Vulnerability and Adaptation to Climate Change in the Semi-Arid Regions of West Africa

CARIAA
Collaborative Adaptation Research Initiative in Africa and Asia

ASSAR
Adaptation at Scale in Semi-Arid Regions

About ASSAR Working Papers

This series is based on work funded by Canada's International Development Research Centre (IDRC) and the UK's Department for International Development (DFID) through the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA). CARIAA aims to build the resilience of vulnerable populations and their livelihoods in three climate change hot spots in Africa and Asia. The program supports collaborative research to inform adaptation policy and practice.

Titles in this series are intended to share initial findings and lessons from research and background studies commissioned by the program. Papers are intended to foster exchange and dialogue within science and policy circles concerned with climate change adaptation in vulnerability hotspots. As an interim output of the CARIAA program, they have not undergone an external review process. Opinions stated are those of the author(s) and do not necessarily reflect the policies or opinions of IDRC, DFID, or partners. Feedback is welcomed as a means to strengthen these works: some may later be revised for peer-reviewed publication.

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Vulnerability and Adaptation to Climate Change in Semi-Arid Areas in West Africa

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List of Acronyms

AEDD	L'Agence de l'environnement et du développement
ASSAR	Adaptation at Scale in Semi-Arid Regions
CARIAA	Collaborative Adaptation Research Initiative in Africa and Asia
CBO	Community-based organization
CCAFS	Climate Change, Agriculture and Food Security
CCLM	Climate Change and Land Management
CDKN	Climate and Development Knowledge Network
CEDAW	Convention on the Elimination of All Forms of Discrimination Against Women
CENSUDI	Centre for Sustainable Development Initiative
CGIAR	Consultative Group on International Agricultural Research
CIC	Community Information Centres
CLURCC	Community Land Use Responses to Climate Change
CMIP	Coupled Model Intercomparison Project
COF	Climate Outlook Forum
CORDEX	Coordinated Regional Downscaling Experiment
CPI	Corruption Perceptions Index
CRP	Collaborative Research Programme
CRU	Climate Research Unit of the University of East Anglia
CSCRP	Cadre stratégique pour la croissance et la réduction de la pauvreté
DANIDA	Danish International Development Agency
DFID	Department for International Development
DRR	Disaster risk reduction
EAP	Environmental Action Plan
EPA	Environmental Protection Agency
FAO	UN Food and Agriculture Organization
FBO	Farmer-based organization
GACCES	Gender Action on Climate Change for Equality and Sustainability
GCF	Green Climate Fund
GCM	Global Climate Model
GEF	Global Environment Facility
GGF	Ghana Green Fund
GHG	Greenhouse gas
GIDA	Ghana Irrigation Development Authority
Gmet	Ghana Meteorological Office
GSGDA	Ghana Shared Growth and Development Agency
ICRISAT	International Centre for Research in the Semi-Arid Tropics
IDE	International Development Enterprises
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change

ITN	Insecticide treated net
LAP	Libya Africa Investment Portfolio
LDC	Least Developed Country
LGP	Length of growing period
MEST	Ministry of Environment, Science and Technology
MOFA	Ministry of Food and Agriculture
MOWAC	Ministries of Women and Children's Affairs
NADMO	National Disaster Management Organization
NAP	National Adaptation Plan
NAPA	National Adaptation Programme of Action
NAPCC	National Policy for Adaptation to Climate Change
NCCAS	National Climate Change Adaptation Strategy
NCCP	National Climate Change Policy
NDA	National Designated Authority
NDPC	National Development Planning Commission
RCM	Regional Climate Model
RCP	Representative Concentration Pathways
REDD	Reduction in Emission through Degradation and Deforestation
RRP	Regional Research Program
SGI	Shallow groundwater irrigation
SREX	Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation
START	Global Change System for Analysis, Research and Training
TCPD	Town and Country Planning Department
UEMOA	Communauté économique des États de l'Afrique de l'Ouest
UNDAF	United Nations Development Assistance Framework
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
WBS	Wa-Bobo-Sikasso
WRC	Water Resources Commission of Ghana
WVBB	White Volta Basin Board

CHAPTER 1

Introducing the Regional Diagnostic Studies Report

Introducing the Regional Diagnostic Study

1.1 The ASSAR project in West Africa

This report, which encompasses the findings of a Regional Diagnostic Study (RDS) for West Africa, was undertaken in 2014-15 to advance understanding of climate change in semi-arid regions of Africa and Asia. The RDS represents the first phase of a research effort under the *Adaptation at Scale in Semi-Arid Regions* (ASSAR) project. ASSAR is one of four consortia generating new knowledge of climate change hotspots under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA[1]). The ASSAR project operates in Western, Eastern and Southern Africa and Western India. The ASSAR focal countries in Africa are Ghana, Mali, Ethiopia, Kenya, Botswana, and Namibia, and in India the focal states are Tamil Nadu, Maharashtra, and Karnataka.

The project spans a five-year period from 2014-2018, and has a three-phase research program: a regional diagnostic phase, a regional research program phase, and a synthesis phase. ASSAR aims to generate new stakeholder-driven knowledge on vulnerability and adaptation to climate change in semi-arid regions, develop innovative communication approaches for effective knowledge sharing on climate change vulnerability and adaptation, and stengthen capacity for adaptation in research, policy and practice domains.

The RDS for West Africa was undertaken through a partnership between START, the Institute for Environment and Sanitation Studies at the University of Ghana, and the International Centre for Research in the Semi-Arid Tropics (ICRISAT) in Bamako, Mali. This RDS aims to develop a systematic understanding of existing knowledge of climate change trends, impacts, vulnerabilities, and adaptation strategies, as well as to identify important barriers to and enablers of effective adaptation in semi-arid regions. Secondly, the RDS serves to identify gaps in research, policy and practice related to climate change adaptation.

The RDS provides a foundation for developing an integrated regional research program (RRP) on climate change vulnerability and adaptation centered around advancing knowledge on socio-economic and biophysical systems, governance and institutions, gender, and wellbeing. The RDS thus provides a broad regional-scale context into which the RRP can be designed to focus on achieving deeper understanding of the multi-faceted nature of vulnerability, adaptation enablers and adaptation barriers.

There are multiple target audiences for the findings generated through this RDS. They include academics and researchers, stakeholders from government, civil society, and the international donor community. The findings of this report will be used to inform a communication strategy that will allow for broader dissemination of key findings from thisRDS.

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1 http://www.idrc.ca/EN/Programs/Agriculture_and_the_Environment/CARIAA/Pages/default.aspx

This RDS report represents the initial step in ASSAR West Africa's efforts to understand and unpack the complexities of vulnerability and adaptation within a dynamic development context that includes population and demographic change, urbanization, land-use change, and advancing communication technologies. The approach taken by the West Africa team in developing the RDS will allow for information produced through the RDS to set the stage for in-depth research to begin in mid-2015. Specifically, this is accomplished through:

- Description of the major socio-economic, governmental and environmental characteristics as they relate to the region's extensive dryland[2] areas (Chapter 2).
- Regional analysis for climate trends and projections that provide key messages about climate change (Chapter 3).
- Exploration of how important development dynamics in the region interact with climate variability and change to amplify vulnerabilities (Chapters 2 and 4).
- Examination of gender and governance dimensions of vulnerability and adaptation (Chapter 5).
- Elaboration of how current risk management practices in agriculture link to climate change adaptation (Chapter 5).
- Synthesizing of important barriers and enablers of adaptation and key knowledge gaps and needs (Chapter 5).

Gender and governance are prominent themes that cut across Chapters 4 and 5. In compiling this report, it was difficult to draw clear lines delineating content for each of these topics that would fit cleanly into vulnerability and adaptation spheres. Thus vulnerability and adaptation dimensions of gender are combined into a single sub-section within Chapter 5, and aspects of governance described in Chapter 5 partially reiterate issues raised in Chapter 4 but with a deeper analysis.

The ASSAR project in West Africa focuses on the dry sub-humid band that extends from the Upper West Region of northern Ghana through southern Mali, referred to as the Wa-Bobo-Sikasso (WBS) transect. This transect features diverse socio-economic conditions set against fairly homogenous biophysical conditions. The region experiences high exposure to dry spells, and has medium-high to high drought risk and strong multi-decadal fluctuations in climate. The region is also experiencing significant land degradation and processes that can lead to desertification. This region is characterized by very high rates of poverty, comparable to those of the Sahel (as described in Chapter 2). The selection of this transect allows the ASSAR project

[2] Drylands span regions classified climatically as hyper-arid, semi-arid and dry sub-humid. The FAO has defined drylands as those areas with a length of growing period (LGP) of 1–179 days.

to link directly with the CCAFS project within the Dryland Systems Collaborative Research Programme (CRP) of the CGIAR, also described in Chapter 2.

1.2 Regional Diagnostic Study methods

The RDS was carried out through an extensive literature review, which was augmented with focus group discussions, key informant interviews, and national expert meetings to gain greater insight on issues that emerged from the literature.

1.2.1 Literature review

The literature review was comprised of academic journal articles covering the region and grey literature, which focused on northern Ghana and Mali. The academic literature search was carried out using the RDS methodology shared across the ASSAR consortium. It consisted of relevant literature (peer reviewed articles and book chapters) published between 2005 and 2014, though earlier references were reviewed as needed. The search was carried out in ScienceDirect, EbscoHost, and general university library search capabilities (with access through Stanford and Pennsylvania State University libraries in the US). The grey literature included policy documents, plans and strategies, project reports and evaluation reports, case study analyses, position papers, and websites from Ghana and Mali.

The team reviewed academic literature from across dryland West Africa that included studies from Senegal, Burkina Faso, Mali, Niger, northern Nigeria, and northern Ghana. However, most of the literature reviewed in the adaptation section of the RDS report (Chapter 5) focused on Mali and northern Ghana, which is where the subsequent field research for the ASSAR West Africa project will take place.

The literature review centered around climate change, though in addition to that focus the team reviewed literature that was relevant to but not explicitly about climate change. Such relevant issues included soil and water conservation in agriculture, changes in pastoralism, land degradation drivers and regeneration efforts, migration, land tenure and land grabbing, gender and governance. This broader scoping of the literature helped in framing the development landscape to better understand issues around enabling and constraining factors that influence the potential for sustained adaptation.

Search terms used specific to climate change included: “climate change” and/or “adaptation” and West Africa” or “semi-arid regions” or “sahel”. Similarly, : “climate change” and/or “adaptation” and “Ghana”/ “northern Ghana” or “Mali” or “Burkina Faso” or “Niger” or “Senegal”. The country and regional layers were also applied to issues of “soil and water conservation”, “pastoralism”, “land degradation”, “migration”, “land tenure” “land grabbing”, “biofuels”, “gender” and “governance”.

Upon completion of the general literature search and in recognition of the importance of the emerging urban theme, the team did a limited search on the urban migration issue through:

- “urban and West Africa” or “semi-arid” or “sahel” or “Mali” or “Burkina Faso” or “Niger” or “Senegal”
- “urban and water and West Africa”, “urban and migration and West Africa”

The team focused on urban issues generally rather than specific to climate change impacts, vulnerabilities, or responses/adaptations, given the complexity and rapid change of urban systems and stressors. However, there were very few articles in the West Africa region, the exception being Accra, Lagos, Kano, and Ouagadougou. Lagos was not considered while Accra was read more generally for issues of rural-urban migration; the Kano and Ouagadougou resourcew were specific to peri-urban land-use change and to urban agriculture. In fact, there were several articles on urban agriculture but none of sufficient relevance for the RDS. We also gave attention to rural-urban migration and water resources, although water resources and urban areas articles were particularly limited. In the end, we concluded that there was not a critical mass of articles on urban issues in dryland West Africa or in links between dryland and coastal cities to allow for analysis in the RDS.

1.2.2 Stakeholder engagement

In Ghana and Mali, three levels of stakeholder engagement (a national expert meeting, focus group discussions at the district level, and key informant interviews) were carried out to corroborate and further define important national and regional adaptation and climate related issues that were identified in the academic and grey literature. The purpose for the stakeholder engagement at the district level was to probe how people at that level understood and were responding to climate change and to explore the extent to which information from the national level was feeding into actions on the ground. The purpose of the national workshop was to better understand the scale of adaptation planning in Ghana and key factors that support/enable the implementation of plans. This stakeholder engagement fieldwork was a preliminary, representative scoping of the decision space not a comprehensive attempt to understand it. In addition, this fieldwork was intended to elaborate on issues that could inform planning of the regional research program.

The general questions that guided the stakeholder engagement events were:

1. Is policy and planning around adaptation to climate change currently being implemented in this district? If yes, discuss since when and how is it implemented and what are the general challenges?
2. If not, did the members of the group hear about any adaptation policy at the national level? What do they know about it? Where do they get their information about what is happening at the national level on adaptation?
3. How is policy/planning taken into account in sectors like agriculture, food security, access to water, health and livelihood security?
4. In what sectors (e.g. health, water, and agriculture) is adaptation planning strongest/weakest?

5. What is driving the climate and climate change planning (at what scale)? Is it top-down directives from the national level? Is it originating from within the region's government? Who are key actors in that regard?
6. Are the plans being implemented or are they just plans on paper? Who is implementing them? At what scale?
7. What factors support/enable the implementation of plans?
8. What are barriers to the implementation of plans?
9. Is there a gender dimension to the development and implementation of climate and climate change plans?
10. Does the inclusion of climate planning add or take away from gender, or have no effect on gender considerations, in conventional (i.e., pre-climate change adaptation) sector planning?

The questions were intended to guide the discussions and not be fully answered in sequence.

1.2.2.1 Ghana:

National expert meeting: A group of 30 participants from national level institutions and sectors, including ministries, local government and non-governmental authorities, humanitarian organizations and the private sector, were brought together in an informal and participatory one-day workshop. The workshop was held in Accra, Ghana in March 2015. Institutional experience and expertise was described on how adaptation planning is carried out at the national level and how institutions are represented in this process; the strengths, weaknesses, opportunities and threats that exist in the planning and implementation of adaptation policies at the national level and how this impacts on the district level; as well as the strengths, weaknesses opportunities and threats that exist for integrating gender dimensions into development and implementation strategies.

Focus group discussions: In three districts (Lawra, Nandom and Jirapa) in the Upper West Region, which comprise the Ghana portion of the the Wa-Bobo-Sikasso (WBS) trans-boundary transect, focused discussions were carried out with a group of an average of 20 people. The selected participants were members of the Climate Change, Agriculture and Food Security (CCAFS) science-policy platforms and composed of traditional authorities, leaders of farmers groups, women groups, NGOs, and representative heads of decentralized government departments. The group was sub-divided to gain additional perspectives of the gender dimensions of climate change vulnerabilities and impacts, adaptation planning and implementation at the district level.

1.2.2.2 Mali:

National expert meeting: This event was held in March 2015 in Bamako with national policy and decision makers to cross-check the local insights and to come up with additional insights on issues left uncovered at the local scale.

Focus group discussions: In Mali, a series of three focus group discussions were held with stakeholders in the district of Koutiala in the Department of Sikasso in southern Mali, which represents the most northwestern part of the Wa-Bobo-Sikasso (WBS) trans-boundary transect. Participants included representatives of different farmers groups, herder groups, women's associations, and representatives of extension services and NGOs.

