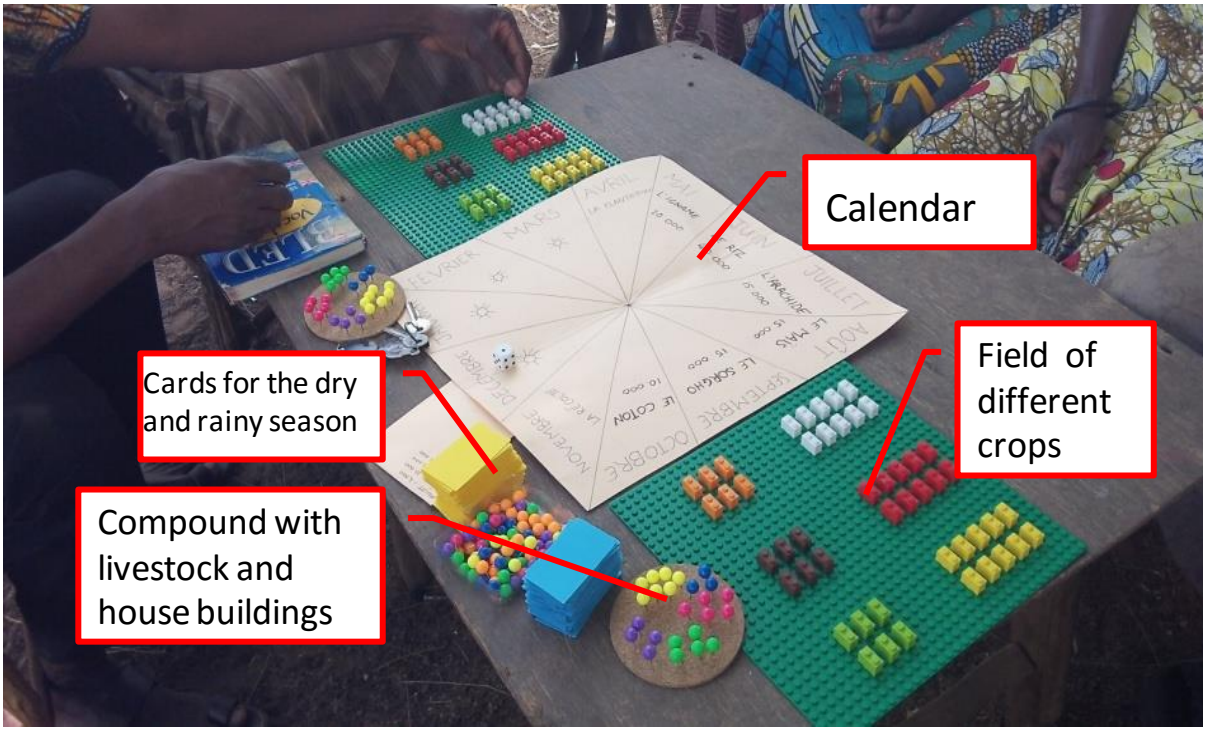


Figure 4.6 Annotated set up of game

A similar colour coding approach was utilised for the livestock counters as well. The livestock were represented by mapping pins on cork boards, with yellow representing chickens, pink for pigs, green for goats and blue for sheep. Unfortunately, these colours could not be so easily connected to the animals based on a traditional association between the animals and colours but participants were still able to memorise the colours nonetheless and the facilitators were able to advise them and remind them as necessary.

A final element that was depicted in the game was the homestead or rooms that comprise the compound. It was important to include this as one of the main areas of impact during a flood event. When houses collapse, rebuilding them becomes an important burden on household resources yet, based on the interviews, there remains a strong impetus to rebuild quickly after a flood. Thus, housing was included and was devised to be subject to floods in the rainy season. Thus when a flood card was overturned, the dice roll would determine not only the proportion of the losses for the relevant crop in the field but also the proportion of rooms comprising the compound/homestead that would 'collapse'. The objective was to simulate this important additional area of impact under flooding in order to understand how these structural losses are offset with assets (whether animals or crops are sold to pay for damage) and to validate the information from the interviews that suggest that reconstruction of damaged buildings is carried out swiftly and as a priority. To do this, the game forced participants to rebuild in the dry season in order to observe

which animals or crops might be sold to pay for reconstruction and any objections to rebuilding the entire homestead were noted to compare with interview data.

The materials selected for the game (Lego bricks and mapping pins- see Figure 4.6) were chosen due to their suitability for the fieldwork conditions. When working outdoors and often on uneven surfaces, it was necessary to select game parts that could be 'stuck down'. For this, Lego and mapping pins were particularly useful. It was also decided that two different component types were necessary to reflect the difference between the farm and the homestead. The Lego boards and Lego bricks were used to represent the fields and farm whereas the cork board was the homestead where the animals return at night and where the rooms that form the compound are located. The distinction helped retain a distinction between the components that were the focus of each different season and that the farm and homestead processes might differ.

The climatic events and animal diseases were designed to be random elements. The climatic events would take place in the rainy season with animal diseases occurring during the dry season, as is the case in reality based on interviews. The climatic events were floods, droughts and normal conditions. These were designed as 'event' cards, similar to the approach used by (d'Aquino and Bah, 2014) that would be shuffled to create a random pattern of climatic conditions as a result. However, the cards were weighted to reflect multiple hazard situations of climate change, with flood and drought cards present at an average of one flood *and* one drought card per year. This would result in hazard events occurring more frequently than at present. For animal diseases, the cards were weighted to an average of one disease per year. However, unlike the climatic/weather conditions, the different types of animal diseases were not equally likely to be selected. Further weighting was applied whereby pig diseases were more common, followed by chicken diseases, then goat and finally sheep diseases. This reflected information from the interviews where pig diseases were deemed most common, followed by chickens. Goats and especially sheep were found to be least likely to be affected by diseases (e.g. BNDas17, BNFir2, BFExp1, BFLof5, GHKal2, GHYor3).

The process of the game was to move around the calendar, with floods, droughts and animal diseases occurring randomly within their prospective seasons. The calendar was thus divided into two seasons: dry and rainy season. The dry season took place over four months and the rainy season over six. At the end of the dry and rainy seasons, one month was devoted to 'planting' and 'harvesting'. These were times at which players were able to trade assets to rebuild or make shifts in their stocks. Originally, players were allowed

to make trades at both the planting and harvesting times but this opened the possibility for players to sell their crops and invest in animals during the rainy season when animals could not be affected by events and to also then sell their animals and invest in crops during the dry season when crops could not be affected by the random events. Although there was no evidence of players deliberately selecting this strategy, after a few attempts at the game it was decided that this should be avoided and thus players were permitted only one opportunity to trade their assets and this was at the end of the rainy season.

At the end of the rainy season, players were also given bonus crops to reflect profits and enable players to work towards growing and increasing their assets. Bonus crops were simply an extra 'sack' of crops for any crop that wasn't completely destroyed in the preceding year. In reality, the 'profit' or bonus crops would reflect the volume of crops planted. However, for simplicity and because different crops produce different ratios of profit, it was decided to stick to just one sack per crop type. In the development and testing phase, different ratio and numbers of bonus crops or the conditions under which bonus crops are distributed were trialled and it was found that one 'sack' per crop type was suitable for preventing an overly long simulation of the game before the impacts were revealed.

Variations were retained regarding the values of the crops in order to reveal whether farmers invest in different crops based on their value. The values assigned per crop were based on the real life values of the crops, however, these values were difficult to determine as prices fluctuate annually but also throughout the year. Crops are generally worth more during the early rainy season when farmers have a low supply and demand is high. The crop prices were derived from interview data and triangulated with secondary data from the FAO. For some crops, data was missing or contradictory. Where this was the case, facilitators and translators were asked to verify the data in advance of beginning the game activity in each case study area.

As the work was carried out in case studies in three different countries, the game had to be modified to reflect differences in each case study. These were differences in the value of assets (crops and livestock), the currency used and the types of crops grown. The adjustments were made from case study area to area but in a manner that retained a degree of comparability across the case studies. For example, with regards to crops, four key crops that are grown in all three case study areas were used as a foundation for all case studies. This allowed for two crop types to be included that could be varied. In Benin and Burkina Faso, cotton is a key crop for many farmers, it is also subject to considerable

debate and as such it was important to include cotton for these two case studies, however, cotton is not produced in the Ghanaian case study. A substitute had to be found. Equally, in Benin, yams are an important crop for cultural/traditional reasons and as such yams had to be included. However, as yams are not grown in Burkina Faso or Ghana, substitutes were needed for these two case studies. In Burkina Faso, the substitute selected was sweet potatoes. Although these are not particularly widely grown, farmers were familiar and experienced enough with the crop to be able to work with it in the game. The important role of sweet potato was that it was similar to yams in that it is planted during the dry season and is harvested early in the rainy season- a characteristic that applies to yams as well. For Ghana, the solution was to include millet. Millet, similar to yams, has a traditional cultural role in the Ghanaian case study. It is also available in two types: early maturing and late maturing. The early maturing variety is therefore a suitable substitute for yams and the late maturing variety is a suitable substitute for cotton.

Each crop was allocated a particular month in the rainy season at which time it would be classed as susceptible to the climatic/weather conditions. If a hazard (flood or drought/dry spell) card was drawn at that time, then that is the crop that would be affected. The month selected for each crop's susceptibility was based on secondary source evidence of when in the rainy season, a crop is most likely to be at a critical stage in its water needs. Slight adjustments were made to spread the crops out over the season but the following Table 4.2 shows the crops that were selected for each month based on a rough approximation of the crop's most likely point of susceptibility to rainfall shortages or excesses:

	Benin	Burkina Faso	Ghana
May	Yams	Sweet potato	Early millet
June	Rice	Rice	Rice
July	Groundnut	Groundnut	Groundnut
August	Maize	Maize	Maize
September	Sorghum	Sorghum	Sorghum
October	Cotton	Cotton	Late millet

Table 4.2 Game crops per case study

For prices, these were based on interviews, key informants and secondary data. An average price was taken where data showed annual and inter-annual fluctuations in prices across the case studies. The final price was also designed to be comparable when

translated into the different currencies of Ghana and Benin and Burkina Faso and these prices are shown in Table 4.3 below.

	Benin (fCFA)	Burkina Faso (fCFA)	Ghana (Cedi)
Cotton	10,000	10,000	n/a
Early millet	n/a	n/a	150
Groundnut	15,000	15,000	200
Late millet	n/a	n/a	100
Maize	15,000	15,000	150
Sorghum	15,000	15,000	150
Rice	40,000	40,000	400
Sweet potato	n/a	20,000	n/a
Yams	20,000	n/a	n/a

Table 4.3 Crop prices for game per case study

Furthermore, the price of cotton was adjusted to take into account fertilizer and pesticide inputs. The price reflects the profit after input materials were taken into account. It was decided to include these elements as they are a major component of cotton production and in order to emphasise the less profitable nature of the crop. As an inedible crop, it was also expected that cotton would illustrate how cash crops could affect vulnerability and resilience, revealing how the dynamics and decision making processes would vary compared to the edible crops.

As players moved through the calendar, the degree of losses from a flood or drought to the susceptible crop of that month was determined by the role of a dice. A 1 resulted in the entire field of that crop being lost whereas a 6 represented no losses. Percentages of loss were assigned to the other numbers on the dice with 2 representing a 25% loss, 3 and 4 both representing 50% losses and a 75% loss represented by a 5. Percentages were necessary as the sheer number of 'sacks' per crop were unlimited and could vary substantially. It was important to provide opportunities for no losses or 100% losses to reflect the reality of some farmer's experiences. In previous experiences, flood and drought events in the case study communities affected different households differently. Some lost more and others less due to the location of their planting. Thus, in the game, each player was asked to roll the dice when a flood, drought or animal disease card was revealed in order to determine the extent to which they would be differentially affected. This reflects

the influence of additional factors such as topography which could not be otherwise represented in the board game.

For flooding, the role of the dice not only determined the loss of the crops but also determined the proportion of rooms in the compound that would collapse. Four rooms were used to make up a complete compound house, making it easy to calculate the percentage losses from the dice and reflecting a typical compound make up of more than two houses. It was important to include this element as a major source of damage in flood events but also to be used as a tool for discussing whether floods and droughts have different impacts and whether that leads to one being seen as a greater concern than the other.

At the end of the rainy season, participants were required to rebuild any collapsed houses. This required trading assets to the sum of the rebuild. Rebuilding was made compulsory to reflect the views given in the interviews that farmers need to rebuild quickly both to house their family but also as a matter of pride. Rebuilding takes place in the dry season and as such, this dictated the timing as the harvest month (November) in the game. By making rebuilding compulsory, it was possible to see how the participants would manage their resources to deal with pressing, non-farming needs. It would reveal whether they saw their animals or crops as the main tradable assets and which crops were prioritized and for what reasons reveals information on the tradeoffs and decision making process that participants might normally go through. Largely, participants accepted the need to rebuild all of their houses but when the participants began to suffer considerable losses and recognized that their assets were low, they would often ask to be allowed to only rebuild part of their house. This was discouraged to try to reveal how participants respond when they are forced to find money in difficult times but sometimes it was allowed to see how that might affect their ability to recover their losses over time.

Participants were encouraged to explain and justify their decisions throughout the game activity. At times, the group observers would disagree or suggest alternative strategies, highlighting the range of approaches to decision making and tradeoffs that were reflected by the interviews. Making the process a group activity, particularly brought to the fore the heterogeneity of approaches to dealing with such hazard event challenges and the discussions of different opinions provided particularly strong insights into this.

The game was designed to be non-confrontational. The two players aimed to do better than each other but did not have to engage in direct confrontation with each other in order

to achieve that. They were even allowed (and, at times, did) to support or advise each other. As the role of the dice gave them different circumstances, it was possible to develop a sense of wanting to support one another in difficult circumstances or to sympathise with an 'opponent' as they were simply unlucky in the role of the dice. This ensured a cooperative atmosphere rather than an aggressive or confrontational one. It also allowed members of the audience to advise both players, reducing a sense of allegiance with a single player but rather recognising that the objective was to play and defeat the system (or climate change) rather than each other.

Another advantage of an advisory group was that the group could be added to at any point. If villagers happened upon the activity as it was in progress, they were welcome to join and add they comments and thoughts. The goal was to facilitate friendly and open atmosphere to encourage discussion about a difficult subject and in this respect the game was an excellent tool, providing a novel experience that took participants away from stock answers. In a region subject to many other research activities, participation fatigue can be manifest in stock answers. Providing a novel group activity with an element of competition that requires focus on the task, reduces the chances of repeating standard answers.

4.9.2 Game implementation

The game was conducted as a workshop-style group activity in each of the villages visited for the interviews (see Figure 4.7 for picture). This was in order to retain the link between the interview data which looks at previous hazard experience and the data that would be collected from the game and scenario activities on hypothetical, potential futures. By returning to the same villages the participatory relationship that had been established during the previous field visits could be retained and participants could see a continued interest in engaging with them. The return visits also provided an opportunity to show participants what had been learned from the interviews and verify that the researcher's impressions were accurate.

Figure 4.7 The game being played in Benin with two players and an advisory audience

Due to problems experienced in the Burkina Faso case study village of Yo, where during the in-depth interview research it became clear that the participants were provided pre-prepared answers, a decision was taken not to return to that village for the game activity. Instead, Yo was substituted with another village within the case study area called Mebar Pare. Mebar is located near to the other case study villages of Loffing and Gnikpierre (see Figure 4.4). Prior to beginning the game activity, a short group interview was undertaken to ascertain whether the experiences of the village were comparable with those of the other villages interviewed in the previous phase. The villagers confirmed that they had experienced floods and droughts and that the impacts of these were in line with those experienced in the other case study areas. As such, it was clear that the village would be a good substitute for Yo and it also highlighted the wider applicability of the research findings to other villages in the area.

In addition to one substitution in Burkina Faso, in Ghana an additional village (Kumbosigo) was included for the game activity to make up for being unable to complete the in depth interviews there on a previous field visit. One in-depth interview had been carried out at Kumbosigo with a female representative of the village which established the experiences of the village with floods and droughts and demonstrated a clear comparability with the other villages. As such, this village was included in the game activity after a similar verification process as with Yo, in Burkina Faso, to verify that the village had the relevant experience and characteristics sought after for the research.

The game activity was recorded on a prepared pro-forma sheet. The pro-forma captured the gender and whether the participant was old, young or middle aged. It was not possible to collect precise and reliable information on age as participants were not always aware of their age or willing to provide it (particularly in Ghana). As such an approximation was used. The pro-forma also collected details on the progress of the game. As shown in the sample provided in Appendix 10.7, the incidence of flood, drought and animal disease cards, combined with each participants score on the dice roll was noted. In the 'harvest' and 'planting' months, decisions on the sale and purchase of assets and house rebuilding were also noted. In addition to the pro-forma, the activity was recorded using a voice recorder, following clear consent from the participants. The voice recordings were transcribed and used to capture detailed information on the discussions of the participants and reasons for the purchase and sale of any assets. Anonymity was assured as the participants full names were not collected and not noted.

4.10 The application of simple scenarios

The final research question seeks to build on the knowledge acquired from research question 1 in order to understand the impacts not just of more frequent hazard events but in particular how multiple hazard incidents in the same season may have a differential impact compared to the single hazard events. In particular, Research Question 3 seeks to understand the extent to which successional floods and droughts have a different impact and whether the combination of floods and droughts in a rainy season (as is likely with greater seasonal variability from climate change) will create a further burden and if so, to what extent. The interviews revealed that the key area for multiple hazard impacts was crop damage, however, an important question remained regarding whether floods and droughts affect the same crops equally. To investigate this, multiple hazard event scenarios were used.

Scenarios can simply be seen as providing hypothetical contexts. Qualitative or quantitative, they are designed to answer "what if" questions about uncertain futures (Lamarque *et al.*, 2013). Qualitative scenarios are particularly well suited to engaging the participation of stakeholders at different levels. Participation is also often used to develop qualitative scenario storylines (Lamarque *et al.*, 2013).

In this research, storylines were not developed, instead, the scenarios were designed with a specific purpose: to elicit information on whether the crops are differentially susceptible to the different hazards of floods and droughts and whether a second hazard occurring in

succession would result in additional losses. A further objective was to understand whether the order of the hazards would affect the losses. The focus was therefore placed on the main crops commonly grown in the area and these were the same crops that were used in the game activity. Of the six crops selected, four of these were common to all three case studies (maize, rice, sorghum and groundnut). The additional two crops were added those that were important to the particular case studies but not necessarily grown in all three. These variations were to include cotton in the Burkina Faso and Benin case studies as an important cash crop, frequently grown in the case study villages in those countries but not grown in the Ghanaian case study area. In Ghana this was replaced by millet and, as the millet is often divided into two types, early and late millet were used to make up the six crops for the Ghanaian case study. In Benin the final additional crop was yam, this was important for cultural reasons and a staple of farmers cropping, carrying a similar status to millet in Ghana as a traditional crop with strong cultural significance. In Burkina Faso, it was difficult to find a comparable crop. In the end sweet potato was selected to reflect the early maturing, dry season planted crops of yams and early millet.

The scenarios that were applied to these crops were as follows:

1) a dry spell drought that constitutes a break in the rains for two weeks, followed by a flood

2) a flood followed by a dry spell drought.

In order to investigate the multiplier effect, the two hazard events would be examined one at a time. Starting with Scenario 1 (drought followed by flood), the respondents were given a board with the relevant six crops depicted by Lego bricks. The board represented the farm and different coloured Lego bricks were used for each crop (see Figure 4.8 for illustration). As the game activity which used the same Lego bricks to represent the crops was carried out first, this not only acted as an ice breaker but also helped the participants to memorise which coloured bricks represented which crops. To aid this, crops associated with particular colours were represented by these colours: for example, maize is often described as yellow, thus yellow bricks were used, white for cotton, orange for groundnuts and red for the 'red millet' also known as sorghum. Four bricks were used for each crop, allowing respondents to demonstrate different degrees of losses, if they wished.

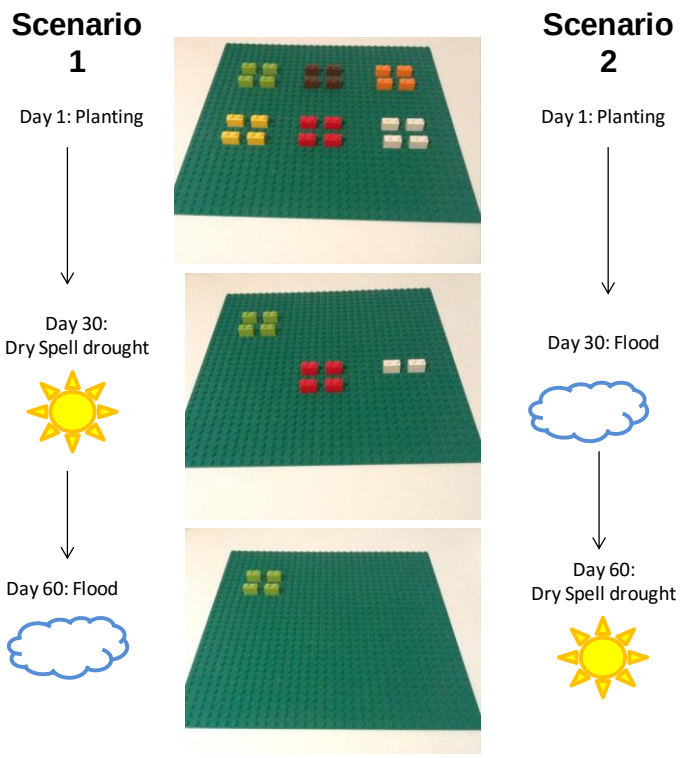


Figure 4.8 Illustration of the scenarios

The scenarios began with an explanation that the field belonged to the researcher and their advice was sought on what might happen if the researchers' field experienced the scenario events. The participants were told that the crops were planted at the same time and that 30 days after planting, the farm experienced a hazard event. For Scenario 1, the first hazard event was a drought. The drought was described as a two week break in the rains (dry spell drought) and the participants were again asked which of the remaining crops would be damaged in this event. The participants were then asked to identify the crops that would be damaged by this event and the Lego bricks were removed to reflect this. Their main discussion points were noted and recorded by the voice recorder. After the first hazard event, the participants were asked whether it would be possible to replant any of the damaged crops. This was noted and represented on the board. The participants were then informed that the remaining and newly replanted crops continued to grow for a further 30 days, at which point a flood event occurred. Using the board as an aide memoire, the crops that were deemed to be damaged were removed from the board. Taking into account any replanted crops, the participants were reminded to think of the replanted crops as being only 30 days old whereas the original crops were 60 days old.

With the remaining crops depicted on the board, the participants were asked for their opinions and comments on the how to manage the outcome. As the results were often that

very few crops remained, the group were encouraged to recommend options for adaptation and coping under such extremes to the researcher who played the role of the farm owner. The strategies suggested were compiled and compared to those mentioned in the interviews, providing triangulation for this information.

After the first scenario was completed, the process was repeated with the second scenario where the floods and droughts were reversed in order so that a flood occurred first, followed by a dry spell drought. If the two week dry spell drought yielded little change at this point, participants were asked if a three week dry spell would alter the outcome. In addition, where a large proportion of crops remained on the board after this second hazard event, the participants were asked to give an outcome if there were no more rains and this dry spell signalled the commencement of the dry season. This enabled the scenarios to be expanded to also consider the impacts of a prolonged dry season drought.

Further discussion on adaptation and coping strategies was again encouraged after the second scenario and this was then followed by a general discussion on experiences with multiple hazard events in reality to determine how reflective or representative of reality the scenarios are and to consider the implications of climate change for the villages as a whole. In response, there was unanimous consensus that the scenario outcomes represented a reality for farmers in the region and raised important questions for them in light of their knowledge of climate change. This demonstrated that the knowledge basis for the responses is based on a reality, albeit limited actual experience, some said that they had experienced similar processes and were aware of the potential to experience such multiple hazard events.

The scenarios were designed to present the hazards at 30 day intervals based on secondary data (FAO; Steduto *et al.*, 2012) and interview data. The 30 day intervals were selected because the secondary and interview data showed that the focus crops were all susceptible to fluctuations in water availability around the 30 days and 60 days mark. This is also combined with a likeliness for water availability fluctuations to occur at such points in time. In order to investigate how hazards might impact crops if they occur during times of susceptibility, to determine the extent to which the hazards might cause real damage, these time frames were particularly helpful.

In reality, floods and droughts can and do occur at different times, not always at 30 or 60 days after planting. This issue was considered and presents a limitation to the data. However, as the objective was to gain an indication and understanding of the extent to

which multiple hazards could affect crops, rather than a detailed modelling effort, this approach was designed to elicit such information without consuming too much of the participants time and without attempting to extract unnecessary levels of data. For qualitative research, an indication was needed and the discussion during the exercise provided sufficient additional information to demonstrate how changes in the timing of the hazard events might influence the results. These are all taken into consideration for the discussion. Furthermore, the consensus that the scenarios reflected a degree of reality for the farmers demonstrates that the outcomes can be taken as broadly representative of the impacts.

In addition to floods and droughts occurring at different times in the crop cycle than the two scenarios presented during the group work activity, it was also acknowledged that magnitude also plays a role in varying the hazard outcomes. Participants sometimes asked for a description of the magnitude of the hazard. For droughts this was a given as a two week break in the rains (or 3 weeks where damages were initially particularly limited). However, for flooding the magnitude provided a more significant challenge. To overcome this, participants were told to imagine a typical or average flood, not too great but also not too mild. Of course, different participants will imagine different magnitudes but the process of a group activity encouraged farmers to build a consensus which reflects an average position.

Another factor to consider was the location of the farm in proximity to water sources. As one of the key crops was rice, some farmers argued that this would not be affected by a drought as rice would be planted in the river valleys and wetter areas of land. In contrast the other crops would be planted where land was higher and less prone to water logging. It was not possible to control for this and farmers were asked to use their judgement taking into account conventions such as these. If rice is normally planted in areas less prone to water logging, then rice is, in reality, less likely to be affected by a drought. Whether this is because of the planting location or not, simply needs to be considered but is not relevant at a grand scale. However, for crops that might be planted in drier or wetter areas, there was potential for disagreement. However, in the course of the discussions, this was not raised in any of the focus groups. Where it become apparent that farmers plant a certain crop in water prone land whereas others plant it in drier areas, the participants were asked to take an average or the scenario board could have been split to represent this.

4.10.1 Scenario sampling strategy

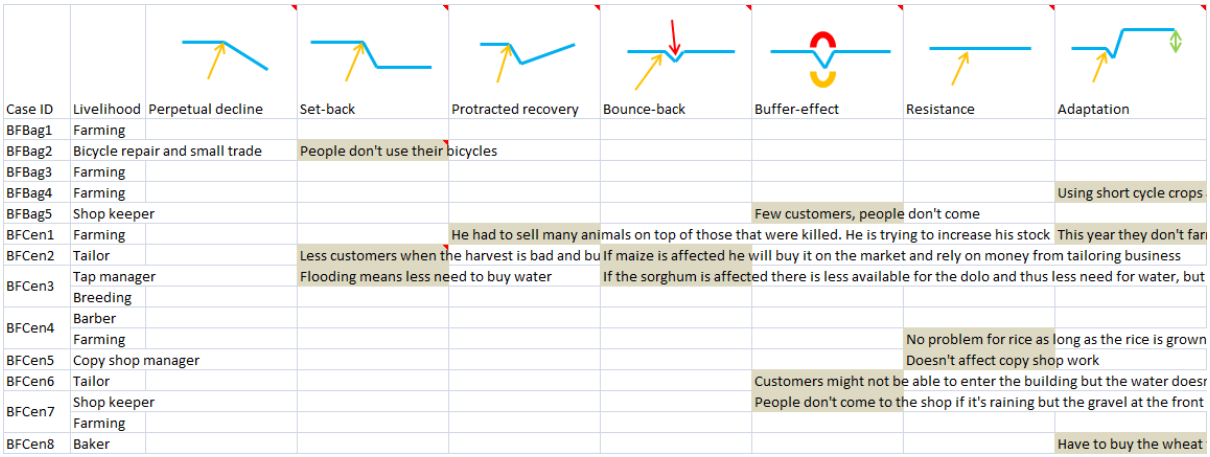
The scenarios were conducted after the game activity during the second phase of main fieldwork. Using the same Lego board and pieces with which the participants were already familiar, the samples consisted of the same villages and same participants as for the game. Once again, the scenarios were conducted as a group activity, aiming for an overall, village perspective rather than a household specific view which would be skewed by the particular circumstances of the household such as whether their fields are located on high land or low land. The group would be encouraged to discuss whether they felt a crop would or would not be affected, drawing on their own experiences and perceptions as a whole before then coming to a consensus on what the outcome would like be.

Due to language barriers, the facilitation was largely carried out by the translators who, as local residents, were familiar with effective tools of diplomacy and facilitation appropriate to the local culture. Where necessary, the researcher was able to provide additional support to ensure that discussions were open and cooperative. This relied on an assessment of whether there was a degree of dominance exhibited by participants and through observation of the group to make sure that a range of participants were sharing their opinions.

4.11 Data analysis techniques

The data for the interviews was collected in a structured format guided by the wellbeing categories listed in Section 4.8.1. The information was divided into impacts and responses for each category and by each hazard (flood, dry spell drought and prolonged dry season drought). For each case study, the impacts and responses for each wellbeing category were transposed into a table to categorise the outcome against the conceptual framework, as illustrated in Figure 4.9. Excel proved an excellent tool for achieving this due to its flexibility to incorporate rich text within large tables.

The tables were constructed for each category of the wellbeing categories. In the first column, the anonymised unique identifier code for the participant was input. The second column detailed the occupation of the participant and the following columns were divided based on the framework classification. From the results table sheets, the impact and outcome was summarised as a simple sentence under the relevant classification. The classification was selected based on the definition of the classification as presented in the Theory and Conceptual Approaches, Chapter 3.



Case ID	Livelihood	Perpetual decline	Set-back	Protracted recovery	Bounce-back	Buffer-effect	Resistance	Adaptation
BFBag1	Farming							
BFBag2	Bicycle repair and small trade		People don't use their	bicycles				
BFBag3	Farming							
BFBag4	Farming							Using short cycle crops
BFBag5	Shop keeper					Few customers, people	don't come	
BFCen1	Farming			He had to sell many ani	mals on top of those that were killed. He is trying to increase his stock			This year they don't far
BFCen2	Tailor		Less customers when the	harvest is bad and bu	If maize is affected he	will buy it on the market and rely on money from tailoring business		
BFCen3	Tap manager		Flooding means less need	to buy water	If the sorghum is affected	there is less available for the dolo and thus less need for water, but		
	Breeding							
BFCen4	Barber							
	Farming						No problem for rice as	long as the rice is grown
BFCen5	Copy shop manager						Doesn't affect copy shop	work
BFCen6	Tailor					Customers might not be	able to enter the building but the water doesr	
BFCen7	Shop keeper					People don't come to the	shop if it's raining but the gravel at the front	
	Farming							
BFCen8	Baker							Have to buy the wheat

Figure 4.9 Sample of results categorised

The tables provided a useful tool for analysing the details of the nature of impacts and responses as well as providing an overview of the state of the participants and the degree to which they could be generally considered vulnerable or able to cope. An important factor to note is that resilience is often denoted by an absence of impact and thus this aspect was not largely captured. On occasions, where participants specified that there was no impact, this could be considered a demonstration of resilience.

From the excel tables, the impacts were combined and condensed into tables in Word, as shown in Appendix 10.5. These tables provide a condensed overview of the different impact and outcomes per wellbeing category and by classification. The tables also provided illustration of the key factors that lead to a vulnerability, coping or adaptation outcome, helping to provide vulnerability, coping and adaptation profiles. The tables combine both the impacts and the responses in order to provide the degree to which there is residual vulnerability compared to effective coping and adaptation.

The analysis of the overall impacts and responses from the interviews was used to demonstrate the overall degrees of vulnerability, coping and examples of adaptation and how they arise from participant's circumstances. This was particularly useful for highlighting where climate change could potential enhance the negative effects and how prevalent this potential could be. In other words, the analysis demonstrated the high proportion of examples where a protracted recovery was central to the most important impacts and responses. As a protracted recovery extends beyond the following rainy season, this provides the potential for compounded impacts in the event of more frequent and potentially also multiple (successional) hazard events. This formed the foundation for the analysis of the game and scenarios as elaborated below.

In addition to revealing the extent to which households are vulnerable, able to cope and adapt, the interview transcripts were also analysed to elicit more details on the decision making processes and justifications for actions to respond to hazard impacts. This analysis was carried out using coding techniques applied through specialised software. Appendix 10.3 contains the coding scheme and example of a coded interview.

A similar scheme of coding was also applied to the analysis of the game, scenarios and discussions following these activities. Appendix 10.3 presents a sample of this coding scheme and highlights the variations from the interview coding. The coding for the game and scenario activities was particularly focussed on highlighting sales, purchases and reasons for choices in the game and overall reactions (e.g. laughter or sadness). This coding provided a more detailed analysis of the decision making processes and approaches during the game and scenarios to help compare with the approaches visible in the interviews.

In addition to coding, the game and scenarios were analysed in a quasi-qualitative manner. In other words, the vast volume of data was analysed through quantitative descriptive statistics that were designed to be indicative rather than revealing statistical significance.

For the game, the outcomes were recorded on a sheet and typed up into Excel into the same format, as shown in Appendix 10.7. The table records the basic information about the location of the activity (village and country), the date of the group activity and the basic characteristics of the players and group. As discussed above, it was neither appropriate nor reliable to ask participants to provide their age, instead players were noted as being young, old or middle aged (Y, O or M) and as being male or female. The characteristics of the group were described as mixed where the group comprised men and women of various age groups. Where only one gender or a particular age group were present, this was noted. Additional notes were also included. For each round, the card that was overturned is noted under the relevant month and the scores of the dice rolls for each player are noted.

The results from the games that were analysed in excel were the crops and livestock that were sold and purchased per round. The pattern of hazards was analysed per round and compared to the sales and purchases to demonstrate where crops and livestock might be sold or purchased more or less than would reflect the experience of hazard impacts. The game provided data on what was sold and purchased, when and how this compared to the

hazard impacts. Through an analysis of these findings and compared to observations during the game, it was possible to deduce typologies of response strategies which are elaborated in the Chapter 6.

With regards to the scenarios, the outcomes were again analysed through Excel. The crops that were damaged and those that survived were recorded alongside each event at each stage of the scenario. Figure 4.10 shows an example of the first stage of analysis and the recording of the impacts for each village to enable a comparison and view key trends. The full results are available in Appendix 10.9.

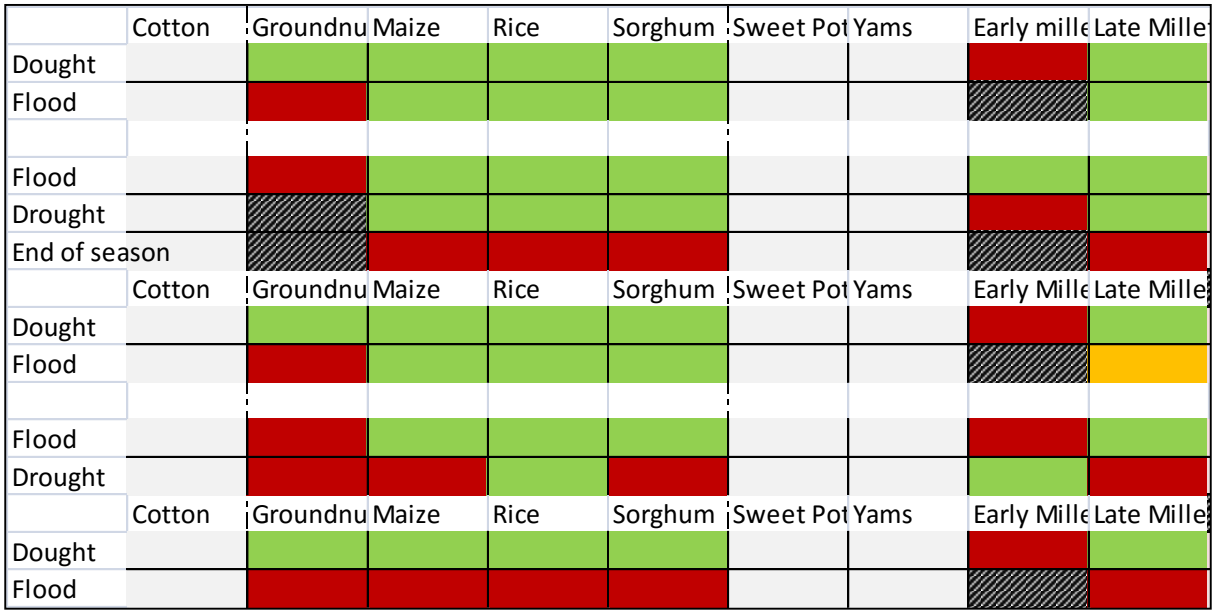


Figure 4.10 Sample of results and first stage of analysis. Where green represents crops that have survivied, red represents crops that are damaged and orange represents crops that are partially damaged

In addition to highlighting the key trends, simple averages of crops remaining at each stage of each scenario were calculated to highlight the most and least resilient crops. In order to calculate the multiplier effect, the percentage of survived crops was derived by summing the number of villages per case study that had the particular crop remaining after the first hazard event and then the second hazard event and these figures were divided by the total number of villages to provide a percentage at the case study level. This percentage, therefore, reflects the average number of villages that would have the crop in question remaining after the first or both hazard events. It does not represent the proportion of yield that would remain. As such, these values are indicative of the degree of multiplier effect at the case study level rather than providing indications of the proportions of yield losses. Although some villages were able to provide an indication of the proportion of yield losses as well, the wide variation between proportions mentioned

in the scenario discussions reflects a strong internal variability within the case study villages. Therefore, and in keeping with the goal of taking a broader, West-Sudanian Savannah perspective of the potential implications for the wider social-ecological system, the results are viewed as averages across and between the case studies.

The advantage of the scenarios was that the results were based on a consensus of the local community which reflected the particular characteristics of their environment. For example, it automatically takes into account the soil type, the hydrological and topographical characteristics of the general area which vary considerably from village to village. Therefore, the scenarios incorporate a level of local knowledge and characteristics that are considerably more detailed than would be otherwise possible with models and that would not be captured by a general assessment.

4.12 A synthesis of the methods

As Figure Figure 4.2 shows, the data collection methods for this research are based on gaining insights into the impacts and responses of flood and drought events at present and under climate change conditions. Standard semi-structured interviews are utilised to collect qualitative data on past experiences with floods and droughts across the case study communities, forming an a-posteriori basis for the investigation into impacts and responses under climate change.

Examining two key forms of change in the nature of natural hazard events (i.e. more frequent flood and drought events and multiple (successional) floods and droughts), more novel and innovative approaches are required. Carefully constructed scenarios are utilised to elicit detailed information on the changes that successional hazards might bring to crops as the main area impacted under current hazard situations. The scenarios are therefore devised to elicit insights on a potential multiplier effect from single to multiple hazards and although these scenarios are analysed in a quantitative manner, they are designed to be indicative rather than statistically representative.

In addition to the scenarios, a participatory game is utilised to elicit more detailed information on responses to more frequent and multiple (successional) hazards under climate change. Responding to the limitations of interviews for examining the future condition, the game is designed to provide a more detailed and dynamic context for decision making to be revealed. The analysis of the game is largely qualitative but with comparisons of crops and livestock sold at different points in the game to reveal trends and typologies of decision making approaches.

Drawing the three methods together, the findings can be triangulated. Decision making processes revealed by the game can be compared with those revealed by the interviews for the present day situation. In addition, the results of the scenarios can be triangulated with evidence from the interviews on crops more or less resilient to floods and droughts and compared to secondary sources of information on crop growth cycles and water demands.

The main approach to analysis is qualitatively driven, with coding of transcripts for the interviews, game activity and post game and scenarios discussion. Qualitative analysis enables the richness and depth of information to be retained but a degree of quantitative analysis helps to bring trends to the fore. Although the trends are only intended to be indicative, they help to validate and clarify the qualitative analysis, reducing any researcher bias.

By conducting the research across three case studies located in different countries, a comparison of the results between the case studies provides an indication of the extent to which the results may also be applicable to the wider West-Sudanian Savannah climate zone. The basis for extrapolating the findings to other communities is detailed in section 4.13 along with the potential limitations of extending the findings where communities benefit from greater governmental support. In addition to extrapolating the findings beyond the case study communities, the findings are also compared with the theoretical literature to provide feedback on where the theoretical literature does and does not offer insights to help explain trends where systems are under pressure. An important objective of this research is to provide an empirical basis to validate appropriate theories of vulnerability, resilience and trajectories of change.

4.13 Limitations and delimitations

The interviews are limited by a lack of capacity to quantify the assets available and sold to fund hazard responses and recoveries. As described in section 4.3, the unwillingness and inability of interview respondents to provide exact numbers of livestock, field sizes and yields, emphasised the need for a qualitative centred approach. On the one hand this limits the potential for mixed methods analysis, however, the focus of this research was on the nature of impacts and responses, for which qualitative analysis was particularly suitable. The large quantity of interviews (n=188) provides a strong foundation for generalisation, although statistical representation could not be explicitly elicited due to a lack of sufficiently high quality statistical and numerical data. Instead, comparisons

between the case studies and analysis of qualitatively derived trends suffice for a basis to extend the findings beyond the case studies, given the large quantity of interviews.

The research focuses on just two types of natural hazards, rather than the full array of hazards that affect the case study communities. The purpose of this limited focus is to reveal detailed insights that retain the complexity and depth of impacts, responses and revealed vulnerabilities, coping, adaptation and resilience, particularly accounting for the way that these aspects may vary with more complex interactions stemming from the two hazards occurring in succession. The data collection approach and analysis are designed to provide an indication of the potential impacts and responses under multiple hazard scenarios, emphasising the depth and richness of data as important for fully capturing complex interacting processes with an emphasis on the role of the social dimension in coupled social-ecological systems. The commencement with two hazards is intended to provide an indication of the need for future studies that extend the range of hazards and multiple hazard interaction types, building on this research as an initial step into a relatively under-populated body of research.

Furthermore, method-specific limitations that are important to highlight relate to the game and scenarios. The game is designed as a simplified model of the social-ecological system, therefore, only key elements are represented. This limits the extent to which the full array of complex interactions may be considered. For example, education, roads and transport as well as access to water are all absent features from the game. Instead, the game focuses specifically on housing, crops and livestock as the most relevant and frequently cited sources of impacts and response processes from the interviews. Therefore, it might be useful to expand and add additional elements of the game, including a more detailed model of the ecological system with topography and hydrology in the future. At present, however, the focus on crops, livestock and housing as the main elements of impacts and responses is sufficient to provide insights on the outcomes of more frequent and successional flood and drought events.

For the scenarios, two scenarios were examined which placed the hazards at 30 and 60 days. These scenarios are designed to examine the potential multiplier effect of multiple hazards as well as providing an insight into whether the sequence or order of the hazards makes a difference to this multiplier effect. In reality, hazard events could arise at different times after planting, besides 30 and 60 days. By extension, the gap between the hazard events might vary as well. This research begins with 30 and 60 days to provide an indication of the potential multiplier effect. Future studies may expand on this to develop

a more nuanced and complex picture of the impacts of successional hazards at different points in the crop cycle and different intervals.

4.13.1 Translation

With regards to reliability, an important factor to highlight is the need for translation support. As the researcher was unfamiliar with the local languages of the case study communities, translators were required to support the data collection process. Of course, with translation there remains a challenge of effective communication between the researcher and the participant both in terms of effectively communicating the question and effectively receiving, understanding and interpreting the participant's response. Translators were sought from the local community to ensure their familiarity with the local context to aid effective translation, however, in the case of the Benin case study, it was not possible to find a translator who was able to translate directly from the local language to English for the first phase of the main field work (interviews). As such, double translation was required with a translator from English to French and a second translator to translate from French to the local language. To ensure that the losses in translation were minimised, the interviews were conducted carefully, with translator's double checking meanings and intentions of the questions and answers with the researcher and participant. As such, the interviews took more time to conduct but the quality of the responses and data was highly comparable with those of the other case studies where single translation was applied instead. For the second phase of main field work, a local translator was found who was able to directly translate from English to the local language which improved the speed of the translation process.

Translators were briefed and trained prior to the beginning of the fieldwork. Test runs of the interviews and group activities (i.e. the game and scenarios) were undertaken with the translators to familiarise them with the approach and objectives of the methods. In addition, different translators were required in each of the three case studies and in the case of the Benin case study, it was not possible to use the same translator for each visit. This had certain advantages as the comparability of results across the three case study areas demonstrated that the influence of translation and translator bias was particularly limited.

4.13.2 Voice recording

In order to ensure an accurate capture of the data and information, voice recorders were a particularly useful tool. Voice recorders allowed discussions to be captured and stored for later transcription. This improves the accuracy of the transcription process and allows

the researcher to concentrate on formulating the next lines of inquiry and the next questions, rather than focussing on note taking. However, as voice recorders are prone to technical difficulties such as running out of battery power as well as problems that might arise with distinguishing the key voices when background noise levels are high, voice recorders cannot be relied on by themselves. As such, the researcher took general notes of the discussions to ensure that the main points would be captured even in the event of a failure of the voice recording equipment. In one instance (BNDas5) this was essential as the interview was not captured due to a fault in the recording equipment. In addition, two other interviews (BNDas8 and BNPor6) were only partially recorded due to the recorder running out of batteries unexpectedly. All of the remaining interviews and group activities were, however, sufficiently captured by the recording equipment.

Permission was always obtained before commencing recording and no participants refused or requested that recording not take place. However, in the case of expert interviews in particular, it must be recognised that the presence of a voice recorder can deter candid remarks. Interviewees are likely to give an official line which may not reflect their personal views. On the one hand, such official lines are particularly useful where institutional responsibilities are difficult to otherwise determine, due to a lack of information about policies and protocols available from open sources such as the internet. Thus, it is valuable to obtain the official line from employees in order to determine the roles and responsibilities of the organisation. On the other hand, it is also valuable to determine the extent to which these roles and responsibilities are upheld in practice and what the barriers to insufficient action may be. In order to elicit this information, questions were formulated to generate a sense of sympathy with the organisation and an atmosphere that the individual or organisation would not be immediately blamed or criticised. In addition, discussions would often continue after the voice recorder had been turned off and notes were therefore made hastily after the interview. Finally, the comments from the expert interviews could be balanced with reports from local residents and 'victims' on their contact with the agencies. Whilst every effort was made to determine a picture of reality, it must be acknowledged that self-interests could influence the comments that individuals made. Thus, questions had to be carefully formulated and triangulated with other sources of evidence, such as provision of statistical data from the agencies on support provided and to where.

4.13.3 Insider/Outsider perspective and researcher bias

The researcher is effectively an outsider in this research, having a different cultural background. This provides important advantages but also disadvantages which must here be made explicit. Firstly, being an 'outsider' to the case study communities carried certain benefits in being able to ask questions that might appear obvious to the local respondents but were not obvious to the researcher. Often detailed justifications for actions needed to be made explicit rather than the answer being assumed and as an 'outsider' it was easier to explain why the participant's full explanation was necessary. Furthermore, as an 'outsider', the context was less familiar and therefore, assumptions borne from personal experience in the communities was less likely to be made and therefore bias the results.

In addition to the advantage of the 'outsider' perspective, it was also found to be highly advantageous that the researcher conducted the interviews, games and scenario activities personally. By being present, observations about the household could be made to verify some of the information provided. For example, the shape and composition of the rooms and houses would be visible and sometimes evidence of collapsed and rebuilt houses could also be found. Furthermore, the dynamic nature of the semi-structured interviews, game and scenarios meant that by being present, the key insights that would build on the data collection across the three case studies could be more easily revealed. Being able to direct the interviews, scenarios and games in this manner, a complete and holistic perspective was developed with considerable detail provided where a local research assistant may have made assumptions. Given that different translators were used in all three case studies, it was important that the researcher conducted the methods in all three case studies in order to enable a degree of continuity between the case studies and to ensure that the same approach was undertaken in all three sites.

4.13.4 Ethical considerations

In order to facilitate an open discussion and meet ethical guidelines, the data collected is all anonymised. Names are not recorded on the electronic versions and participants in the interviews were provided with anonymised participant codes which relate to the location of the interview in a particular village within the case study. Information that might help a participant be identified such as age and family composition were not collected. First and last names were asked at the start of the interview to ensure that participants were not all from the same family and to facilitate an interview on familiar terms, where the participant's agency and personal opinions were recognised and to facilitate a polite interview where the participant could be referred to by name. However, names were not

recorded on the electronic copies and will not be made available to third parties. In order to ensure that participants were comfortable to participate and did so based on free will, participants were invited to participate and consent was sought to use a voice recorder to capture the interviews.

5 Results and Analysis: The Present Day Impacts and Responses

The aim of this research is to understand the impacts of natural hazards, specifically floods and droughts as defined in the local context, on the social elements of the coupled social ecological system and how households respond to these impacts. From an understanding of the current impacts and response processes, the research then examines whether response capacities will be sufficient to cope with the climate change conditions of more frequent floods and droughts as well as floods and droughts that occur in close succession. If coping capacities are not sufficient, the research examines the likelihood that adaptation measures will be engaged and the extent to which these measures might make up for any shortfall in coping capacities is also explored.

In order to achieve the aims of this research, the research was divided into three methodological approaches, each of which contributes to a specific element of the research aim (see Table 5.1). This chapter is structured along the three methodological approaches, commencing with the interviews that aimed to understand the current impact and response processes, followed by the game activity which was developed to provide insights on coping and adaptation strategies under climate change conditions of more frequent hazard events. The third part of this chapter is dedicated to an in depth consideration of the multiplier effect that flood and droughts in succession may cause. Finally, adaptation is addressed by drawing on results from all three data collection processes (the interviews, games and scenarios). Together, these sections provide deep insights into existing vulnerability, coping and adaptation processes and how these are likely to be translated under climate change conditions of more frequent and multiple (successional) hazard type events.

		Hazard Impacts	Coping	Adaptation
Interviews	Present Day (RQ1)	X	X	X
Game	Future (RQ2)		X	X
Scenarios	Future (RQ3)	X		

Table 5.1 Research questions and approach overview

In order to understand impact and response processes of the present day, interviews were conducted with household members/individuals across the three case study areas. As described in the Methodology Chapter, the interviews were structured by the wellbeing categories in order to ensure the full range of potential impacts and responses were considered, not only the livelihood impacts that are frequently the sole focus of studies.

This was important for ensuring a holistic perspective in line with the social-ecological systems and post-positivist approach.

For each wellbeing category, the interviewees were asked to detail the impacts of flood and drought events on that particular aspect of life (e.g. livelihood, health etc). This provided detailed information on the breadth of impacts for floods and droughts. Further probing revealed cascading impacts thereby enabling the indirect impacts to also be captured. Following on from a study of the impacts, the response processes were then explored in a similar manner, covering the breadth and depth of impacts in order to understand the degree to which the full suite of impacts could be coped with and to reveal any adaptation strategies that have been enacted to mitigate hazard impacts. For each impact under each wellbeing category, the interviewees were asked to describe how they responded to these impacts, detailing the actions that they took, the knock on effects of these actions and the reasoning behind their response(s). The conceptual framework was used to analyse the results and categorise the responses along the vulnerability-coping scale.

5.1 The impacts of floods and droughts

Combining the three case studies, there were a variety of impacts across the wellbeing categories. Table 5.2 illustrates the range of impacts mentioned under flood and drought conditions. This provided an important indication of where potential multiplier effects may occur from flood and drought events that occur in succession, which guided the approach to answer Research Question 3, as detailed in Chapter 6, below. However, for RQ1, this table serves to illustrate the broad range of impacts and variations between the hazard types. As is evident from Table 5.2, the impacts of floods and droughts touch on almost all of the wellbeing categories (with only local politics never mentioned) but to different degrees.

	Flood	Drought
Livelihood	151	148
Housing	121	8
Health	48	37
Water	1	63
Transport	47	4
Social Relations	10	15

Happiness	8	11
Education	9	6
Fuel	5	2
Machines	1	4
Customs	0	1
Local Politics	0	0

Table 5.2 Impacts cited per interview category

The broad range of impacts not only varies depending on the hazard but is also further complicated by interactions between the categories as the impacts cascade. Beginning with flooding, the following sections present the impacts of the hazards from the perspectives of individual households to provide an insight to the range and depth of impacts on local communities in the case study areas overall. Following from an examination of the impacts, the chapter will then present findings on response strategies, taking the perspective discussed in the Theory and Conceptual Approaches Chapter (Chapter 3) that sees vulnerability as mitigated by coping strategies and adaptation.

Table 5.3 demonstrates the range of impacts of flood events as reported by interview respondents. As Table 5.3 illustrates, the most frequently mentioned impacts were crop damage, followed by house or room collapse and household items being damaged in this process. In addition, impacts on health, specifically malaria caused by mosquitoes that become more prevalent under flood conditions but also indirectly when flooding within houses creates damp conditions which can lead to coughs and colds, were also regularly mentioned as impacts of flooding.

Damage	Count
Crop damage	132
Rooms collapse	105
Mosquitoes and malaria	32
Items damaged	25
Difficult to travel	21
Crop stores damaged	18
Less custom	16
Temperature issues	14
Road degradation and poor conditions	13
Damp rooms	13

Table 5.3 Top 10 most frequently cited flood impacts

Less significant direct impacts include disruptions to transportation routes/roads and dampening of firewood which is often a primary source of fuel. These less significant impacts were often mentioned after probing and were seen to be only problematic in particular circumstances, such as if firewood had not been correctly stored or if the alternative routes in and out of the village were also affected, something that was not likely for most villages. These impacts were the first order/direct impacts mentioned as a result of flooding. However, further probing found that cascades of impacts and indirect impacts exacerbate the overall strain that floods place on individual households and the wider community.

As Figure 5.5 illustrates, the direct impacts of flooding cause a web of cascades and indirect impacts, in particular affecting education (which was not mentioned as being directly impacted) health and livelihoods. Education was impacted where roads made travel to schools difficult or impossible for children. From the perspective of health impacts, these were derived directly from illnesses triggered directly by the increase in mosquitoes from the flood and also less directly from illnesses that develop from damp and partially collapsed houses/rooms. In terms of livelihoods, the direct impacts of crop damage are supplemented by demands on livelihood for covering the healthcare costs derived from illness triggered by the flood event or the poor housing conditions as a result of house/room collapse. In addition, health impacts were found to have a knock on effect on livelihood by reducing the productive capacity of the household if the person or people affected would normally provide support in livelihood activities. As such, the interaction between livelihood and healthcare is a two way process. Equally, impacts to livelihood have cascading impacts on education as households are less able to pay for the school fees, uniforms and supplies without which young people are unable to attend school. However, the school system is flexible enough that children can return to school in following years if fees can be paid (where required) and school supplies purchased. This allows students to complete their education, albeit over a longer period of time.

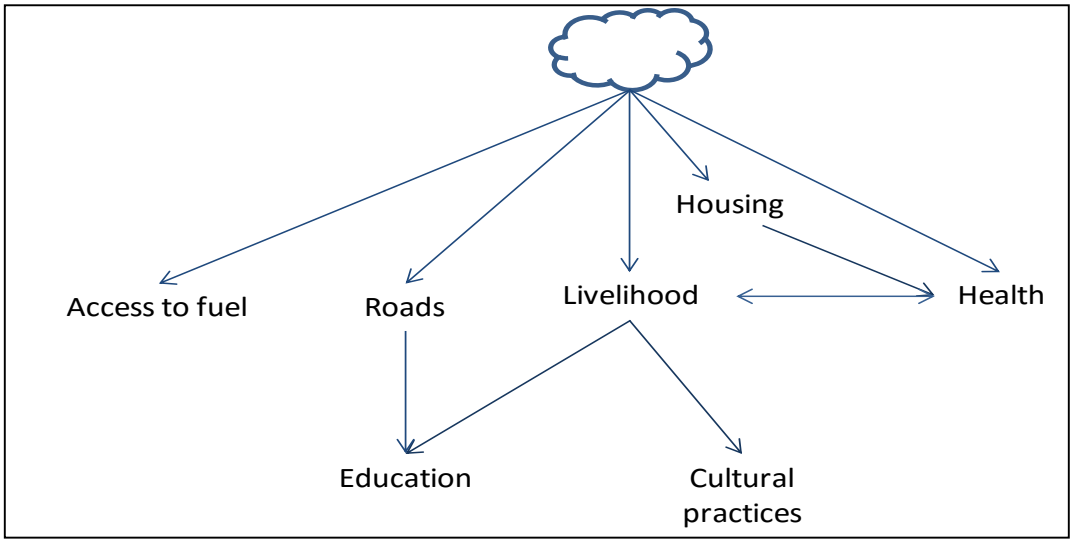


Figure 5.1 Web of impacts caused by flooding

Of the various impacts mentioned, damage to crops was deemed by far the most important and problematic impact. As Figure 5.1 shows, livelihood impacts are central to many other aspects of well-being, but livelihoods are also the aspects that are not easily dealt with. As interview respondents commented, the impacts on education, roads, access to fuel and also less serious health complaints, are all seen as minor disruptions. In contrast, the damage to buildings and damage to crops were seen as more severe impacts.

As highlighted in Chapter 2, the case studies experience two types of localised droughts. One type is the prolonged dry season due to either an early cessation or rains and/or late onset. The second type of drought that is recognised in the local context is a dry spell during the rainy season, typically extending beyond two weeks. Although the impacts for both types of droughts are largely similar there are some differences.

For both types of droughts, impacts on livelihoods through crop damage or an insufficient growing season were mentioned. In addition, health impacts were also mentioned under both types of drought, although these impacts centred on temperature changes that occur when there is a lack of rain. For prolonged dry season type droughts, the range of impacts was slightly wider than for dry spell droughts. As Figure 5.2 illustrates, other impacts of droughts were lack of water access and inability to use tools to plough hard land that would normally be softened by the rain. For dry spell droughts, crop damage was the dominant area of impact with some additional impacts on health.

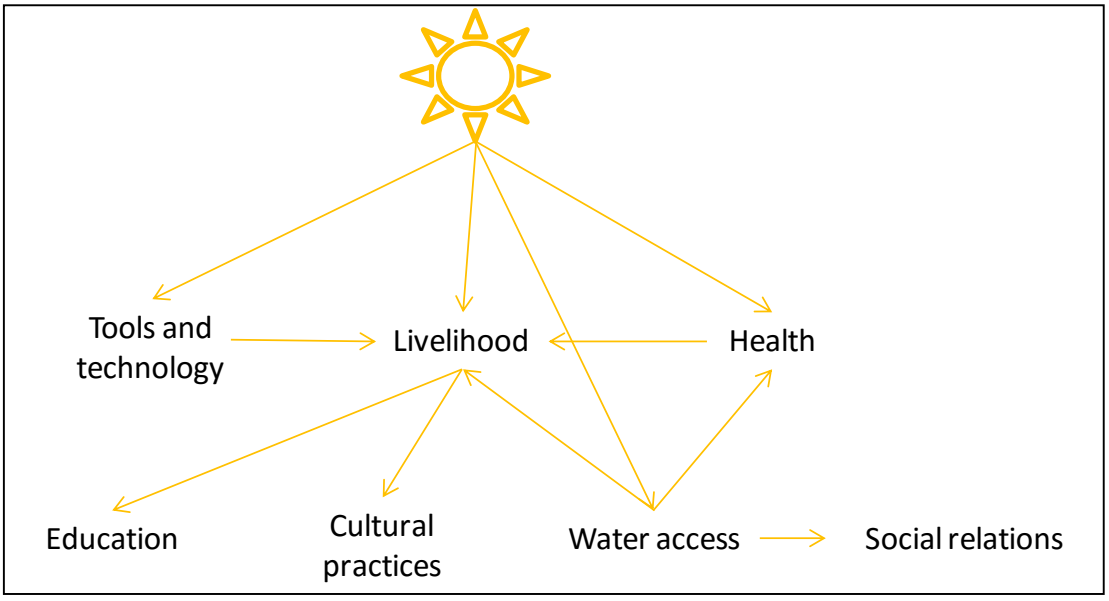


Figure 5.2 Web of impacts caused by droughts

The mechanism of impact on crops also varied between the hazard types. Prolonged dry season droughts impacted on crops by reducing the length of growing season, placing a strain on traditional seeds that required the full length of the season to mature. Delayed planting caused stress to farmers and increased demand for tractors to plough hard land, creating a further strain on financial resources where tractors or cattle ploughs had to be hired. In contrast, dry spell droughts disrupted the growth of already planted crops, reducing their productivity or even damaging the crops to the extent that they had to be replanted, placing a strain on household labour resources.

Other direct impacts are limited access to water and increased illness. In terms of access to water, it was found that the population were generally able to access water from wells and boreholes, however, drier conditions meant that fewer wells and boreholes were available as some dried up as supplies diminished alongside increasing demand. This leads to situations where long queues develop at the remaining productive wells and boreholes. Consequently, water collection takes considerably longer and the knock-on effect of this situation is that women, who are usually responsible for collecting water, have to spend more time at the wells having less time for other household tasks. The long queues can lead to social tensions which can erupt into arguments and fights. As interviewees commented, the situation becomes 'boxing season' (BNSet13) and male community members/husbands may be required to step in to resolve arguments.

Limited water not only creates challenges for water women to collect enough water for household tasks, but it also creates problems for livestock, particularly those normally

kept near to the house. When local water pools and ponds dry up, animals need to be shepherded to rivers and larger pools of water further afield. For smaller animals, such as chickens, this is not possible and thus it becomes difficult to supply the livestock with sufficient water resulting in some livestock deaths. One interviewee (BNTet3) mentioned leaving their larger animals to find water themselves. Without shepherding, the animals may not return either as they might get lost, choose not to return or be stolen en route. As such, the lack of water available for animals often resulted in further losses for livestock, the primary household asset.