CHAPTER 2

Regional to sub-national context in West Africa

Regional overview

2.1 Major socio-economic, governmental and environmental characteristics

This section provides an overview of demographic and economic facts and trends in West Africa in general, and Ghana and Mali in particular, and provides country data snapshots on these two countries. The section then examines the development dynamics in the semi-arid and dry sub-humid areas that comprise a significant portion of the West African drylands.

2.1.1 Population and demography

The West Africa region spans humid, sub-humid, semi-arid and arid climate regimes. It is currently home to over 340 million people, and constitutes 39% of sub-Saharan Africa's population (PRB 2014). The regional population is expected to exceed 400 million by 2020 and 500 million between 2030 and 2035. The fertility rate in West Africa is 5.4, with a rate of natural increase of 2.7% (Ibid). The current population growth rate in the region is 2.6% but is expected to fall below 2% between 2020 and 2025. Demograpically, the population is young, with 60% of West Africans being less than 25 years of age and 70% under the age of 30 (OECD 2007). Based on projections to 2050, Ghana's population will increase by 56% compared with current levels and Mali's population is projected to increase by 117% (Table 1). West Africa currently has a significant urban population (currently at 45%), which, consistent with the forecasts for the rest of sub-Saharan Africa, is on the rise.

While French and English, and to a lesser extent Portuguese, are widely spoken in West Africa, the region is trite with ethnic diversity, which lends itself to a substantial number of indigenous languages. There are about 30 languages spoken in the region by more than 1 million people about 1,200 languages spoken by a lesser number of people. Major languages include Hausa (more than 30 million speakers), Yoruba, Fulfulde, Igbo (more than 20 million speakers each), Mandingo, Akan, Gbe, Moore and Kanuri (from 10 to 5 million speakers) dominate the West African linguistic landscape (see Piccolino and Minou 2014).

Table 1: Ghana and Mali population trends

Ghana	
2014 population	26.1 mil
2050 estimate	46.0 mil
Natural increase	2.4 %
2015 population as a multiple of 2013	1.8

Source: Population Reference Bureau (PRB) 2014

Mali	
2013 population	15.5 mil
2050 estimate	37.2 mil
Natural increase	3.1 %
2015 population as a multiple of 2013	2.4

Source: Population Reference Bureau (PRB) 2014

2.1.2 Economic development and growth

It is difficult to speak in general terms about macroeconomic performance in West Africa in light of the significant socio-economic and geo-political variance among the countries in the region. Yet, there are notable trends in the region, both in terms of economic growth and progress in the achievement of the millennium development goals (MDGs).

With a projected economic growth rate of 7.4 % in 2014, West Africa is the fastest growing region in the continent. The region is undergoing regional and global integration - 15 of the 16 countries in West Africa (minus Mauritania) are members of the Economic Community of West African States (ECOWAS), a regional economic group in the region. The bulk of West Africa's population resides in rural areas and their livelihoods are still largely dependent on agriculture. Agriculture accounts for about 30% of regional GDP. Another distinctive feature of West Africa is its long coastline of approximately 15,000km (Only four countries in West Africa are landlocked), which supports coast/marine-based livelihoods (see Madzwamuse 2010).

In Ghana, the economy is expected to maintain strong growth in the next few years as a result of oil and gas production, improved infrastructure, private-sector investment and political stability. Ghana has made substantial progress in meeting the MDGs, as targets for the reduction of extreme poverty and access to safe drinking water have been achieved, while targets on hunger, education and gender are on track. Still, the country has not met its MDG targets related to maternal and infant mortality, sanitation and employment, and much of these challenges are in the dry northern region. The 2014 UNDP Human Development Report ranked Ghana 138 out of 187 countries (see UNDP 2014).

In Mali, the economy grew by 5% in 2013 (after the economic recession triggered by the political crisis of 2012) and the trend is expected to continue in the next few years. The Government has worked with the international community to ease the humanitarian crisis; still, the poverty rate has risen to 42.7% in 2012 from 41.7% in 2011. The 2014 UNDP Human Development Report ranked Mali 176 out of 187 countries (see UNDP 2014).

Tables 2 and 3 provide country profiles of Ghana and Mali, respectively.

Table 2: Ghana country profile

Government	Ghana has a unitary system of government. Power is formally shared among the Executive, Parliament and the Judiciary. The country has been undergoing a substantial decentralization process (Ayee and Dickovick 2010).
Population	Ghana has more than 26 mil people with predominantly rural population - about 56% of the people live in rural areas (PRB, 2013). The country is urbanizing rapidly. The most densely populated parts of the country are the coastal areas, the Ashanti region, and the two principal cities, Accra and Kumasi.
Literacy Rate	71.5% of the total population, Male: 78.3% Female: 65.3%
Land area	238,535 km2 or 92,099 sq mi
Administrative divisions	Ghana is divided into 10 administrative regions: Northern, Eastern, Western, Central, Upper East, Upper West, Volta, Ashanti, Brong-Ahafo and Greater Accra.
Economic development	Ghana's economy has maintained average annual growth of about 6.0%. In the next few years, the economy is expected to grow by about 8%, due to improved oil/gas production, private-sector investment, infrastructure and political stability
Ethnic composition	Ghana is ethnically heterogeneous (75 ethnic groups): Akan 47.5%, Mole-Dagbon 16.6%, Ewe 13.9%, Ga-Dangme 7.4%, Gurma 5.7%, Guan 3.7%, Grusi 2.5%, Mande-Busanga 1.1%, other 1.6%
Religions	Christian 71.2% Muslim 17.6%, traditional 5.2%, other 0.8%, none 5.2%
Languages	Asante 14.8%, Ewe 12.7%, Fante 9.9%, Boron (Brong) 4.6%, Dagomba 4.3%, Dangme 4.3%, Dagarte (Dagaba) 3.7%, Akyem 3.4%, Ga 3.4%, Akuapem 2.9%, other (includes English (official)) 36.1%

Sources:

Ghana embassy US, public information http://www.Ghanaembassy.org/index.php?page=population

Ghana_ECOWAS country profile: http://www.ecowas.int/member-states/Ghana/

Africa Economic Outlook – 2014: Ghana

Table 3: Mali country profile

Government	Mali has a tripartite system of government consisting of executive, judicial and legislative branches, with check and balances under its constitution. However, the country has undergone a number of coups, including one in 2012. The country has gone through phases of decentralization (Wing and Kassibo 2010).
Population	The population size in Mali is 15.5 million; predominantly rural (68% in 2002). 5–10% of the population are nomadic. Major cities in Mali include Bamako, Kayes, Koulikoro, Sikasso, Segou, Mopti, Gao, Timbuktu and Kidal
Literacy Rate	33.4% of total population. 43.1% male, 24.6% female.
Land area	1,240,192 km2 or 478,839 sq mi
Administrative divisions	Mali is divided into 8 regions and the district of Bamako, each under the authority of an appointed governor. Each region consists of five to nine districts, which are divided into communes, which, in turn, are divided into villages.
Economic development	The economy returned to growth (5%) in 2013 after the economic recession triggered by the complicated political crisis of 2012.
Ethnic composition	Mande 50% (Bambara, Malinke, Soninke), Fula 17%, Voltaic 12%, Songhai 6%, Tuareg and Moor 10%, other 5%.
Religion	Islam (90%), Christianity (1%), Other (9%)
Languages	Mali is multilingual. Official language is French. Other national languages include Bambara, Bomu, Tieyaxo Bozo, Toro So Dogon, Maasina Fulfulde, Hasanya Arabic, Mamara Senoufo, Kita Maninkakan, Soninke, Koyraboro Senni Songhay, Syenara Senoufo, Tamasheq, Xaasongaxango

Sources:

Mali Country Profile: Library of Congress http://lcweb2.loc.gov/frd/cs/profiles/Mali.pdf

Africa Economic Outlook – 2014: Mali

Republic of Mali, US embassy Mali Fact sheet http://www.maliembassy.us/index.php/about-Mali/government-a-politics

2.1.3 Development dynamics in dryland West Africa

Development challenges in the West African drylands have traditionally been analyzed through the prism of biophysical constraints in the wake of the "environmental urgency" that arose from the Sahelian drought, the world's strongest desiccation event on meteorological record (Batterbury & Warren, 2001). The late 1970s to early 1990s Sahel drought was the most spectacular of the contemporary droughts, which resulted in the death of over 100,000 people, displacement of nearly three-quarters of a million people and triggering of widespread famine. Understanding of the causes of the late 20th Century Sahelian drought has shifted from a focus on land degradation as the main causal factor to a combination of factors that include changes in sea surface temperatures (Zhang and Delworth, 2006) and an increase in aerosal loading in the northern hemisphere that may trigger shifts in the tropical rainfall belt (Hwang et al., 2013). As a whole, the West Africa region has recovered from the late 20th century drought, as evident by sharp decline in the percentage of the region's aggregate population that is undernourished, between the early 1990s and the beginning of the second decade of the 21st century (FAO, 2014); however, areas of the Sahel remain highly food insecure.

West Africa's dryland region has been long and misleadingly labelled as "the Sahel", perpetuating the image of a relatively homogeneous entity, in terms of climate, agro-systems, and socio-economic status. In reality, the region hosts an enormous variety of biophysical environments (Vlek, 1995) intertwined with highly contrasted socio-economic, demographic and land use conditions (Raynaut, 2001).

The latitudinal climatic gradient for West Africa (Figure 1a), features a complex spatial arrangement with respect to population (Figure 1b) with the longitudinal juxtaposition of a more sparsely occupied Western half and a more densely populated Eastern half. Across the region, land and water per capita ratios inversely correlate with market access such that the drier Eastern half has greater market integration than the wetter Western half, offering contrasting rural development trajectories. Figure 2 depicts this situation and points to where there are expections to this general rule (i.e. high population density and market integration in Senegal and the Mossi Plateau of Burkina Faso in the Western half, and within the eastern half, low population density and market integretion in Kebbi and Niger States in northern Nigeria and in Chad.)

One dominant assumption about the region is that poverty and vulnerability have a strong latitudinal north-south (dry-wet) gradient. However, the reality in the West African drylands is that the spatial distribution of poverty is not intrinsically linked to latitude. Correlation analysis of poverty, population density and rainfall carried out by Traoré et al. (2013) indicated that poverty rates are somewhat independent from the latitudinally distributed aridity index and to some extent from population density as well. High poverty was observed in high aridity (Zinder region, Niger), and low aridity (Kwara State, Nigeria) areas and in high density (Northern Nigeria) and low density (Northern Benin) areas (Figures 1a-c). Similarly, relatively lower poverty was present in high density (Senegal) and low density (South West Burkina Faso), and in high aridity (Mauritania), and low aridity (Niger State, Nigeria). Based on best available data, therefore, it is no more justifiable to stratify poverty levels with the aridity index than with population density, to predict how to target vulnerability reduction and sustainable intensification efforts in the West African drylands.

From the Niger-Nigeria trans-boundary area, the largest urban conurbation of the dryland tropics (Kano and its satellites) has experienced Boserupian intensification[3] of agricultural land use southwards (e.g. Plateau State: Stone, 1992) and today provides invaluable examples of what other areas of the region may experience tomorrow. However, before increasing population densities can result in sustainable, intensive farming systems (Harris, 1996), critical thresholds must be crossed. The relatively stunted Western half of the region now features in this transition stage where land scarcity in the Sahel ecotone, historically most hospitable, results in migratory spillovers towards the dry sub-humid Sudanian and Guinean agro-ecologies with the worrisome prospect of a 'sealing-off' of North-South and South-North natural resource flows, including surface waters and livestock transhumance.

ASSAR's target domain is the dry sub-humid region. This domain faces the collusion of two significant development obstacles: constrained access to water resources with a very strong, almost exclusively mono-modal seasonality (bio-physical constraint); and constrained access to international markets with the large dominance of landlocked conditions, for both the majority of 'Sahelian' countries and the dry hinterland areas of coastal countries (socio-economic constraint).

Capturing these transient conditions may offer, particularly with the advent of modern information technologies, the opportunity to bypass some traditional intensification bottlenecks such as abusive mining of the resource base, systemic nutritional deficiencies (from soils to humans), ineffective governance and lack of citizen engagement and equitable control over resources. In that regard, another peculiar asset of West Africa is the co-existence of contrasted agricultural legacies from multiple historical forms of organized state, the latest (and not the least) being the trans-boundary governance systems inherited from the British and French colonial rules and resulting in a mosaic of socio-ecological conditions, consumer preferences, and place-based development pathways (see e.g. OECD, 2006).

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[3] Boserupian intensification refers to the link between population densities and their effect on agricultural methods. As population densities rise agriculture generally intensifies.