In terms of health, the interviewees felt that the main health impacts were related to increased dust, such as respiratory problems in the prolonged dry season. Some, such as BNDab3 and BFGni2, commented that the drier conditions of both types of drought, which were often accompanied by higher temperatures, tended to exacerbate existing illnesses and make people more prone to illnesses that they would otherwise be resilient towards. In addition, reduced crops available for consumption due to drought damage on crops, increases the risk of malnutrition which in turn leads to an increased propensity towards illness. This additional health burden has the same effect as in the case of flooding, in that it reduces the productive capacity of the household where the affected person is normally engaged in livelihood activities. As such it potentially reduces income which is compounded by any healthcare costs that are required to treat more serious conditions that may have been exacerbated. The reduced income from damaged crops and lower household productivity, makes meeting healthcare costs particularly challenging.

5.1.1 Case study variations in impacts

The analysis above has demonstrated the range of impacts from the perspective of the three case studies overall. When considering the case studies individually, there is very little variation between the case studies. The most notable difference between the case studies is that the Burkina Faso and Benin case studies highlighted impacts from floods and droughts on businesses besides agriculture. In the few cases where other business activities were engaged, interviewees commented that floods and drought might reduce the amount of custom they received as most customers are farmers who are generally unlikely to be able to pay for goods and services when yields are low. In Ghana, impacts on custom were not mentioned. This reflects a clear focus on agricultural activities amongst the interviewees in Ghana whereas in Burkina Faso and Benin, some additional occupations were also present and seen as important enough to mention in those interviews.

5.2 Multiplier and cascading effects

The aim of this research is to understand how more frequent but also multiple (successional) hazards, as anticipated under climate change, might place an additional strain on local communities and whether or not these communities will be able to cope with or adapt to these impacts. A first step in answering this main research question and aim is to understand the present day situation in terms of impacts and responses. In the previous sections, the impacts under each of the two hazards of interest were presented. In order to understand where a potential multiplier effect may take place, the impacts have been compiled as shown in Table 5.4.

Table 5.4, below, shows the frequency that each impact was mentioned and whether these impacts were mentioned as flood or drought impacts. The green shading denotes impacts that were mentioned under both hazards and thus impacts that may potentially be exacerbated under a multiple hazard event situation. However, looking at the table in detail, some of the hazard impacts, although mentioned under both hazard types, the impacts are not mentioned with a comparable frequency. For example, mosquitoes and malaria were mentioned as being exacerbated by both floods and drought conditions. However, mosquitoes and malaria were mentioned considerably more under flooding than droughts. Similarly conflict and tension were more frequently mentioned under drought conditions than flooding. Thus, although there potentially is a multiplier effect for these aspects, the multiplier effect is likely to be limited.

By far, the most frequently mentioned impact of floods and droughts was crop damage. Furthermore, crop damage was mentioned with almost equal frequency under both hazard types. This is clearly an important aspect of impact but also of particular concern from the perspective of a potential multiplier effect from successional hazard events. However, it is unclear from these results alone whether the same crops are likely to be affected by the two different hazards, in which case there would likely be a limited multiplier effect from both hazards occurring in succession, or whether different crops might be affected and thus a strong multiplier effect may be experienced. Chapter 6 provides insights to answer this remaining question through the application of scenarios.

	Impact	Flood	Drought	TOTAL
1.	Crop damage	132	138	270

2.	Rooms collapse	105	0	105
3.	Mosquitoes and malaria	32	2	34
4.	Difficult to travel	28	2	30
5.	Livestock damage	7	21	28
6.	Temperature issues	14	11	25
7.	Items damaged	25	0	25
-	Thirsty animals	0	25	25
9.	Less custom	16	7	23
-	Affects agenda	1	22	23
11.	Harder to find water	0	21	21
12.	Malnutrition and hunger	2	18	20
13.	Conflict and tension	4	15	19
14.	General and exacerbated illness	10	8	18
-	Crop stores damaged	18	0	18
16.	Road degradation and poor conditions	13	4	17
17.	Worry	5	11	16
18	Livestock deaths	15	0	15
19.	More time spent on basic tasks	0	14	14
20.	Damp rooms	13	0	14

Table 5.4 Top 20 impacts by hazard. Blue shading reflects a flood only impact, red reflects a drought only impact and green shading reflects impacts caused by both hazards

In addition to demonstrating potential multiplier areas of first order multiple hazard impacts, combining the web diagrams from the flood and drought impacts demonstrates a particularly complex pattern of potential cascades and interactions. Figure 5.3 below depicts the main potential interactions and cascades of impacts between the hazards. The diagram shows particular crossovers between floods and droughts in terms of health, livelihood, education and cultural practice impacts. With feedback/cascading effects between health and livelihoods suggest these areas to be particularly heavily impacted by multiple hazards. In particular, livelihoods remain at the centre of direct and indirect impacts. This reiterates the importance of understanding the multiplier effect of floods and droughts in succession on livelihoods.

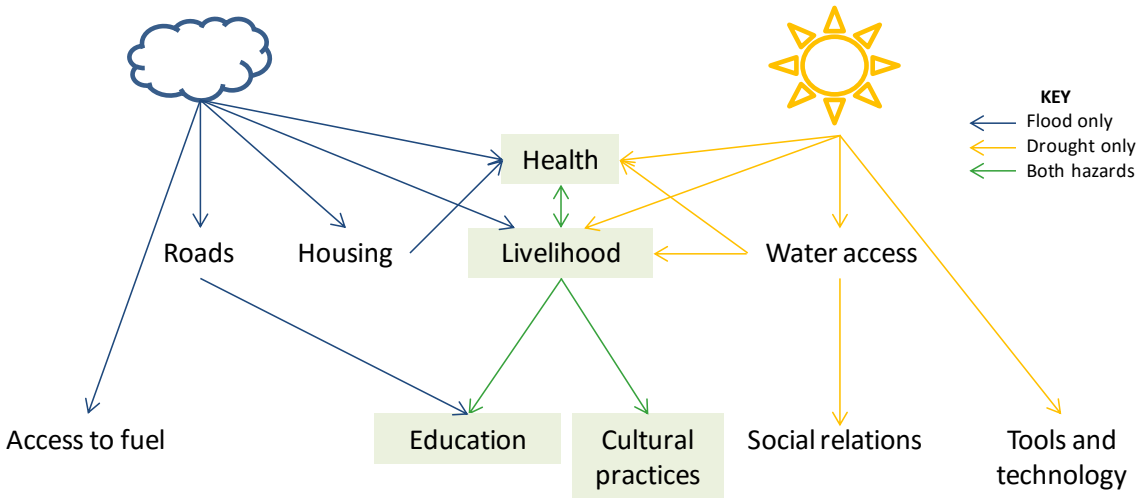


Figure 5.3 Web of impacts for both floods and droughts

5.3 Synthesis of impacts

The first part of this chapter has demonstrated the wide range of impacts from floods and droughts as individual events. The range of impacts and cascades from first order impacts to knock-on effects is clearly important as feedbacks exacerbate the impacts of key areas such as livelihoods and health. These cascading impacts are important to reveal and account for in considering how more frequent and multiple hazard events might affect the case study areas. Such complexity was revealed through the twin approaches of basing the interviews on the wide range of well-being categories which elicited information on broader impacts than simply livelihood or health, and the further probing undertaken through in-depth interviews. These two approaches helped reveal the complex cascades and full range of impacts for both hazards.

Putting the impacts of floods and droughts together, the interview results helped present a case for examining a multiplier effect that may occur through successional flood and drought events. The web of impacts shown in Figure 5.3 revealed the range of cascades and interactions but Table 5.4 highlighted the particular need to consider a potential multiplier effect on crops and the respective impacts of these effects on other aspects such as livelihoods and health. A key question that is addressed by the scenario approach, described in the following Chapter 6, is whether the same crops or different crops are affected by the different hazards and what this means for successions of flood and drought events in the same season.

In addition, to understanding the impacts of floods and droughts, the interviews also aimed to reveal coping and adaptive strategies that might mitigate the impacts and reduce the potential for calamity under climate change. The interviews were designed to

enable an understanding of the current situation, with the participatory game being used to understand how coping and adaptation might vary under climate change from the present day situation. The following section presents the findings from the present day response approaches, using the analytical framework developed and presented in Chapter 3 to categorise the responses.

5.4 Responses to floods and droughts

Based on the theoretical insights from the literature, this research takes the perspective that vulnerability can be mediated by coping and adaptation strategies. As such, following from the study of flood and drought impacts, the interviews undertaken the first phase of fieldwork, were also used to examine response mechanisms and processes. This is used to develop a baseline of coping and adaptive capacities from which to then consider the implications of climate change. In addition, the descriptions of reasoning behind the selection and decision to undertake certain responses was also revealed by the interviews to provide a further platform for understanding decision making processes under climate change conditions.

Using the conceptual framework, different degrees of coping and vulnerability are defined, in order to better consider the 'degree' to which the response processes resemble coping and vulnerability, recognising that in real world environments, coping and vulnerability may be manifest in different ways, each of which may exhibit a different degree of coping capacity or vulnerability, where vulnerability is seen as the propensity to harm from an ex-ante perspective and realised harm from an ex-post perspective (Birkmann, 2007).

By taking a retrospective, ex-post approach, it was possible not only to identify the coping and adaptation strategies enacted but also to reveal the full extent of the recovery process over time, looking beyond the superficial level of action to see the degree to which the households had coped or remained vulnerable. This approach particularly emphasises the need to consider vulnerability and coping along a scale, with those that achieve a complete recovery more quickly being more resilient than those that recover more slowly or are not able to complete the recovery at all. In this, the use of the conceptual framework was particularly helpful for the analysis.

With the emphasis placed on achieving a full recovery, the research looked beyond the direct and superficial impacts, looking at the cascade of impacts but also the cascades of the response process. This approach takes the perspective that assets utilised to facilitate

a recovery from the impacts constitute coping capacity. Thus, in order to be prepared for future hazard events, it is important to recover not only from the damages but also to recover the coping capacity, ready to deal with a future hazard event of the same magnitude to the same extent. As the research on current experiences was intended as a foundation for understanding the ability of households to cope with more frequent hazard events as in the case of climate change, a cut-off point of twelve months for recovery was used to differentiate between bounce back recovery and protracted recovery with more than twelve months for complete recovery being categorised under the latter.

To determine the type of recovery process in order to categorise the response as exhibiting vulnerability, coping or adaptation, interviewees were asked to describe and detail how they responded to the impacts of floods and droughts. Their recovery actions were followed through until all assets had been recovered and the household was in the same position as prior to the hazard event. It was particularly challenging to determine when a household had recovered from the specific flood or drought event because the longer the recovery process took, the more likely it was that additional problems would arise that also needed to be responded to and thus set back the initial recovery process. It was not possible to completely untangle the recovery process for the flood and drought events from other problems or additional flood and drought events. Therefore, the accounts of the recovery process were taken as an average which also included the reality that other burdens on coping capacities can arise during this time and set back the recovery process. With 188 interviews carried out, the average perspective provides an overview of the time required to recovery but the detailed recovery process carries relevance for development of the game and scenario methods to assess future capacities to cope and adapt to more frequent and multiple hazard type events under climate change conditions.

5.5 Vulnerability: Spiralling decline and set-backs

As demonstrated in the Theory and Conceptual Approaches Chapter (Chapter 3), vulnerability is taken as the residual impact/harm after coping strategies have been implemented. Vulnerability from the ex-post perspective, therefore, can be assessed as impacts that are not recovered from. The analytical framework distinguishes two categories of at the vulnerability end of the continuum which are labelled 'spiralling decline' and 'set-backs'. Spiralling decline is defined as a situation where a hazard event has triggered a cascade of continual losses, for which coping strategies are unable to halt the continual decline. Set-back is defined as a loss that is sustained from a hazard event but where coping strategies are not employed to recover these losses.

Based on the interviews under phase 1, examples of spiralling decline and set-backs were rare. In particular, spiralling decline was found to only occur under a particular cocktail of circumstances. Spiralling decline was found where a hazard event affected a person with virtually no capacity to recover losses due to their inability to participate in livelihood generating activities. In addition, this inability to generate an income was combined with a lack of social networks or connections that could assist in such cases. When these underlying circumstances coincided with a hazard event that not only caused physical losses but also health impacts, or where underlying health impacts were exacerbated, this is where a lack of coping capacity could lead not only to set-backs but a spiralling decline as the household struggled to afford medical care to overcome the illness and with a lack of livelihood means and support networks, the ill health could continue to decline with no hope for recovery.

There was one clear example of such a situation of spiralling decline (BN2012Som) in the interviews conducted. In contrast, set-back vulnerability was more common. Set-backs occur when the hazard losses or damages are not recovered but where this does not lead to a continual decline in household well-being. In the interviews set-backs occurred in two ways: voluntarily and involuntarily.

Voluntary set-backs took place where losses or damages caused by a hazard event were deemed minor or where the household felt that replacement was not important. As such, households could choose not to recover certain assets and to simply accept the loss. Examples of voluntary set-backs were found in BNDab4, where the household decided not to replace the bed that was damaged as this was not deemed to be important to them to replace. It must be mentioned that in such cases, the voluntary set-back is often a result of tradeoffs between the benefits that replacing the damage items and assets would bring compared to the benefits that would accrue if other household assets, such as livestock, were not sold to replace these damaged items but were rather retained to breed and multiply. As such, it is possible that whilst the examples illustrate voluntary set-backs at present, (i.e. where the household has decided to accept the losses rather than recovery), they may recover the losses or replace the damaged items in the future, if their household wealth increases.

In contrast to voluntary set-backs, involuntary set-backs occurred when households were unable to replace damaged items because they had insufficient assets to sell in order to generate the necessary funds for a recovery. Again, such situations were rarely revealed in the interviews, however, they tended to occur when the losses were particularly high

and available assets particularly low (e.g.GHKal7 and BFSor11). This situation was found in several interviews and tended to occur where the damages were a combination of crop damage and building collapse. With lower yields, assets could not be spent on rebuilding collapsed rooms as they would be needed to manage the more primary need of providing sufficient food for the year. As such, households were forced to manage with the fewer rooms that they had until a future point when they might be able to replace the damaged buildings as well.

5.6 Coping: Protracted recovery, bounce-backs and buffers

The conceptual/analytical framework illustrates a range of types of coping, from 'protracted recovery' to 'buffering'. The key factor in differentiating between the coping types is time, with "buffering" taking place over the shortest period of time and constituting actions and/or application of resources to minimise the impact of a hazard event in a way that allows the household to resume normal activities and well-being as soon as the hazard event passes. "Bounce back" refers to a recovery process that takes place in the aftermath of a hazard event. In the theoretical literature, 'bounce back' is usually referred to as a rapid recovery and return to the pre-hazard event state. However, for this research, with the key interest in climate change increasing the frequency of hazard events so that they potentially occur on an annual basis, bounce back is seen as a recovery that takes place over a period of up to twelve months. Twelve months is taken as a crude estimate of when the next rainy season commences and the point at which, particularly under climate change, the household may experience floods and droughts again. The goal is to understand if the household is able to complete their recovery before the next hazard event. Therefore, bounce-back recovery is taken as an example of a return to pre-hazard conditions in time for the next potential hazard event.

Protracted recovery is the third type of coping strategy and is determined using the same cut-off point as bounce-back recovery, only with protracted recovery representing a recovery process that exceeds twelve months. Protracted recovery is important to illustrate households that are currently able to cope with hazard events as they generally occur less frequently than every year. However, with climate change increasing the frequency of hazards, these households may become unable to cope.

Beginning with 'protracted recovery', the following sections present the findings of the interviews under Phase 1 of the research. In each case, recovery is taken as a complete return to the same situation as prior to the hazard, however, it must be noted that there

were some challenges to identify the point at which a complete recovery has been achieved as other processes and demands on assets can arise during the hazard recovery process but which are not related to the hazard impacts. Equally, the household may choose to replace damaged items and assets with similar but different items and assets. For example, it may be that if a household sells pigs to pay for reconstruction to their houses, when they are able to replace these pigs they may choose to purchase goats instead. Thus, the distinction between ongoing and completed recovery is not necessarily clear and a degree of judgement is necessary. During the interviews, respondents were often asked if they had fully recovered all their sold assets. If they replied that they had not, further questioning would reveal if this was because they had chosen to invest in different assets or if they were still in the process of trying to recover.

5.6.1 Protracted recovery: Livestock

The most commonly employed response to hazard impacts that required financial resources to facilitate a recovery was to sell livestock. This applies, for example, to replacing damaged crops from floods and droughts, reconstruction and repair of flooded houses, healthcare costs stemming from illness triggered or exacerbated by either hazard.

When livestock are sold, the choice of species and quantity to be sold is subject to more complex decision making processes. Interviewees mentioned several strategies and considerations that influence their selection of livestock to sell. Interviewees such as BNTet2 and BNDab6 favoured selecting the animal that best fits the value of the need. For example, if large financial resources are required to facilitate the recovery, then a more valuable animal will be sold rather than several less valuable animals. This applies to both the selection of species, for example choosing to sell sheep over chickens, or it may apply to the selection of the individual animal, such as choosing to sell a larger sheep rather than a smaller one. This can be seen as the 'fits the price' approach. There is a reasonable logic to such approaches as the sale of a single animal rather than several cheaper animals leaves a greater number of animals available to reproduce and thus increase the household's wealth, recovering from the losses more completely.

In contrast to 'fits the price', other approaches such as those used by interviewees GHYor7 and GHYor9, were to select animals seen as weaker. This may be applied to the choice of species to be sold, such as selling pigs because they are more prone to diseases and may be lost in the dry season anyway, but it may also be applied to the selection of specific individual animals, such as those that are older and thus less likely to reproduce. In addition, males would be sold rather than females as females have potential to breed and

as such the animals would be sold for consumption as meat, rather than as assets for a more successful farmer. A similar strategy is the sale of animals that breed quickly based on the notion that the sold animals can be rapidly replaced by the remaining stock. This is an approach mentioned by interviewees such as BNTim1 and BNDas4 and can be seen as a "minimising compound losses' approach.

Another strategy that was used, and is in contrast with the 'fits the price' approach, is the 'volume based' selection of animals. In other words, the animals selected for sale are based on selling those that are most numerous and to ensure that the household retains a variety of animals. Such approaches see the sale of smaller animals such as chickens which are often more numerous as preferable to the sale of sheep or cows for which a household may only have one or two available. This approach is here labelled 'volume based selection'. Farmers would limit the number of animals sold to roughly half of their herd size. Sale of a larger proportion than this would, therefore, indicate a household experiencing severe challenges and would also result in a longer, more protracted recovery compared to selling a small proportion.

Ultimately, a combination of strategies and complex tradeoffs are involved in the selection of livestock to fund recovery and a household may choose one selection criteria to deal with one hazard event and a different one for a different hazard event. Essentially, the results demonstrate that the choice of animals to be sold is based on an assessment of the household circumstances and available stock at the time, reflecting similar findings from Sakdapolrak (2014). From this point, a decision will be made based on mental calculations of which strategy will be least costly and allow the most rapid recovery. The decisions are clearly a subjective process and based on mental rather than actual calculations. They balance a range of considerations such as the value, the volume, the reproductive capacity and susceptibility to diseases. The decision is then taken based on the context of the available resources.

Based on the experiences reported in the in-depth interviews and as illustrated in Figure 1.6, the sale of livestock usually represented a protracted recovery as livestock required time to be replenished; even relatively small numbers of livestock would take time to be replaced. Livestock replacement rates depend upon the size of the herd, the number of females and the species. Chickens breed most quickly with a gestation period of up to 1 month, whereas cows have a 9 month gestation period. In addition, breeding tends to take place during the dry season when animals are free ranging rather than the rainy season when they are tied up individually to prevent them from damaging crops.

On average, it took farmers 3 years to replenish their livestock after the event. This was due to the factors mentioned above and as a result of annual losses from diseases such as African Swine Fever which is particularly prevalent during the dry season and can decimate of swine herds in the region on an annual basis.

The timing of livestock sales also has an impact on the amount of money made from the sale. The prices are lowest during the rainy season because "people know very well that in the rainy season farmers are always in need of money" (BFLof1). This is combined with the idea that animals don't produce as well during the rainy season because they are tied up individually to prevent them grazing off crops and that farmers will sell animals if they have too many to provide sufficient grazing space. As with crops, the highest prices could be achieved during the dry season from February to May. However, December was deemed the best time to sell because this is when potential buyers are most abundant as this is the festival period where animals are more frequently consumed. Therefore, farmers often sell their livestock when needs arise just before the beginning of the early harvest in June and July. They do not sell their livestock unless they really need to because their livestock function as their savings. Furthermore, livestock have the potential to breed and thus increase the household assets if they are retained. They, consequently, receive a lower price, losing money compared to a sale at a more expensive time in the dry season if they are forced to sell some livestock, but this approach ensures that their 'assets' can multiply if they do not need to make a sale.

The results confirm that livestock assets are seen as a form of banking wealth and are used as a recovery mechanism in the event of a flood or drought event. The selection of animals to sell is based on a several decision making criteria and a combination of these combined with the household context leads to the ultimate decision which balances needs with long term security. The decisions are taken by individual household members subject to internal calculations and tradeoffs, aimed at minimising a compounding of the hazard event losses.

Taking the time taken to replenish livestock sold into account is central to understanding the risks inherent in the recovery process and how these threaten the full recovery of households. The time taken to replenish sold livestock must be taken into account as part of the recovery process, in terms of a full recovery to the same situation as prior to the hazard event. From this perspective, the results have demonstrated that the full recovery process through the sale of livestock takes more than twelve months, reflecting a protracted recovery.

Protracted recovery mechanisms are important to consider in the context of climate change due to the anticipation of an increasing frequency of hazard events. Any rainy season carries the potential for a flood or a drought (or both) event. If a full recovery has not been completed by the following rainy season, the household is at risk of being unable to cope with the next hazard event as an event of the same magnitude as the original event would arguably require the name number of livestock sales, but if 50% were initially sold, selling the same number would leave perhaps only a small number from that years' breeding process and these would be insufficient in the event of an additional hazard. At present, these households appear to be 'coping' but the findings indicate that the protracted recovery induced by the sale of livestock assets has the potential to lead to spiralling decline and eventually vulnerability under climate change. Whether households will be likely to exhibit gradual declines and failures to fully recover or whether they will adapt proactively are themes that were examined in greater detail during the game activity, as described in Chapter 6.

5.6.2 Protracted recovery: Loans

In addition to the sale of livestock, another option for inducing a recovery from a flood or drought (or both) is the taking out of loans. However, loans are often seen as an option of last resort due to the stigma associated with them and the negative impact of interest.

Whilst there are some organisations that can provide loans such as rural banks/micro finance or cooperatives, most loans are sought from friends and family. For loans from rural banks or cooperatives, the individual requiring the loan would be known to the organisation and thus the loan may be based on their reputation. As such, if a loan is taken out, whether from friends, family or organisations, it is seen as a priority that the loan is paid off first, before any other investments or luxuries (BF 2012RPF).

Loans can be provided in cash or goods such as crops and seeds to meet the household needs but they may also be given as loans in service provision. For example, if an individual requires repairs to their vehicle but are not able to pay, the repairs will done with the expectation that they are paid for later, when the individual can afford this; "they won't speak in terms of paying cash. They will speak in terms of debts" (BNDas16) and "if a regular customer doesn't have money, you are compelled to do it for him simply because you know that any time he comes ... he [will] pay" (BFCen4).

Repayment of loans can be achieved through cash, goods, services/labour, or a combination of these. Where repayment is in goods, this takes the form of crops which are

loaned with based on the notion that they may be sold for a higher market price later. For services/labour, this usually entails working on the farm of the friend or relative from which the loan was taken.

Loans are repaid following a good harvest. Where loans are paid off promptly, this represents a protracted recovery as repayment comes after the next main harvest, around twelve months later (see Figure 5.4). Where loans were not paid off following the next main harvest, interest accrued making it more difficult to completely pay off the debt and recover. Under such circumstances, loans have the potential to lead to spiralling decline, particularly floods and droughts result in poor harvests within the repayment period, highlighting the challenge that more frequent flood and drought events present (as illustrated in Figure 5.4).

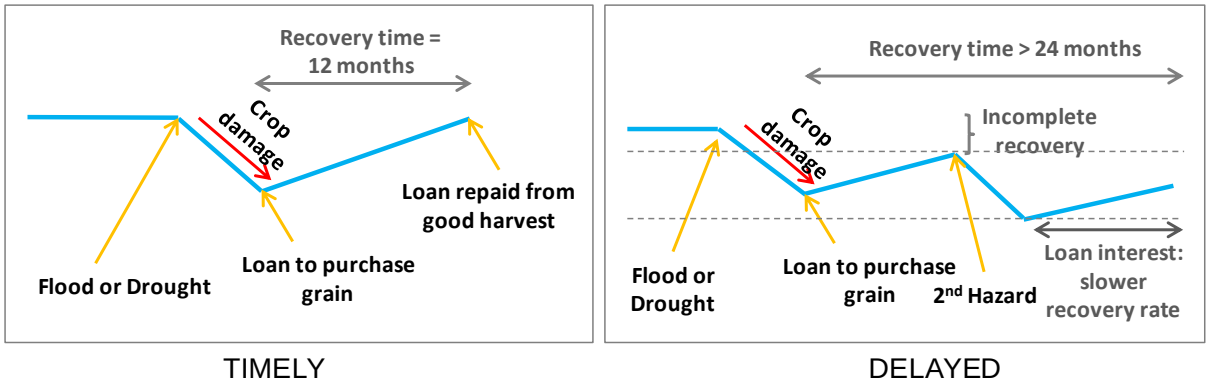


Figure 5.4 Comparison of timely and delayed loan repayment

5.6.2.1 Bounce-back recovery: seasonal migration

Interview respondents such as BNTim3, BFTam2 and BFSor5 mentioned the role of seasonal migration in helping them to cope with the impacts of floods and droughts. Seasonal migration normally entails a single member of the family migrating during the dry season to work on farms or to provide labour services such as cleaning. In the Burkina Faso and Benin case studies, migration usually involves moving to the south or neighbouring countries where the climate has more favourable farming conditions during the dry season in the case studies or where more populous towns and cities provide employment opportunities.

Seasonal migrants are expected to return and to contribute some of their earnings to support the household. However, interview respondents also mentioned that this is not necessarily possible and instead their migration has simply reduced the burden on the household rather than generate additional financial resources. BFKou5 also commented that seasonal migration had become a regular strategy and that despite not being able to

generate a profit, this was preferable to staying during the dry season where he would be more of a burden. Where migration is more regular and permanent, this is classed (based on the conceptual definitions in Chapter 3) as adaptation and is elaborated upon in Sections 5.7 and 5.8 below.

5.6.2.2 Bounce-back recovery: Minor strategies

In addition to the main coping strategies of selling livestock and taking out loans, more minor strategies were also employed to illustrate a degree of bounce-back recovery where impacts were less severe. Common minor strategies used to cope with minor livelihood losses were the sale of small items and processing of goods to increase their value. The small scale trade items often sold included nuts and fruit collected from trees and processed goods such as de-husked rice and powdered grains such as seeds from the Baobab tree. These items were usually produced by the women in the household and are used to supplement the income from farming, particularly where additional needs arise. The interviews suggested that small scale trade would normally be undertaken when small household items had been damaged and needed replacing or where the harvest was slightly deficient. Women also use small scale trade to generate additional funds for school supplies to support children and thus it constitutes a widely used minor coping strategy.

Besides the trade of small items and processed goods which can be used to compensate smaller losses and damage to crops, other minor coping strategies include reducing the frequency of meals and children being unable to attend school for the year. Whilst these strategies risk longer term detrimental impacts such as malnutrition that might lead to illness and an inability to complete school in the normal time, the strategies represent examples of bounce-back recovery as they are undertaken for up to one year and after a better following harvest, can return to normal meals and school attendance. However, as in the case of loans, above, if the following year also incurs floods and droughts, this could lead to a persistent decline in well-being from which a recovery is not possible. Therefore, the strategies of reducing meals and school attendance are also at risk under climate change conditions and it is likely that a household may have to shift to selling livestock to pay for school fees and additional grain in the event of further flood and drought events, this would push them from a situation of bouncing back to protracted recovery.

5.6.3 Buffering

The interviews provided examples of buffering where the impacts of floods and droughts were seen as temporary. This was particularly the case for housing where floods cause the house to become damp but the house does not collapse, it is able to withstand the water.

Where houses are damp, household members either seek to stay with neighbours and relatives or they sleep on raised benches to avoid the water until it has subsided. They light fires to dry out the houses shortly after the floods have passed and in this manner are able to return to their houses as normal when the flood waters have receded.

Additional temporary measures that are undertaken to cope with the less severe hazard impacts of flooding include the use of mosquito nets. Mosquito nets are often made available by governmental and non-governmental organisations during flood events to help households cope with the additional mosquitoes. The nets are encouraged to be used permanently to increase resilience to mosquito borne malaria which is endemic in the region, however, some households only use the nets during flood events and thus the nets comprise an example of buffering.

For droughts, buffering actions include the provision of bowls of water for livestock unable to be shepherded to rivers and shepherding larger animals to rivers for water. When women have to queue for longer periods of time at the wells and boreholes, they have less time available for all of their normal household tasks. As such, they compromise and postpone the least urgent tasks, such as cleaning the house (which would also require additional water). These responses are all examples of temporary actions that interview respondents mentioned as helping them to manage the impacts of floods and droughts.

5.6.4 The role of organisations

In addition to household driven response strategies, government and non-governmental organisations are also available to support the recovery process.

Governmental organizations in all three countries have been set up to respond and support those affected by natural hazards such as floods and droughts. In Ghana the primary agency responsible for responding to floods and droughts is the National Disaster Management Organisation (NADMO). In Burkina Faso, the equivalent is the Conseil National de Secours d'Urgence et de Réhabilitation, (CONASUR) and in Benin Agence National de Protection Civile (ANPC). In addition to the governmental institutions, non-governmental organisations (NGOs), such as the Red Cross, are also operational in the case study areas to provide support in the event of a hazard occurrence.

Based on recent experiences of hazard events the national organisations and NGOs face many challenges in delivering support to those in need. Firstly, the hierarchical nature of both the governmental organisations and NGOs makes timely delivery of aid particularly problematic. Information on flood and drought events works up to higher decision making

levels in order to release any available resources to aid the victims. This process can be lengthy as reports of victims must be compiled and sent to the national level offices for approval. Thus, where aid is released, it often arrives months or even years after the event. In Ghana and Burkina Faso, aid can take months to arrive (BFExp1 and GHKal4) and some in Benin commented that they had even received aid 3 years after the flood event that they experienced. Obviously, in such circumstances, the result is that "when [the aid] arrives you may have already managed and may already be ok" (GHKal4). Indeed, in the case of Timbouni (Benin), BNTim2 said that when receiving the aid three years after the event; "the help was not really relevant…we were no longer in need of it…in fact it was a good year" (BNTim2).

Although untimely aid has limited benefit in helping local people to cope with the hazards that they face, however, it is still appreciated, as a symbolic gesture; "in our tradition, the gesture is important, the intention is very meaningful… even if it took time, it is something good". GHKal4 also commented that "it is still useful, even if it comes late". Indeed, those working in the institutions recognized that "the aid, the support, it is just a gesture, symbolic" (BFExp1) and saw their value more in terms of providing moral support; "The first aspect to deal with is the psychological. Workers talk to people so that they know that people are there and that they will try to help" (BF2012Exp_Agric dept).

Other challenges related to aid relate to the recognition of hazard events and the inclusion of victims in assessment reports. Interview respondents such as BF2012EAct and BN2012Min highlighted that drought events are often not responded to by the disaster management and aid organisations as these events are particularly difficult to measure. There was even evidence of a tendency among the disaster and aid management organisations to view losses and damage incurred under drought conditions such as prolonged dry spells as the fault of the farmer for not following 'correct' planting advice (Interview: BF2012AS). This research found that the fluctuations in the rainy season make it effectively impossible to know when the 'correct' time for planting is as the seasons vary so considerably from year to year. Thus, there remains a gap in recognition of droughts that are increasingly affecting large numbers of farmers. Some approaches to manage the impacts of drought are being considered, such as in Benin where crop stores provide cheaper grains when the market price increases, however, it remains to be seen how effective these are.

Where aid is made available, this usually comprises items designed to meet short term, basic needs. Pots, pans and basins, mattresses, tents and mosquito nets help provide

shelter and facilities to cook and wash. Grain is also a key part of aid but this is also provided to meet urgent needs rather than to compensate for the full extent of losses experienced to crops. Whilst these provisions can help, interviewees from the governmental agencies and NGOs accepted that the aid provided was "not substantial, it's just some small things that will help them live for a few days" (BFExp1). This was reflected by the victims such as BFLof7 who commented that the grain they received "wasn't enough at all". However, many interviewees understood that the resources available to the NGOs and governmental organizations were limited; "they don't have means at the district level, they can only offer small support" (BNDas10). As such, households must still depend on their own capacities to cope with and recover from hazard events. Government and NGO support is severely hampered by bureaucratic processes and a lack of sufficient resources.

5.6.5 Synthesis of responses

The interviews showed that minor coping strategies can manage minor impacts of flooding in order to provide quick recoveries and can be seen as examples of "coping". In contrast, where the impacts are more significant, the coping strategies available tend to result in the sale of livestock assets in order to generate financial resources to pay for goods and services to recover the damage. At a superficial level, the recovery takes place rapidly with grain stores being replenished and houses reconstructed within a few months of the dry season. However, taking the sale of the livestock into account, as is required when considering the full recovery process, it became evident that the recovery process takes considerably longer to complete. Whilst this period varies considerably based on the extent of the losses and the size and composition of the livestock available with their capacity to reproduce and be replenished, the average period of time required to recover livestock, based on the interviews was around 3 years. However, given that many interviewees had experienced hazards less than 3 years before the interviews were conducted, it is likely that this average figure is an underestimate.

Based on the information obtained from the interviews, it seems that most households experience a combination of coping, bounce-back and protracted recovery. The protracted recovery stems from the time taken to replenish sold livestock and as livestock are the key recovery asset, this clearly presents a considerable concern for climate change where hazard events are likely to occur more frequently, potentially on an annual basis. The outstanding question from these findings was whether coping strategies would change as climate events became more frequent and whether adaptation would be triggered to

reduce the impacts and improve the ability of the system to pertain despite the changing climatic conditions.

5.7 Adaptation strategies towards floods and droughts

Adaptation is defined in Chapter 3 as a permanent adjustment or change that can occur in anticipation or reaction to a stress or threat, such as floods and droughts. In this research, the interviewees highlighted several actions and adjustments that can be seen as adaptation strategies that have been developed in response to perceived increases in flood and drought events. Of particular note is a trend in coping strategies becoming more frequently used to the point that they are now seen as permanent and normal actions, carried out every year.

One of the most frequently mentioned examples of coping strategies that are becoming permanent, and therefore adaptation strategies, are additional sources of income. In Section 5.6.2.2, above, small scale trade in processed goods was mentioned and shown as an example that facilitates a bounce-back recovery. However, as GHSum5 mentioned, small scale trade is becoming increasingly prevalent and, as such, is now seen as a permanent activity and standard contributor to the household income. In addition, Section 5.6.2.1 described the use of seasonal migration as an example of bounce-back recovery. Seasonal migration is, by its very nature, temporary, however, seasonal migration is becoming increasingly routine to the point that some households such as BFKou5 see it as a routine action. These trends in short term coping strategies that become more regular and permanent to the point where they can be considered adaptation strategies are primarily driven by the increasing frequency of flood and drought events.

In addition to temporary strategies becoming more permanent, the interviews also revealed a range of other adaptation strategies. Overall there were variations in the degree to which different households and individuals attempted to adapt and the strategies that they were drawn towards. However, the most common adaptation strategies visible related to changes in the timing of sowing seeds, shifts in the location of crops in fields, changes to collapsed buildings when they were reconstructed, the use of improved seeds, and alternative occupations. Taking these in turn, this section begins with adaptation through changes to sowing time.

5.7.1 Attempted adaptation: Timing

The farmers frequently reported changes in the timing, duration and quality of the rainy season as impacting on their crops. They regularly referred to a degree of unpredictability

to the rains, that the patterns of the rainy season have changed and that this has led to increased losses through floods and dry spells where rainfall has occurred in abundance or has been absent at critical periods in the crops growth cycle. To combat this, farmers have tried to determine new patterns of the rainy season, experimenting with changing the time at which they plant their crops based on advice from agricultural extension workers and their own experiences and observations: "We are trying lots of different strategies but none are guarantee[d]" (BNPor10).

The strategies most commonly adopted are to prepare the fields early in order to be able to benefit from the rains as soon as they arrive and to wait until the initial rains and prolonged dry spell, that appear to occur more regularly in the current climate, have passed and the main rains are more clearly established before planting. Neither of these strategies are guaranteed to bring success as the rains vary from year to year. As such, these strategies are effectively gambles and farmers often change between these strategies, as shown by BNTim4 who comment that they had previously planted after the rains but due to flooding, were now thinking about planting earlier so that the crops could be established before the peak of the rainy season. In addition, BFBag4 and BFGni1 commented that they had shifted to planning earlier due to the potential for a short rainy season. However, others decided to plant later to ensure that the rains were fully installed to avoid losses in a dry spell (e.g. BFBag3, BFKou5, GHSum1)

Planting early is particularly advocated by farmers such as BFBag4 who adopts this approach so that the plants are mature before the floods arrive. However, there is a risk that if the rains begin early but then stop and break for more than two weeks, the crops will have begun to germinate with the first rains but will then fail as they do not receive the water that they need to continue growing. This results in the crop having to be re-sown, reducing the seeds available as grain to eat and pushing the household closer towards taking out a loan for additional seeds (GH2012Boa). Interviewees BFGni1 and GHGam2, among others, reflected that such experiences of rains failing after an onset in April or May was a common experience and consequently many farmers have come to accept that they are likely to need to re-sow their crops, at least once and, at times, two or three times; "we will sow some of the grains and if it starts raining and if the rain keeps coming then fine, but if it stops at a certain time and the crops die, you have to re-start sowing again. That is what we are doing each year" (BFGni1). This approach constitutes an example of coping capacity rather than adaptation because although farmers expect to re-sow and prepare for this, it still requires an input of resources that would normally be

used by the household. When farmers take more seeds for replanting, this can leave them with less for the household's dietary needs and subsequently risks hunger later in the year (BFPar-Bag). It is therefore an example of coping with the dry spell hazard through adjustments at the time but can potentially lead to problems for the household later, at which point this would reflect an example of a more long lasting recovery process where the household endures suboptimal conditions until the next harvest.

The other strategy for dealing with the unpredictable precipitation of the rainy season is to instead wait until it is clear that the rains have properly begun and breaks are less likely. For farmers adopting this strategy, they are less likely to lose grain by replanting; "at times people are even afraid to sow, that is why some people will sow late... it's better that ... the rains set in properly" (GHSum1). However, this approach risks leaving the sowing until a point where the season becomes too short for some crops. In Benin, 2013, this situation was realised as the rains began early and some farmers were able to capitalise on this, risking replanting. Others, however, waited for the rains to properly 'set in' and subsequently waited until the beginning of August to till their land and sow their seeds. The result of this was that there was not enough time to plant all crops or for crops with a longer lifecycle such as maize to grow. If the rains are delayed until August, this strategy would result in a set-back since the farmer will have to accept a reduced yield regardless of the conditions of the remainder of the season.

Essentially, neither of these strategies is 'guaranteed' to produce a sufficient yield. As BF2012Exp_WT comments, "there is no pattern now. There is a change in the climate [but] it is hard to tell what patterns there are". One year, planting early may yield the best results, the next, planting later might be better; "farming is like lotto, a game of chance. Someone can plant early and fear and someone can plant late and get [something]" (GH2014Kum). As such, many feel that attempting to find patterns is impossible and thus there is no way to prepare or adapt to it; "We can't be cleverer or more cunning than nature. As you don't know, you can't predict when a dry spell will come, you can't take dispositions against it" (BNTet1) and "although the dry spells are becoming frequent ... they don't come at the same time each year, [so] we are not getting any strategy to adjust or be prepared for them... as it is not a cycle with a specific well known date, it is difficult for us to adjust or make any calculation [prediction]" (BNPor6).

In terms of adjusting the planting or sowing time, there were two main strategies highlighted: planting early or planting late. As the findings demonstrate, neither strategy was necessarily more successful or less risky than the other. Essentially, the fluctuations

of the seasonal rainfall patterns are too severe from year to year for the farmers to be able to adapt their planting times in a such a way. This raises the question as to whether planting time is an example of adaptation or mal adaptation. In reality, it is an example of neither as it is neither universally successful nor a failure, but rather it is an example of attempted adaptation.

5.7.2 Adaptation: Relocation

Similarly to timing, relocation is another example of an attempt to make a considerable adjustment to hazard exposure or susceptibility in order to reduce vulnerability. Relocation refers to changes in the location of both farms and houses.

With regards to changing the location of farms, exposure to flooding specifically and, to a degree, also to droughts is dictated by the location of farms in risky areas. The river valleys are particularly exposed to floods, while higher land may be too well drained and dry in a season on little rain. As such, some farmers have responded reactively to previous floods and droughts by relocating their plots. In dry years, farmers would subsequently seek land nearer to the river valley and following particularly wet years, they would be more likely to move away from the river valleys. However, it was not always possible to move their plots to a new location as they desired.

For farms, in the Ghana and Burkina Faso case studies, there were reports of limited land available for alternative farming sites. In Ghana, it was mentioned that "you won't get a place around here. You have to go into the forest" (GHYik1) and "when it gets to the point where they think they are no longer [getting a good yield] then they have the forest where they can go and crop" (GHKul1). Moving into forest land was not mentioned in any of the Burkina case studies but it was mentioned in Benin (e.g. BNSet4) where it was said that land could be appropriated simply by clearing it. However, there were indications in both the Ghana and Benin case studies that this was not necessarily a legal process (e.g. GHKul1 and BNDas15).

In general terms, respondents in Dassari (BN) commented that finding new land "is possible, it is findable but not easy" (BNDab4) and many commented that they had already been able to relocate their farms (BNDab5, BNDab7, BNFir7, BNPor5, BNSet7, BNSet12 ,BNTim2). However, in Burkina Faso, villages such as Gnikpierre highlighted a lack of alternative land and explained that this was a consequence of the land tenure system which sees land divided up between children over generations. As such, there is limited land available and households often have to manage with risky land (BFGni1).

When re-location of the cropping area is not possible, interviewees in Burkina and Benin mentioned an alternative strategy to adapt to the floods that they experienced by changing the where they grew particular crops. They focussed on growing the more water tolerant crops such as rice in the more flood exposed areas: "we got to know that apart from rice, we [shouldn't] grow anything close to the rivers because rivers are risky zones and if you grow cotton and millet there and ... if the place is flooded you are going to lose your cotton and millet so since then we are not longer growing cotton and millet close to the rivers. Close to the rivers, the only thing you can find is rice" (BFPar4) and "the crops that don't like too much water, I don't grow them any more in the areas that ... hold water" (BNDas13). However, one respondent found the flooding problem near to the rivers and in the depressions was too significant for even rice to tolerate and thus quit cropping the area: "they used to grow rice over there but now they are no longer growing rice over there due to the occurrence of floods in this area" (BNTet3).

With both floods and droughts as opposite extremes, efforts to relocate in order to avoid one hazard can inadvertently increase exposure to the other hazard. Diversifying land and utilising both dry and wet areas could help alleviate some of the risks, although some losses would effectively be guaranteed. However, as presented above, land availability is a considerable barrier to this approach in many villages in the case study area but another barrier is limited labour supply. Households crop as much land as they can achieve through their manpower. In many instances, additional labour support is required to crop sufficient land to supply a yield that would meet the household's needs. The labour support has to be paid for and the costs are justified by the expected value of the yield. If farmers spread their resources over a range of land, knowing with certainty that the part of that yield will consequently not be successful, they may not be able to justify the costs of the additional labour as easily.

The two adaptation strategies (change to timing of planting and relocation) have highlighted the challenges that farmers face in trying to adapt to the two opposite hazards of floods and droughts, combined with the potential for a short rainy season due to a delayed onset and/or early cessation of rains. As such, these strategies, whilst examples of adaptation, are clearly limited in their effectiveness. In contrast, those who change the location of their houses provide an example of a clearer adaptation strategy.

As houses only collapse under conditions of flooding, it is easier to adapt by rebuilding a collapsed house on raised ground. Whilst there were examples of houses being reconstructed in different locations, the nature of the compound houses (where houses

comprise separate buildings as rooms which are ringed by a single outer wall that encompasses all of the rooms and the central courtyard), it is not possible to reconstruct a single room particularly far away from its original location. As such, rooms are often reconstructed in the same (e.g. GHSum8) or slightly different locations but when asked, interviewee BF2012Flo mentioned that the flood waters had extended to the new location of the room. Others simply adjusted the location slightly and took other measures such as elevating the floor height (GHYor4 and BFLof4)

An alternative adaptation approach for reconstructed houses and rooms was to use different materials and change the shape of the house. However, there was considerable disagreement over which shape or materials were most resilient. Interviewees such as BNDab3, BNTet5 and BFFir5 argued that the traditional shape and materials was more resilient to flooding, whereas interviewees such as BNDas9 and BFPar5 selected a more modern, square shape and construction with bricks and cement. Once again, this demonstrates the lack of clear adaptation options. Some feel one approach is best while others advocate the opposite. The strategies are essentially gambles and the more certain adaptations such as constructing buildings out of concrete or locating houses and farms in more resilient locations is limited by budgetary, physical and cultural constraints.

5.7.3 Adaptation: Improved seeds

Another example of adaptation is in the use of 'improved seeds'. In the past and under the traditional expectations of the rainy season, rains should last for approximately 6 months but in recent years this has been reduced to around 4 or even 3 months. The challenge that a shorter rainy season presents is that the traditional seeds for the staple crops in the three case studies are rain-fed and require a growing period of approximately 6 months. Clearly, with the current situation the traditional seeds are no longer able to provide the yields previously attained and upon which local households rely upon. Fortunately, improved seeds with shorter life cycles have been developed that reduce the growing period by approximately two months.

Improved seeds with short cycles are the most widely cited and acknowledged adaptation strategy across the three case studies. Both experts and farmers mentioned the short cycle, improved seeds as an adaptation strategy. It was explicitly raised in 30 of the in-depth interviews across all three case studies and recognised as a positive option to help adaptation to the shorter rainy season. Respondents commented that "the new improved seeds with a shorter lifecycle are good. We can get a lot from these. The older type of seeds are no longer beneficial" (BF2012DA) and that "with this kind of change in the pattern of

the rainy season they can't grow anymore the old seeds. Now they are increasingly planting the short lifecycle seeds" (BNDas10). Thus the reason for beginning to use the short cycle, improved, seeds is always given as a response to declining yields ("the change was motivated by the decrease in the previous yields" BNTet1) and a realization that the rainy season length had become reduced ("Nowadays, we are using the shorter one that will fit in the new raining calendar" BFTam2).

Despite the general acceptance of the need to transition to the short cycle/ improved seeds, there are barriers to their adoption. The main barrier is access to the seeds. Typically, the improved seeds can first be obtained from institutions and organizations such as the Agricultural Departments and extension services (BF2012Exp_Agric dept, BNDab2, BNPor1, BFBag4, BFCen1 and GHYik11), however, the seeds are not necessarily available for free, as Gh_Exp_Boa 2012 commented; "normally they would have to buy the seeds and for this they may need to take out a loan". This creates additional burdens and presenting a challenge for farmers that may already be struggling, after consecutive poor harvests. An additional drawback with the seeds, as BF2012Exp_Oue described is that the improved seeds can yield seeds that can be 're-used' up to 4 times. Furthermore, if the improved seeds are genetically modified seeds rather than simply short cycle varieties, then it is not possibly to use the seeds from the harvest the next year and the seed need to be obtained every year.

Another barrier to wider uptake relates to the quality of the produce and storage potential of the improved seeds. Although some felt the seeds were of equal quality whether the improved or traditional varieties (BNDab6 and BFTam2), in the case of BNDab2, the female respondent highlighted that the improved seeds produce grains that depreciate in quality more rapidly over the time they are stored than the traditional varieties. She felt that the grains of the improved varieties could be stored for less time: "the longer the cycle, the better the paste [with] the maize of the long cycle, the paste is still good months after compared to the short cycle" and that "if it wasn't due to starvation and the need to cope with the shortage of rains, they [would] have stayed with them [the long cycle seeds] rather than changing to the short cycle maize". Another interview respondent mentioned that "the only problem that it has is that the fruit that bears the gain, the cob, the new one is smaller".

Thus, whilst the short cycle seeds are being increasingly adopted to address the challenges caused by the reduced length of the rainy season, there are some areas for improvement which present barriers to full and widespread adoption. Issues of access to the improved

seeds, costs involved compared to the traditional seeds which could be collected from the previous harvest and differences in quality and storage life of the grains restrict the full transition from long to short cycle varieties.

5.7.4 Adaptation: Additional sources of income

As mentioned above in Section 5.7.3, additional sources of income are often employed to compensate for some of flood and drought induced losses of crops. Short term and temporary strategies such as processing rice and shea butter help provide a small additional income. Although as interviewees such as GHSum5 mentioned, these short term strategies are becoming more permanent: "it has become something like our profession, so we do it all year round" and thus becoming adaptation rather than coping strategies, there is also evidence from the interviews that other permanent additional occupations are increasingly being adopted to adapt to the impacts of floods and droughts.

The adoption of additional, secondary occupations, to support the income from farming can be seen as a combination of reactive and anticipatory adaptation. As BNDas 14 comments "since farming is dependent on the climate, that if bad events like droughts or floods happen, I will have a lot of problems, that's why I knew it would be good to start another business" and "as agriculture here depends on the weather, sometimes crises or catastrophes like floods or droughts can come and prevent you from achieving your expectations, so the shop could help me maintain my standard of living" (BNSet1). In other words, the adoption of a permanent additional source of income is undertaken as a reaction to past flood and drought losses as well as in anticipation of future flood and drought losses.

The most common additional sources of income to supplement farming were shop keeping, tailoring and the sale of local beer. It is interesting to note that in many cases, these additional sources of income were often undertaken as a partnership between the men and women of the household. In some case such as BNDas5, the women of the household had proactively decided to open up their own businesses under their own initiative. However, other examples such as BNTet 6&7 and BNDas11 saw shops and tailoring businesses set up as a partnership and with the direct support of both husband and wives in a household. However, similarly with the additional (temporary) sources of income, women tended to be more frequently involved in additional sources of income, but the gender balance has somewhat shifted from the very female dominant shorter term, temporary sources of income. One exception to this is the sale of local beer which is clearly

dominated by women as they cook and brew the beer but also sell it to farmers to provide them with 'strength to work in the fields' (BFPar6).

Although the alternative sources of livelihood are undertaken to support predominantly farming households with diminishing yields, these occupations are not necessarily immune from the impacts of floods, droughts and changing climatic conditions themselves. Occupations such as the brewing and sale of local beer rely directly on successful sorghum yields. With low sorghum yields, there is unlikely to be enough sorghum available with which to produce the beer. Furthermore, businesses such as shops and tailors can be indirectly affected by floods and droughts because they rely on local farmers for their custom. As BNDas16 commented: "floods have a big impact on my clientele because most of my customers are farmers so if there are floods on the farms, naturally they won't have enough income and this will impact also their spending". Similarly, for millers, the connection between good yields for farmers and good business is even starker. In years where customers suffer, one miller commented that he would find it necessary to work for severely affected customers without payment: "in those scenarios [floods] people come with a small bowl of crops to grind and in some cases I work for them for free because I know that this person is in trouble" (BNDab9).

For tailoring and hairdressing, the impact of flood and drought events was potentially less severe as, although many customers may be farmers, the customer base can be broader. One tailor in Burkina Faso (BFCen9) highlighted that he tended to serve government employees who not only have a resilient source of income but also receive a steady income over the course of the year, thereby reducing the strong 'seasonal' effect that can occur with other customers like farmers who have more money soon after the harvest and less in the 'hunger period'. However, where farmers comprise a considerable proportion of the total customer base, a bad year for farmers will have a negative effect on those offering services of 'luxury' rather than necessity. Farmers with a poor harvest will have less money available to spend on 'luxuries'. Interviewees confirmed this, saying; "we try to avoid some pleasures that we normally allow ourselves so we live a basic life, focussed only on the basic needs" (BNDab2).

In contrast to the occupations that are directly and indirectly affected by the suffering of farmers, there are also some occupations that benefit from floods and droughts. One of the main beneficiaries of flooding are masonry and carpentry services. When houses collapse, there is pressure of the farmers to rebuild these quickly; "If I didn't rebuild the house as quickly as I did, it would have been like a shame in the eyes of the neighbours,

it would have shown me as being incapable as a man or part of society" (BNDas9). This pressure helps to provide business for masons and carpenters. Another beneficiary of the hazards, this time for droughts, is the tap manager (BFCen3) who is paid on commission. During times of water scarcity, particularly when the rains are delayed, the tap manager receives more business as wells begin to dry up. The main business comes from local beer producers who need water for the brewing process. Shop keepers can also benefit, if farmers come to them to buy crops that they have lost.

5.8 Transformations

A transformation is defined in the Theory and Conceptual Approaches Chapter (3) above as a fundamental change in the nature and outputs of a social-ecological system. At the local and individual household scale, transformations can be seen where households shift from agriculture to another source of livelihood. This is different to the adaptation described above because adaptation involves making changes such as additional sources of income but making these changes in order to support the main source of income (farming) so that the household can remain a farming household. In contrast, transformations occur where farming is abandoned and the household takes up a different occupation or, indeed, leaves the social-ecological system altogether. The following sub-sections present the two main transformations that were visible from the interviews: alternative occupations and permanent migration.

5.8.1 Transformation: Alternative occupations

Alternative occupations sometimes included occupations that others use to supplement farming. The difference here is that some of these 'supplementary' income options have been adopted as the only or main source of income instead rather than in support of farming. An example of this is BFCen2 who uses tailoring as his main source of income and BNFir6 and GHSum1 who have trained as teachers. Although these 'transformed' individuals and households still grow some crops, these are done as a token effort and, rather, the main source of income is unrelated to farming.

The clearest examples of transformations are those who have shifted from subsistence agriculture to employment as teachers, cleaners and security guards. These individuals receive a salary and thus have a stable income that is immune from the effects of floods and droughts. In Benin and Burkina Faso, it was difficult to find people employed in such a manner as there are few employment opportunities. This is particularly the case in the Benin case study and can be attributed to the location of the case study area as remote

from a larger town. In Burkina Faso, a few examples of people employed in non-farming economic activities could be found in the town centre but in Ghana, many more opportunities were available. However, the abundance of employment opportunities in Ghana resulted in many farmers continuing to farm but with a secondary/additional source of income to supplement years where the yields were low. Therefore, examples of transformation through alternative occupations, was relatively low in all three case studies. The trend is instead towards adapting by taking on additional sources of income but at present, the majority of households remain focussed on agricultural activities and are thus susceptible to impacts from flood and drought events.

5.8.2 Transformation: Migration

The example of transformation through alternative occupations as described above, demonstrates a relatively positive transformation. In contrast, migration represents a more negative situation. Although seasonal migration is seen as a coping strategy (see section 5.6.2.1, above), more permanent or long term migration results, instead, from an inability to continue farming due to severe losses.

Interviewees such as BNFir10 and BFPar-Bag highlighted migration in a manner that reflects a collapse in the social-ecological system for that household. Both interviewees had previously migrated for several years after their farms were no longer tenable. They stayed abroad long enough to build up enough capital to return and re-start their own farms. In the case of BFPar-Bag this took four years and for BNFir10 3 years. These interviews demonstrate that migration is often undertaken in the hope that enough capital can be raised to re-start farms and thus return to their former social-ecological system regime. However, the time taken to achieve this demonstrates the challenges in returning to the former system state.

In all three case studies, migration was mentioned as an example of a transformation that occurs after the social-ecological system of farming in that community becomes untenable for a household- usually after severe losses from floods and droughts. However, key differences were evident in where people migrated to.

As Figure 5.5 shows, the main destinations for those migrating from the Burkina Faso case study were Cote d'Ivoire and Ghana. These are established destinations for migrants from Dano (Burkina Faso), however, some concerns about migration to Cote d'Ivoire were raised in the interviews as a previous political uprising in Cote d'Ivoire in 2010-2011 had targeted migrants. For the Dassari case study in Benin, Nigeria was the main destination

for immigrants. Despite official language differences between Burkina Faso and Ghana, Benin and Nigeria, the attraction of the climate and economic status of these countries was a sufficient enough pull for migrants. In the case of Dano, there was nowhere within Burkina Faso that offered agricultural production during the dry season as Dano is one of the wettest areas of Burkina. However, in Benin the south would have a climate suitable for attracting north to south migration of farmers during the dry season in Dassari, but the economic prosperity of Nigeria sees more people migrating there instead. In Ghana, however, migration was predominantly internal. When asked, interviewees struggled to contemplate temporary or seasonal migration abroad. Instead, as GHSum1 states; "especially the youth... some will definitely rush to down south to see whether they can manage with whatever work they can get there".

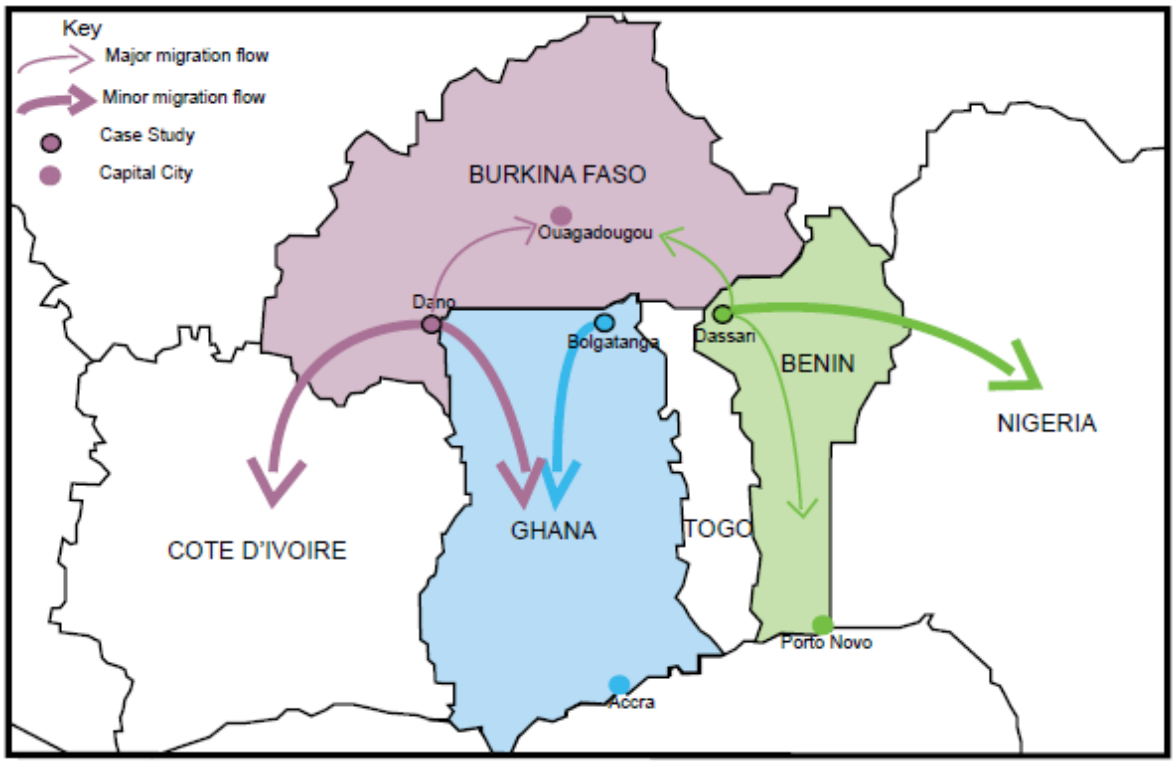


Figure 5.5 Main migrations destinations from case studies

5.9 Case study differences

Overall, the case studies were found to exhibit highly comparable impacts and response approaches to each other. The range and nature of impacts were similar across the case studies, as were the responses, in particular the focus on livestock assets which leads to the dominance of protracted recoveries that raise concerns for a future under climate change. Despite the many similarities which can be said to stem from the similar climate

and social-ecological system conditions, there are some differences between the case studies.

One of the most striking of differences between the case studies is the emphasis placed on cotton in the Burkina Faso and Benin cases. Cotton production is heavily promoted by the Burkina Faso and Benin national government in order to increase production of cash crops and exportable produce. As such, support is provided to enable access to fertilisers and pesticides necessary for cotton production, as well as facilitating access to markets by arranging to collect cotton in bulk and providing payment through cooperatives. However, the emphasis on cotton creates challenges for farmers who apportion parts of their land to cotton production that might otherwise be used for food production. Thus, farmers are committed to selling this crop and are therefore dependent on the market price at the time of sale via the cooperative. In contrast, with other crops, the farmers have a choice of selling or consuming the crops themselves. They also have a choice of when to sell if they choose to do so. This means that if the market value of the crop decreases, they can keep the crop for themselves to contribute towards the household's dietary needs. This option is not available for cotton as a cash crop alone. In addition, cotton farmers find themselves in debt as they take the fertiliser and pesticides as loans. Paying off this loan is a priority and problematic if the cotton crop fails and/or market prices are particularly low. Thus, the farmers in Burkina Faso and Benin are somewhat tied to cotton production and thus have a more restricted coping capacity than those that do not grow cotton and the Ghana case study, in particular.