Figure 1a. Extent of drylands in West Africa

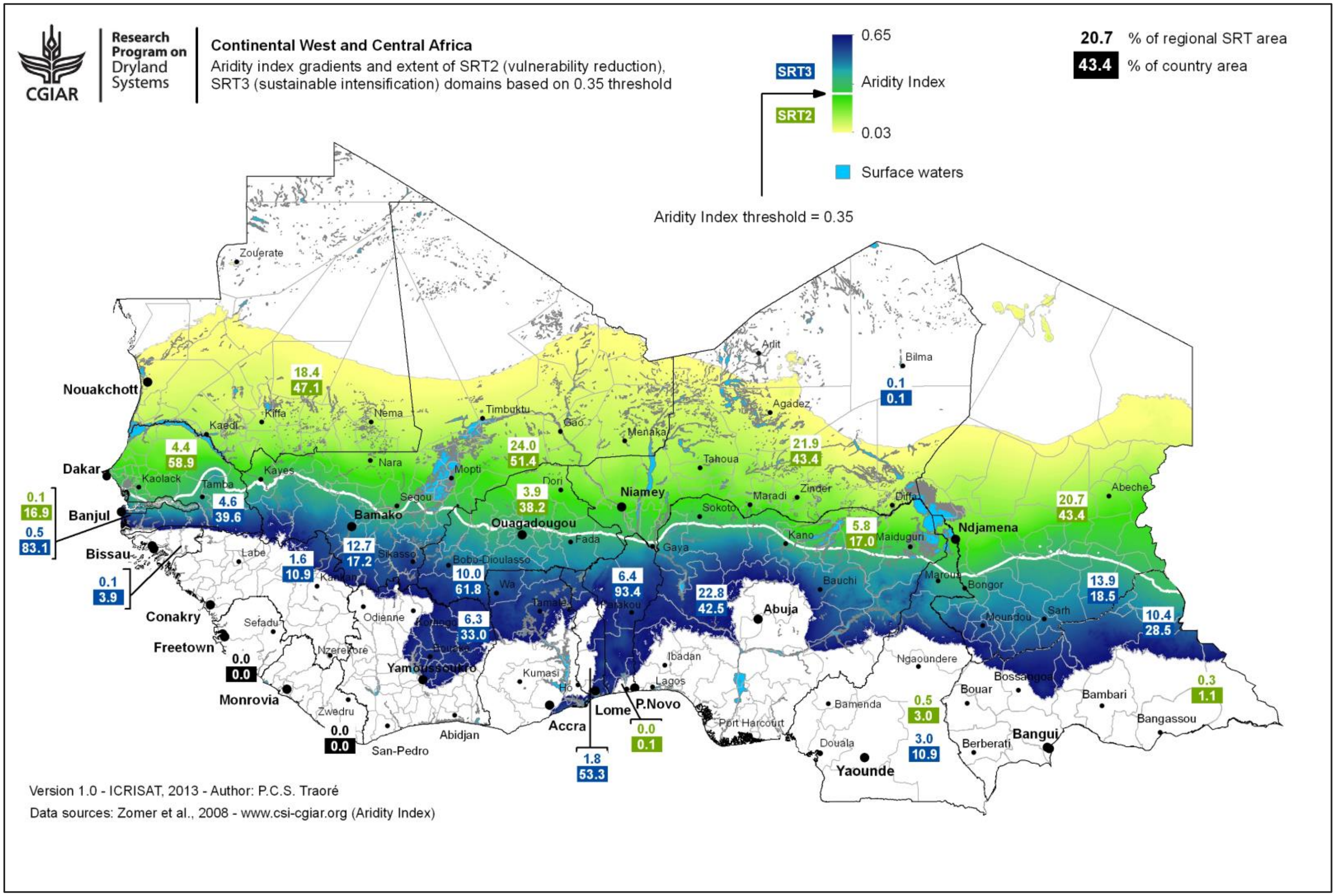


Figure 1.b. Population densities in dryland areas of West Africa

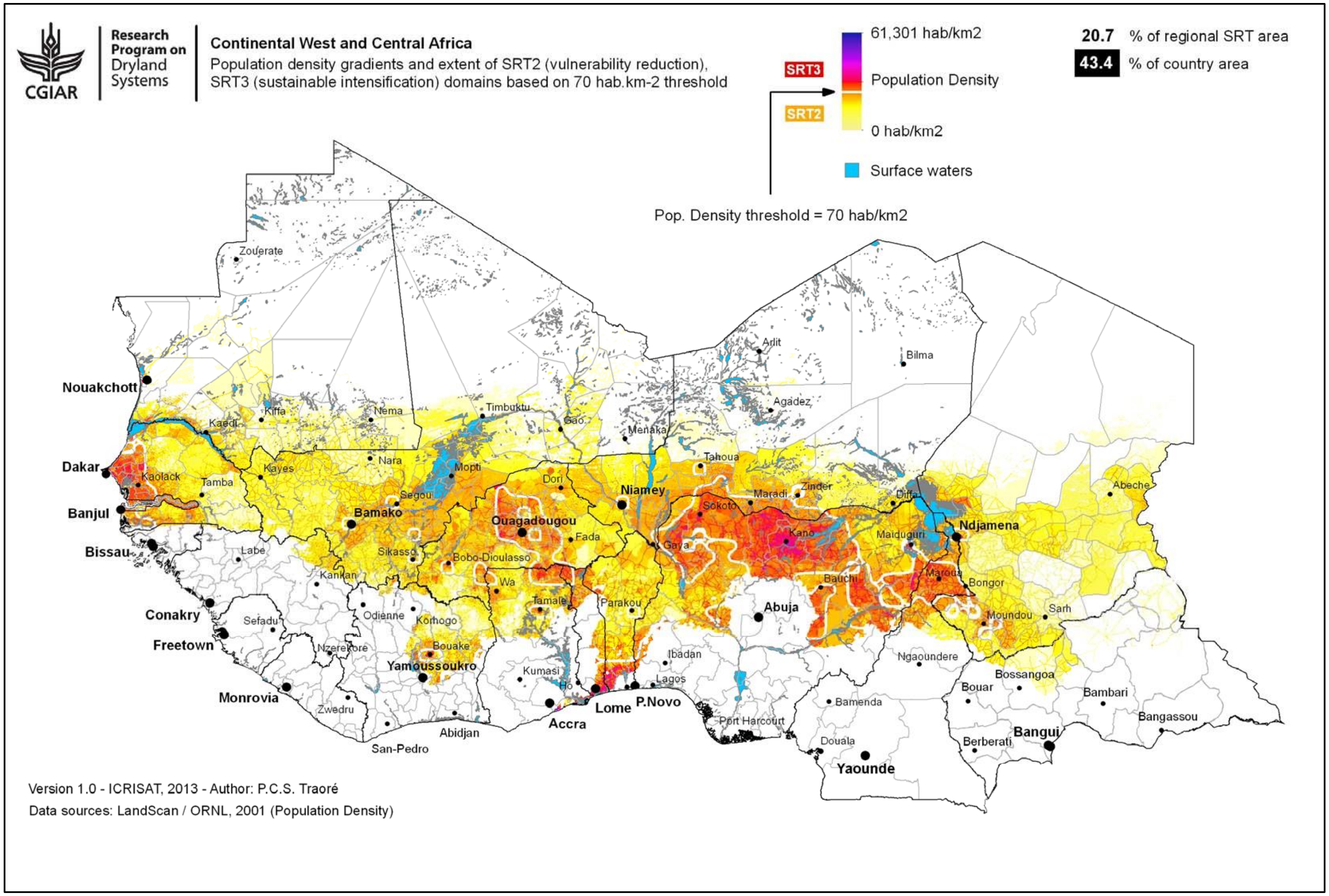


Figure 1.c. Distribution of poverty in dryland areas of West Africa

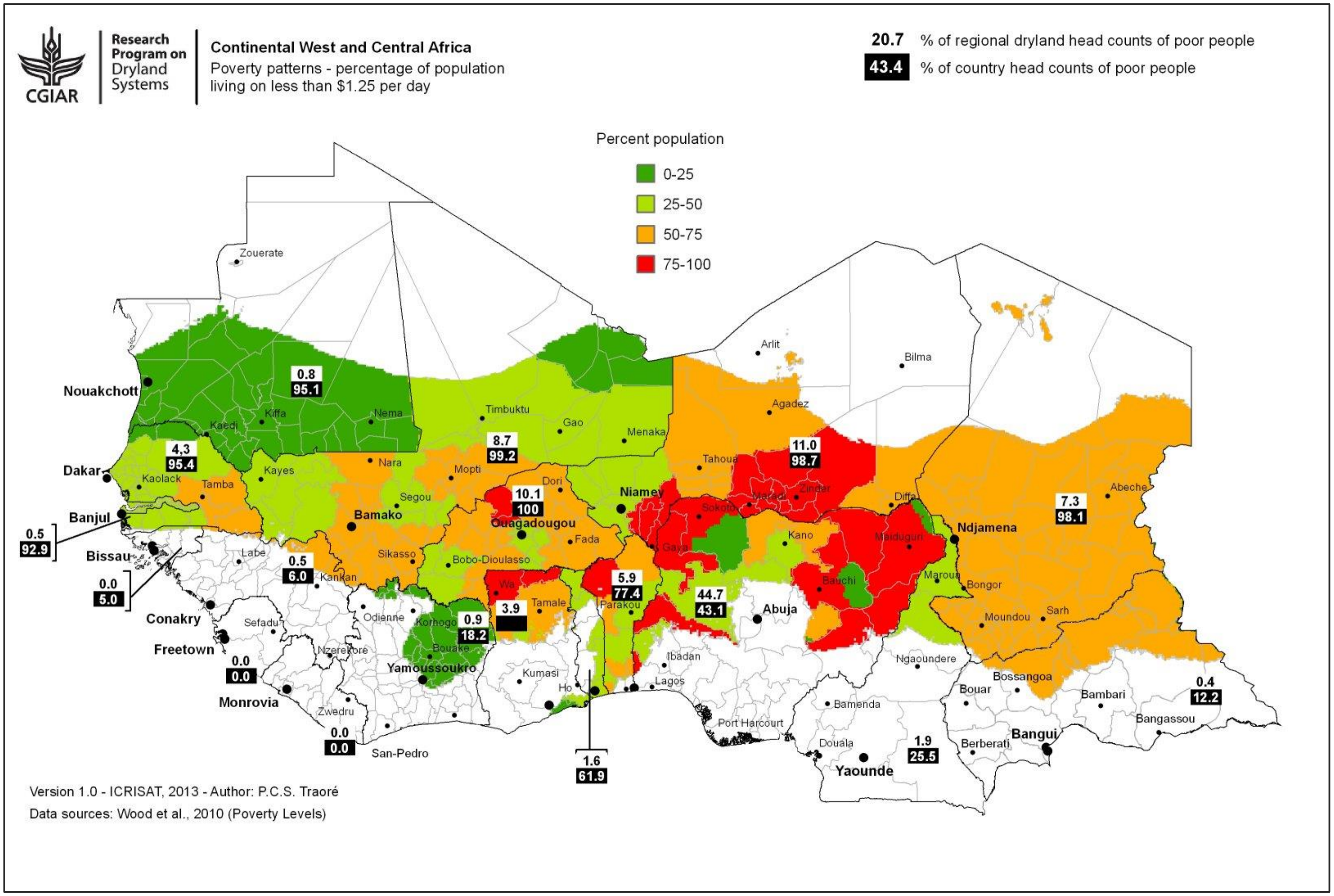


Figure 2.

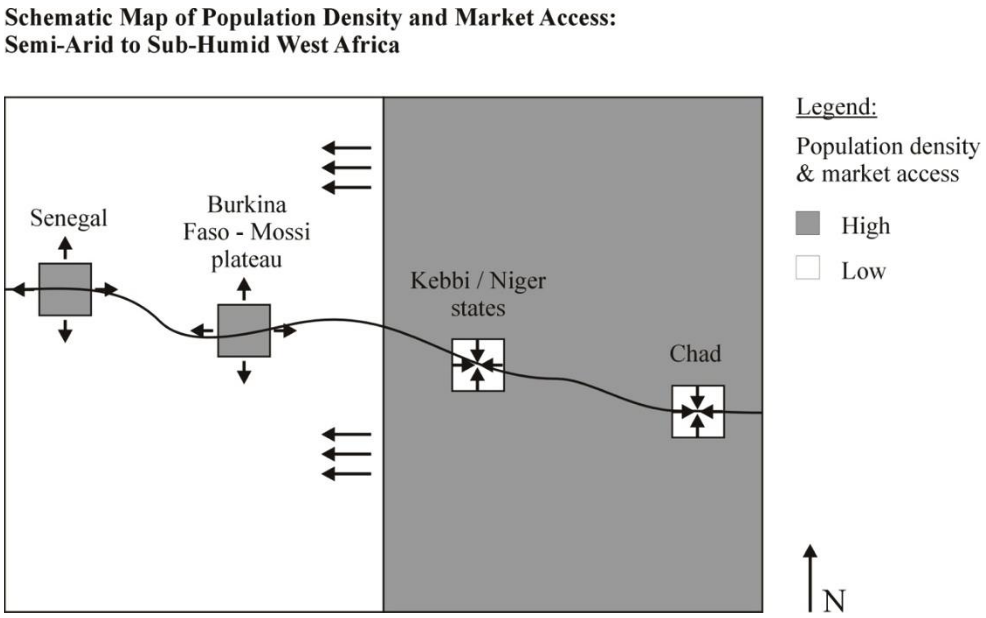


Figure key: The white half represents the western part of the West African dryland region and the grey half represents the eastern part of this region. The smaller boxes within the two halves are exceptions within their respective regions. See discussion on page 14. *Source*: Traoré et al., 2013

2.2 Key socio-ecological systems in the western half of the dryland region

In West Africa, ASSAR's focus is on the Wa-Bobo-Sikasso (WBS) trans-boundary transect, an action site of the Dryland Systems Collaborative Research Programme (CRP) of the CGIAR. The area straddles the Upper West Region (Ghana), the Hauts Bassins Region (Burkina Faso), and the Sikasso Region (Mali) and host to an estimated population of about 5 million over a surface area slightly below 100,000 km^2. This focus stems from (i) the wide longitudinal range in socio-economic conditions covered by WBS, (ii) their manifest transcription in the spatial dynamics of resource use, and (iii) potential large off-site impacts of changes in the use of the local resource base.

WBS is representative of the Western half of the West Africa region, characterized by variable population density gradients, from shallow to locally steep,, and by a resulting continuum of extensive and intensive agricultures, in contrast to the significantly more (and more homogeneously) populated Eastern half of West Africa (Nigeria-Niger complex). CGIAR Dryland Systems field sites are located at Yagtuuri (Lawra District, Ghana), Mahon (Koloko Department, Burkina Faso) and Kani (Koutiala Circle, Mali). The ASSAR project will focus on the Ghana and Mali sites. These field sites display variable population densities, contrasted levels of historical state and private infrastructure, investments, and mechanization, which are also reflected in the inherent organizational sophistication and innovative capacity of individual farming communities (van Mele et al., 2011). The area that encompasses this transect has moderate to high drought risk, and has single growing season with high rainfall intensity and significant risk of dry spells.

Owing to a relatively favorable natural resource base in the Sudano-Guinean belt, the WBS action transect features a juxtaposition of intensified, cotton-based rainfed, agroforestry-based, and more traditional rainfed production systems with cereals (maize, millet, sorghum, lowland rice), pulses (cowpea, peanut, Bambara nut) and tubers (potato, sweet potato, yam). Levels of crop-livestock integration (cattle, small ruminants, swine and poultry) vary in a context of moderate but locally declining agro-biodiversity, sustained but locally stabilizing nutrient mining. The WBS transect is an intermediate zone for pastoralists thus providing important socio-economic teleconnections between the dry sub-humid and the semi-arid areas. These teleconnections are expected to change as transhumance continues to decline and the region's agricultural land base intensifies.

The WBS transect is characterized by a generally intermediate level of food security (supply of calories per capita) but poor nutritional status (e.g. lowest national ratings in Mali) in spite of Mali and Ghana overall scoring relatively high among 187 countries in terms of dietary quality (Imamura et al., 2015). The absence of very large urban centers in the vicinity relieves the rural hinterlands from exposure to large, deleterious environmental impacts but also limits market-driven development opportunities. The imminent completion of the first direct and uninterrupted paved road corridor throughout the WBS transect, and connecting to Ghana's coastal region, is progressively unlocking accessibility to the 6th, 7th and 8th largest urban economies of West Africa (Accra, Bamako, Kumasi). This paved corridor will serve to at least partly integrate market, transport and communications systems between the coast and the interior (Deen-Swarray et al., 2014), and is likely to generate both positive (significantly alter input prices) and negative (increase exposure to external trade shocks) effects. With intensification of the agricultural base, the WBS transect is expected to take on greater importance for national and regional food security.

The Dryland Systems Collaborative Research Program (CRP) of the CGIAR has prioritized efforts to greater capacitate local communities to sustainably enhance resource use efficiency (land, water, labor, agro-biodiversity, etc) of their production systems, and thereby helping to mitigate the environmental impact of agricultural intensification. This entry point stems from the premise that sustainable land and water management is a prerequisite to sustainable intensification and vulnerability reduction in WBS. The variable rates of land use and land cover change witnessed in WBS implies that the natural resource base is constrained but not always strongly limiting in supporting these sustainable intensification goals (Demont et al., 2007). Emerging private sector investment in agricultural supply chains is also bringing important changes to this region. For example, Ghana Guinness has recently committed to sourcing up to 50-70% of agricultural produce locally for their malting and brewery industries, providing potential to intensify agricultural production in cereal and tuber producing areas of central and northern Ghana .