Another difference between the Burkina Faso and Benin case studies compared to the Ghana case study is the location of the Ghana case study in proximity to the larger market and amenities of Bolgatanga. Bolgatanga as the region capital and a larger central town, provides more opportunities for alternative occupations and sources of small trade to help cope with hazard impacts. As such, the adaptation options in the Ghana case study are somewhat broader whereas in the Burkina Faso and Benin case studies, transformations are more likely where coping capacities are insufficient.

5.10 Synthesis of insights from the present day situation and potential implications for a future under climate change

The results from the interviews demonstrated that the individuals and households in the case study communities are largely able to cope with flood and drought events. The few examples where coping was not demonstrated were examples from people who were

unable to generate income themselves, usually due to old age, and who also suffered from weak or non-existent support networks. These people suffered set-backs from hazard events rather than spiralling decline.

Similarly to the more extreme end of the continuum, examples of individuals and households in the communities that were resilient or even adapted to floods and droughts were also rare. Instead, degrees of adaptation and resilience were visible but no interviewees were completely resilient and adapted as adaptation strategies suffered limitations. In particular, the diversification of livelihood sources was predominantly dependent upon other farmers as customers. Thus, many respondents with other sources of income commented that a bad year for farmers would also result in a bad year for their business (e.g. BNDas14, BNDas16, BFCen2). As such, the majority of the interviewees, fell into the coping categories of buffering, bounce-back and protracted recovery, with protracted recovery as the most frequently revealed outcome. This is because livelihoods are central not only to the impacts but to the recovery process. Thus, if livelihoods are affected and are also the source of funding for recovery, losses are compounded.

The results found that impacts were most frequently felt on crops which affected livelihoods and these impacts were recovered from by the sale of livestock. Applying assets in such a way also has to be considered in the context of a full recovery, to understand how easily and rapidly a household may be able to return to their previous state, prior to the hazard. From this it is possible to determine whether they will have recovered before the next potential event.

As the results from this research found, households were not able to recover within twelve months and thus fall into the category of protracted recovery. The average recovery was closer to three years. Under climate change projections, the chance of a second hazard event occurring before the full recovery is complete increases. As depicted in Figure 4.2, an important question arising from this is whether the second hazard event will prompt adaptation and if so, what the nature of that adaptation might be? Based on the adaptation strategies revealed by the interviews, it appears that current adaptation strategies are insufficient to ensure resilience to the impacts of floods and droughts at present, let alone a future where these events are more frequent or complex. Will new strategies be conceived under the increased pressure of more frequent and multiple hazard events or will households experience further declines and potentially near or exceed crucial thresholds? These are the questions that the second phase of research was

developed to answer (Research Questions 2 and 3). The results for this second phase of research is presented in the following Chapter.

6 Results and Analysis: Impacts and Responses to a Future under Climate Change

The findings from the first phase of fieldwork, namely the interviews, helped elicit information on the present day impacts and responses to floods and droughts. The interviews demonstrated that impacts touch many aspects of life, however, the impacts on agriculture were particularly dominant. In addition, the examination of the response processes highlighted a deficiency in response options and in particular, a slow 'protracted' recovery in most instances of crop damage. The slow full recovery was caused by a dependence on livestock to fund the replacement and repair of damage but livestock took time to replenish and this resulted in average recovery times of around three years.

Looking to a future under climate change, flood and drought events are expected to increase in their frequency and, due to their connection with seasonal variability trends, it is also expected that floods and droughts will increasingly arise during the same rainy season. The limited experience of these multiple (successional) hazard events to date led to the need to develop more novel approaches to reveal the potential for a multiplier effect where floods and droughts occur in succession. As the following section reports, the application of scenarios provided insights into the complexities involved in multiple hazards and the overall multiplier effect that these bring.

After reporting on the impacts from multiple (successional) flood and drought events, this Chapter will then detail the results of the participatory game activity that elicited information on responses to and outcomes of both more frequent and multiple hazard events. As Table 6.1 demonstrates, together, the two parts of this chapter help shed light on a future under climate change. Comparing these insights with the present day, this chapter concludes with a summary of the shifts that climate change induced more frequent and multiple hazards are likely to encourage.

		Hazard Impacts	Coping	Adaptation
Interviews	Present Day (RQ1)	X	X	X
Game	Future (RQ2)		X	X
Scenarios	Future (RQ3)	X		

Table 6.1 Research questions and approach overview

6.1 Multiplier effects: Findings from the scenarios

Climate change predictions and trends that imply future conditions where the rains of the rainy season are disrupted by lengthy dry spells, which in this context constitute

droughts, and periods of condensed heavy rainfall which in this context lead to floods. At present, the rainy season is already showing signs of disruption and although this tends to constitute droughts or floods, there are times when households experience both types of hazard events in the same rainy season. This is likely to become more frequent but given the limited current experience with such successions of hazard events, the research used multiple type hazard event scenarios to investigate the nature of impacts that such events would contribute to.

The interview results highlighted that crop damage was not only the most frequently cited impact of the two hazard events but it was also almost equally cited for floods and droughts. Clearly a multiplier effect is possible where the two hazard events occur in succession, but from the interviews it is not clear to what extent there might be an additional impact from the two hazards if they affect different crops or whether the crops that might be damaged by the second hazard event are the same as those damaged by the first hazard event and thus there is no additional impact. To analyse this further and contribute to answering Research Question 3 which aims to understand the potential multiplier effect of two hazards, two scenarios were developed, as described in the Methodology Chapter (4).

The first scenario featured a dry spell drought followed by a flood. The second scenario comprised a flood followed by a dry spell drought and, where possible, this was extended to become an early end to the rainy season. The purpose of having the two scenarios was to firstly identify the multiplier effect (if any) that a second hazard event contributes and secondly to understand whether and to what extent the hazard order affected the losses, i.e., would it make a difference if the flood came first or the drought?

The results found that there was a clear but complex multiplier effect of the second event and that the order of the hazards did make a difference. Beginning with Scenario 1, these findings are explained in detail.

6.1.1 Scenario 1 results

The first scenario (Scenario 1 or S1) comprised a drought event occurring 30 days and a flood event occurring, additionally, at 60 days after planting the crops. As Figure 6.1 shows, all of the crops experienced additional losses from the first to second hazard event, however, the severity of additional losses varied considerably.

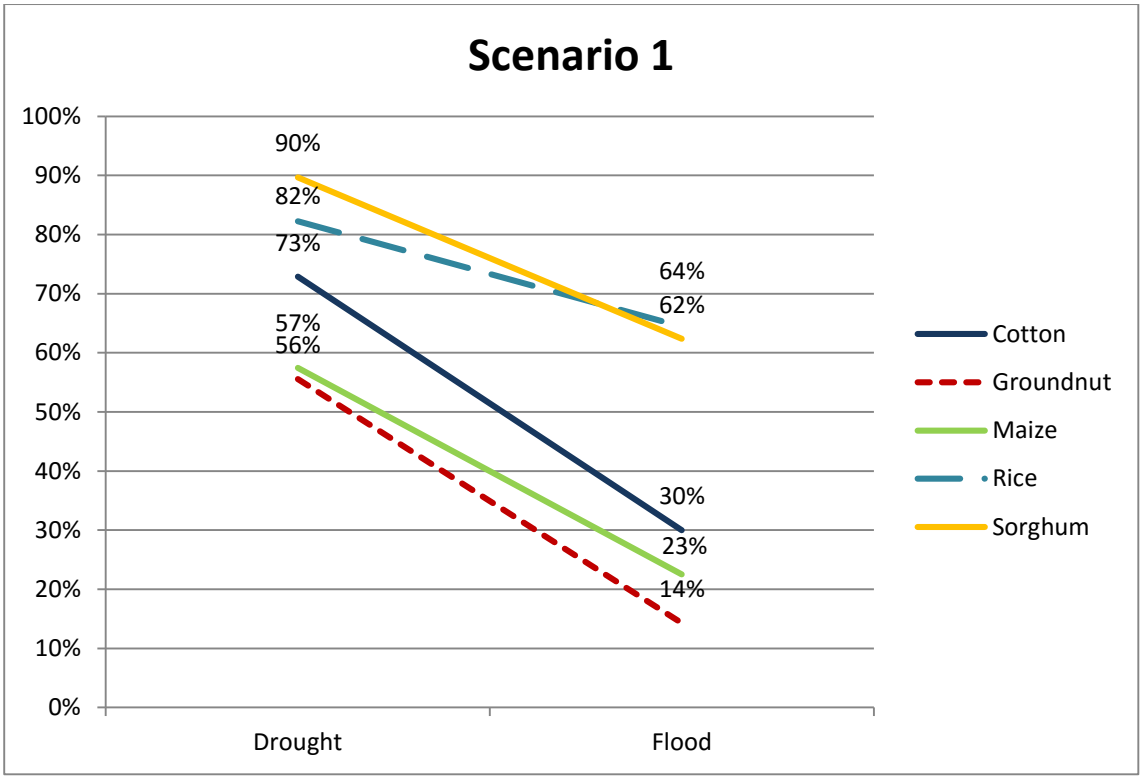


Figure 6.1 Results of Scenario 1

Overall, rice and sorghum appeared to be most resilient with minimal losses under the first hazard and almost two thirds of respondents expecting some remaining sorghum and rice to survive after the second hazard event (the flood). This compares well to the findings under the interviews that also highlighted rice and sorghum as relatively resilient crops. In contrast, groundnut and maize were least resilient under Scenario 1, with just over half of the villages reporting that these crops would survive the first hazard but this figure reduces to less than a quarter (23%) for maize and only 14% for groundnut after the second hazard event of a flood.

The multiplier effect of the second hazard event is particularly stark under Scenario 1 with an average of 72% crop types remaining after the first hazard compared to only 39% after the second hazard. As such, the multiplier effect of the second hazard event can be seen to have almost doubled the extent of losses from the first hazard event.

6.1.2 Scenario 2 results

The second scenario (Scenario 2 or S2) comprised a flood event at 30 days and a dry spell drought event occurring additionally at 60 days after planting. Under this scenario, the losses were particularly extensive after the first hazard event (flood) which reduced the crops across the case study communities by approximately 50 to 90% for all crops except rice (see Figure 6.2). Rice is well known for its resiliency to flooding and, thus, it is not

surprising that 94% of villages felt that rice would withstand the first hazard event. In contrast, the other crops fared considerably less well. Sorghum was the second most resilient crop but still experienced losses in almost 50% of the villages sampled. This was followed by maize and cotton which were reduced by around two thirds. Finally, groundnut was substantially affected by the first hazard event, with 90% of villages reporting that it would be destroyed by a flood at 30 days after planting.

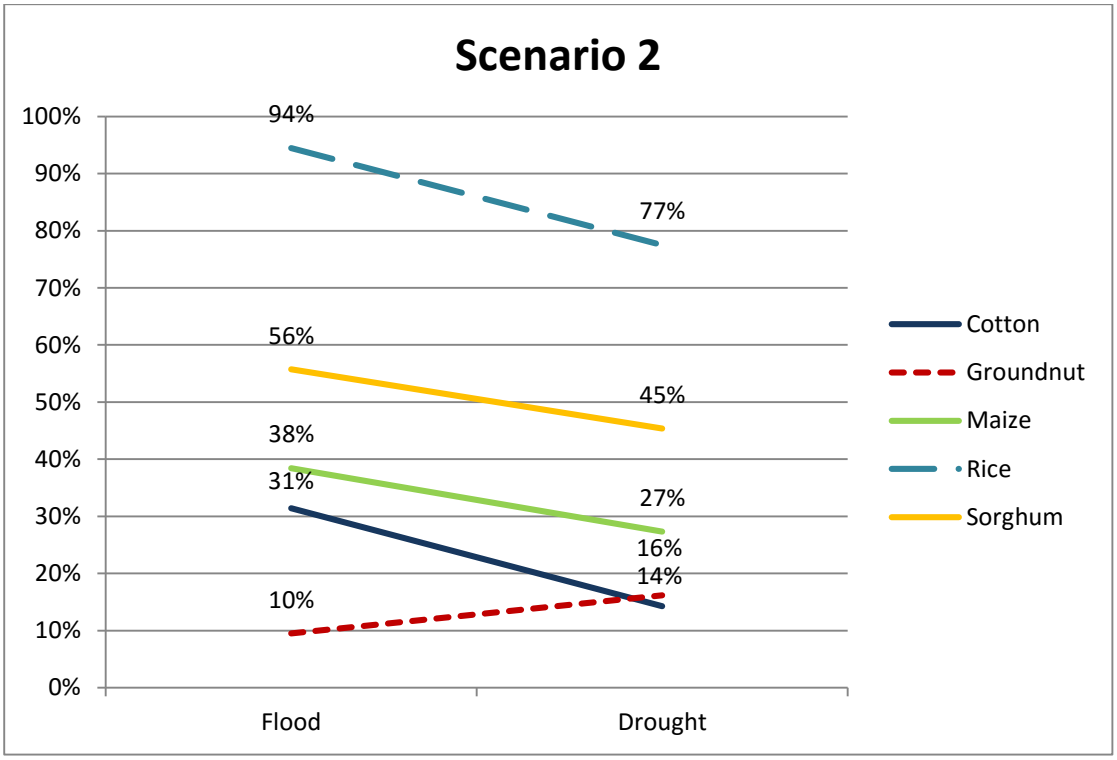


Figure 6.2 Results of Scenario 2

It is interesting to note that in the case of groundnuts, the losses experienced diminished at the point of the second hazard event under Scenario 2. This increase in groundnuts is related to the shorter growing period for groundnuts that led to some villages arguing that damaged groundnuts could be replanted and would thus be somewhat resilient to a drought event 30 days later. However, the final availability of groundnut, even taking some replanting into account, was still found to be present in only 16% of the villages sampled after both hazard events.

The multiplier effect for Scenario 2 is less severe for sorghum and maize, with minor additional reductions for these crops. Taking this into account as well as the slight increase in availability for groundnuts after replanting before the second hazard event, the overall multiplier effect of the second hazard was to compound the average losses of

46% after the first hazard event to 36% after the second hazard, which constitutes a further loss of 10% from hazard one to hazard two (see Figure 6.2).

6.1.3 Comparison of scenarios

Both scenarios clearly demonstrate a multiplier effect from the first hazard event to the second. Whilst there is a difference in the multiplier effect of the second hazard under Scenario 1, compared to Scenario 2, the total losses after both hazard events are similar for both scenarios. After both hazard events had occurred in Scenario 1, the average remaining crops were 36% of the originally planted crops. For Scenario 2, this figure was 39% representing a very small difference, particularly given that the values provided here are only indicative and general averages from across the various villages in all three case studies. Therefore, it can be argued that the overall losses after both hazard events was not dependent on the order of the hazards.

Although the total losses were very similar between the two scenarios, the initial impacts and degrees of multiplier effect were significantly different, with large extents of losses occurring under the first hazard of Scenario 2 (the flood event) and less substantial additional losses incurred under the second hazard event (the drought). In contrast, under Scenario 1, the initial losses under the first event (the drought) were less substantial than the first losses under Scenario 2 but these losses increased substantially under the second hazard event of Scenario 1 (the flood). The conclusion that can be drawn from this comparison is that flooding has a greater impact on crops than droughts. Whilst there may be a small degree of difference regarding whether the flood occurs at 30 days or 60 days, generally, floods can be seen as the more destructive event during the crucial growth phases of the crops. Whilst droughts have a less significant impact on crops compared to flooding, the effects of both hazards occurring in succession means that the impacts are exacerbated and crucially crops decline from around losses of around 25% to 50% after the first hazard event to around 1/3 of their original composition (i.e. losses of around 65%) after both hazards.

6.1.4 Crop resilience insights

The results of the scenarios demonstrate that overall, rice and sorghum are the most resilient crops and groundnut is the least resilient with cotton and maize in the middle of the two ends of the continuum (see Figure 6.3). Although rice and sorghum are more resilient than the other three crops, regardless of the hazard orders, there were differences in the resilience of maize, cotton and groundnut when comparing the first scenario with the second.

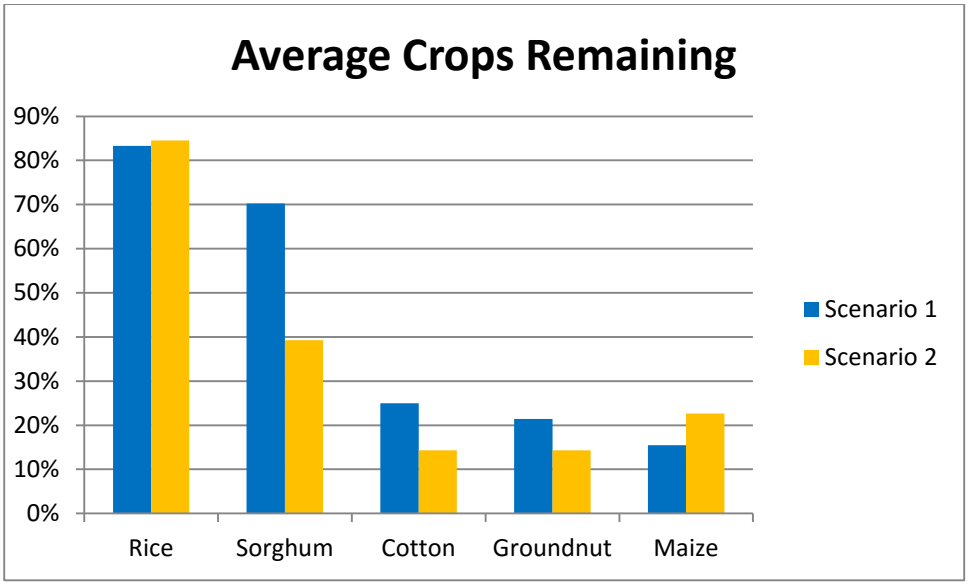


Figure 6.3 Average crops remaining after both hazard events

Under scenario 1, maize was found to be least resilient followed by groundnut. However, under Scenario 2, Cotton was found to be least resilient with groundnut slightly more resilient due to some replanting efforts. Under Scenario 2, maize was in the middle of the ranking for most to least resilient crops. These results are important because they illustrate that the older, more traditional crop of sorghum is more resilient than maize and cotton which are rising in popularity. This raises an important point that for climate change adaptation, cotton and maize are less suitable and beneficial than the traditional crops of sorghum and rice. Groundnut is also highly vulnerable, however, it is normally grown in smaller quantities as a supplementary rather than staple crop. It is worth noting that, rice is a crop often permitted to be grown by women on their own fields. The relative resilience of rice therefore bodes well for securing women against climate change impacts.

In addition to the key cross case study crops described in the Scenario analysis above, the scenarios did also include some locally specific crops in the analysis. These crops were yams in Benin, sweet potatoes in Burkina Faso and Early and Late Millet in Ghana. These crops are excluded from the main scenario analysis because they were exclusive to only one case study but also because they were grown over a different portion of the rainy season. Sweet potatoes, yams and early millet were all planted in advance of the rainy season and were thus harvested early when other crops were only 30 days old. In addition, late millet was planted later in the season and was thus, also out of sync with the main crops analysed. As such, these crops were excluded from the analysis of the main scenarios but the findings from the Scenario activity found them to be generally resilient to the hazard event examined. These crops may, therefore, provide a valuable buffer to the losses

that could occur to the other crops due to their different growing period. However, it is recognised that this buffer is limited by the limited storage time of the crops and therefore, they cannot be seen as a substitute for the main crops analysed under the scenario assessment.

6.1.5 Case study differences

The results of the scenarios presented above take an overall view across the three case studies. The insights and trends presented in this analysis are designed as insights into the overall trends of the wider West-Sudanian Savannah region. However, to understand the extent to which these trends may be applicable beyond the case studies, it is important to determine the degree of variation within and between the case studies themselves.

The results of the scenarios were found to be highly variable from village to village. Some villages in the case study were highly resilient to the scenarios that other villages were highly affected by. These differences reflect variations in the characteristics of the case study villages. Characteristics that vary include topography, soil, hydrology, weather variations but also different approaches to planting and farming, with some villages favouring certain techniques such as planting seeds under soil mounds where others plant directly into the level ground. Whilst these differences are important to acknowledge as they demonstrate a heterogeneous set of communities, by taking averages of the case study areas, it was found that the variations between the case studies was not as diverse.

At the case study (rather than village) scale, the proportion of impacts varied significantly between the case studies, with average values for Benin being generally lower than for Burkina Faso and Ghana. An important caveat is that the average values are purely indicative and not statistical measurements. Therefore, it is the trends rather than the actual values that are most important. In this regard, the trends visible in each of the case studies are highly comparable with impacts being greater with two hazards than one and with the first hazard of scenario 1 generating less substantial impacts than the first hazard of scenario 2 and thus the multiplier effect is greater under Scenario 1 than Scenario 2. These are the trends that can be considered applicable to the wider West Sudanian Savannah but the variations, particularly the large variations at the local level (which have also been noted by others such as Salack *et al.* (2015)), emphasise the need to recognise communities as varied and heterogeneous. The trends provide an overall insight into the wider implications of local processes but for the development of appropriate coping and adaptation strategies, a local level approach that is sensitive to the diversity of the case studies might be required.

6.1.6 Summary of findings from the scenarios

The findings of the scenarios have illustrated that there is a multiplier effect associated with a second hazard event. This multiplier effect is complicated by the order of the hazards and by local level conditions and characteristics, however, the overall outcome of floods and droughts occurring in succession is a similar degree of losses with approximately two-thirds of crops being lost over communities as a whole.

The scenario findings highlighted that floods have a more substantial impact on crops than droughts but that droughts do add to the losses incurred by flooding to result in significant total losses where the two hazards occur in succession. In addition, rice was found to be the most resilient crop, potentially due to its resilience to flooding which is otherwise seen as the more damaging of hazards but also because it is typically grown in areas less exposed to droughts. The findings highlighted newer crops such as cotton and maize as being less resilient compared to the more traditional sorghum. This highlights an important point for Burkina Faso and Benin where cotton production is encouraged at a national level and across all three case studies where maize is increasingly displacing less palatable and desirable but hardier traditional crops such as sorghum.

6.2 Decision making processes and responses: Findings from the game

The scenario activity demonstrated that multiple (successional) hazard events are likely to lead to deeper losses than single hazard events. As such, a key question that this research aims to answer is whether deeper losses incurred under multiple hazard events such as successional floods and droughts might result in different responses compared to more frequent but single hazard events, and also whether both of these types of changes to hazard periodicity would result in different responses to the present day. In order to understand the implications and potential outcomes of both more frequent and multiple hazard events, particularly given the dominance of protracted recovery types of coping revealed by the interviews on present day responses, a participatory game was designed to simulate climate change conditions on the main elements of the social ecological system.

The game comprised key elements of the social-ecological system with a focus on agriculture and livestock as the main areas affected by and used to cope with the impacts of floods and droughts. Added to this was the potential for damage to housing caused by flooding as this was a major flood impact, cited by 56% of all interviewees, which demanded significant financial resources and was therefore important to include.

The game was conducted with two players and an audience to provide advice and options. The activity was concluded with a discussion that aimed to elicit further insights about the decision making process, coping and adaptation options in order to understand whether more frequent hazard events would trigger adaptation options or result in a continuous decline.

6.2.1 Classic trends

The results of the game found that present day coping strategies prevailed even under the more severe conditions of more frequent and multiple hazard events. The main strategies revolved around the sale of livestock and crops that are considered assets rather than food. Thus, cash crops (i.e. cotton) and livestock were initially sold to cope with losses in the early stages of the game. The specific livestock species or crop selected for sale was based on the same three approaches elicited in the interviews (see Section 5.6.1). These were 'fits the price', 'minimising compound losses' and 'volume based'. In particular, 'fits the price' and 'minimising compound losses' were the first strategies engaged with and 'fits the price' was the most common of these two.

The 'fits the price' approach to selecting crops and animals for sale was to base the decision on the value that was needed to pay for the recovery. As such, players would select more valuable crops and livestock so that a lower quantity would have to be sold. Such an approach minimises the quantity of losses which, particularly in the case of livestock, would allow the animals to be replaced more quickly than if a larger number of less valuable livestock was required. However, the speed of reproduction did vary between animals and essentially this would have to be taken into account which is why pigs would be sold rather than goats which were valued as the same price as pigs, because pigs could be more rapidly bred. This strategy was particularly visible where players sought to sell rice as rice was more valuable and, thus, only one sack was required when several sacks of other crops would need to be sold to achieve the same money.

Where 'minimising compound losses' was used as a strategy, the livestock selected most frequently for sale were chickens. Chickens were believed to be particularly easy to replace and thus were frequently sold but also frequently purchased with any residual money from the sale and purchase of crops. Other crops and livestock that were perceived as being less beneficial and, thus, less desirable to retain were yams in Benin, which were noted as not being able to be stored for long periods of time, and goats due to their susceptibility to disease and illness when the weather fluctuates. In addition, in the Burkina Faso and Benin case studies, cotton was prioritized for sale as a cash crop since

it could not be eaten and is usually sold to pay off fertiliser and pesticide debts incurred for its production. Pigs, were particularly mentioned in GH2014Kalbe as being sold because they could be quickly replaced due to their higher birth rates. This 'easily replaced' perspective is another way to minimise the compounding cascading of hazard losses and was evident both in the games and in the interviews for the present day approaches.

The key strategies outlined above are also complicated by certain local preferences. As Figure 6.4 shows, yams and cotton were sold disproportionately frequently given the frequency of hazard events that they experienced. In addition, maize was sold less frequently despite experiencing, on average, fewer hazard events and losses. This reflects how preferences for the sale and retention of certain crops skew the results. In the case of yams and cotton, as described above, cotton is seen as an asset to be sold with no value in retaining it. Equally, yams cannot be stored for very long and thus it is typical for yams to be sold rather then stored. For maize, the reluctance to sell is based on a preference for maize. Interviewees and game participants such as BFYo5 and BF2014Pare explicitly mentioned needing to have some maize to feed to children who 'do not like the taste' of traditional sorghum. Thus maize is a preferred crop and this was reflected in the game outcomes.

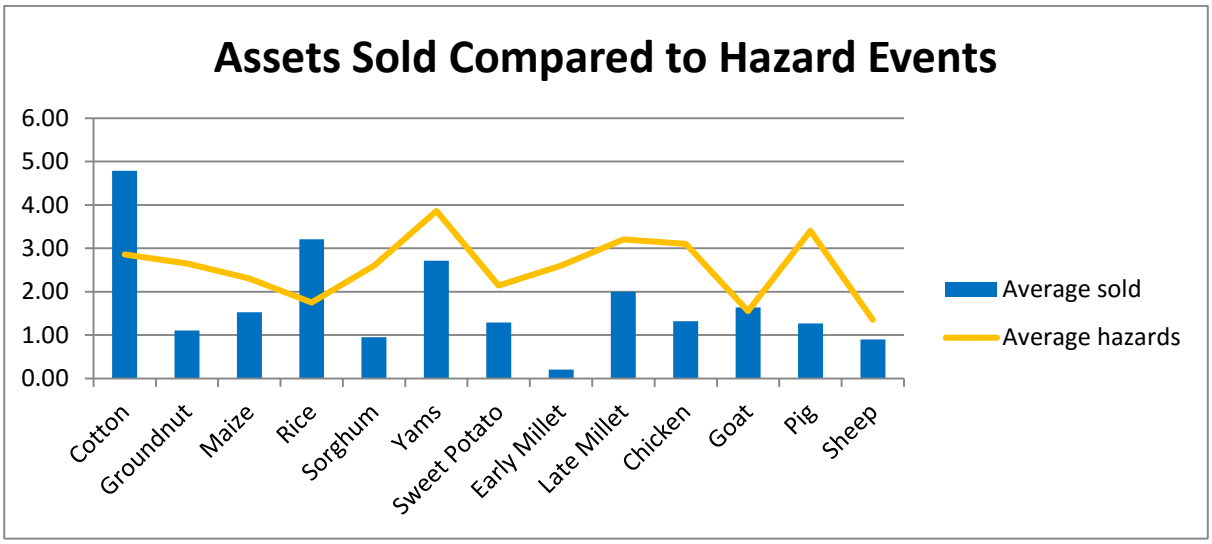


Figure 6.4 Total sales of crops and animals compared to hazard frequency

The discussion between audience members helped to highlight the differences in these perceived strengths/weaknesses. For example, in the games played at the villages of Kourri and Sorian, in Burkina Faso, audience members suggested that the players sell their cotton as this is not edible. The players accepted this advice and proceeded to sell all

of their cotton, acknowledging that cotton is not as 'useful' as other, edible, crops. However, as one player proceeded to sell all of the cotton, other audience members highlighted that some cotton should be retained as it is beneficial to have some diversity, although only keeping a small amount of cotton rather than all of it. At other times the players, such as Player 1 in Gnikpierre (Burkina Faso), did not take the advice of the audience, believing that their preferences would be more beneficial. The subtle differences between preferences and the debate ensuing with the audience and between the audience and players emphasises that there is no clear winning strategy and players have to make choices based on their perceptions of which livestock and crops are more or less beneficial. Comparing the results of the games, it becomes apparent that there are very few clear choices.

As could be predicted from the insights of the interviews, the application of the same coping strategies despite the increasingly frequent (effectively annual) flood and drought events, the games demonstrated a gradual erosion in resources and capital over time as players simply responded to losses by selling the livestock and cotton that matched their needs. Players often aimed to retain at least a small quantity of each animal and each crop and therefore, as the game progressed and losses accumulated, 'volume based' strategies were increasingly engaged. These strategies resulted in the sale of the crops and livestock (although there were usually few livestock available at this point) that were most abundant. In addition purchases were focussed on simply trying to maintain minimal levels with desires to retain more favoured crops fading as the losses accrued and the situation became more desperate.

6.2.2 Systems under pressure: Strategy shifts

As the game progressed and losses accumulated over time with the more frequent hazard events, the households would begin to notice a steady decline in their 'non-edible' assets. At this point, their strategies would often shift, moving away from the patterns revealed by the interviews and became most centred on 'volume based' approaches.

Figure 6.5 demonstrates how a clear shift in the sale of animals occurred between the 5th and 6th rounds of the game, on average. A similar shift can be seen in Figure 6.6 with regards to the sale of cotton. This is because cotton, as a cash crop, is usually viewed in a similar manner to livestock, i.e. as an asset rather than a crop for consumption that should not be sold.

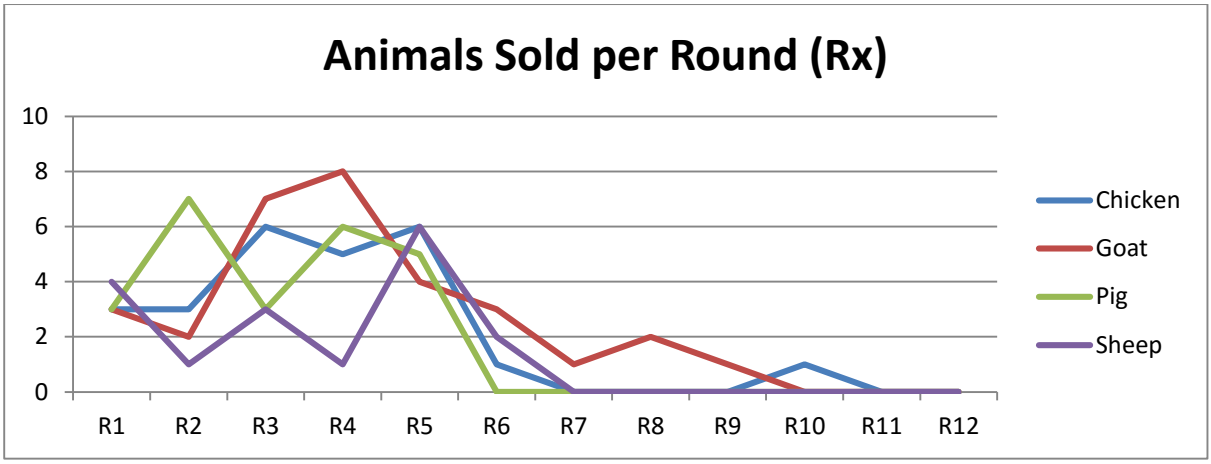


Figure 6.5 Total animals sold per round of the game

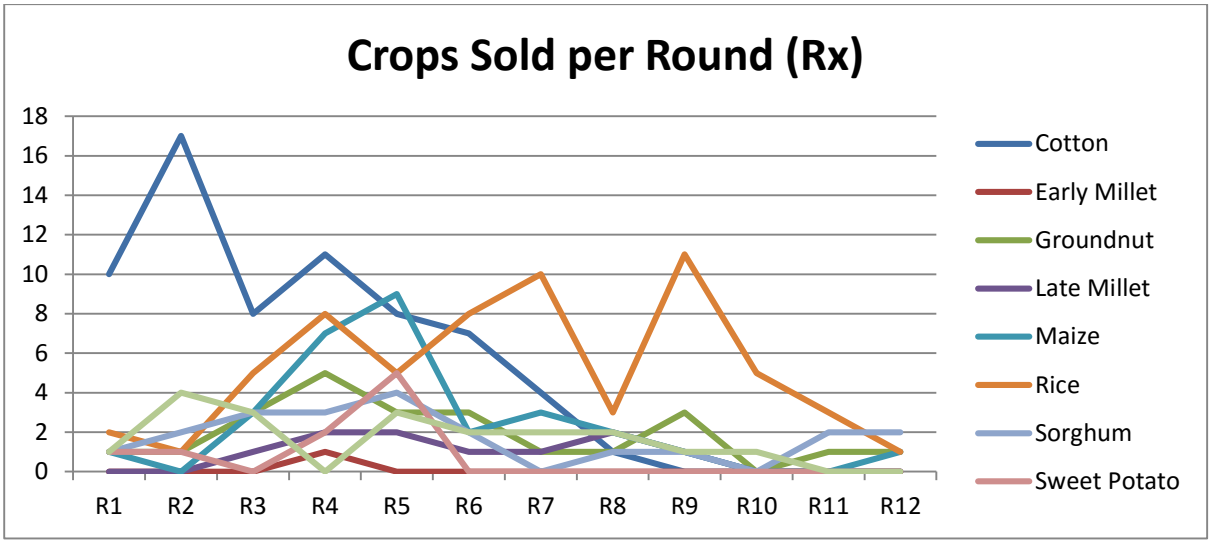


Figure 6.6 Total crops sold per round of the game

As Figure 6.5 shows, from Round 6 onwards, the sale of animals declined to almost zero, reflecting a loss of almost all, if not all, livestock. At this point, sales of edible crops were engaged with. The higher frequency of sales of rice reflects the higher value of rice and the sale of rice in a 'fits the price' approach, which is the primary strategy for selecting specific crops and livestock for sale. Besides the sale of rice, there are no clear trends in sale of other crops. This reflects the employment of 'volume based' strategies whereby the most abundant crops remaining were selected for sale. As the flood and drought events occurred randomly and therefore affected different crops in different games, the application of the 'volume based' approach means that the most abundant crops are sold and these varied considerably between the games based on the random and varied impacts on the crops over the course of the game.

In addition to revealing strategies to determine which crops and livestock should be sold, the game also revealed several strategies for purchases (and non-purchases) of crops and livestock. It would be expected that where hazard events were high, affected crops and livestock would be replaced and where hazard losses were not high, purchases of the unaffected crops and livestock would be low. Such approaches were evident in the game, however, in terms of replacing affected crops and livestock, it was rarely the case that full losses were completely replaced. This was due to the limited resources available with which to replace any substantial losses, particularly as the game advanced and losses accumulated. Thus, in order to cope with substantial and critical losses, where crops and livestock were replaced this was done based on two key strategies: 1) maintaining the minimum and 2) prioritising the replacement of important losses.

In terms of maintaining the minimum, this was a strategy most frequently adopted for cotton as cotton was frequently sold but also often affected by hazard events. As such, players often resulted in particularly low levels of cotton on their game boards. In order to ensure that they still achieved some output and retained cotton as a sale option, players would also replenish some of their cotton, thus enabling them to achieve bonus crops in the harvest. This is a common strategy, mentioned in the interviews (i.e. that they must always have some, yams etc) and clearly reflected in the game.

For the second strategy, replacing important losses or aiming to horde certain crops, this was particularly evident for sweet potato in Burkina Faso and, to a lesser extent, maize. Both crops were affected by few hazards and infrequently sold but still purchased. A similar approach was visible with regards to chickens which were also sold but frequently repurchased. In particular the players in the game in Firihoun (Benin) commented that it is important to always have a chicken at the house so that it can be eaten to welcome visitors to the house.

In contrast to the examples mentioned above, where crops and livestock are replaced, there were other examples of crops and livestock that were not replaced, despite severe losses. Often, this was the case where losses where accumulating and players were concerned about their capacity to replace livestock and crops. Instead, they adopted an approach whereby they hoped for a better following year and would replace those less critical livestock and crops if that better year did materialise. In addition, where the losses had accumulated and players had very few remaining crops and livestock, some players questioned if they really had to replace the rooms that had been damaged by floods and droughts (e.g. BF2014Gnikpierre and BF2014Sorian). They argued that in reality they

felt that they could manage with only two or three rooms and whilst this was evidenced by the interviews as well, they were encouraged to try to replace the rooms as social pressure would dictate.

Usually, the anticipated 'better year' did not materialise and even after several rounds of severe losses, game participants remained hopeful of better following years. This is reflective of perspectives in the present day, elicited by the interviews. However, it shows how gradual losses can accumulate with a lack of adaptation. Adaptation approaches were very rarely mentioned. Instead, where severe losses were incurred- such as would occur under multiple (successional) hazard events, the participants spoke of migrating or 'looking for jobs' (e.g. BN2014Tetonga, BF2014Loffing). These are the same adaptation strategies and transformations that are used in the present day to respond to hazard impacts. In the present day, these strategies are not deemed sufficient to retain the social-ecological system and thus imply that the system may tip towards a change in the population size and the proportion of people dependent on farming in a future of more frequent and multiple (successional) hazard events under climate change.

6.2.3 Variations: Counter-classic

The classic strategy detailed in the previous sections was adopted by most players. However, there were several instances where one or both players adopted a different strategy to the game. In particular, one different strategy evident in the games played in Firihoun (Benin), Porga (Benin) and also Pare (Burkina Faso) was a strategy here labelled the 'counter-classic' strategy.

The counter-classic strategy is an approach that is the complete opposite to the classic approach. This counter-classic strategy comprises the retention and expansion of assets, in particular livestock, by selling crops instead. This strategy was visible in the games in Firihoun, Porga and Pare appeared to be adopted by particularly competitive participants. It appears that in order to appear more successful, the players adopting counter-classic strategies of hording livestock as a display of wealth and success, selling crops to manage hazards impacts in a way that would disguise their losses. Counter-classic Players were highly resistant to the requirement to rebuild any collapsed buildings, preferring to keep their livestock assets intact and arguing that they felt able to manage with fewer rooms.

The counter-classic strategy does not appear reflective of genuine strategies. Although some farmers may attempt to mask their losses and negative situation by selling crops to retain animals. Indeed, some farmers may calculate that it would be better to sell

particularly abundant crops in order to retain livestock that might breed and thus be more valuable. However, this is unlikely as interviewees and game players commented, livestock and assets should be sold before 'food', "I get some animals, I am going to sell some of them because, as for the food, I won't touch that because if I start selling some of the food I don't know how the whole year will be" (BF2014Pontieba). Indeed, one of the counter-classic strategy players in Mebar (Burkina Faso) even commented that "I'm planning to sell cotton and pigs because I don't want to touch the other foods because they are food and I'm scared, I don't know what will happen in the coming years", yet they adopted the counter-classic strategy and actually purchased pigs and sold edible crops. This is likely to have been done in order to appear more successful and to experiment with a different approach.

In terms of success, this strategy was not necessarily more or less successful than the classic approach as eventually, players had to start selling their livestock and were equally unable to manage the more frequent flood and drought events than those playing with a classic approach. The only strategy that demonstrated an element of successful adaptation to the more frequent and multiple hazard events was the 'adaptive approach' described in the following sub-section.

6.2.4 Variations: Adaptive approach

The other alternative approach visible in several of the Burkina Faso case studies, specifically, (e.g. Pare, Gnikpierre, Kourri and Mebar) was, what is termed here, an 'adaptive' approach. The handful of games where adaptive approaches were utilised revolved around the adaptive strategy of banking their wealth. In these games, players would sell livestock and crops to replenish losses (particularly to their compound houses) but rather than matching the sale of assets to the price of the asset to be replaced or rather than using the change from transactions to purchase additional crops or livestock, these players asked to place some of their money in the bank. This enabled them to reduce their exposure to floods, droughts and animal disease epidemics by removing some of their assets from the risk. In addition, the players reinvested their wealth from the bank to build more resilient concrete houses, strengthening their resilience to flood events.

Banking was a highly successful strategy in the few games that it was applied. This was particularly demonstrated by the game in Loffing where the players swapped half-way through the game and after sustaining continual losses, the new players attempted to bank some of the assets and subsequently increased their overall wealth, becoming more resilient to the hazard events and disease outbreaks. This was a result that was never

exhibited in the classic or counter-classic games and highlighted the potential for banking to help farmers adapt to climate change conditions of more frequent hazard events. However, in reality, banking is relatively inaccessible to the majority of rural farming communities in the case study areas. This is because opening a bank account typically requires the presentation of documents such as proof of homeownership or birth certificates, which many farmers do not possess. In addition, farmers believed that a certain amount of money would be required as a deposit and paperwork such as land ownership deeds and birth certificates or identification that these rural farmers often do not have. As the BNDas16 highlighted, banking is often not available to farmers. This backs up the comment by BFGni1 that the local communities are aware of strategies and approaches that could help them face the challenges of floods and droughts but they are unable to access these strategies due to prohibitive costs or paperwork. This confirms the lack of evidence for successful adaptation strategies in the present day and suggests that adaptation to respond to and manage more frequent floods and droughts in the future is equally unlikely to be achieved.

6.2.5 Case study variations

Besides slight variations in crops such as yams being included in the Benin games and sweet potatoes in the Burkina games, the main difference between the games was the role of cotton. In Benin and Burkina Faso, where cotton is cultivated, cotton was often treated in a similar manner to livestock, being sold early on before edible crops. Cotton was often disliked by some of the players who immediately aimed to sell their cotton arguing that they did not like cotton and thus only wanted to keep a minimum amount to achieve an additional sack per harvest.

Another variation between the games was the adoption of the adaptive approach with banking in some of the Burkina Faso games. Banking was not utilised in the other games because players did not ask about it. In the Burkina Faso games, players asked about banking in several games, suggesting that they are more aware of the value of banking than in the other case study areas.

Finally, there was an interesting variation in the treatment of the case study unique crops in Benin and Burkina Faso. In Benin, yams were often sold early as a non-desirable crop whereas in Burkina Faso, sweet potato was horded. This may reflect the familiarity of the players with the crops. In Benin, yams are widely grown by the vast majority of farmers for traditional reasons. Therefore the farmers are aware that it is a necessary crop but not a particularly useful crop as it cannot be stored for long. In contrast, in Burkina Faso,

although farmers are familiar with sweet potatoes, very few of the interviewees grew sweet potatoes which suggests that they may not be aware of limitations such as storage time but they favour sweet potatoes highly and thus prefer to retain the crop.

6.2.6 Explaining differences: Influence of hazard context

Whilst the game revealed different approaches to decision making, it helped to put these decision making strategies into the hazard context and in particular, when taking the temporal component of the game into account, it is possible to see how decision making processes shift over the course of the game, reflecting the accumulation of impacts from more frequent and successional hazard events.

In games where the classic strategy was prevalent, decisions on sales and purchases focussed on the classic approaches of selling livestock and assets to replace critical losses. However, as climate impacts accumulated, these strategies were forced to shift toward the sale of more abundant assets. For purchases under the classic approach, these are initially low, with farmers hoping for a better year and not concerned about minor losses. However, as the game progresses and losses accumulate, the strategies shift towards replenishing important crops and maintaining a minimum where losses are high. Even under a counter-classic approach, the strategies are essentially the same but the opposite trend, with crops prioritised over livestock and efforts to preserve crops are transferred to preserving livestock.

One of the objectives of the game was to examine if the more severe impacts from more frequent and multiple hazard events would promote adaptation or if the impacts would simply accumulate over time as suggested by the protracted recovery status of many household livelihoods, as revealed by the interviews. The game revealed a striking lack of adaptation. The only examples of adjusted approaches were the games where players utilised banking. However, as these players explained, banking is not a realistic option for them in the present day due to the bureaucratic processes required by banks. As such, the outcomes of the games were a sustained erosion of resources.

Another objective of the game was to understand whether more frequent hazard events would be responded differently to multiple (successional) hazard events. As the scenarios demonstrated, successional hazard events result in more severe and sudden losses than simply more frequent hazard events. In games where severe losses were incurred due to a rapid succession of hazards and or high rolls on the dice which translated to large proportions of the respective crop being lost, the audience would often remark about the

severity of their situation and begin discussing migrating, looking for jobs, taking loans and moving in with neighbours. Even where these sudden losses occurred early in the game while the players had relatively large portions of their original quotas left, the suddenness of the losses sparked considerations of adaptation strategies and transformations that effectively reflect an inability to sustain their place in the social-ecological system. However, the adaptations and transformations discussed remain strategies and outcomes that are already available and deemed of limited effectiveness. Thus, it remains to be seen whether innovative adaptation strategies can be developed as climate change increasingly takes place. This is possible but there is no evidence from the game activity that this will be achieved.

In addition to the insights on multiple (successional) hazards, the game demonstrated that where losses take place more gradually and accumulate over time, people are less likely to consider adaptation or transformation, remaining hopeful that the next year will be better. As such, these players often reached a point at which their livestock and crops were vastly depreciated before they realised the severity of their situations. This reflects rigidity traps as, by this point, players had too few resources remaining to consider adjusting their strategy by investing in certain crops or livestock. They simply had to continue playing as helpless victims. As such, the players lost their sense of agency and the games ended early, before a clear winner could be determined as the players felt that their decisions were then predetermined by their limited resources.

6.3 Lessons for climate change: A synthesis of findings

The interviews showed that most people experience a protracted recovery when there is a hazard event that requires the sale of livestock to recover from. Taking more than twelve months to recover puts them at risk of being affected by climate change which is projected to increase the frequency of hazards and also cause more frequent successional hazard events.

The scenarios demonstrated how multiple (successional) hazards are likely to lead to deeper losses as floods and droughts affect crops that may have survived the first hazard event. The multiplier effect varies depending on the order of the hazards and floods were found to be more harmful than droughts. Using a participatory game, the implications of these deeper losses were examined and the potential outcomes of more frequent hazard events were also revealed.

The participatory game demonstrated that current strategies to respond to hazard events are likely to continue to form the foundation for responses to more frequent and multiple hazard events. A distinct lack of viable adaptation strategies means that the sale of assets such as livestock and cotton will be prioritised and as losses accumulate, crops will then need to be sold. Where adaptation strategies and transformations were mentioned, these were the same adaptations and transformations currently utilised in the case study communities and thus represent inadequate solutions to the challenges of climate change.

Where losses accumulate gradually, a sense of hope for a better following year increases the risks of individuals and households sliding into rigidity traps. In contrast, the deeper losses incurred from multiple (successional) hazard events are more likely to motivate adaptation or transformation. However, as demonstrated above, these adaptations and transformations are unlikely to enable the successful continuation of agricultural productivity on the present day scale. Over time, it can be expected that agricultural productivity will decline as farmers shift towards other sources of income or migrate.

7 A Discussion of the Research Results and Findings

The findings of this research have provided important insights into the changes that more frequent and multiple (successional) hazard events may bring to the West Sudanian-Savannah communities in a future under climate change. In addition, these insights, when compared with the theoretical literature, present empirical evidence to enhance conceptualisations pertaining to vulnerability, resilience, coping and adaptation.

7.1 The social implications of hazards today

Regional climate models imply an increased intra-seasonal variability towards precipitation patterns in the West-Sudanian Savannah zone as a result of climate change. With prolonged dry spells condensing rainfall into more intense events, floods and droughts are expected to become more frequent and to potentially occur in succession in a future under climate change. In the West-Sudanian Savannah, trends of an increasingly disrupted rainy season are already being recognised but important questions about the longer term implications of these changes remain.

This research focuses on the social dimension of the tightly coupled agricultural dominated social-ecological system in rural West-Sudanian Savannah communities. In order to determine the likely implications of climate change on these communities, this research engages with theories relating to the key concepts of vulnerability, coping, adaptation and resilience which have been developed into a framework for an analysis of the present day situation.

In the present day, trends of seasonal variability are becoming increasingly apparent to local communities. By analysing the recovery process, it was found that the prevalence of livestock and loans as key responses to flood and drought impacts leads to a protracted recovery. The extension of the recovery into the following rainy season and beyond, places these rural communities at risk of climate change impacts. However, it was not clear from this initial analysis whether the communities would simply continue with their present day strategies or whether they might innovate and develop new or adjusted coping and adaptation approaches. Finally, there was also an important question about the longer term implications of these pathways, specifically whether the social-ecological system might persist, transform or even collapse.

7.2 Insights into impacts and outcomes of more frequent hazards

As the literature indicated, coping capacity is not a direct proxy of actual coping applied in order to respond to and recover from a flood or drought event. The interviews revealed that decisions on which assets to apply in order to recover are based on general approaches such as the sale of livestock as a first resort to fund repairs. This is a standard strategy applied throughout the case study areas but also revealed by other studies and literature such as McEntire (2004), Bonye and Godfred (2011) and Adams *et al.* (1998). However, the details of which livestock, what quantity and when they will be sold is more complex. In line with the findings of Adams *et al.* (1998) and Schoon and Cox (2012), this research also found that decisions on what to sell incorporate complex tradeoffs and vary from person to person. The complexity in the tradeoffs illustrated in this research confirms the arguments in the literature that coping capacity is not equal to coping strategies actually applied in reality. The ex-post perspective, however, helped to reveal general approaches to selecting coping strategies which act as an important foundation for considering how coping capacities might be used in a different future under climate change. One of the key lessons provided by the interviews was that decisions on utilising coping strategies are taken at the time and based on an evaluation of available resources. Therefore, resources are sold when they are needed, rather than waiting for the time that they will receive the highest value. This is due to the uncertainties inherent in agricultural lifestyles that restrict forward planning. The lack of forward planning makes coping but also adaptation strategies reactive rather than anticipatory. This suggested that as conditions change due to climate change, the households are unlikely to take proactive action to enhance their coping capacities or adapt, they will simply respond to the circumstances as they develop.

The study of more frequent hazard events found that a gradual decline was likely to arise over time as losses accumulated through a protracted recovery. Due to a persistently positive outlook that resulted in beliefs that the following year might be better, combined with reactive approaches to coping rather than forward planning, more frequent hazard events were found unlikely to motivate adaptation and changes to coping strategies. Instead, the current coping strategies would be relied upon, leading to a gradual erosion of resources and assets and by extension, coping capacity. In line with the literature (Nelson *et al.*, 2012; Abel *et al.*, 2006; Bonye and Godfred, 2011), this was found to culminate in rigidity traps.

Rigidity traps are presented in some of the theoretical literature as arising from stability. Gunderson and Holling (2002) portrays this stability as a system state that is sought by

people and societies but that this eventually culminates in an increased potential for collapse. In the case of this research, rigidity traps were not found to be entered in to through a desire to stabilise the system but rather through an ineffective response to threats which leads to a gradual and subconscious decline. Rigidity traps can arise in both ways- deliberately or accidentally, however, the potential outcomes remain the same: collapse or transformation.

In this research, collapse is seen as too strong a description for the outcome of rigidity traps. Given the inherent interconnected nature of social-ecological systems in the region, it seems unlikely that the system will completely collapse and potentially become devoid of people as in historical examples of collapse presented by Nelson *et al.* (2012). Instead, the interconnections that members of the case study communities have with others outside of these communities are likely to sustain those that remain in the case study areas through remittances. This is an artificial prop for a system that is otherwise unlikely to be sustained without suitable adaptation strategies.

Others who remain in the case study areas under the conditions of more frequent floods and droughts driven by climate change, are likely to be those that undergo a transformation. There is some evidence of transformations taking place in the case studies already where some interviewees were found to have shifted from agriculture to other occupations such as tailoring and shop keeping. Although it was found that the desire to farm remained strong and even those whose primary occupation had shifted, these people still retained small farms for their personal use or hired labourers to manage their crops. This suggests that it is particularly difficult to define clear-cut examples of transformation. Similarly to collapse, the research findings suggest that communities are likely to tend towards change such as transformation but may not make a complete leap to a new system regime, just as they are unlikely to suffer a complete and definite collapse. As such, the concept of rigidity traps is particularly useful for highlighting the declining options and capacities that will constrain the communities.

The focus of this research on the social dimension, specifically decision making processes, has allowed the research to highlight the role of perceptions in promoting rigidity traps. The research found that rigidity traps arose where communities retained a particularly positive outlook, hoping for a better following year and thus continue to utilise the same coping strategies as under present conditions. As such, the perspective taken was often particularly short term. Respondents would tend to view yields as relatively isolated from their observations of longer term trends in climatic change. Although many interview

respondents and game participants pointed towards trends in increased seasonal variability that provide challenges in the form of floods and droughts, perception of change often did not influence action to adapt and adjust coping strategies. In this manner, households continued to employ the same strategies at present, resulting in a gradual erosion of resources that increased their rigidity. Holling (1973) and Abel *et al.* (2006) both highlight the role of gradual or more subtle triggers of collapse. Indeed, Abel *et al.* (2006) found that a failure to anticipate problems combined with a lack of feasible solutions and a dependence on counterproductive strategies were likely to promote collapse. These are all features that were present in the case studies for this research, highlighting the propensity towards collapse in a future under climate change where attention is not paid to the gradual accumulation of impacts. Through a focus on decision making processes, this research has particularly emphasised how a lack of adaptation options and failure to anticipate can contribute to the development of rigidity traps.

7.3 Implications of successional hazards

In contrast to the rigidity traps that were found to be likely to arise under more frequent flood and drought events, multiple (successional) hazards were also found to be more likely to motivate adaptation and coping capacity adjustments. The scenario activity highlighted that successional flood and drought events could be expected to result in additional losses to the farm. The scenarios demonstrated a multiplier effect that found crops that survived the first hazard event were unlikely to survive the second. Although the multiplier effect varies depending on the order in which the hazards occur, the overall losses after both hazard events were very similar and came to around 1/3 of the originally planted crops. Through the game activity, these deeper losses were found to promote more alarmed reactions. These stronger reactions reflect a recognition that the household faces considerable challenges and that alternative approaches may be required to respond to these.

Where deeper losses occurred in the game, even if many livestock and crops remained on the game board, the deep losses provided more of a shock and promoted discussion of migration and alternative occupations. From this it can be expected that potential new adaptation strategies are more likely to be motivated by the deeper losses and thus by conditions of multiple hazards rather than in the example of more frequent hazards that result in a gradual decline and rigidity traps that restrict adaptive capacities. This reflects the arguments of Korf (2002) who stated that livelihood strategies vary depending on "whether people have to deal with gradual trends or sudden shocks". Here, Korf (2002)

suggests that the choice to adapt rather than relying on coping strategies is related to the nature of the preceding hazard event(s). From the findings of this study, this argument can be extended and exemplified to suggest that where gradual trends in more frequent hazard events occur in the West Sudanian Savannah context, households are likely to depend on their usual coping strategies. In contrast, deeper losses stemming from successional flood and drought events is likely to lead to increased motivation to adapt or transform. These differences are illustrated in Figures 7.1 and 7.2 .

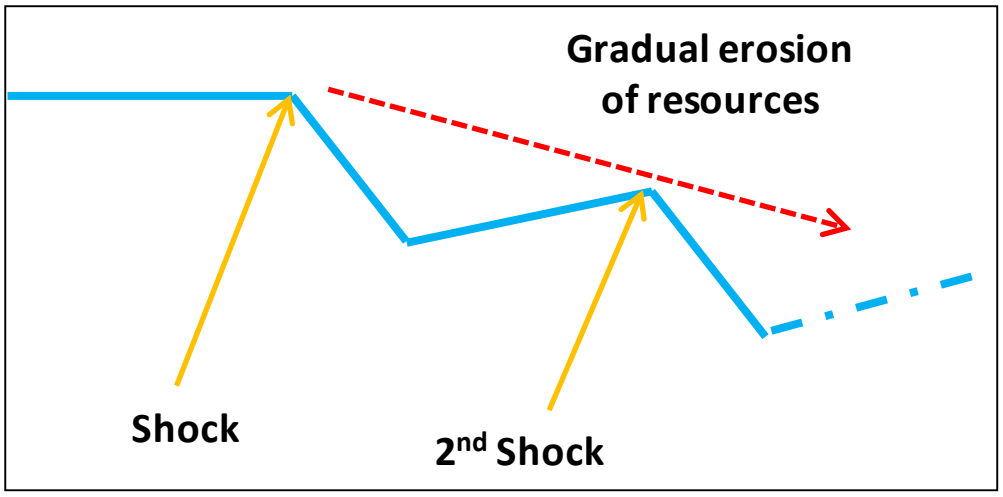


Table 7.1 Gradual erosion of resources stemming from more frequent multiple hazard events

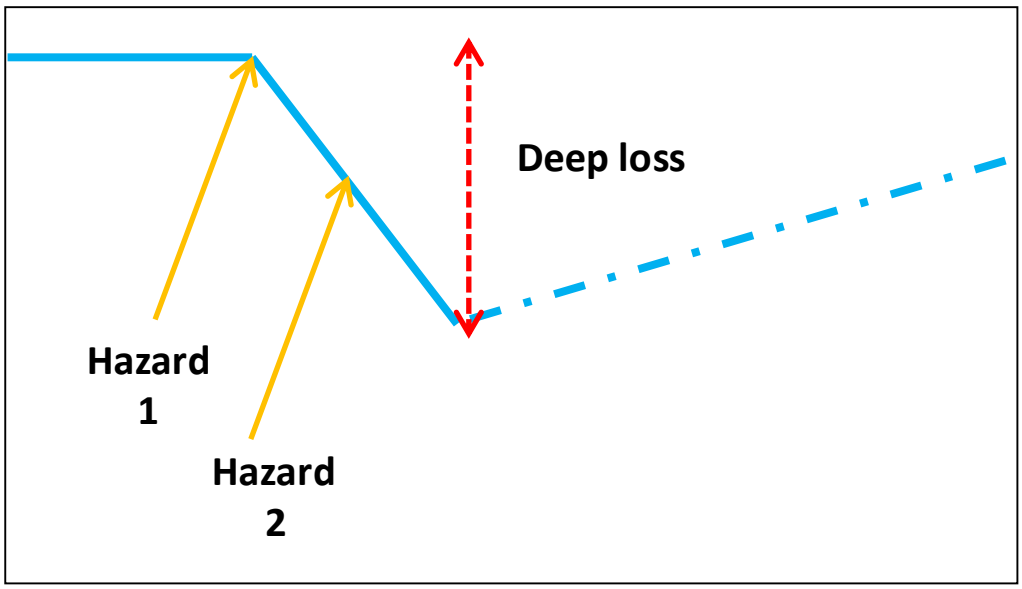


Table 7.2 Deeper losses stemming from multiple (successional) hazard events

7.4 Thresholds of change

As the comparison between the multiple (successional) and more frequent hazard situations demonstrate, the thresholds for change vary depending on the nature of the preceding hazard event(s). The literature concerned with tipping points and thresholds for regime change acknowledges that tipping points and thresholds are dynamic (Kinzig *et al.*, 2006; Walker and Meyers, 2004). However, despite the recognition of this dynamic nature, the literature tends towards calls for approaches to identify and measure tipping points and thresholds of change. This research provides a counter argument that suggests that instead of trying to identify particular tipping points and measure thresholds, it may be more appropriate to identify and measure the conditions and processes that influence the change in the thresholds. The findings from this research highlight how thresholds vary depending on the nature of the preceding hazard event(s). Deeper loses, such as those arising from successional flood and drought events, are likely to lower the threshold for a regime shift or change. In contrast, the gradual decline in resources associated with more frequent hazard events is likely to raise the threshold for regime shift or change.

The prior hazard context not only determines how the threshold is likely to change, it also determines the potential outcomes of exceeding the threshold with multiple (successional) hazard events likely to leave sufficient resources available to consider a wider range of adaptation and transformation options, whereas more frequent hazard events and a raised threshold provide an opportunity for resources to decline considerably before the threshold is reached, at which point the resulting rigidity promotes the likelihood of a collapse rather than adaptation or transformation.

Of course, collapse can be viewed at different scales and in the context of this research, the scale of interest is the case study community. Individual households are likely to reach their tipping points for collapse at different times. Some houses in the case study area have already exceeded their coping capacities, migrated and then returned to try again. Others will be able to last longer before reaching their tipping point. Therefore, the trends at the community scale are likely to emerge more gradually but it can be expected that with more frequent hazards, there will be a gradual decline in coping capacities that leads increasing numbers of individuals and households to migrate or transform.

Walker and Meyers (2004) ask if thresholds can be identified in advance. The findings from this research suggest that trying to determine a specific threshold is less useful than understanding the processes that influence the position but also the likely outcome of a

threshold being crossed. With the application of appropriate techniques to determine the characteristics of communities and their decision making processes under different conditions of stress, such insights can be developed. Whilst a particular prediction on when a tipping point or threshold is likely to be reached may not be possible, the identification of threshold influences and outcomes can at least provide an impetus to take action in advance to either raise awareness of rigidity traps or provide new adaptation options that remove the threshold.

7.5 Adaptation today and tomorrow

Adaptation was found to take place in a relatively reactive manner. The main adaptation strategies employed were related to a diversification of sources of income or livelihood. Most households have temporary sources of additional income that can be relied upon as coping strategies and, as interviews highlighted, these temporary strategies are becoming more permanent. The shift towards engaging temporary strategies on a more permanent basis was highlighted in the literature by Berkes and Jolly (2001) who argued that this is a trend likely to emerge as climate change takes place. The findings of this research add weight to this argument but more particularly, emphasise a potential shifting role for women as a result of this increasing dependence on alternative sources of income.