Intensification has important implications for near to medium-term adaptation in that it provides opportunities for livelihood diversification and for investments in agriculture that can enhance risk management. On the other hand, such large changes need to be understood in the context of how they produce winners and losers. Understanding how these important shifts play out is important for addressing potential inequitable development outcomes—an issue that takes on greater urgency given the strong likelihood that extreme events associated with climate change will increasingly disrupt livelihoods and economic development thus undermining social welfare.

Examining vulnerability and adaptation to climate change through the lens of agricultural intensification will entail understanding important complimentarities between the two realms with respect to enhanced water productivity, investments in markets that may spur agro-system diversification, and conservation of the resource base that protect soils from erosion and runoff. As well, this examination will entail understanding tensions and contradictions that can arise, such as where intensification proceeds without due consideration of a warmer and more unstable climate, leading to potential maladaptation, or where climate change adaptation agendas disproportionately drive development efforts that result in shortchanging discovery of synergies between intensification and adaptation or that impede efforts towards sustainable intensification. The RDS is intended to provide a foundation of knowledge upon which to examine these issues during the regional research phase of ASSAR.

CHAPTER 3

Climate

Climate

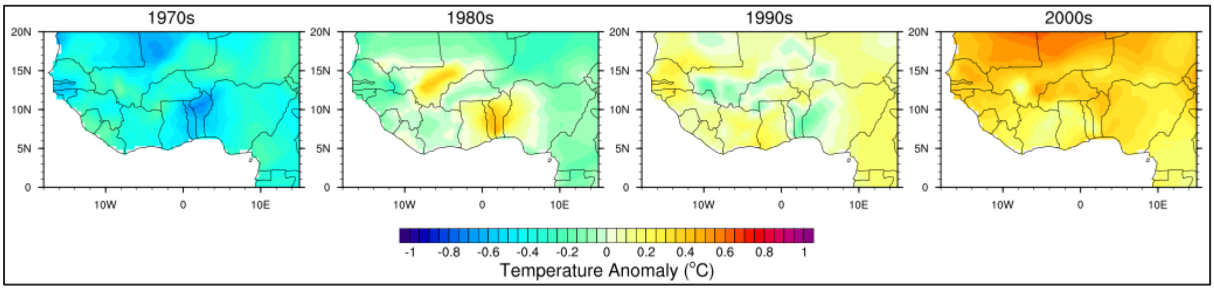
This section describes climate trends and projections for West Africa, with the latter focusing on findings from the IPCC 5th Assessment Report. This section also highlights key studies that explore how climate change could potentially chang characteristics of the rainy season in the future.

3.1 Climate variability in West Africa

The climate of West Africa is characterized by high interannual variability as well as significant inter-decadal variability. Figure 3 shows the difference between the mean decadal (ten year) temperature and the mean temperature over the 1963 to 2012 period over the region. There is a clear warming signal as all locations in West Africa were warmer, on average, in the 2000s than in the 1970s. The 2000s were particularly warm in the northern part of the region with parts of Mali and Mauritania at least 1.5°C warmer in the 2000s compared to the 1970s. However, it is also apparent that in some locations more recent decades have been cooler than preceding decades; for example, Togo, Benin, western Nigeria and southern Mali were all warmer in the 1980s than in the 1990s.

Figure 3.

Difference between decadal mean temperatures and 1963 to 2012 mean temperatures at each grid cell.



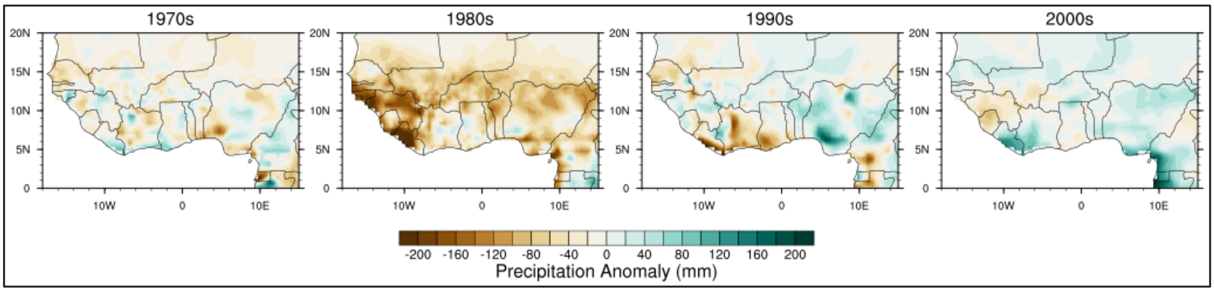
Source: Data is taken from the CRU TS3.22 dataset

Figure 4 shows the difference between the mean annual rainfall total for each decade and the mean annual rainfall total over the 1963 to 2012 period at each grid cell, illustrating considerable variability in rainfall on multi-decadal time scales. The figure shows that the 1980s was a particularly dry decade for much of the region, which coincides with Sahel drought that caused considerable hardship to communities across the region. By contrast, the 2000s were slightly wetter for much of the region, with the exception of Guinea, Sierra Leone, southern Mali and southern Ghana.

Lebel and Ali (2009) suggest that while there has been a recovery of the rains in eastern parts of West Africa, there has been a continuation of drought conditions in western regions, which is consistent with the observed data shown in figure 3.2. In another recent review, Druyan (2011) notes that since the 1990s, seasonal rainfall accumulations over the Sahel have somewhat recovered, but not to the levels seen in the 1950s.

Figure 4.

Difference between decadal mean annual rainfall totals and 1963 to 2012 mean annual rainfall totals for each grid cell.



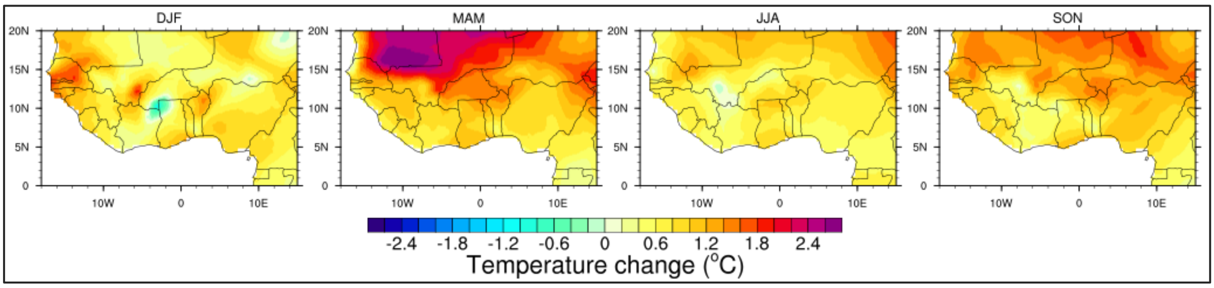
Source: Data is taken from the CRU TS3.22 dataset

3.2 Climate trends

To determine whether or not, and by how much, the climate has changed in the recent past, trends in temperature and rainfall are calculated from the available observed data. Figures 5 and 6 show the seasonally averaged spatial and temporal changes in temperature over West Africa during the period 1963 to 2012. Despite annual and decadal variability, across all seasons and locations temperatures have increased over this period, with the exceptions of some localized cooling in the border region between Burkina Faso, Ghana and Cote D'Ivoire as well as the northeast region of Niger during winter, and southern Mali in summer. Averaged across the whole region and all seasons, temperatures in West Africa have increased by approximately 1°C over the past 50 years. Temperature increases were generally higher (0.6 to 3.0°C) in northern parts of the region, particularly in Mali and Mauritania in spring (MAM), and lower (0.4 to 1.4°C) along the coastal regions of West Africa. Whilst there has been an increase in temperatures in most locations in all seasons, the highest increases are found in the spring (MAM) and autumn (SON) seasons; note that Senegal also shows large increases (over 1.5°C) in winter.

Figure 5.

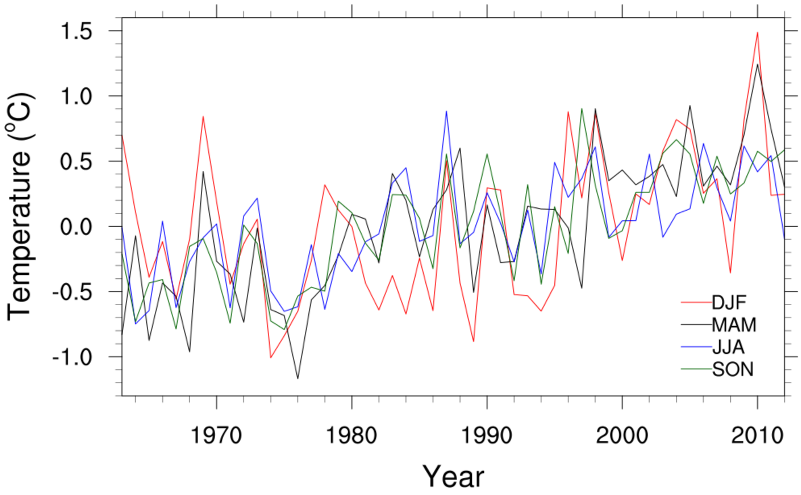
The change in temperature between 1963 and 2012 at each grid cell, according to a linear trend, for the four seasons: DJF, MAM, JJA and SON.



Source: Data is taken from the CRU TS3.22 dataset

Figure 6.

Time series of the land area averaged seasonal temperature changes in West Africa between 1963 and 2012.



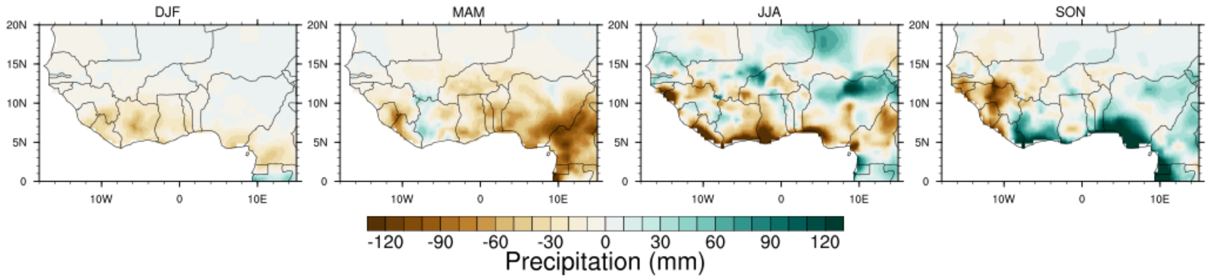
Source: Data is taken from the CRU TS3.22 dataset

Figure 7 shows the change in total rainfall for each season from 1963 to 2012. There appears to have been a shift in the rainy season along large stretches of the coastline, with decreased rainfall in spring and summer but increased rainfall in autumn. However, along western parts of the coastline, from Liberia to Senegal, there has been no increase in autumn. Further north, the signals are mixed with seasonal increases and decreases evident in different regions. During the dry winter season, there is a weak signal of drying in southern parts of the region. Crucially, the patterns of change are not consistent everywhere and rainfall in West Africa, as described in prior sections, is highly variable so any signals of systematic change need to be assessed for whether they are statistically significant.

Observations of rainfall are subject to substantial uncertainty. Therefore the evidence presented here must be treated with caution and the conclusions must be interrogated in the context of additional regional and local scale information and observed datasets. In particular, linear trends in rainfall are not entirely reliable as an indicator of change, especially in semi-arid regions where year-to-year variability is high.

Figure 7.

The change in rainfall between 1963 and 2012 at each grid cell, according to a linear trend, for the four seasons: DJF, MAM, JJA and SON.



Source: Data is taken from the CRU TS3.22 dataset

3.3 Trends in extreme rainfall and temperature

To better understand the impacts of historical climate variability and future climate change on communities and ecosystems, it is often more relevant to focus on the less frequent but more severe weather and climate events that influence exposure and vulnerability.

A report by Climate Development Knowledge Network (CDKN 2012) summarizes the findings of the Intergovernmental Panel on Climate Change (IPCC) special report on managing extreme events (SREX, IPCC 2012). Changes to temperature and precipitation extremes in West Africa observed since the 1950s, with the period 1961-1990 used as a baseline, include increase in temperature of warmest and coolest days, increasing frequency of warm nights, decrease in cold nights, increased dry spell duration and greater inter-annual variation in dry spells in recent years. Because of sparse and unreliable observations across much of West Africa, and given statistical issues associated with deriving trends in extremes for short sampling periods, all of the findings are stated with medium confidence. The SREX report also stated that there has been a decrease in the amount of rainfall received in heavy rainfall events, while stating that rainfall intensity has increased, which seem somewhat contradictory. An earlier study by New et al. (2006) showed evidence of increase in dry spell durations and rainfall intensity, with the observed trends for temperature extremes more apparent than for precipitation.

3.4 Future Climate Projections

3.4.1 IPCC Fifth Assessment Report findings

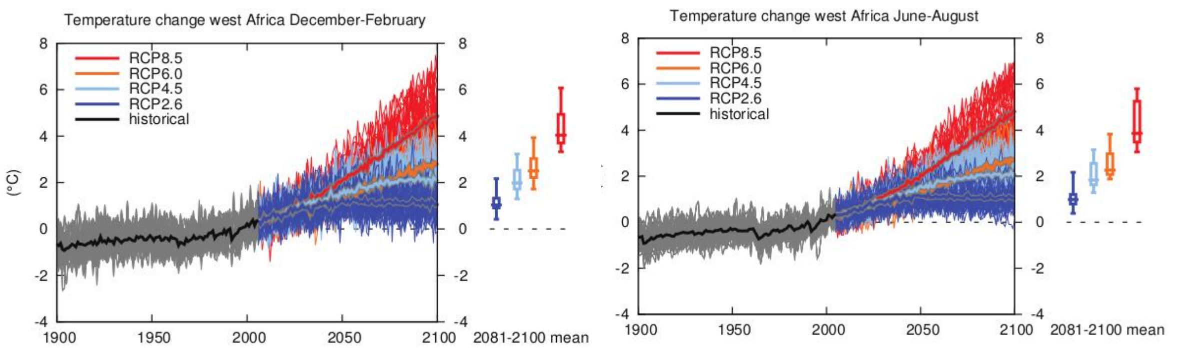
Climate change projections span a range of possible future climates. This range results from substantial uncertainty in key climate processes as well as different future greenhouse gas (GHG) emissions scenarios. The scenarios are expressed in terms of Representative Concentration Pathways (RCP), which represent different future levels of GHG emissions. These RCPs range from a future scenario of a low rate in the growth of GHG emissions (RCP 2.6) up to a very high rate (RCP 8.5) and with intermediate rates (RCP 4.5 and 6.0).

The projections shown in this section are taken from the available output of the latest generation of Global Climate Model (GCM) experiments. The IPCC fifth assessment report (AR5) provides a synthesis of the output from approximately 40 GCMs developed at institutions across the world. The model simulations were conducted as part of the fifth phase of the Coupled Model Intercomparison Project (CMIP5) to generate a set of climate projections for the coming century. This section presents some of the model results relevant for West Africa.