The findings of the research highlighted that women have a more diverse range of income sources being traditionally excluded from the main farming activities. As climate change increases the need for alternative incomes, women may become more valued and important to their households. There is already a trend in women becoming more economically active with comments in the interviews that highlight how women are also being increasingly permitted their own fields to farm as well as taking on their own businesses or working in partnership with their husbands to manage additional businesses. Climate change increases the value of women to households and this may enhance current trends of women becoming increasing economically active and independent. This finding contradicts much of the climate change literature that argues that women are often disproportionately affected by climate change. Although it is true that women feel certain hazard and climate change induced burdens more than men (e.g. having to spend more time collecting water when there is a drought), climate change can also provide an opportunity for women to become more valued and independent, as the need for adaptation strengthens and men remain devoted to farming.

Although some adaptation strategies were evident in response to floods and droughts as they currently occur, in most cases, these strategies were found to be insufficient for fully enhancing resilience to floods and droughts. Many of these adaptation strategies such as livelihood diversification are helping to cope with the impacts of floods and droughts due to seasonal variability but households are still unable to completely recover from these events before the next rainy season. In addition, many of the recently introduced adaptation strategies such as farming different crops or the use of short cycle seeds, still have limitations which hinder their effectiveness. As Cannon and Müller-Mahn (2010) highlight, if communities are unable to adapt to the present day situation, it is unlikely that they will adapt when the conditions worsen, such as under climate change. To test this argument, this research conducted a participatory game activity that also addressed the potential for new strategies to be innovated as conditions declined.

Although there is evidence of transformations in the present day situation, the important lesson from the game and from the literature on rigidity traps is that anticipatory transformations and also adaptation strategies can often require an injection of resources (Kates, 2000). In the context of the case studies, resources may be required to purchase materials with which to start sowing clothes or to purchase the stock for a shop. Rigidity traps occur where the resources available for these options decline, thus limiting adaptation but also potentially limiting transformation, since transformation and adaptation options in the case studies are similar.

Whilst deeper losses are more likely to motivate adaptation strategies, an important finding from the research was the limited nature of adaptation options. Emphasised during the game activity, where deeper losses were experienced, the discussion often turned to options such as migration and looking for jobs. Migration and jobs were both found to be carried out to different degrees, with additional occupations representing adaptation and shifts from farming to a different occupation representing transformation. Equally, seasonal migration was found to be an adaptation strategy while longer term or permanent migration was reflective of a transformation. Where these options were employed as adaptation strategies, they were found to be relatively insufficient for fully enhancing resilience. As such, the game was not able to demonstrate examples of innovative adaptation. Most responses revolved around currently available strategies or strategies that are restricted such as banking which requires paperwork that farmers are often unable to provide. Although, innovation could be sparked at any time, these findings add emphasis to the arguments of Cannon and Müller-Mahn (2010), that it should not be

assumed that adaptation options will automatically transpire when the needs become severe enough. It must be recognised that if communities are presently unable to enhance their resilience, this is likely to persist and may even worsen under greater pressure.

7.6 Methodological reflections and evaluation

The overall approach of this research is based on assessing the current situation with particular emphasis on understanding the impacts of and response processes towards locally defined floods and droughts. The knowledge of the current impacts and responses was used as a platform from which to examine the outcome of more frequent and multiple hazard events in a future under climate change. The use of relatively novel and unique methods has been central to achieving this goal where standard qualitative and quantitative approaches would have been inadequate. This section aims to reflect on the application of these methods, highlighting their achievements but also their limitations.

The first part of the research was designed to examine the current situation. Common approaches towards local level vulnerability assessments were generally found to focus on underlying conditions and potential coping capacities that often were not hazard specific and were also unable to account for the decision making processes that influence the translation of coping capacity to actual coping. Given the uncertainties inherent in looking towards the future under different (climate change) conditions, it was felt that an ex-post approach to vulnerability and coping would provide a more robust, a-posteriori grounded, foundation from which to consider the future.

7.6.1 Reflections on the interviews

Interviews were selected as a method for developing the base line, ex-post perspective as they allowed a greater depth of information to be collected on the impact and response processes currently employed after flood and drought events. The interviews enabled a degree of flexibility so that the most important and relevant impacts could be focussed upon but where a broader range of impacts, including cascading impacts were also identified and acknowledged. For the information on the recovery process, interviews provided the flexibility to probe deeper into the reasoning and decision making processes that the individuals undertook. Due to the flexibility that the interviews allowed, it was important and highly beneficial that the research undertook these interviews personally. This allowed the strands of most value to the overall research objectives to be honed in on. In addition, by undertaking the interviews personally, it was also possible to observe and collect additional information through the expressions of the interview respondent.

Visiting the interview respondent's homes also added further background detail to place the responses in context.

The interviews were analysed through the application of the conceptual and analytical framework described in Chapter 3. The framework was highly effective at assisting the analysis and interpretation of the interview data, enabling outcomes to be categorised in a manner that highlighted the degree to which the communities and their members were vulnerable, able to cope or adapted to floods and droughts at present. It was surprising that in communities considered highly vulnerable from a global perspective, very few households and individuals fell into the higher vulnerability categories of set-back and spiralling decline. For those that fell into set-back, i.e. where the impacts were not recovered from, this did not always denote a high vulnerability, as sometimes the set-back was a voluntary choice not to recover. Thus, the set-back sub category could be divided into voluntary and involuntary types of set-back. The original conceptualisation of set-back was based on the involuntary type, where households were unable to recover losses, despite their desire to achieve this. The voluntary type is less severe as it suggests that households could recover but choose not to. An important question arises as to whether these sub-categories could or should be added to the continuum to reflect the difference between voluntary and involuntary lacks of responses.

Where voluntary set-backs occurred, these were in cases where losses were deemed to be less important and not critical to well-being. They were losses to elements that could be seen as luxuries rather than necessities. Whilst it is important to acknowledge that these losses do occur and thus to not mis-label households as resilient, the nature of the losses implies that the damage is not significant and therefore of less concern. In terms of the continuum, the objective was to identify households that are already unable to cope with natural hazards or may become less able to cope in the future under conditions of climate change. The research is therefore centred on critical impacts from hazards and losses to more essential elements of household well-being. Whilst it is important to acknowledge that less serious losses can also occur, the focus must remain on critical impacts and losses and thus no additional category will be added for involuntary set-backs.

The sub category of bounce-back also provided some minor challenges. In the theoretical literature, bounce-back was seen to reflect a rapid return to the pre-hazard state. However, in this research bounce-back was taken as a recovery that is completed in the period between the more immediate cessation of the hazard event and up to one year, at which point it would be labelled a protracted recovery. This period of up to twelve months

seems to be longer than that envisioned by theoretical literature/perspective, however, it was extremely helpful to view bounce-back as taking place in up to twelve months in this context because many recovery processes, such as reconstructing houses and replenishing lost grains, take place at particular times in the year, when conditions allow. For example, reconstruction of houses takes place in the dry season and the purchase of grains may be delayed until later in the year when it becomes clearly necessary. In addition, the cut-off of twelve months was helpful from the perspective of a future under climate change where the potential for hazards to reoccur is connected to the rainy season. As such, in this context, the conceptualisation of bounce-back as up to twelve months was particularly helpful and relevant. This may not be the case in other contexts but was highly appropriate for the context of this research. It should also be highlighted that the twelve month cut-off was applied flexibly as a crude estimate of when a recovery should be complete. The key objective was to establish whether or not the recovery is complete by the point at which the next hazard event may occur, i.e. the next rainy season. As such, the interviews asked if a complete recovery has been achieved by the next rainy season, rather than using the twelve month cut-off point exactly.

The conceptual framework was, therefore, highly effective at operationalising the vulnerability, coping and adaptation concepts. The sub categories that were developed in the framework helped to differentiate between different hazard outcomes in a manner that fit the reality of experiences based on the interviews and helped to identify the potential for climate change conditions to exacerbate vulnerability.

7.6.2 Reflections on the game

To examine the impacts and responses with regard to increasingly frequent and multiple hazard events as anticipated under climate change, the participatory game was designed to represent key elements of the social-ecological system, acting as a simplified model. The game filled a methodological gap as interviews were unsuccessful at eliciting information on hypothetical futures. The game included the key crops, livestock and compound houses. Floods and droughts were designed to arise at random, reflecting the uncertainty inherent in climatic conditions. As a game played between two people, there was an element of competition to motivate efforts to meet the challenge that simulated climate change would bring. In some cases, there was a more highly competitive atmosphere than others, however, this did not appear to influence innovative adaptation, instead it resulted in counter-classic strategies that gave the impression of success at first but ultimately resulted in the same degree of losses as the classic strategies.

The game was highly effective at placing participants in the context of a future under climate change, successfully overcoming the problems that were encountered when trying to address a hypothetical future through interviews. As such, the game tapped into decision making processes that guide decisions at present but are also likely to provide the same foundation for future decision making. The comments from interview respondents that they would look at their resources and assets at the time of needing to recover from hazard impacts was demonstrated to also be the main approach used in the game as well. This provides an important foundation for other work on climate change, highlighting the value of understanding the processes and mechanisms at play in social-ecological systems rather than simply trying to quantify and measure assets that may not necessarily be selected or even available to be selected due to tradeoffs and changes over time.

Innovative adaptation occurred rarely and this may have been a reflection of the game design where players felt they could only work with the elements of their system as presented on the game board. However, the discussion following the game provided an opportunity for players to raise potential adaptations or approaches that they would use in reality. At this point the players and the advisory audience offered strategies that are the same strategies currently adopted in response to hazard impacts as revealed by the interviews (i.e. jobs and migration). Combining the general sense of fatalism, that the outcomes were 'God's intention' with the same impressions raised in the interviews for the present day situation, it appears that the limits on adaptation and adaptive innovation that were visible in the game are not restricted by the game but genuinely reflective of restrictions and barriers to adaptation in reality. Of course, it is possible that new adaptation strategies may arise in the future that could not be foreseen at this point but may enable a successful adaptation to climate change. Whilst the game cannot predict such unforeseen developments, it does serve as an indication and warning about the implications of a future under climate change if new adaptation strategies are not developed.

The game was designed as a simplified version of the real social-ecological system, however, it was felt to be reflective of reality. The comments of participants and audience members, particularly emphasised this. Participants also commented that they learned from the game, in particular, it raised their awareness of the challenges of climate change and the trends that they are already witnessing of more frequent hazard events and seasonal variability. As such, the game can be seen not only as a tool for gaining further

insights into decision making processes but it may also act as an educational tool, raising awareness of the need to respond before slipping into rigidity traps. The participatory game clearly demonstrates the importance of addressing local perspectives in order to develop approaches to manage climate change impacts. Understanding how coping capacities are applied as well as local perspectives that influence the propensity towards (or lack of) proactive adaptation, is essential to ensure the success of any new adaptation approaches that might be introduced.

Games are often used as participatory and educational tools. Often applied to common pool resource problems, games tend to be based on zero-sum designs. In this game, the 'winner' was determined as the person that had the most resources left after several rounds. Thus the players could be competitive with one another but their actions and choices would not directly affect the other player. Both were free to exercise their agency. In this way, the game was highly effective at accessing insights difficult to otherwise obtain. In particular, the game illustrated a difference between spread out hazards and multiple hazards, suggesting that deeper/more severe losses would motivate adaptive behaviour or migration. The scenarios built on this by demonstrating that multiple hazards would bring deeper losses to crops and in particular, illustrating which crops would be better able to resist or more resilient towards both hazards.

7.6.3 Reflections on the scenarios

The scenarios were designed to demonstrate the potential multiplier effect that may occur. However, only two scenarios were able to be examined. The scenarios were designed to reveal whether the order of the hazards might affect the nature and degree of multiplier effect. The results found that the multiplier effect was more significant under Scenario 1 where the first hazard was a drought and the second hazard was a flood. However, the total losses from both scenarios were highly comparable, with almost identical results after both hazards events. A limitation of the scenarios was that the scenarios examined the two hazard events at the same points in time, with the first hazard occurring at 30 days and the second at 60 days. These intervals were selected based on secondary source information that showed that the key crops examined would all have germinated and still be growing and not matured by 60 days, thus the potential for impacts would be present. These intervals were, therefore, selected to make it easier for the respondents to consider the impacts in a uniform manner, however, there were some challenges with the case study unique/specific crops, as these were normally planted before the main planting and harvested earlier.

Whilst the participants were asked to consider that the case study unique crops had been planted at their normal times and at 30 days, they would experience a hazard event, even though 30 days would be perhaps in May instead of June or July, the participants struggled to view the crops in this way and thus the results for these crops could not be included with the others, as they were not comparable. However, the case study unique crops did provide an interesting insight into the value of crops that can be planted during the dry season and harvested early. These crops are already well documented as providing support during the hunger period but are grown in limited quantities. The results of the scenarios suggest that although the early planted crops cannot be stored for long periods of time, their availability near the beginning of the rainy season may make them a useful buffer for deeper losses that floods and droughts bring that could affect almost all of the standard crops.

The timing of the hazards was kept constant for the scenarios, however, timing is likely to have a considerable influence on the impacts of hazard events. This is another element of complexity that could be added to the scenarios and would be useful to examine in future research. Importantly, whilst questions remain, this research is able to demonstrate that a second hazard event does have an additional impact and that this impact is not simply doubled but is also complicated by the spacing of the hazards, the timing of them and the order, although the total impacts may reflect less variation, if the second hazard is to be added to data on the first hazard, the degree of multiplier effect will be more or less substantial depending on which hazard occurred first. Secondly, the overall impacts provide an important warning that multiple hazards are likely to cause deep losses that motivate migration or adaptation but with limited viable adaptation options available, the rural subsistence West African farmers can be seen as highly vulnerable to climate change.

Although the overall trends across and between the case studies were highly comparable, at the local scale there was considerable variation in the scenario results between individual villages. Part of these variations can be attributed to the different environmental conditions of each village. Factors such as topography, soil types, hydrology and even weather can vary significantly between the villages and also within them. However, Salack *et al.* (2015) also recognise high variability between villages and argues that environmental conditions do not fully explain the heterogeneity. Indeed, human factors such as planting techniques and timing of planting can also play a role in determining outcomes at the village level. Although the internal variability is high, at the

case study level trends arise that can be validated by the interview findings and secondary data that verifies the most and least vulnerable crops. Furthermore, when comparing the overall trends with the other case studies, similar patterns emerge. Therefore, this internal variability can be taken as a natural feature of the diversity of the environmental and human conditions at the village level but the overall trends provide the important insights for decision makers at the policy level. Indeed, the objective of the scenarios was to provide trends and insights, given the qualitative analysis focus of this research. Although figures could be generated, these are only indicative and devised to help illuminate the overarching trends. The relatively small sample size of nineteen villages makes the quantitative findings insufficient for extrapolation on a statistical basis. Instead, the comparability of the trends and similarities between the case studies provide a different, more qualitative basis for deriving lessons at a broader scale.

7.6.4 The case study approach

Central to the research approach was the use of case studies. As highlighted in Chapter 2, the case studies were selected through the WASCAL project for which this research forms a part. The choice to cover all three case studies was made on the basis that the three case studies shared a common foundation of rural, subsistence agriculture based communities in the West Sudanian-Savannah climate zone. The premise for the case study approach was that if the three case studies are relatively similar in their impacts and responses to present and future conditions under climate change , the findings of this research may have a broader reach, enhancing the prospect for their applicability in other similar communities. Thus the scope of the research could be extended beyond a contribution to the broader theoretical literature but also to the broader practical level with recommendations for policy makers in other countries.

At the individual and village level, there was a high degree of variability, as described above. This variability reflects the homogeneity of the case study communities. However, by focussing on trends at the case study level (i.e. trends over the various villages sampled in the case study area) and by comparing these trends between the three case studies, key trends emerged that enabled important findings to be identified that could also be applied further afield. The high degree of comparability between the case studies in both the present day and future hazard conditions demonstrates the potential for the research to be applied to other rural, subsistence agriculture based West-Sudanian Savannah communities. However, the comparability of the case studies also highlights the lack of institutional/governmental influence on local level processes. Where communities have a

higher input and connection with national level processes and policies, particularly those that aim at hazard risk management and agricultural adaptation, the research may not be as applicable. Therefore, the applicability of the research to other similar communities is dependent on the degree of influence that different institutions or government policies have on the local level.

8 Conclusion

8.1 A future under climate change for West Africa

The overall objective of this research was to shed light on the potential implications of climate change manifest as more frequent and multiple (successional) flood and drought events in the West Sudanian Savannah climate zone. In particular, the research identified a gap in understandings of the potential multiplier effect of more than one hazard and what this implies for the social dimension of the coupled social-ecological system. In other words, do two hazards double the impacts and three hazards treble the impacts and how would these impacts affect the vulnerability, coping, adaptation and resilience of the case study communities?

The research found that most members of the community are currently able to cope with the impacts of floods and droughts through the sale of livestock, additional sources of income and temporary migration. However, the research highlighted that these response strategies, particularly the sale of livestock, result in a protracted recovery that extends beyond the following rainy season. This is important as the following rainy season carries the potential for further floods and droughts to occur, particularly under climate change conditions. The key question that arose from this understanding of the present day responses to floods and droughts was what will happen if floods and droughts do become more frequent and do increasingly occur in succession: to what extent will the communities be able to cope and what might be the outcome if they cannot?

To answer the question of responses and coping under conditions of more frequent hazards, the research develop a participatory game to examine decision making processes and to reveal the trends that might occur over time as hazard impacts accumulate. The results of this research found that adaptation options that are largely lacking. Where adaptation was enacted, i.e. through banking, this was recognised as a hypothetical strategy but one that cannot be utilised in reality due to constraints in terms of the conditions required to be fulfilled in order for subsistence farmers to open bank accounts. A lack of innovative adaptation was also revealed, verifying perspectives from the interviews on the present day approaches which suggest an underlying fatalistic perspective and belief in God's will. As such, hazard impacts accumulated over time.

As the hazard impacts accumulated, two trends were visible. The first trend was that sudden and deep losses were often responded to dramatically with game participants

commenting that they would have to migrate or take a loan or job. These comments often occurred early on in the game when stocks were relatively high but large losses were felt keenly. In contrast, when losses accumulated gradually with less frequent hazard events, the players continued to play unconcerned or with hope that the following year would bring an improvement. Only when their assets began to reach critical levels, particularly when livestock were too few to multiple, did the participants realise the weakness of their situation. This latter example illustrates rigidity traps and shows that as losses accumulate gradually, coupled with fatalistic beliefs, households are likely to become trapped in their circumstances with limited assets available to retrain and develop a new skill that might enable a transformation. As such, migration is a likely outcome and this may result in a long term loss of labour which is particularly concerning given that food security goals depend on these agricultural communities.

The findings from the participatory game not only highlight the risk of rigidity traps but they also demonstrate the dynamic nature of thresholds. The findings suggest that thresholds for change are not fixed and not single points in time, rather regime change is likely to take place gradually and accumulate to become visible as wider trends at the community level. Complete collapse is unlikely, particularly as external network connections often prop up the system. However, a key finding is that the dynamic nature of thresholds for regime change is likely to be based on the hazard event experiences that lead to an evaluation of the situation. The research therefore presents an argument that focus should be placed on understanding the processes that influence regime shifts and threshold dynamics rather than trying identify tipping points which are often elusive and dynamic.

In addition to examining the impacts and potential responses to more frequent hazard events, the research also examined the potential multiplier effect of floods and droughts that occur in succession. Recognising that with increasingly frequent hazard event conditions, floods and droughts may occur in the same rainy season and this might have a differential impact on damage. The findings revealed that there is a multiplier effect on crops and that this depends on the order of the hazard events but is also likely to depend on the timing of the hazards. The multiplier effect is significant, particularly where droughts occur first, followed by floods. Indeed, floods were found to have a more significant impact on the crops than droughts but that droughts would affect slightly different crops causing a cumulative effect on the overall losses that would mean that up to two thirds of the crops across the communities could be lost. Such deep losses as would

be expected under a multiple hazard situation suggest deeper losses that might increase the motivation to adapt or migrate.

8.2 Contributions to natural hazard research

This research has highlighted the need to better account for the differential cascading and cumulative effects of different hazard events occurring in succession. The research emphasises the need to enhance the extent to which these effects are built into multiple hazard risk assessments and maps and advocates the need for a different perspective, focussing on understanding the processes that underpin impacts and responses rather than quantifying features and system components.

The research has utilised relatively novel methods, adjusting them in order to better answer the research questions. In particular, this research has demonstrated the value of participatory games for eliciting information on decision making in future contexts, placing the participants in a future hazard context to directly make decisions on how to respond. This expands on the current uses of participatory games as predominantly social learning tools to enhance the management of common pool resources. Whilst the participatory game used in this research does have a social learning element to it, the focus was to reveal decision making processes at the individual or household level. The insights revealed through this activity have shed light on the need to focus on understanding the factors that influence threshold changes rather than trying to identify and measure tipping points.

In addition to providing insights on the importance of understanding the processes that influence thresholds and regime shifts, this research has also contributed to the practical literature on rigidity traps. Importantly, this research shows how rigidity traps can arise in coupled social-ecological systems that are also connected to communities elsewhere. The research does not expect a complete collapse in the entire social-ecological system but does demonstrate how rigidity traps can derive from accumulations of losses as people migrate and shift to providing labour services as opposed to self-employment.

Much of the hazards literature is centred on large, high intensity hazard events. Some of this focus has derived from a desire to focus attention on those places most at risk. However, this research highlights how smaller intensity but high frequency events are also important to consider. The hazards that affect the communities that form the focus of this research do not normally result in high losses of life or high value damages, from an economic perspective. However, the damages to livelihoods and shelter are particularly

problematic for these communities that have limited coping and adaptive capacities. This research has shown how these damages could accumulate over time with climate change increasing the frequency of the hazards and therefore increasingly the potential for the social-ecological systems to collapse. As such, this research emphasises the need to further expand research on lower intensity hazards and gradual processes of vulnerability and risk.

8.3 Limitations of the research

The focus of this research was vulnerability to multiple hazards, however, the study was limited to examining only two natural hazards. The choice of the hazards was guided by the importance and relevance of the hazards to the local communities and that they could be highly influenced by climate change. Other natural hazards are present in the case study areas, for example strong winds and storms. These hazards could also interact with the floods and droughts that were studied, creating multiple hazard risks. However, it was decided that the focus of the research should be placed on two hazards in order to provide a basis for multiple hazard research approaches that could be built upon in the future. The additional hazards would have complicated the study further, providing different types of interactions (for example, storms can influence the periodicity of flooding and are therefore not mutually exclusive as is the case for the flood and drought hazards examined in this research) and different spatial distributions, with some hazards only prevalent in one or two of the three case studies. The aim of the research was to provide an indication as to the potential multiplier effects of multiple hazards but the results are limited to the two key hazards examined.

The research is spatially explicit as it focuses on rural communities in the West Sudanian Savannah. The findings are specific to this region and it must be recognised that the single rainy season conditions are central to the premise and results of this research. With additional rainy seasons, the impacts of floods and droughts would be more complex and may not be as severe. This research is, therefore, limited to applying the findings only to the West Sudanian Savannah climate zone. However, by studying three case studies, providing an extended/intensive approach, the results can be seen as applicable at least beyond the case studies, to other areas with similar profiles.

For the scenario and game activities, the sample sizes are relatively small. As such, the analysis is primarily qualitative and values are used indicatively rather than as statistical representations. In addition to concentrating on two natural hazards, the scenarios

activity also examined only two scenarios and was not able to examine the influence of temporal variation in hazard onsets. More complex models and scenarios could examine this in the future.

8.4 Opportunities for future research

It is hoped that this research will provide a foundation for further investigations into the complex cascades and interactions that occur in multiple hazard situations. This research was designed as a starting point to demonstrate the need and value in accounting for the multiplier effects the multiple hazards may create, with a particular focus on the social dimension of coupled social-ecological systems. Thus, with this foundation, the following extensions and further research can be suggested.

Firstly, this research focussed on two natural hazards, specific to the case study contexts. Expanding the approach to other natural hazards could expand understandings of the different ways in which hazards can interact and the different outcomes of these interactions. In particular, it would be useful to examine non-mutually exclusive, cascading and combined hazards, such as storms and floods or strong winds and floods.

As highlighted above, the scenarios examined the difference that hazard orders made on losses and the multiplier effect. An area for further research would be to examine the influence of the temporal side, examining the difference that different intervals between the hazards may bring. Furthermore, the scenarios could be examined in a quantitative manner through crop modelling and the outcomes could then be applied to decision making models or built into a game to understand the differential impacts and responses that might arise.

Expanding the scope of hazards and hazard interactions considered could yield further theoretical and practical insights to help address the challenges that may arise, particularly with climate change influencing more frequent hazard events and with population growth influencing the number of people and assets exposed to hazards. Further research could also consider a range of natural and man-made or natural-technical hazards.

There is a need to better understand and account for the multiple hazard impacts and the translation of these into vulnerability should be better incorporated into future multi-hazard risk maps. The current approaches are woefully inadequate. This research has

provided an initial step towards enhancing multiple hazard risk and vulnerability assessments and it is hoped that future research will build on these early insights.

8.5 Implications and recommendations for policy and decision makers

The research emphasises the importance of and need to account for cascades and interactions as well as the multiplier effect of multiple hazards. However, the research also illustrates some areas of concern for policy makers at a practical level. In particular, this research has revealed a considerable lack of viable adaptation options. The adaptation options currently available are, at least, only able to partially increase resilience to flood and drought events. Those strategies that have relative success, such as the Dreyer Foundation with their reservoir that enables dry season farming, are indicative of the success that concerted efforts to engage with and actively involve local communities combined with a complete systems perspective can achieve. However, these approaches are resource intensive and require continued commitment and a locally sensitive approach.

Floods and droughts, as opposite hazards, require different adaptation strategies. It is highlighted here that given the propensity to experience both types of hazards, adaptation strategies must be sensitive to both (opposite) types of hazards. Current adaptation approaches such as changing the timing and location of cropping are often able to increase resilience to one type of hazard, thereby increasing the susceptibility to the other hazard type. Adaptation strategies need to be developed that are conscious of and sensitive towards both hazard types, to avoid adaptation for one hazard resulting in maladaptation to the other.

The research has found that traditional crops are likely to fare better than more modern additions under more frequent and multiple hazard situations. Whilst cotton provides a source of cash income, it is particularly challenging to produce in the communities studied. Whilst cotton may survive one hazard, the multiple hazard research suggests that it is one of the weaker crops under multiple hazard conditions. With regards to maize, a similar finding has been revealed. This emphasises the need to ensure that farmers who grow a range of crops should still designate large proportions of their land to the more resilient crops of sorghum and rice, limiting the quantities of more susceptible maize and cotton. Cotton is particularly risky given its dependence on global market prices. Crops that can also be used as food and provide nutrition in the case that the global market price declines could be a more suitable option to enhance local resilience.

Efforts are needed to develop better adaptation strategies that focus on making agriculture more resilient. However, these strategies need to be aware that a dependence on fertilisers, pesticides and seeds that all have to be purchased by the farmers places communities at the mercy of the prices and accessibility of these products, which in turn may undermine resilience gains. Finding ways to better cope with shortfalls in rain from dry spells such as small scale, locally managed irrigation schemes and better approaches to drain fields under flood conditions could be more beneficial.

Finally, organisations and institutions need to work together with the communities that they serve. They need to recognise the benefits of combining the wealth of local, traditional knowledge and perspectives with scientific insights as well as better understanding how new approaches and technology can fit into the social-ecological system as a whole. Understanding the decision making processes, considerations, concerns and perspectives of the rural communities will help organisations to develop strategies that better cater for the needs of community and reduce the risk of maladaptation.

Without adequate adaptation strategies, the risks of multiple and more frequent hazards under climate change increase the likelihood that rural communities will decline as the residents migrate away. In the cases of Burkina Faso and Benin, this migration is largely international and thus presents a concern from a food security perspective. To avoid losing valuable agricultural labour, concerted efforts should be made to support farmers and develop viable adaptation options that allow them to continue to farm in these key agricultural areas. In addition, raising awareness of the creeping effects of more frequent rather than multiple (successional) hazard events is particularly important to avoid the rigidity traps that are likely to weaken the position of households, pushing them towards collapse.

8.6 Future challenges for West Sudanian Savannah communities

This research has revealed the complexity and cascades in hazard processes with a particular focus on low intensity hazards in tightly coupled agriculture based social-ecological systems. The complex and cascading interactions have highlighted the important impacts that low intensity hazards can have on closely coupled SES.

Through the application of novel approaches designed specifically for this research, the results shows that more frequent hazards under climate change increase the likelihood that communities will slide into rigidity traps. With limited adaptation options, these

communities are likely to migrate over time, potentially leading to a collapse in the social-ecological system that is essential to national food production.

By examining the effects of multiple (successional) hazard events, also anticipated under climate change, this research has found that the impacts of floods and dry spells in the same season are likely to be significantly deeper than simply a single flood or dry spell drought event. These deeper impacts may motivate communities to act more rapidly, before their resources decline to critical levels. However, the lack of available adaptation options limits the capacity to respond to these impacts in a manner that sufficiently enhances resilience.

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10 Appendices

10.1 Summary of Wellbeing categories derived from literature

The following table details the literature sources and wellbeing categories derived from these. These categories were grouped and cross referenced with vulnerability indicators from the World Risk Report to ensure that all potential aspects of vulnerability, coping, adaptation and, by extension, resilience would be captured by the categories derived from the wellbeing and vulnerability literature.