Globally, average annual temperatures are projected to rise by 0.3 to 2.5°C by 2050, relative to the 1985 to 2005 average, but projected changes are higher for land areas. Figure 8 shows that in West Africa temperature projections range from a change of approximately -0.5 to +4°C in winter and from 0 to +3.5°C in summer by 2050. Lower temperature increases are more likely under a low emissions scenario and higher temperature increases are more likely under a high emissions scenario.

Figure 8.

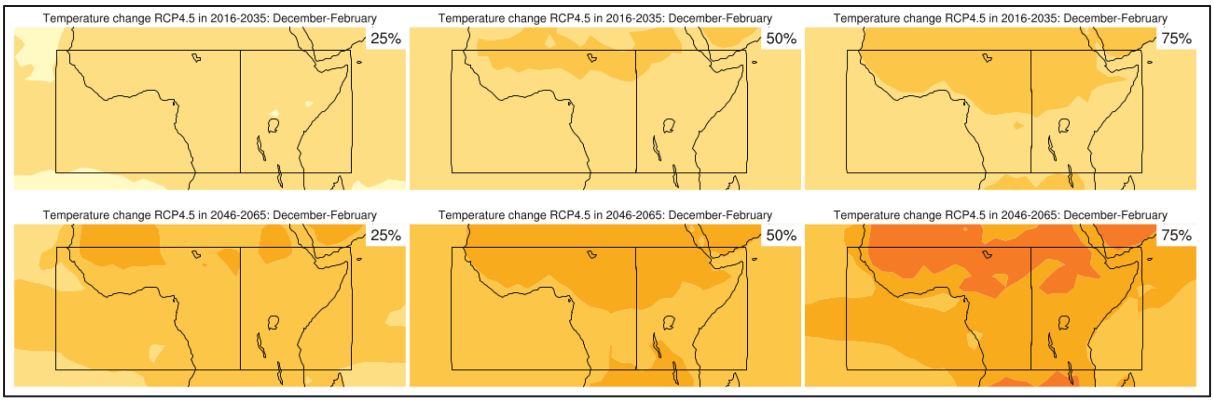
Time series of temperature change relative to 1986–2005 averaged over land grid points in West Africa in December to February (left) and June to August (right).



Source: IPCC (2013)

Figure 9.

Maps of temperature change in West Africa in December to February for 2016–2035 and 2046–2065 with respect to 1986–2005 according to the RCP4.5 scenario. The left column show the 25th percentile (i.e. a quarter of models are below these values), the middle column shows the median and the right columns shows the 75th percentile (i.e. a quarter of models are above these values).



Source: IPCC (2013)

Projected changes in temperature vary spatially. Figure 9 shows that, for the RCP4.5 (mid-range) emissions scenario, northern regions of West Africa are projected to warm more than other regions, continuing the observed trends shown in section 3.2. The figure shows that by mid-century half of all model simulations project a warming in winter of between 2 and 3°C for northern regions of West Africa and between 1 and 2°C for southern regions of West Africa. In the summer season (not shown), the spatial pattern is broadly similar but the magnitudes of change are slightly less than those projected for the winter. Beyond increases in average temperatures, the IPCC report states "it is virtually certain that there will be more frequent hot and fewer cold temperature extremes over most land areas on daily and seasonal timescales as global mean temperatures increase".

Future projections of rainfall change are subject to substantial uncertainties and model simulations disagree on the likely direction and magnitude of change. In West Africa, variability on interannual, decadal and multi-decadal time scales, as experienced in the past, is expected to continue to be the dominant influence on future rainfall. *For the next few decades up to 2050 any signal across the model ensemble remains either weak or non-existent.*

3.4.2 CORDEX Projections

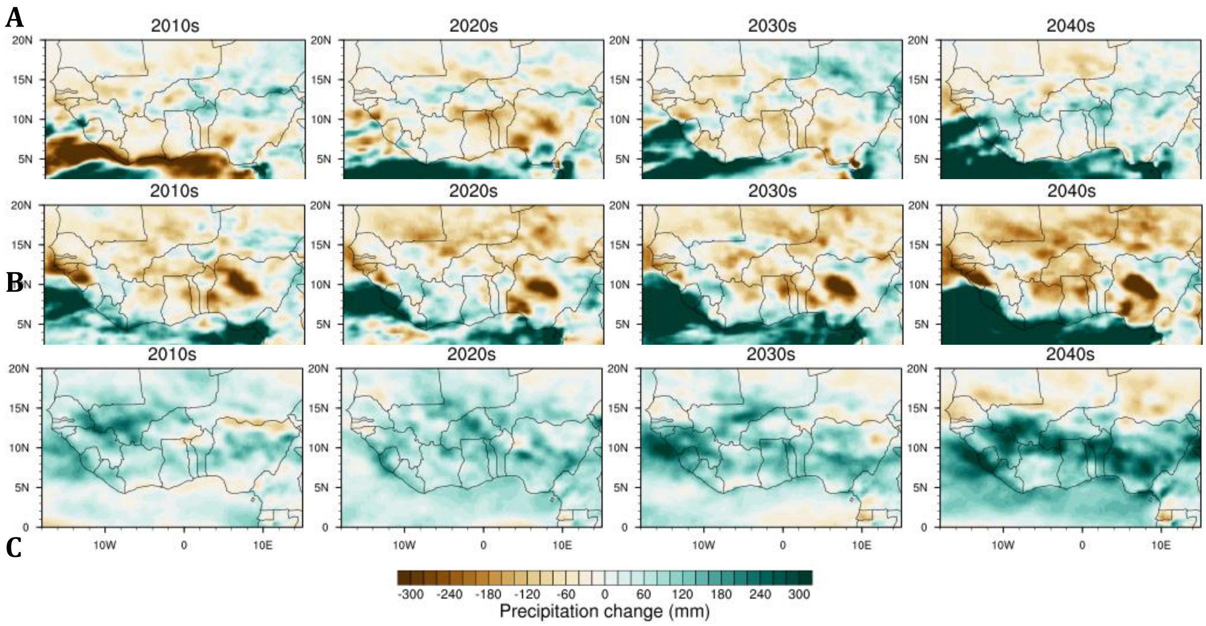
The Coordinated Regional Downscaling Experiment (CORDEX) uses the latest generation of regional climate models (RCMs) to provide 50 km resolution projections of climate change up to the year 2100 for regions across the world. The models are driven by GCMs used in the IPCC AR5 report. Here, some example CORDEX model projections are presented showing possible future regional climate change scenarios for West Africa. It should be noted that all projections shown are for the same GHG forcing scenario, RCP8.5; this scenario is often categorized as "business as usual" with respect to GHG emissions.

The model projections shown in Figure 10 are taken from combinations of two GCMs (HadGem2 and ICHEC) and two RCMs (KNMI and CCLM4), all driven by the RCP8.5 scenario. A more rigorous exploration of future climate scenarios would involve analyzing many more GCM-RCM combinations that are being made available in the CORDEX project. However, for demonstrative purposes it is useful to look at some of the available data to examine the nature of future climate output. Figure 3.8 shows model projections of future rainfall change for four decades. The average annual rainfall change for a particular decade is calculated by subtracting the decadal average from the average annual rainfall over the period 1950 to 2000 in the model.

The model projections indicate very different responses of the regional climate for the selected future GHG forcing scenario. Model C projects wetting across the region with some central regions projected to have up to 300mm more rainfall by the 2040s. This contrasts considerably with the Model A and Model B projections, which use a different RCM. Over land the climate change signals from these projections are mixed. However, model B suggests considerable drying in Senegal, Guinea and central regions of Nigeria. Over the ocean both of these projections show very large increases (over 300mm) in the annual average rainfall; the only exception is in model A where the ocean closer to the land is projected to become drier in the 2010s.

Figure 10.

Difference between decadal mean annual rainfall totals and the 1950 to 2000 mean annual rainfall totals, at each grid cell, for three CORDEX models under the RCP8.5 scenario: A = HadGem2-CCLM4; B = ICHEC-CCLM4; and C = ICHEC-KNMI.



Even with the output of only three model simulations, *there is no consensus on the direction of change in rainfall for the future.* Disagreement in rainfall projections in West Africa and across the Sahel is a common finding amongst a number of studies (Roudier et al., 2014) further underscoring the level of future uncertainty. The Druyan (2011) review finds some studies show unambiguous evidence of drying in the Sahel during second half of the 21st century with implications for increasing drought risk (e.g. Held et al 2005, Cook and Vizy 2006), while other studies project a wetter Sahel (e.g. Maynard et al., 2002; Kamga et al., 2005).

There is, however, much better agreement that temperatures are likely to increase. Figure 11 shows decadal changes in temperature for the same set of GCM-RCM combinations under the RCP8.5 scenario. In all model simulations, temperatures across the region are projected to rise. There is greater warming in the north, which corroborates with the CMIP5 GCM projections and the observed warming experienced in the last 50 years (see sections 1.4 and 2.1). Model A projects the greatest magnitude increase by the 2040s with mean temperatures projected to increase by up to 3°C across the Sahel and above 3°C in the Sahara. For the southern coastal part of the region, temperatures are projected to increase by at least 2°C by the 2040s, which represents a dramatic acceleration of temperature increases compared to the historical record. The changes are smaller in model B and C but all areas are projected to warm by at least 1°C by the 2030s and 1.5°C by the 2040s.

Figure 11.

Difference between decadal mean temperatures and the 1950 to 2000 mean temperatures, at each grid cell, for three CORDEX models under the RCP8.5 scenario: A = HadGem2-CCLM4; B = ICHEC-CCLM4; and C = ICHEC-KNMI.

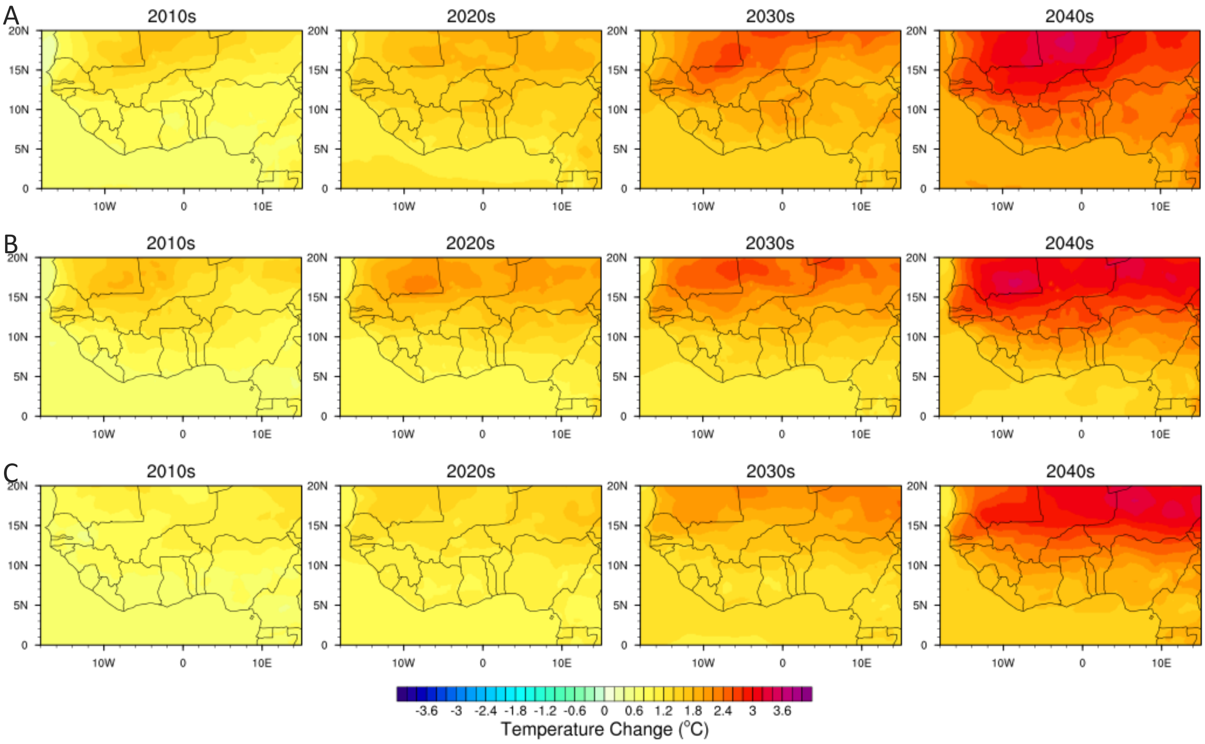
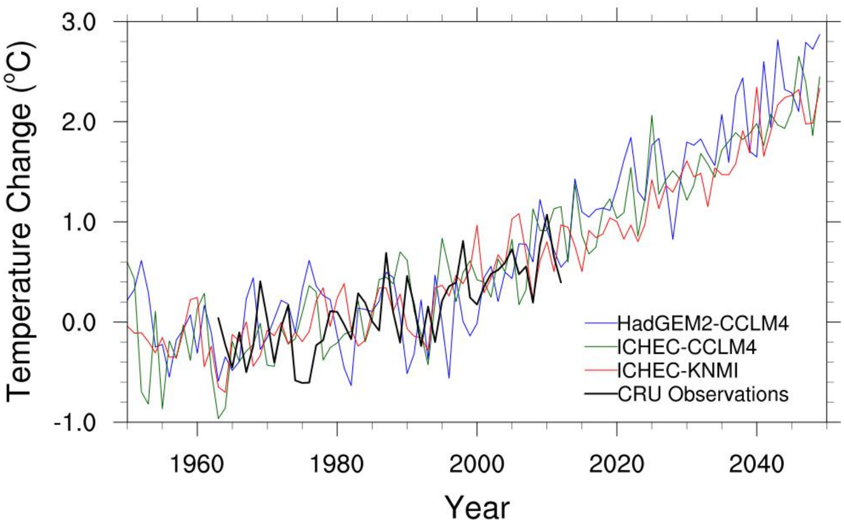


Figure 12.

Time series of the change in West Africa annual average temperatures from the three CORDEX models analysed (see key). The model changes are relative to the average of the models in the respective domains from 1963 to 2000, while the CRU TS3.22 observational data (from 1963 to 2012) are relative to the observed 1963 to 2000 average.



Unlike rainfall, changes to temperature on the decadal time scale appear to be dominated by a systematic warming signal as opposed to multi-decadal variability. This can also be seen clearly when aggregating temperature changes over the region and analysing the time series' of model projections. Figure 12 shows the change in annual average temperature for the three model simulations, as well as the observed changes from the CRU dataset. All model simulations appear to capture the warming trend over the past 50 years and project a steepening of this trend in the future. By 2050, there is some uncertainty in the projected temperature change – even from a very small sample of simulations all driven with the same GHG forcing scenario – with the three simulations projecting a 2.1 to 2.8°C warming by 2050. The divergence of models would likely be much larger if additional simulations and forcing scenarios were included.

3.5 Impacts of future climate change on characteristics of the rainy season

Future projections of climate change in West Africa are uncertain, particularly with respect to changes in precipitation, thus divining impacts of future climate change on agriculture, biodiversity, human health and other critical societal areas is difficult. This uncertainty carries into model projections, providing contrasting evidence with regards to future impacts in the region. A range of crop models, hydrological models and other impacts models are used to determine the impact of climate change on agriculture, water resources, biodiversity and other key sectors in the region but most studies require climate model projections that span a wide range of possible futures. The use of multi-model, model-method ensembles of projections is a more robust way of assessing impacts of future climate change than are assessments based on a single model. While the output of a single model simulation should certainly be treated with caution, even an ensemble of regional model projections cannot be expected to provide reliable quantitative "predictions" (Daron et al 2014). Rather, the projections show possible scenarios of future change.

Ibrahim et al (2014) examined changes to rainfall in Burkina Faso using five different GCMs to conduct their analysis. Their findings show the number of low rainfall events is projected to decrease by 3% while the number of strong rainfall events is expected to increase by 15 % on average. All five models project the rainy season onset to be delayed by one week on average and a consensus exists on the lengthening of the dry spells by approximately 20%.

According to Sarr (2012) a delay in the onset of rainfall and a lengthening of dry spells is also projected for many regions in West Africa. Although signals are mixed, a reduction in rainfall during the onset period and an increase in rainfall in the latter part of the season have been projected for West Africa in some of the recent CORDEX simulations (Mariotti et al 2014). Other studies also find that the overall length of the rainy season may be reduced in some parts of West Africa (e.g. Biasutti and Sobel 2009) with a risk of a reduction in the length of the growing period in the Sahel region (Cook and Vizy 2012).

CHAPTER 4

Risks, Impacts and Vulnerability

Risks, Impacts and Vulnerability

4.1 Overview and context

The ASSAR project views vulnerability in the climate context as comprising a set of conditions that shape the likelihood of exposure to climatic hazards and sensitivity to their effects (the likelihood of adverse consequences resulting from exposure), and the degree of capacity to cope and adapt to avoid or mitigate harm. Sensitivity is dependent on a set of highly interacting environmental, social, economic and political factors and drivers that contain within them important structural drivers of inequality that serves to intensify vulnerability (Tschakert et al., 2013).

The vast majority of climate vulnerability studies from West Africa focus on rural systems, which is a reflection of the region's agrarian base and the high climate sensitivity of rainfed agriculture that predominates across West Africa's drylands. The critical issues framing vulnerability within the rural space include environmental degradation of agro-ecosystems, large-scale land-use change with mostly negative implications for socio-ecological sustainability, changing entitlement to land and other productive resources reflected through the changing nature of pastoralism and the erosion of traditional land tenure and usufruct arrangements, and the rising toll of conflict in rural areas. There is a notable dearth of studies on vulnerability related to the urban context of semi-arid interior cities in West Africa. (Most of the recent urban climate-vulnerability studies in West Africa have focused on a few large coastal cities, chiefly Accra, Abidjan, Dakar and Lagos.) The lack of an urban focus in the extensive semi-arid region of West Africa is an important gap given the growing importance that secondary cities will play in the strong urban growth trajectories projected for Africa over the next several decades (Roberts, 2014).

This section explores the multi-stressor context of vulnerability in dryland (semi-arid and dry sub-humid) areas of West Africa, and how that vulnerability plays out in terms of impacts related to extreme events and the high intra- and inter-annual climate variability. A central component of this section relates to how large-scale land and resource-use change influences the ability of farmers and livestock keepers to manage risks and vulnerabilities and avail themselves of opportunities. In several of the sub-sections, the report describes responses emanating from both climatic and non-climatic stimuli that have a strong bearing on managing vulnerability and building adaptive capacities. These responses revolve around changes in farming practices and production systems, and shifts towards greater diversification and mobility.

A major dimension of the literature analyzed in this section revolves around multi-dimensional land- and resource-use change within which are embedded issues of policy and governance. The relationship of these changes to vulnerability and adaptation for current and medium-term climate change is premised on the following assumptions:

- Strategies and approaches for bolstering food production, stabilizing livelihoods and achieving greater socio-environmental sustainability strongly overlap with much of the current measures proposed for adapting to climate change in dryland West Africa (Barron et al., 2010; Cooper et al., 2008). Thus, understanding the factors that either inhibit or promote efforts towards achieving more productive, stable and sustainable agroecosystems is critical for intensifying current good practices and developing relevant responses to adaptation

- Factors additional to a changing climate baseline may be playing a role in increased impacts from climate variability and extremes. In the West Africa context, these factors include extensification of agriculture onto increasingly marginal drought-prone soils, reduced mobility of pastoralists that diminishes their capacity to manage drought risks, and increasing prevalence of built structures to store river water that increases sensitivity and exposure of downstream water users to low water levels and drought (Galvin, 2009; Mbow et al., 2008; Morand et al., 2012; Roncoli et al., 2008; Traoré and Owiyo, 2013).
- Resource governance in dryland West Africa is undermined in situations where poorly planned decentralization, inflexible top-down policy directives, increased tenure insecurity and land grabbing, and macroeconomic changes unfavorable for small-holder agriculture prevail. Poor resource governance in turn reduces farmer options for managing risks related to soil and water management, and forests and rangelands that are critical for adapting to change (Dieye and Roy, 2012; Kalame et al., 2009; Hounkonnou et al., 2006; Kalame et al., 2008; Laube et al., 2012; Mbow et al., 2008; Skutsch and Ba, 2010).

These three issues are explored in Section 4.4, which describes critical challenges around land degradation, poor water resource capture and utilization, poor governance and lack of land tenure security that serve to deepen vulnerabilities.

4.2 Who is vulnerable?

Vulnerability is circumscribed by poverty, a low asset base, lack of adequate safety nets, services and infrastructure, reliance on livelihoods that are directly or indirectly climate sensitive, and poor political agency. In rural areas, vulnerable groups include low-income households engaged in fishing, farming, and pastoralism, non-diversified farmers, such as cotton farmers in Mali, and migrant workers (Simonsson, 2005). In urban areas vulnerability is largely defined by lack of access to regular employment, inadequate and unsafe housing, and poor or absent urban services related to water, sanitation and health. Within both urban and rural spheres, women, children, the elderly, the sick and the disabled are the most vulnerable. Refugees, internally displaced people and other victims of conflict are also among the most vulnerable. Vulnerability is also manifested through migration in West Africa, as female-headed households left behind by migrant male laborers and relatives who do not receive remittances from migrants (Simonsson, 2005).

Focus group discussions with farmers and women's groups held in northern Ghana in conjunction with this RDS noted in particular the vulnerabilities of female-headed households where men have migrated, youth who have been forced to migrate south because of food shortages and lack of opportunities in the north, and the elderly and handicapped who have few resources to respond to extreme events.

4.3 What are important climate dimensions of vulnerability?

High levels of poverty, lack of social safety nets, climate-dependent livelihoods and low asset bases increase sensitivity to drought and often leads to liquidation of assets (e.g. distress sale of livestock) that further intensify vulnerability (Batterbury, 2001; Speranza et al., 2008). Drought is insidious and its effects are often experienced well before, or at scales much larger than, official drought declarations. For instance, agricultural droughts (linked to poor soil nutrient and moisture conditions, lack of timely planting with respect to the rains, poor quality seed, lack of draught animals, labor shortages etc.) are very situation dependent and often occur well before meteorological and hydrological drought. Prolonged exposure to these risks erodes household resources, creating situations in which chronic stress predisposes producers to agricultural drought even in the absence of meteorological drought, and increases sensitivity to shocks from extreme events.

High variability of seasonal rainfall, related to onset and offset of the rainy season and occurrence and length of dry spells within the rainy season, is another important climate facet of vulnerability. For example, household seed supply in semi-arid systems often experience bottlenecks, given the practice of serial resowing of crops as a hedge against an uncertain onset of the rainy season. This situation strains seed supplies and results in poor and uneven crop establishment, which is a significant contributor to the productivity gap in dryland agriculture (Challinor et al., 2007; Harris, 2006). Dry spell duration and timing can have a strong influence on food production; for example dry spell longer than 15 days that coincide with sensitive crop growth stages can cause substantial yield reductions (Barron et al., 2003). Increased seasonal rainfall variability (including longer dry spells between rains) and higher temperatures that increase evaporative losses from the system are very likely to occur under future climate change, thus magnifying current risks in rainfed crop production. These kinds of risks could even occur in areas where mean annual precipitation increases.

While the drought and desertification narrative dominates the discourse of climate change in dryland West Africa, flooding and heavy rainfall events also contribute to vulnerability and may become more important as climate change intensifies. Heavy rainfall is an important trigger for flood events, and land-use change associated with surface sealing of degraded soils, concretization of land surfaces, and haphazard development in flood prone areas intensifies flood potentials. The late 1990s and early 2000s period has experienced an uptick in damage associated with flooding in dryland areas of West Africa (Tschakert et al., 2009). The 2007 West African floods were particularly noteworthy for their widespread extent (affecting all countries in dryland West Africa and affecting urban and rural communities). Nearly 800,000 people from across the region were affected with the strongest impacts occuring in the Upper Volta Basin, with widespread damage to crops, livestock and infrastructure. The 2007 floods were followed by severe flooding in the western Sahel in 2009 and 2010 (Samimi et al., 2012).

4.4 What are important risks, impacts and development drivers that influence vulnerability?

In unpacking the complex issue of vulnerability, the question of who is vulnerable to climate change, and what factors influence the extent of vulnerability of different groups, should be contextualized by asking *what* they are vulnerable to. Non-climatic development drivers, including structural inequalities heavily influence the severity with which extreme climate events impact vulnerable groups (Tschakert, 2007; Tschakert et al., 2013). Thus it is critical to identify and articulate these non-climatic drivers in order to adequately assess current and future vulnerability to climate, and to understand the implications of broad-based vulnerability reduction on the ability to adapt to current and future climate change.

4.4.1 *Water resources management*

Water access is of preeminent importance in dryland areas, and made all the more so by concerns over how climate change may potentially exacerbate inadequate and inequitable access to water resources. In West Africa, river discharge deficits exceeding rainfall deficits have been documented from basin to regional level for several decades (e.g. Mahe and Olivry, 1999). While meteorological drought is an important proximate cause of diminishing water resource levels and has been well documented after the onset of Sahelian droughts around 1970, slow-onset changes in land use associated with population growth also have a strong and rapidly increasing influence on hydrological, agricultural and socio-economic drought types. For example, Favreau et al. (2009) and LeBlance et al. (2008) determined that land-use conversion from grasslands and dry forests to agriculture had a larger influence on surface runoff (greater sealing of surfaces leading to increased runoff) and groundwater recharge (higher rates of recharge due to fewer deep rooted trees uptaking groundwater) in the Sahel than did the severe late 20th century drought in that region.

Fifty percent or more of rainfall can be lost to non-productive pathways such as surface runoff or soil evaporation (Biazin et al., 2011), and in the upper Volta basin rainfed agriculture has been estimated to productively use only 14% of the total rainfall (Lemoalle and de Condappa 2010). However, more granular scales reveal opposed on-site and off-site impacts of rainfall decrease on surface hydrology as described by Mahe (2009). In predominantly semi-arid river basins such as the Nakambe (Volta basin), desiccation can paradoxically be associated with large increases in river discharge due to a high baseline population and increasing population densities that amplify pressures on the land base leading to overgrazing, soil compaction, tree mortality and consequently increased runoff. Conversely, in predominantly sub-humid river basins such as the Bani (Niger basin), desiccation has been shown to coincide with greater decreases in river discharge, most probably associated with the multiplication of small dams and other anthropogenic interventions to improve water harvesting and sustain the productivity of water-demanding agro-production systems.

The scalar dimension of water securement at the local level also manifests through off-site effects that exacerbate vulnerability in downstream locations. This is becoming increasingly apparent in West Africa where major river basins encompass large biophysical and socio-economic heterogeneities and water resource management at watershed and river basin scales creates a range of complex issues around scale in terms of water withdrawals (Oyebande and Odunuga, 2010; Ward and Kaczan, 2014). Since the droughts of the 1980s in the Bani river basin, the "*each village wants its dam*" paradigm has led to the proliferation of small dams and other community-level hydraulic infrastructures, many of which may not be correctly calibrated (Roudier and Mahe, 2010). Such structures are estimated at 600 or more (Ferry et al., 2011). The accelerated anthropization of the basin and modification of the hydrological regime is believed to strongly contribute to the nonlinear relationship between rainfall and runoff: Mahe (2013) notes that a 20% decrease in rainfall coincided in a decrease of over 65% in the Bani's outlet discharge. Also, in Mali's Niger Inland Delta fishermen are experiencing reduced flood volumes because of an increased number of dams in the upper Niger basin that is undermining their ability to sustain livelihood from fisheries (Fossi et al., 2012). Box 1 identifies potential areas of conflict over water resources.

As summarized by Morand et al. (2012) "[t]he increasing construction of built structures to store and/or abstract water from the upper and middle parts of most West African rivers has resulted in decreased annual flood peaks in downstream areas and inundation of floodplains. When this coincides with a dry period, then impacts can be quite significant." It is likely that climate change will further amplify regional water vulnerabilities though the extent to which climate change will drive increased water shortages relative to other socio-environmental drivers (i.e. population growth and land-use land-cover change) is highly uncertain. An important finding of the IPCC 5th Assessment Report was that population growth and development could have a larger influence on future water scarcity in Africa than climate change (Niang et al., 2014).

Despite the influx of international aid for investments in water resource projects, such as dams, irrigation canals and wells, particularly during the late 20th century Sahel drought, fragile areas continue to degrade (Douxchamps et al., 2012). Case studies in Sudan and Nigeria, for example, indicate that the vulnerability of communities to changes in the water balance was amplified by the lack of off-farm livelihood opportunities, reliance on marginal and degraded lands, high poverty levels, insecure water rights, inability to economically and socially absorb displaced people, and dysfunctional governance institutions (Osman-Elasha and Sanjack, 2008; Nyong et al., 2008). Roudier and Mahe (2010) note that while the overall reduction of floodplain extent linked to the general decrease in discharge regimes may suggest a reduced vulnerability of populations during extreme flooding events, the reality is that often, populations have shifted habitat closer to the main river beds, keeping them exposed and vulnerable.

There have been relatively few comprehensive (multi-model, multi-method climate model ensemble) studies in West Africa of how climate change will impact surface water resources. One recent study by Ghile et al (2014) focuses on the Upper and Middle Niger River Basin to examine the impact of future climate change on river flows. The study uses the output of 15 GCMs from the CMIP3 and CMIP5 experiments. Their analysis of climate projections reveals no consensus in future trends of precipitation but all models project increases in temperature (mean change across the models of 2.1°C by 2050). They conclude that projections for the year 2030 indicate high probabilities of unacceptable minimum flows for Markala, the Mali-Niger border and Niamey but that projections imply relatively low risks of unacceptable climate change impacts on the present large- infrastructure investment plan for the Basin.