Dwyer *et al.* (2004)	**Adger (2007)**	**Cutter *et al.* (2003)**	**Tapsell *et al.* (2010)**	**Schindler (2009)**	**Kumpulainen (2006)**	**Adger *et al.* (2004)**	**Brooks *et al.* (2005)**
Age	Population with access to sanitation	Socioeconomic status	Age	Average income per household	Population density	Economic wellbeing (GDP, GINI, Debt)	Economic well-being and inequality
Income	Literacy rate	Gender	Gender	Annual icnome per capita	Culturally significant sites	Health and nutrition (calorie intake etc)	Health and nutritional status
Residence/ tenure type	Population composition	Race and ethnicity	Employment	Gini Index of household icome distribution	Significant natural areas	Education	Education
Employment	Maternal mortality	Age	Education	Livestock as an indicator for household wealth	Fragmented natural areas	Physical infrastructure	Physical infrastructure
English skills	Literacy rate	Commercial and industrial development	Family/ household composition	Land resources as an indicator for household living standards	Tourists	Institutions	Governance
Household type	Calorific intake	Employment	Nationality/ethnicity	Land tenure	GDP	Geographical and demographic factors	Geographic and demographic factors
Disability	Voice and accountability	Rural/Urban	Housing type and number of rooms	Household size	Education rate	Dependence on Agriculture	Agriculture
Insurance	Civil liberties	Residential property	Rural/Urban population	Labour	Dependency ratio	Natural resources and ecosystems	Ecosystems
Debt and savings	Political rights	Infrastructures and lifelines	Awaressnes, preparedness and previous experience	Availability	Risk perception	Technical capacity	Technological capacity
Gender	Life expectancy at birth	Renters	Access to decision making	Dependency ratio	Institutional preparedness		
Injuries	Government effectiveness	Occupation	Trust in authorities	Cultivated areas in rainy season	Medical infrastructure		

Residential damages	% of population employed in agriculture	Famuly structure	Illness or disability	Holdings	Technical infrastructure		
Reciprocity	GDP per capita	Education	Length of residence	Livestock index	Alarm systems		
Community integeration	Educational expenditure as % of GDP	Population growth	Flood warning system	Number of cattle			
Bonding, Bridging, Linking and Isolation	Health expenditure per capita	Medical services	Flood type and return period				
Social participation	Rule of law	Social dependence					
Civic participation	Regulatory quality	Special needs population					
Sense of efficacy	GINI coefficient						
Cooperation							
Communicatio n modes							
Emotional support							
Network size							
Common action							
Community support							
Gall (2007)	**Eakin and Luers (2006)**	**Tapsell *et al.* (2010)**	**Bhattacharya and Das (2007)**	**Vincent (2004)**	**Cannon *et al.* (2003)**	**UN ISDR (2009)**	**Cutter *et al.* (2000)**
Social	Wealth	Lack of access to resources	Agricultural sensitivity	Economic well-being and stability	Initial well-being	Vulnerable rural livelihoods	Population and structure
Economic	Diversity	Limited access to decision making	Deomgraphic sensitivity	Demographi c structure	Livelihood and resilience	Poor urban and local governance	Differential access to resources
Institutional	Participation	Lack of social capital	Health sensitivity	Institution and infrastructur e stability	Self-protection	Ecosystem decline	Wealth or poverty
Infrastructural	Equality	Beliefs and customs	Economic capacity	Global interconnect ivity	Social protection	Climate change	Level of physical or structural vulnerability
Institutional capacity	Institutional change	Building stock and age	Human capacity	Natural resource dependence	Social and political networks and institutions		
Economics	Policy	Frail and physically limited individuals	Infrastructure capacity				
Rural population	Social capital	Weak infrastructure & lifelines					
Demographics	Youth education levels	Population shifts					

Trade balance	Investment in health	Increased mobility

Joiner *et al.* (2012)	**Adger (1996)**	**Kelly and Adger (2000)**	**Adger (2000)**
Education	Income from risky resources	Poverty (marginalisation)	Economic growth, stability of income and economic well-being
Health status	GDP	Inequality	Environmental variability
Food and water	Inequality	Institutional adaptatiion	Mobility
Healthcare access			

10.2 Interview Transcript Sample

BNDab6: Interview transcript. Interviewer (I) Respondent (R) Translator (T)

I: Apart from farming, does he do anything else?

R: No

I: What crops does he grow?

R: maize, sorghum, rice, groundnut, bambora beans, yams, millet, soya, chilli peppers, beans

I: and the animals?

R: Goats, sheep, dogs, pigs, chickens

I: Has he ever experienced flooding in the house?

R: He never experienced floods but the heavy rains

I: What damage did the heavy rains do?

R: It made houses collapse and damages farms

I: Did his house collapse when they had this heavy rain?

R: This room that we are seeing, it is this year that he built it. It collapsed. It was damaged years before

I: So it's just this year that he rebuilt?

R: Yes. It was just last year, 2012, that he rebuilt it

I: So how long did it take to rebuild it? When did he start?

R: It collapsed in August 2012 and directly in the dry season in January, he started rebuilding it

I: So what was the room that collapsed used for?

R: It was a bedroom

I: And did they lose any items inside the bedroom when it collapsed?

R: It spoiled some of his things, his bed, some of his clothes and his wife's clothes

I: And did they have to replace any of these things?

R: During that damage he also lost some dishes and that they have replaced them because they were important/replaced the important ones

I: How did they replace them? Did they have some money they could use or did they have to sell something?

R: When that happened he borrowed money to buy these dishes

I: And has he repaid the money yet?

R: He hasn't returned it all yet, he has completely returned all of the money that he borrowed

I: For rebuilding the house did he have to buy any materials for that or labour?

T: I asked him which things did he buy for rebuilding his house

R: Yes, everything that he used as material he borrowed money to buy them and he's expecting that after the harvest of this year he will get the money to return it to the people who lent him the money

I: So which crops is he likely to sell in order to get the money back?

R: Currently, as he hasn't harvested yet and doesn't know how the rainy season will go on, he can't foresee which crop he will sell to get the money. He will wait for the rains to end and to see how he will harvest each crop and from that also due to its price on the market, he follows the market also so there are many things to wait for before taking the decision

I: Which are his main crops out of all the things he grows, which are the most important?

R: Sorghum

I: And after that?

R: Maize

I: He has some animals so will he also sell some animals to pay back the money that he borrowed?

R: In his mind, he's waiting for the crops. He is foreseeing to get the money from the farm to pay back all his debts but in case the farm doesn't meet his expectations he could use the animals to come to his rescue

I: How many of the animals does he have?

R: 1 dog, 5 sheep, 3 goats, 2 pigs, 5 chickens

I: So which of these animals would he sell if he needs to sell an animal?

R: He can't say anything also, he will wait to see the gap of money that he might have and to see which animal he might sell to the meet the gap

I: So we talked about flooding in the house, has he experienced it in the farm as well?

R: The sorghum field and it had beans in it and when the flood happened, the flood only spoiled the beans, the sorghum survived

I: And when did this happen?

R: 2005

I: So he didn't lose too much then, was he able to cope?

R: He didn't lose much. That year they dealt with the crisis by doing jobs. He and his wife went to work in other farms to get the money

I: When they worked in the other farms, is it just at the harvest time and do they also have time to work in their farms?

T: first we have to know in which period did they go to look for work

I: Yes

R: It was just after facing this difficulty/damage in the sorghum field with the beans, the next year, it was during one agricultural campaign that they felt this so they waited for the following farming time to go to work with other farmers in their farms to get either money or fresh crops which they brought home to secure themselves to have enough to eat before going to their own farms

I: So how long will they work in the other farms?

R: One week

I: Do they have any other problems when there's flooding in the area, for example problems with transport or something like that?

R: Generally when there is heavy rains, these particular days are difficult for them. They don't go to farm because generally roads and the paths they use to go to the farm are not practical/impassable so they don't go to the farm just after the rain

I: Is it a big problem if they can't get to the farm?

R: It's a problem because as farming is their main activity, not going to the farm is like not going to work or your business

I: But will the crops suffer if you don't go the farm for one or two days?

R: Yes to not go to the farm for two days is a problem when there are weeds in the farm but when there is no activity [like no weeds growing] then it is not a problem

I: Is there anything they can do to get to their farms when there is flooding, is there a boat or something, do they make any changes?

R: No particular equipment

I: Can they swim?

R: [Joking and don't take question seriously]

I: Are there any other problems that they have with flooding?

R: They say that when there are a lot of rains mostly people are in the bas fonds or nearby the river, the people who have their farms very close to the rivers and they are not able to swim but enter the water, the water can sweep you away. So it's drowning/death that comes from a lack of water skills

R: Other things will be, his wife added that when there are a lot of rains, when there is a lot of rain and the rivers overflow, they experience Caymans, they leave the water and enter the farms because as the water is overflowing and due to their displacement, they spoil many things. Also hippos they also leave the water in the river and sometimes they attack people and they can get injured and even they can be killed.

T: It is the period that many people face being bitten by snakes because you are in the water, something can bite you so you won't know what it is. It could be snakes and they are full of venom

R: There are other things, diseases, like mosquitoes, cholera also which might happen, diseases like this.

I: What are the main problems they experience when there's a prolonged dry season?

R: When they have a prolonged dry season they know it will be very bad, very tough here. Starvation is knocking.

I: What other problems do they have?

R: Generally the first crops that you grow at the beginning of the dry season they die as they lack water [first crops after the initial rains]

I: What else do they have, apart from problems with their farms?

R: That sometimes they get also about the farm, they used to experience that some people could harvest two times but when there is a long dry season it is impossible for them to harvest two times. Normally the first harvest they get is very helpful to help them cope with maybe the shortage of the harvest from the previous year. Unfortunately you cannot harvest this [first time] and that makes you more vulnerable to shortage of food

I: So when would they normally, if the rains worked properly, when would they normally do the first harvest?

R: Currently, now. In May you grow it and in July/1st of August, as it is the maize of 2.5 months, if they start it in May they can have the first maize ready for eating in July

I: Have they always grown the maize of 70 days or is this a new thing?

R: They have been sowing it for a long time. They would sow the maize of 70 days. The difference between these that they used to grow and which of the agricultural extension

service brought them is just the difference of colour. The one the parents used to grow was yellow but the ones that they brought them now is white. Currently they are using the white more than the yellow.

I: And they get these from the agricultural service?

R: From CERPA

10.3 Coding scheme

The coding scheme shows the coding system for both the interviews and game with scenarios activity

INTERVIEWS				
CLIMATE CHANGE				172
	(Un)predictability			68
	2012 Season			51
	2013 Season			152
Resilience				367
Impacts				1644
	Loss of capital			13
RESPONSE				3
	General coping			938
		Temporary occupation		53
		Ration		5
		Change to sowing time		65
		Change to field area		14
	Anticipatory action			24
	Aid			81
		Neighbourly support		62
		Family support		19
	Loans			92
	Recovery incomplete			46
	General Adaptation			256
		Secondary occupation		35
		Migration		61
		Relocation		74
		Short cycle seeds		84
	Mal adaptation			20
	Non adaptation			67
	Inaction			143
MULTI-HAZARD				175
DROUGHT				228
	Politics			19
	Tools and tech			82
	Livelihood			1043
	Housing			17
	Health			87
		Animal health		116
	Education			30
	Roads and transport			9
	Access to water			298
	Access to fuel			7
	Happiness and social relations			75
FLOOD				247
	Politics			10
	Tools and tech			33
	Livelihood			1000
	Housing			731
	Health			109
		Animal health		36
	Roads and transport			152
	Education			36
	Happiness and social relations			53
	Access to fuel			19
	Access to water			4
CUSTOMS				73
INSTITUTIONS				284
Fertiliser				108
COTTON				171
	Would drop if could			10

	Cotton does not work well			7
ASSETS				7
	Savings			71
		Stock		67
		Livestock		167
		Cash		166
	Timing of sales			47
CRIME				21
DRY season farming				111
LAND AVAILABILITY				21
				12251
GAME and Scenarios				
	General Comments			87
	Rationalisation			2
	Adaptation/ Action			4
		Move in with others		4
		Migrate		5
		Loans		3
	Sale			0
		Yam/Sweet potato/early millet		44
		Rice		60
		Groundnut		22
		Cotton/Late millet		81
		Maize		34
		Sorghum		18
		Pig		30
		Sheep		16
		Goat		33
		Chicken		25
		Banking		2
	Purchase			0
		Yam/Sweet potato/early millet		28
		Rice		9
		Groundnut		12
		Cotton/Late millet		30
		Maize		22
		Sorghum		9
		Pig		37
		Sheep		21
		Goat		20
		Chicken		63
		Banking/ pocket money		37
	Reason			0
		Leftover money		25
		Preemptive sale		9
		Fits price		12
		Retry/missing		17
		Prefered crop		6
			Rice	2
			Maize	3
			Yams	3
			Sorghum	3
			Cotton	1
		Undesired crop		22
		Prefered animal		6
			Goat	1
			Chicken	3
			pig	6
		Undesired animal		21
			Goat	1
	Housing			22
		Concrete house		10
	sad			10

	laughter			71
	shocked			33
	resigned to fate			9

10.4 Interview Pro Forma Sample

Pro forma were used to aid the analysis of the interviews. The information from the interview transcripts were placed in the table besides the wellbing categories and separated into impacts and response actions. The pro forma also contains basic background information

Date:	Survey no:	Village:	Commune:	Country:	Time:
22.07.2013	2	Firihoun		Benin	

Name: REMOVED to ensure anonymity
Contact number:
Occupation: Farming and pig trade guide and Cigarette company helper

General information:

Crops (in order of importance): yams, maize, petit pois (Bambora beans), groundnuts, soya, gombo (legumes), beans and rice. Dry season: sweet potatoes
Animals: cows (1 female and 2 male), sheep, goats, donkeys (mostly used as transport), pigs, chickens, ducks, pigeons
Other sources of income not deemed good source of money, except for work for cigarette firm but this isn't regular, only ad hoc work. The pig trade work is just a small amount of money.

FLOODS

Experience: Yes in field in 2012 and 2011

FLOODS	Impact/Problem	Action
Livelihood (crops, livestock, business)	Damaged maize which doesn't like water, and beans. Lost all from maize (including beans) and yams also affected.	1) Dug some drainage channels in yams farm which removed the water but by the time it had done this it had already spoiled some yams. 2) Took a loan to get food to eat. Borrowed money from neighbours and friends. Other activities were insufficient to support him 3) Still repaying loan. Pays back partly in money but mostly in bags of crops. Thinks he can pay back debts this year based on progress so far (he is currently ploughing one farm) 4) Pigs suffered from peste and died so couldn't sell them 5) Will concentrate on farming, if had extra means, would put this into farming not starting another business
Access to water		Get water from river, 1km away [i.e. if pump broken]. Activity reserved for women. Would take more time i.e. leave house at 4am and

		return at 10(am) or leave at 6 or 8 and back at midday. Sometimes they sleep there. Would postpone work in yam field- such as transplanting seeds from one field to another or neglecting weeding. Sometimes he would also get involved in looking for water. Neglect looking for termites.
Access to fuel		
Housing	Room for fowls collapsed killing almost all (c. 60 which normally cost 2,000-2,500 each) (in 2012 "last year") only has 1 female and 2 chicks	Couldn't use animals to help in crisis so obliged to take loans of either money or crops. Needs 3 female and 2 male chickens to begin rebuilding chicken numbers. Chicken eggs cost 75CFA. To recover he would have to buy at least 60 eggs, probably around 80 given likelihood of losses. Will rebuild chicken house but with different shaped roof- more sloped. Will use aluminium instead of thatch.
Health	Floods cause health problems like coughs, mosquitoes, malaria and toe sores	
Education for children		
Roads and transport		

Practicing of religion and customs

Self-esteem and happiness

Machines and technical resources

Local politics

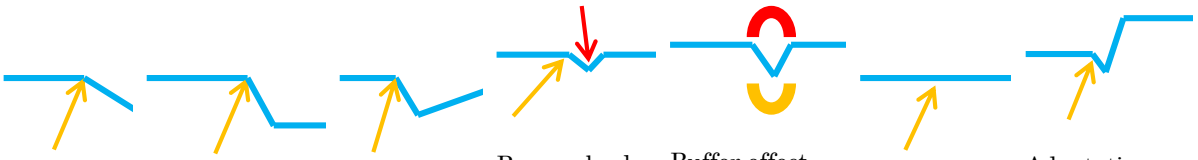
10.5 Interview Analysis Sample

As part of the interview analysis, the responses to the hazard impacts were categorised by the sub-categories developed in the analytical and conceptual framework. The following image shows a sample of this categorisation process for the Burkina Faso case studies.

Analysis

Burkina Faso, Flooding

Livelihoods



Perpetual decline	Set-back	Protracted recovery	Bounce-back	Buffer effect	Resistance	Adaptation
	Have second occupations that rely on normal activity (bicycle wear and tear) or farmers having extra money to spend more	Have to sell many or large proportion of animals	Receive aid from government/ action sociale (institutions) or family (often living elsewhere)	Postpone activities and work or temporarily have less custom until floods recede	Grew rice	Use short cycle crops
	sell their animals when prices are lower	Take loans/borro w money	Sold a few animals/sma ll proportion	Took small dispensation such as elevating their stored crops to prevent damage to previous harvest	Have secondary occupations that serve government employees such as copy shop	Plant early
	buy grains instead of contribute to other plans		Sold valuable crops to buy more of the cheaper crops		Grew pepper	Move their farms to elevated land, away from rivers
			Rationed food		Farm on elevated land	Dug drainage channels

10.6 Game Transcript Sample

Sorian Transcript

- This year the rainy season wasn't good, wasn't good at all because it didn't rain the whole of the season and weren't able to get a lot of crops
- To me the problem was it didn't start early. It started somewhere around the month of May and within September there was a break and the crops weren't able to stand that

Which crops were affected the most?

- Maize, the majority was maize. The maize was the most affected, then groundnuts and even the rice. He didn't get a lot.

Which survived the best?

- Only sorghum and millet were resilient because there we normally used to start cultivating them very early so whatever, how the rain behaved it would definitely stand it

And then the year before, did they have problems with flooding?

- Last year we didn't, 2012, we didn't experience any real problem. The harvest was good.
- Because the rainy season wasn't good this year we are experiencing a lot of problems of water. We are experiencing a lack of water. That is why the trees are not producing a lot. They didn't produce a lot, that is because there is a lack of water

But the well, does that have some water in it?

- There is a bit of water but it is at the bottom but it is not clean because when a well is starting to dry up, the water at the bottom turns dirty

Introduction to game

- We are all sleeping at the school!

Do they ever have it where they have so many floods and droughts as here?

- He is saying that even the last two years it happened, flooding several times

So now they have to rebuild their houses so they have somewhere to sleep.

- That for the moment, what he's going to do, he's going to build only 2 houses because he's not financially strong

Ok, so we try it this way

- He's going to build only two houses for the moment and then one for the people in the house, the other one for the animals. That is what he's going to do because he's not financially strong
- That he's going to sell some of the animals

For two houses he needs 20,000 so he could sell one pig or one goat

- He's going to sell this [sheep]

That's worth 30,000 so he would have 10,000 left. What does he want to use the 10,000 for? He could have 2 chickens or he could have 3 rooms?

- That he's going to buy … that he's in need of rice
- That he wants a sack of rice then he's going to sell one goat and two chickens plus the 10,000

And the other person, for his house?

- The main problem is building the houses and for that one, I think he's going to sell the cotton. He won't sell any animal, only the cotton to build the house

Ok, one sack of cotton is one room, so how many rooms?

- He said 4

Ok, so the whole house

- I was asking him whether in their house they are eating cotton or what? He said that they are now understanding the game

So maybe next time he will sell it. So we continue. So they get their extra animals. This one gets one pig and one chicken and this one gets one pig, one goat and one chicken. So now it's the harvest. So now they have the chance to buy things and sell things if they want.

- He's going to build two houses.

What about the sorghum? He doesn't have any, does he need it?

- He's going to sell cotton to buy sorghum. This [3 cotton] is for two sacks of sorghum.

What does he want?

- Sorghum

2 sorghum. The sweet potatoes. So we continue with the dry season. So he gets one more chicken and he has a pig and he also gets one more chicken and a pig.

- They are laughing that this is real life

So they have a chance to rebuild and buy things now

- We still get food, now we have to solve the problem of the house. I am going to sell the cotton and build my house. I finally sell the cotton and build my house but I will still have one sack of cotton

Continue

- This is bad, we don't have anything
- I'm going to sell some of my pigs

Yes, he has a lot of pigs!

- I don't have maize, I don't have sorghum, enough sorghum
- I'm going to sell two of the pigs
- I'm going to buy the maize

He can get two sacks of maize for two pigs and he still has 10,000 left

- 1 cotton

Ok, so are they happy now?

- No he's going to sell this to buy maize

So that's 50,000 so then he gets 3 maize and he has some left. He has 5,000 left so I can give him a chicken. So they happy?

- Yes

Now he gets one more chicken and he also gets one more chicken. So we continue to the rainy season.

- I asked them whether they won't buy anything

Yes if they want to buy something, or they can do it here as well.

- That he's going to sell 4 chickens for 2 cotton
- What do you want me to sell. We have to sell the chickens because they are many. He'd like to sell 3 chickens and buy a sack of maize

Ok, so are they ready?

- Yes
- There is no more, your maize is finished! What is this game!

So it's the harvest. Do they want to rebuild their houses now?

- We have to rebuild the houses
- The guy wanted to sell all of the cotton, the other said no, you shouldn't just sweep the thing like this. Something should be left in the silo.

This is 30,000, so he wants 3 rooms? Does he want to buy some maize? For some maize?

- For some maize

And the other one?

- 3 for maize

Ready to continue?

- Yes
- We have chickens and we have a problem of rooms [needing to be rebuilt]

What does he want? Houses. So then he just has 10,000 left

- 2 chickens
- For three houses, three rooms
- For three bags of maize
- They also have some small maize

Yes, so we continue to the dry season

So just their first impressions of the game, how did they find it with the floods and droughts happening so often?

- This your game is an interesting game. It creates the situation of real life. In real life we also do the same calculation thinking over what to do when there is this problem or when there is the other problem, how we are going to do, what are we going to sell, where are we going to sell it, how are we going to cope with the whole situation. This is real life. You're game is interesting.
- The game also talks about floods and droughts. Let me tell you that at times, there are years when we experience both floods and droughts the same year, the same time. What I'd like you to know is your game is interesting and we can easily spend some time on this!

10.7 Game analysis pro forma sample

The following sample shows the recording of the game's progress and the actions that the players took at each stage

Village	Country	Date	Player 1	Player 2	Group
Sorian	Burkina Faso	06.03.2014	Middle aged Male	Middle aged Male	Male

Round	May	June	July	Aug	Sep	Oct	SOLD	BOUGHT	Dec	Jan	Feb	Mars	BONUS	SOLD	BOUGHT
Card		F	F		F	D									
P1		6	3		5	3	1xSh, 1xGo, 2xCh	Ho (only 2 rooms), 1xR					1xPi, 1xCh		
P2		3	3		5	1	4xC	Ho					1xGo, 1xCh, 1xPi		
Card	D				D				Go						
P1	2				6		2xC. 3xC	Ho (remaining 2 rooms). 2xS	1				1xCh, 1xPi		
P2	4				3		3xC. 2xC	2xS. 1xSP	6				1xCh, 1xPi		
Card			D	F											
P1			2	4											
P2			2	2											
Card				D							Pi	Pi			
P1				6			2xPi	2xM, 1xC			4	3	1xCh	3xCh	1xM
P2				3			1xC, 2xPi	3xM, 1xCh			4	1	1xCh	4xCh	2xC

Card	D			F					Ch							
P1	3			6			1xC, 1xGo. 3xCh	Ho (3 rooms). 1xM	5							
P2	3			6			2xC. 3xCh	Ho (2 rooms). 1xM	1				1xCh			
Card					F					Ch		Pi				
P1					5		1xC. 2xGn	Ho (1 room). Ho (2 rooms), 2xCh		6		5				
P2					4		2xGn	Ho		3		1				

Key

P1	Player 1	R	Rice
P2	Player 2	S	Sorghum
F	Flood	SP	Sweet Potato
D	Drought	Ch	Chicken
‘2’	Number rolled on dice	Go	Goat
C	Cotton	Pi	Pig
Gn	Groundnut	Sh	Sheep

M	Maize	Ho	House Rooms

10.8 Scenario Transcript Sample

Sample of scenario activity from Kumbosigo (Ghana)

SCENARIOS

Scenario 1 drought at 30 days

So we'll do the scenarios. They know the crops [from the game]. If I had this on my farm and these crops, I planted them and they are now 30 days old and there is now a drought for two weeks, which of them will I lose?

- It depends
- Nothing happens to them. Sometimes a month, some of them [can survive].
- They will come back to their senses but in the afternoon they will sleep
- Early millet, one month old, early millet is affected because when they are stalks at this level.

Scenario 1 flood at 60 days

So I lose the early millet and I've got the rest. So then it continues, they grow and get to 60 days and it's maybe the middle of August and there's a flood, which ones will be damaged?

- If it over rains, they all die.
- When you get every one or two weeks. If they get every two or three days rain, everything's ok because they don't want too much water
- Moderate

So, if there's too much water, it rains every day, they all die, these will all die

Scenario 2 flood at 30 days

Ok, so we start again. So this time I planted these, they are all 30 days old and it's now the beginning of August and there's a flood, which will I lose?

- You planted them when? Because some of them will not be there, the early millet will not be there

So that's already harvested

- August it's guinea corn, beans, groundnuts and rice

And the maize?

- We have it but they don't want too much water
- So the early maturing ones, those who plant those ones, by August they have harvested

So we say that these are the late maturing ones

- At times you allow the corn to dry on the field because you don't have places to keep them. That means that August/September, they will start plucking them but they have matured July, August ending
- So the maize, too they will be out

So from what I have left, if they are only 30 days old, which ones will I lose?

- These will not be 30 days in August

Let's say the beginning of August because I had to plant late.

- Only the rice will survive and the rest will go

Scenario 2 drought at 60 days

If I have the rice and then it gets to 60 days and we are now in September and there is a break in the rains for two weeks, will the rice survive?

- It depends, those that are in the valley will survive but those in the upland will not be alright.
- The farming is like lotto, a game of chance. Someone can plant early and fear and someone can plant late and get. So when it gets to that stage, you will divide your farm in two. You will plant here early and [here late]
- But chief is also saying that it's possible that they will survive because even last year the rains didn't come for a long time, some still got some bags
- No, what he's saying, me, I used to get about 9 bags in that field.

So last year was a bad year, they didn't get much, so what can people do to get through to the next year? What strategies?

- Like chief was saying, we are now in the modern world, if you are not lazy, you won't get the better food but to eat, you can manage because there are some jobs we have outside. You can contract. But in those days [in the past] there was nothing like that.
- Even if you don't grow, food will come from other places cause they have brought food from so if you go to the market, you will [get food]. The problem now is to get money to buy so what they do are these menial jobs, go build
- You will be able to eat feed your family. If you just want to survive, these days it is easy to survive. Only if you look proud, if you say you will not partake… those boys, the youth they have started to look for something
- The woman is passing some information that tomorrow there will be some contract work and that they should avail themselves
- There's money, there's money everywhere, only [not] if you look proud.

So in the game we put some prices on the bags of crops but they are really rough. So the maize, a bag of maize

- Bag of rice
- 1 million [old cedi]

- Let's come to the millet. The late millet is 100 cedi.
- Guinea corn, 100

Maize?

- 200, 2 cedis x40, it will be 80, 80 cedis
- 600 [rice] the one with the shells, he sold it 600 but the ones that are shelled will be more. 40 x 3 cedi, 120.

The next question is, out of all of the different crops, which would they say is most resistant to floods and droughts?

- I think the rice, the late millet and the guinea corn, they can withstand these two

Which animals suffer the least diseases

- I don't know whether because of the climate change, those days we didn't have these epidemics, about animals dying like that. Of late, these robbers [type of parasite/disease] [are a problem], when they eat it, they choke on it. You see some very nice animal walking and then someone buys it because the robbers are in the stomach and then the pneumonia, early in November, when the weather is setting in, you have pneumonia
- Now which of the animals die often
- All the [brown/ground?] ones
- Sheep and goats, the cows are better
- It's between goats and sheep
- Diarrhea and pneumonia, that's for the goats and sheep
- And the swine fever, for the pigs, those days [in the past] it was around here but now it is coming. It can wipe out entire fleets [herds], when it enters it defeats everything, there is no mercy from it

In the game we didn't have any cows but are cows something that most people own, do some people have cows or just a few?

- The cows are there [they have them]
- The houses that don't have cows, are mostly few
- Customs and our traditions, they use the cattle to pay dowries so at least every house has to have two or three or five. It is a family thing, everyone has to have [them]

If I was to build a house like this one here with an aluminium roof like this one and I was to pay a mason.

- You have to look for labour
- Or you mean the mud or cement? The traditional one?

Yes, the traditional one

- 1500

- When you start building, you will need labourers to help you and they will charge you by day. Then you come to the mason and the mason will come and charge and plaster. Then the carpenter will come, who is the worst [most expensive] now.
- Ok, 2500 and the wood, 1500, the ordinary, the mud.
- So roughly 1500
- Then the transport, so at least 1500, you can manage with 1500.

Translators' comments: they would rather sell animals than food but not if they only have a few animals.

10.9 Scenario Results

The following depicts the results from the scenario activity carried out in each village. An 'R' indicates where replanting was deemed possible.

	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early Millet	Late Millet	Village
Drought										Gnikpierre
Flood										Gnikpierre
Flood										Gnikpierre
Drought										Gnikpierre
	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early Millet	Late Millet	Village
Drought			R							Pontieba
Flood										Pontieba
Flood										Pontieba
Drought										Pontieba
End of season										Pontieba
	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early Millet	Late Millet	Village
Drought			R							Sorian
Flood			R lost	R lost						Sorian
Flood										Sorian
Drought										Sorian
	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early Millet	Late Millet	Village

Drought										Mebar
Flood										Mebar
Flood		R								Mebar
Drought										Mebar
End of season										Mebar
	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early Millet	Late Millet	Village
Drought										Dano Pare
Flood										Dano Pare
Flood										Dano Pare
Drought										Dano Pare
	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early Millet	Late Millet	Village
Drought										Kourri
Flood										Kourri
Flood										Kourri
Drought										Kourri
	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early Millet	Late Millet	Village
Drought		R	R			R				Loffing
Flood										Loffing
Flood										Loffing
Drought										Loffing
	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet	Yams	Early Millet	Late Millet	

						Potato				
Drought		R	R							Dababou
Flood										Dababou
Flood										Dababou
Drought		R Lost	R lost							Dababou
End of season										Dababou
	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early Millet	Late Millet	Village
Drought		R	R	R Ok lowland						Tetonga
Flood										Tetonga
Flood										Tetonga
Drought										Tetonga
End of season										Tetonga
	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early Millet	Late Millet	Village
Drought	R	R	R							Setiendiga
Flood	R ok		R ok							Setiendiga
Flood							or L			Setiendiga
Drought										Setiendiga
End of season										Setiendiga
	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early Millet	Late Millet	Village
Drought			Ok if high land							Firihoun

Flood										Firihoun
Flood										Firihoun
Drought										Firihoun
End of season		?								Firihoun
	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early Millet	Late Millet	Village
Drought		R	R							Porga
Flood										Porga
Flood										Porga
Drought										Porga
	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early millet	Late Millet	
Dought										Sumbrungo
Flood										Sumbrungo
Flood										Sumbrungo
Drought										Sumbrungo
End of season										Sumbrungo
	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early Millet	Late Millet	Village
Dought										Yorugo
Flood										Yorugo
Flood										Yorugo
Drought		Or N/A		LS if 3 weeks						Yorugo

	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early Millet	Late Millet	Village
Dought										Kumbosigo
Flood										Kumbosigo
Flood										Kumbosigo
Drought				L if high land						Kumbosigo
	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early Millet	Late Millet	Village
Dought				Ok in lowland						Kalbeo
Flood								harvested		Kalbeo
Flood										Kalbeo
Drought								harvested		Kalbeo
End of season										Kalbeo
	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early Millet	Late Millet	Village
Dought										Yikene
Flood								harvested		Yikene
Flood										Yikene
Drought										Yikene
End of season										Yikene
	Cotton	Groundnut	Maize	Rice	Sorghum	Sweet Potato	Yams	Early Millet	Late Millet	Village

Dough t										Gambigb o
Flood										Gambigb o
Flood		?						?		Gambigb o
Droug ht		?						?		Gambigb o
End of seaso n		?						?		Gambigb o