Box 1

The peculiar disposition of West Africa's large river systems

The eastern part of the West Africa drylands region, which is highly populated (see Chapter 2), has major river systems flowing southwards (e.g. Lower Niger River basin), with the exception of the Lake Chad basin and the Chari River. The opposite situation prevails in the western half of the region where most of the rivers flow from south to north, with the important exception of the Volta basin. Northward flowing systems are particularly important as they redistribute water resources towards lower rainfall areas against the climatic gradient. As population density increases along the Sudano-Guinean belt following the SSE-NNW bissector, so do the density of dams of various sizes (mostly small and poorly calibrated) altering lateral water flows with diverse potential consequences including: flow interruptions (as has recently been witnessed on the Niger river in Niamey), stream capture (e.g. upper Niger by lower Niger; or more recently in the Mouhoun and Volta basins). The inevitable conflicts over water in this region of West Africa spans inter-community to inter-sectoral to international scales. The Wa-Bobo-Sikasso transect straddles both northward (Niger) and southward (Volta) flowing basins, which provides an opportunity to investigate diverging, multi-scale water use impact trajectories linked to the reduction of per capita water resources.

4.4.2 Land degradation and drought

The dominant situation across dryland areas of West Africa is one of degradation of rangelands, dry forests, and agricultural areas, leading to increased soil erosion, declining productivity of food and fiber and diminishing integrity of natural systems (Boardman, 2006; Kalame et al., 2009; Mbow et al., 2008). Susceptibility of agricultural lands to degradation is a particular concern in areas where population pressures and diminishing productivity have contributed to increased reliance on charcoal production (Marchetta, 2011) and to agricultural expansion onto lands that are marginal for crop production. For example, in Burkina Faso expansion of crop agriculture onto marginal lands has increased exposure and sensitivity of cropping systems to drought and has exacerbated tensions between farmers and the herders who have traditionally used these areas as rangelands, and depend on access to pastures and water points (Demont et al., 2012; Roncoli et al., 2008; Shapland et al., 2013). Box 2 examines the broader governance failures that have served to exacerbate land degradation.

Increasing exposure to drought that is linked to land-use change is also evident in Senegal where rapid conversion of savannah grasslands and dryland forests to crop production has coincided with decreased rainfall (Mbow et al., 2008). Similarly in northern Ghana, soil erosion, bush fires and overgrazing are increasing exposure to drought (Armah et al., 2011) and wildfire risks to forests in northern Ghana and Burkina Faso have increased due to fragmentation and degradation of forests (Fobissie et al., 2009; Kalame et al., 2009). While drought is the dominant concern in this region, flooding is also a persistent risk. The past decade has witnessed severe flooding in West Africa causing destruction of infrastructure and crops and intensified land erosion and degradation (Sarr and Lona, 2009). In 2009 a flooding event in Burkina Faso resulted in 9300 ha of cultivated fields being destroyed. While, in northern Ghana, heavy rains destroyed over 630 drinking water facilities and nearly a million tons of cereals in 2007 (Dosu, 2011).

In northern Ghana, most state-owned protected areas have experience widespread degradation over the past decades through illegal encroachment and other drivers of change (Ayivor, 2012). Additionally, a number of the sacred groves have been destroyed as a result of urban expansion and infrastructure development as the traditional values and beliefs upon which the groves were established are being abandoned. In the Kassena-Nankana District of the Upper East Region of Ghana, Adaba (2005) reported that rapid population growth coupled with unsustainable farming practices has resulted in forest degradation and decline in soil fertility, with negative effects on biodiversity, water resources, and livelihoods. Wildfires are an important contributor to deforestation and forest loss in the dry savanna zone of Ghana, accounting for an increasing annual loss of 3% (US$24 million) of gross domestic product (EPA, 2003). Apart from the economic costs, wildfires also reduce biodiversity through shifting floral composition towards fire-tolerant species, such as *Milicia excelsa* and *Antiaris toxicaria*, which dominate in post-fire savannah landscapes in Ghana (FORIG, 2003). The management of protected areas in northern Ghana is critical given that only 16% of the country's forest reserves occur in the north.

Declining soil fertility and agricultural pest and disease pressures are important covariate stresses that interact with climate (Antwi-Agyei et al., 2012; Bugri, 2008b; Dieye and Roy, 2012; Dugje et al., 2006; Laube et al., 2012; LeBlanc et al., 2008). For example, the parasitic weed *Striga* (spp.) is widespread throughout cereal-producing areas of Africa, including West Africa, causing yield losses as high as 80 percent. *Striga* is prevalent on drought prone, low-fertility status soils and is a factor in abandonment of unproductive agricultural lands (Dugje et al., 2006; Stringer et al., 2007).

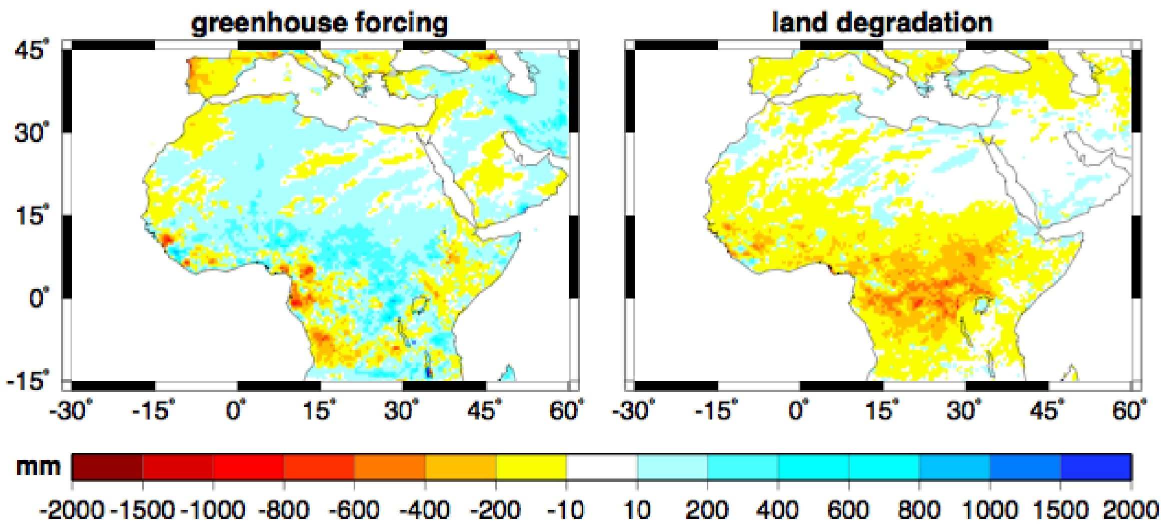
These various manifestations of land degradation strongly interact with climate variability and change in semi-arid and dry sub-humid systems that are water and nutrient limited and have short growing seasons. These include:

- More intense rainfall and higer winds that increase soil erosion and runoff, particularly on degraded lands.
- Reduced soil water holding capacity and higher soil temperatures on degraded lands that exacerbate negative effects of dry spells durations.
- High abiotic pressures (weeds, nematodes, striga, etc.) that diminish the tolerance of crops to water and heat stress.

Moreover, land degradation influences local and regional climate dynamics though changes in surface albedo, heat fluxes, and changes in evaporation and particulates that alter land surface energy balances and moisture transfer between land surface and the atmosphere (Paeth and Thamm, 2007). In Figure 13 below, these authors point to a potentially larger influence on medium-term regional climate change in Africa from increased land degradation as compared with increasing greenhouse gas concentrations.

Figure 13.

Estimated changes in annual precipitation in 2025 due to enhanced greenhouse gas concentrations (left) and from ongoing land degradation (right).



Source: Paeth and Thamm, 2007

Box 2

Decentralization, policy failures and resource governance

Decentralization of governance authority over natural resources management, while having potential to better address local management needs, has thus far largely not been successful as local governments are ill equipped, and do not hold discretionary power from the state, to assume responsibilities over natural resource management (Hilhorst 2008, Benjamin 2008). This lapse in governance brought on by decentralization has been attributed to an increase in degradation of forests and rangelands in Senegal, Northern Ghana, and Mali (Berry, 2009; Mbow et al., 2008; Skutsch and Ba, 2010), and has exacerbated tensions between farmers and pastoralists in Mali (Crane, 2010). One counterexample to these failures of decentralization is evident in Niger where devolution of tree ownership from the State to traditional authorities in the 1990s was an important factor in catalyzing reforestation and afforestation of croplands across more than a million hectares in southern Niger (Reij and Smaling, 2007; WRI, 2008). Localized tree ownership in turn catalyzed the emergence of markets for urban fuelwood and fodder-producing tree products.

Aside from incomplete decentralization, top-down policy interventions by the State also contribute to accelerated land degradation, as in the case of Senegal where state-initiated agricultural policies have driven land-use conversion pressures that have exacerbated exposure of farming communities to drought (Mbow, et al., 2008). In Burkina Faso, Mali and Ghana, top-down, highly standardized government policies affecting dryland forests prevent local communities from accessing forest resources that are important for helping them manage risks and adapt to climate change. These policies lack incentives to curb illegal incursions that contribute to dryland forest degradation (Fobissie et al., 2009; Kalame et al., 2009), or that consider the increased demand for charcoal production to meet household energy needs (Duku et al., 2011). Section 5.4 examines decentralization and adaptation in detail.

4.4.3 Large-scale land acquisition

Increased integration of global markets has increased external investments in Africa, which in turn present both perils and opportunities. One of the important concerns in West Africa and elsewhere in Africa is the emergence of long-term land-lease arrangements for large-scale production of export food crops and biofuels. These land deals in sub-Saharan Africa are often portrayed as land grabbing that is detrimental to smallholder farmers. While there is potential for large-scale land leases to spur investments that produce macro-level benefits in growth of GDP and government revenue (Cotula et al., 2009), the present reality is that such land-lease arrangements very often lack transparency and deprive existing landholders of traditional access to agricultural lands (Schoneveld et al., 2011).

The push for renewable energy sources under the Kyoto Framework catalyzed a surge in external land acquisition for Jatropha production. In Ghana, the government granted approval to the ScanFuel Company to cultivate Jatropha for biofuel production on 400,000 ha of land (Duku et al., 2011). However, these external pressures to initiate a biofuel industry in Ghana has been purely speculative given the absence of a domestic market or policy and regulatory framework for the industry (Antwi-Bediako, 2013). Moreover, loss of land for smallholder agriculture in favor of biofuel production increases pressure on adjacent fallow resulting in a net decrease in terrestrial carbon stocks (Schoneveld et al., 2011; Rasmussen et al., 2012). These external influences on Ghana's land base coincides with a transition from traditional to statutory land tenure systems initiated by the state, which has led to corruption in land allocation and increased land tenure insecurity for smallholder farmers (Ubink and Quan, 2008).

Cases of large-scale acquisitions of land are also occurring in Mali, such as in the Office du Niger area (Ségou region of south-central Mali). They include government-backed investments of the Libya Africa Investment Portfolio (LAP) aiming at developing commercial export agriculture through a subsidiary 100,000 ha of land (Clavreul, 2009); and an 11,000 ha allocation to a regional organization of which Mali is a member (UEMOA). Also in the Ségou region, Goulden and Few (2011) describe an irrigated sugarcane production scheme enabled by a public-private partnership between the Malian state and companies external to Mali, and financed by the African Development Bank. The 14,000 ha irrigated area that will encompass the Markala Sugar Project will result in the relocation of local communities and a reduction in land available for rainfed agriculture and pasture.

4.4.4 Changes in pastoralism

Reduced access to pastoral corridors and other changes underway in pastoralism across semi-arid West Africa exemplify how climate and non-climate drivers intersect to enhance vulnerability. As described by Nelson et al. (2007) "[C]ommon property systems characteristic of pastoralism are breaking down as privatization of the commons occurs. Sedentarization is resulting in reduced seasonal movements. Agriculture is encroaching on grasslands. Climate is changing and variability increasing. These factors do not necessarily individually and in isolation affect pastoralism nor do the responses occur in isolation, but rather they are the result of multiple people acting in response to multiple stresses." The role of the state in influencing pastoralist economies is diminishing as formal governance systems over land resource management devolve towards decentralization (Galvin, 2009); this has prompted pastoralist groups to advocate for a stronger role of the state in maintaining support for extensive pastoral resources (Crane, 2010; Dieye and Roy, 2012).

Diminution of rangeland productivity and forage quality in the Sahel, coupled with declining rainfall, contributes strongly to vulnerability of pastoralist livelihoods, and is playing an important role in spurring migration of pastoralists from the Sahel to the Guinea Savannah zone (Basset and Turner, 2007), and in the transition by pastoralists away from extensive livestock keeping in favor of crop production (Roncoli et al., 2008). Transhumance has historically played a strong role in managing risks associated with drought and rainfall seasonality, and its apparent decline is increasing vulnerability of pastoralists to drought in cases where options to diversify away from livestock keeping are limited (Traoré and Owiyo, 2013).

Herder-farmer conflict in West Africa has increased as northern pastoralists have extended further southwards into regions dominated by crop agriculture, while at the same time farmers have expanded crop production into lands used primarily by pastoralists (Crane, 2010; Obioha, 2009; Roncoli et al., 2008; Traoré and Owiyo, 2013; UNEP, 2011). In the Volta basin the most frequent cause of conflicts between farmers and herders is the destruction of crops and stored food by cattle. Box 3 describes perspectives on conflict gained through focus group discussions held in conjunction with this RDS.

Box 3

Local perspectives on pastoralist-farmer dynamics

Focus group discussions and key informant interviews held at the district level in southern Mali and northern Ghana (in conjunction with this RDS) revealed a local-level perspective on how the changing access to land is impacting pastoralists' livelihoods.

Participants in the Kouchiala district of southern Mali noted that the pressure on the land base has increased due to growing population density and subsequent number of nuclear families. In response to this increased pressure, the Union of Cooperatives of Livestock Sector came out with the initiative to delineate corridors for animals; however, as one farmer noted "*conflicts between farmers and pastoralists are common place in our region. There are corridors delineated for pastoralists but because of the land pressure these corridors are sometimes used by farmers as fields for growing their crops*." Interestingly, external efforts to promote rural development and adaptation may be hardening delineations of farmland with implications for herders: a Switzerland Cooperation-supported initiative is promoting Jatropha planting as additional income sources for farmers through local production of soap from the Jatropha grain. However, in addition to these benefits, the farmers are using the trees to delineate fields, which is believed to be a response to increasing conflicts over land use.

Fulaani herders interviewed in the Lawra District of northwestern Ghana noted:

"*Because we now move more widely from place to place in search of grazing land and water than we used to do, our livestock frequently experience different environmental conditions that pose risks for loss of weight, reduced milk output and spread of diseases. Access to veterinary service is an important limitation in addressing the spread of diseases because in the last ten years we move frequently. We used to access veterinary service every month. However, in recent times, the access has been reduced to twice in a year and further to once a year because of limited officers. Also bad farming practices, which encourage bush burning, is reducing the amount of grasses for our cattle*."

4.4.5 Disease burdens and malnutrition

The effects of climate on human health are manifested through climate-sensitive diseases, food and waterborne illnesses, and inadequate food and water that lead to malnutrition. A significant portion of West Africa's human disease burden results from climate-sensitive diseases such as meningitis, diarrhea, Leishmania, and malaria (Anderson et al., 2011; Halvorson et al., 11; Philippon et al., 2009; Sultan et al., 2005; UNDP, 2010). There are marked seasonal variations in outbreaks, with the disease burden being greatest during the dry season for many of these diseases. For example, the highest incidence of meningitis is observed in Ghana's northern region especially Upper West and Upper East (UNDP, 2010), and meningitis incidence is greatest during dry, hot, and dusty seasons (Codjoe and Nabie, 2014). Meningitis is among the most significant contributor to disasters caused by epidemics in Mali (Simonsson, 2005).

The relationship between climate variability and change and disease is complex particularly in West Africa where projections of future rainfall contain significant uncertainties. For example, the output of 19 GCMs predicted changes in rainfall that differ in their sign and range from a decline of 400% to an increase of 260%, making it difficult to predict the future of vectoral capacity for malaria in West Africa (Yamana and Eltahi, 2013). Epidemic meningitis may be extending southwards below the Sahel due to environmental changes (deforestation and desertification) though the exact role of climate change in range expansion of meningitis epidemics is uncertain (Savory et al., 2006).

Future increases in the rate of malnutrition in the region are expected to result from the both increased demographic and climatic changes. For example in Mali "approximately one quarter of a million children will suffer stunting, nearly two hundred thousand will be malnourished, and over one hundred thousand will become anemic" in the pastoral-farming transition zone by 2025 (Jankowskaa, 2012).

CHAPTER 5

Adaptation

Adaptation

5.1 Setting the context for adaptation

Groups viewed as being on the hard edge of vulnerability often prioritize the need to address fundamental development and security challenges well ahead of climate change adaptation (Speranza et al., 2008; Tschakert, 2007). Community-based studies from West Africa that were analyzed in this RDS further reinforced this observation, to the extent that communities prioritized many other concerns in addition to or above that of climate change. These concerns included *inter alia* lack of access to money, credit, and markets, poor educational opportunities, inadequate infrastructure, lack of rural employment, poor health, food insecurity, water access, declining soil fertility, land shortages, land tenure insecurity, agricultural pests and diseases, crime, conflict and political instability (Antwi-Agyei et al., 2012; Bah et al., 2003; Bé né et al., 2011; Bugri, 2008b; Dazé, 2007; Dieye and Roy, 2012; Djoudi and Brockhaus, 2011; Nielsen and Reenberg, 2010; Tschakert, 2007; Westerhoff and Smit, 2008; Wood et al., 2004).

While climate intersects with several of these concerns, addressing climate change is not the foremost priority, thus underscoring the need to consider adaptation in the broad context of vulnerability reduction and risk management rather than through focusing on prescriptive technologic options for adaptation. A development-centered vulnerability reduction approach is more robust in the face of future uncertainties and more durable with respect to addressing societal priorities in which climate change is amplifying other risks associated with poverty and underdevelopment.

5.2 Current risk management practices and their link to climate change adaptation

This section examines current options and practices for addressing food, water and livelihoods security that generate clear co-benefits for better managing climate risks and adapting to climate change. Issues examined in this section include those related to farming systems improvements, such as through soil and water conservation, irrigation and small reservoirs, and crop genetic improvement (sections 5.2.1-3); better management of natural areas that bolster livelihoods and help manage risk (section 5.2.4); and diversification and migration responses that are stimulated by both opportunities and stresses and that have a climate dimension embedded within other livelihoods concerns (sections 5.2 5-6).

5.2.1 Soil and water conservation in agriculture

(See Section 4.4.2 for an examination of land degradation related of relevance to this section.)

Conservation agriculture[4], within larger efforts at agricultural intensification, is an important response for ensuring food security that has clear links with adaptation to climate change. Key practices include timely access to fertilizer inputs, contour-ridge tillage, stone lines, tied ridges, terracing, crop residue management and mulching, *zaï* pits, agroforestry, farmer-managed natural

[4] Conservation agriculture refers to soil management practices that minimize soil disturbance, maintain soil cover and enhance agro-biodiversity.

regeneration of field trees, and rainwater harvesting (Barron et al., 2010; Bayala et al., 2012; Bhatari et al., 2008; Douxchamps et al., 2012; Hessel et al., 2009; Garrity et al., 2010; Lahmar et al., 2012; Larawnou and Saadou, 2011; La Rovere et al., 2008; Mdemu et al., 2009; Padgham, 2009; West et al., 2008; Yiridoe and Langyintuo, 2006). Conservation agriculture principally links to adaptation through its affects on reducing soil erosion and stormwater runoff and increasing soil water holding capacity, which enhances water productivity and helps to better bridge dry spells (Mdemu et al., 2009; Niang et al., 2014; Vohland and Barry, 2009).

The extent to which the above conservation practices have become normalized in dryland agroecosystems of West Africa is unclear. One important exemplar of positive large-scale change in semi-arid agricultural landscapes is in southern Niger, where farmer managed natural regeneration of field trees across more than a million hectares has shifted the trajectory of agricultural landscapes towards restoration and resilience (WRI, 2008; Larwanou and Saadou, 2011). Improved land tenure security, decentralization of tree ownership from the state to local communities, the presence of markets for fodder tree products, together with the abatement of severe drought conditions in the Sahel contributed to this transformative change. A common counternarrative to this success story is where lack of land tenure security creates a strong disincentive for investment in land improvements as in the case of Mali (Ebi et al., 2011) and undermines the ability to use land resources to manage shocks, as in the case of Burkina Faso and northern Ghana (Kalame et al., 2008). Box 4 describes local perspectives on conservation agriculture and adaptation that were derived through focus group discussions held in conjunction with the RDS.

Box 4

Local perspectives on conservation agriculture and adaptation

Information from focus group discussions and key informant interviews held at the district level in southern Mali and northern Ghana (in conjunction with this RDS) demonstrate strong recognition by farmers of the link between resource degradation and climate risks, and the efforts underway, largely by local actors with minor support from the state, to implement more sustainable land management practices.

In a discussion on local adaptation responses held with farmers, extension agents and NGOs in the Koutiala District in southern Mali participants emphasized the important role that the cotton company is playing in promoting anti-erosion practices in the region, which include planting of Cailcedrat and Teck trees, establishment of stone lines, and incorporation of crop residues in soils to enhance soil moisture retention. Given the economic importance of cotton, this effort has been aided by extension agents and NGOs. Such support is not the case in areas where cereals and other basic commodities are produced. Tree planting is also an important focus of NGO-led activities in the Koutiala District. For example, women's cooperatives are becoming increasingly involved in shea butter processing as well as producing shea seedlings to diversify their income sources. Jatropha seeds are used in soap making and harvesting of jujubier fruits provide additional sources of income for women.

In the three northern Ghana districts (Lawra, Nandom and Jirapa), there was strong recognition that unsustainable land management practices related to poor soil organic matter management, increased reliance on chemical fertilizers, bush burning, and felling of trees in fields, are diminishing the soil resource base and contributing to drought risks and high soil temperatures. Programs initiated through the Ministry of Food and Agriculture and local NGOs are playing a positive role in helping farmers to identify problems and provide solutions, such as in the areas of soil management (though stone lines and Zaï pits), water conservation, sustainable fuelwood extraction, fire management, use of improved crop varieties, etc. Due to the limited access to planned adaptation strategies, one farmer noted "*In our own way, we have started practicing sustainable land and water management in some of the communities and we are now using these communities as learning points for other farmers elsewhere*." (Though there were also widely expressed misgivings about the way NGOs interface with communities, see Section Box 10.)

In both Mali and Ghana local perceptions of climate change revolve around changes in the quality of the rainy season. Farmers note that rains are coming later, long soaking rains are becoming less frequent, as rainfall seems to produce lower volumes and there are more heavy rains that destroy crops and infrastructure. Water sources are becoming scarcer, grasslands for animals less productive, and crop yields are declining. It is of course unclear the extent to which these changes can be attributed to climate change but the motivation to act is certainly being driven by the climate change discourse that has permeated down to the local level.

5.2.2 Water management—small reservoirs and irrigation

(See Section 4.3.a for a related discussion of water withdrawals and surface water hydrology.)

Small reservoirs are another important risk management strategy widely deployed in West Africa. Small reservoirs offer multiple-use potential to better meet household and livestock water needs, and to expand irrigation to diversify towards high-value market production and thus reduce reliance on climate-sensitive rainfed production. Such structures could offer a viable mechanism for expanding irrigation in the region appropriate with adaptation goals, though there are potential downside risks related to upstream-downstream water resource access. There has been a significant investment in small reservoirs throughout Burkina Faso and Ghana over the last few decades (Bharati et al., 2008; van de Giesen et al., 2010). With over 1,050 small and medium-scale reservoirs, Burkina Faso has one of highest density of reservoirs in the region (Leemhuis et al., 2009), and in northern Ghana there are nearly 950 small reservoirs and dugouts (Namara et al., 2010).

Farmers are increasingly adopting irrigation in response to climate risks and market opportunities (Gueneau and Robinson, 2014; Namara et al., 2011). Out of the 22 large public irrigations projects in Ghana three are in Northern Region, two in Upper East and none in Upper West Region, yet groundwater irrigation is the major source of water for dry season farming in northern Ghana because of scarcity of surface water. Shallow groundwater irrigation (SGI) is an example for a purely farmer driven innovation without any involvement of state agencies, NGOs or (international) donor organizations (Schraven, 2010). Pilot communal borehole irrigation systems were developed in the Upper East. Upper West, and Northern regions of Ghana in 2000 under the Village Infrastructure Project of the Ministry of Food and Agriculture (MOFA). Table 4 summarizes the irrigation responses in northern Ghana provided through NGOs, CBOs, and donor projects

Table 4: Number of irrigation responses in Northern Ghana

REGION	NUMBER **Small dams**	**Dugouts**	TOTAL	LAND AREA (HA)
Upper West	84	54	138	712
Upper East	149	129	278	895
Northern	131	398	529	649
Total	364	581	945	2,256

Source: Namara et al., 2010, 2011

Major barriers to participation in irrigation development and related responses include the availability and transportation of material, work load and input costs such as for pumps and accessories (Agyare et al., 2009), insecurity in land tenure, maintenance and use of communal infrastructures, traditional customs that hinder uptake of new technologies (Laube, 2009), lack of affordability of irrigation at the household level (Lagger, 2011; Green, 2008), especially for women (Nation, 2010), lack of access to information and limited institutional support and capacity. Some NGOs such as International Development Enterprises (iDE) are working to reduce cost barriers to participation in irrigation by linking farmers to micro finance institutions to access loans (Lagger, 2011).

The ongoing implementation of Integrated Water Management Plans, such as that initiated by the Ghana Water Resource Commission through support from the Danish International Development

Agency, provides an avenue to address climate change adaptation needs. Major government actors include the District Assembly, White Volta Basin Board, Water Resource Commission, Environmental Protection Agency (EPA), the Ghana Irrigation Development Authority (GIDA), Community Water and Sanitation Agency, and Ghana Water Company Limited. NGOs both local and international play key roles, especially with funding and implementation.

However, the existing institutional arrangements such as NADMO, WRC, GMet, White Volta Basin Board, and NGOs need to be coordinated towards a common platform for climate-water dialogue because despite the potential for significant information generation across these various stakeholders groups, access, flow and sharing of information is weak (Schiffer, et al., 2008). Moreover, the way schemes are developed and implemented is dependent on the roles and influence of different actors (governments, local authorities, local communities and donors). For instance, MoFA (2007) noted that institutional mandate and governance system for private sector involvement in irrigation is unclear. Similarly, governance mechanisms cater mainly for public irrigation schemes while many informal schemes are not integrated into irrigation planning (Evans et al., 2012).

5.2.3 Crop genetic improvement

Genetic improvement of existing crop varieties for enhanced drought and high temperature tolerance and faster maturing genotypes are being widely promoted as an adaptation strategy in rainfed agriculture areas. Reduced length of the growing period (LGP) as a result of climate change is a concern across Africa (Thornton et al., 2010), and thus 'short-duration' crop varieties are viewed as an important response for managing climate risks, including in West Africa (Barbier et al., 2009; Laube et al., 2012; van de Giesen et al., 2010).

The deployment of shorter-duration crop varieties has become prominent in several areas of Burkina Faso, Mali, Ghana, and Senegal. For instance, one farmer interviewed in the Koutiala District in Southern Mali (in conjunction with this Regional Diagnostic Study) noted "*When I compare our current agricultural practices to what we used to do just a few years back I see many changes. Most of the farmers are now growing early maturing varieties of maize, sorghum and millet, because the duration of the rainy season is becoming shorter*." Similarly a farmer in northwestern Ghana noted that "*one day I went to MOFA [Ministry of Food and Agriculture] and told them that now the rain comes late and when it rains for about 3 months. MOFA asked me to use 75-day maize on my farm. That year I had good yield. Since then, I have been using this type of maize. I told my friends about it.*"

However it is unclear whether the risk that short-duration varieties is trying to address is from a reduction in LGP or more fundamentally be the result of a decrease in average plant available water associated with cropland expansion onto marginal soils (Haussmann et al., 2012). While long-term climate change projections indicate reduced growing season length, the present reality is that growing seasons in West Africa are quite variable. Thus, overreliance on short-duration varieties as a 'solution' to climate change may represent a technological lock-in for farmers that increases their risks, as in the case of Senegal where late season rains resulted in high crop spoilage losses where short-duration varieties were widely promoted (Tschakert, 2007). Moreover, agricultural landscapes in West Africa have high micro-variability in biophysical characteristics that require flexible management strategies, ones that rely on both landraces and improved varieties.

There are important downside risks associated with an increasing reliance on short-duration varieties, which require careful consideration in developing breeding programs in complex landscapes. These include:

- *Over-emphasis on relatively tenuous components of historical climate change*: When comparing historical station data for the [1951-70] and [1971-90] climatic cycles, these two periods representing the wettest and driest on record, the average reduction in the LGP from the most extreme observed dry period is in the order of a 5 days, which hardly bears any significant impact upon crop performance because of high levels of phenotypic plasticity (ability of crop plants to alter growth in response to environmental stress), and the fact that farmers avoid risk through different varieties and planting schedules. For future climate change, Singh et al (2014) showed that longer (not shorter) crop durations offsetting temperature increases and maintaining the crop cycle constant should result in yield increases for sorghum, particularly if they are combined with higher heat tolerance.
- *Decreasing varietal fitness to climate variability*: If reducing the average cycle of the crop yields only marginal benefits, these may be negatively offset by the increased risk of making a plant more susceptible to climate variability, which often comes with shorter cycles. Indeed, the push towards greater use of short-duration varieties has resulted in photoperiod sensitivity being largely bred out of modern varieties (Dingkuhn et al. 2006; Folliard et al., 2004), creating genotypes that may arguably be more adapted *on the average*, but are in fact dramatically more maladapted to inter-annual variability in LGP, which remains essentially stationary between wetting and desiccation cycles; preserving continued adaptation to inter-annual variability is a prerequisite to adapting to climate change (Washington et al., 2006; Haussmann et al., 2012).
- Under-estimating the potential new biotic stresses brought about by shorter-duration varieties within the larger biophysical system. At a production systems level, a new maturity group can potentially disrupt existing ecological equilibrium and the distribution of environments amenable to pest or weed development. The alteration of the local landscape genetic build-up is one hypothesis behind the locally significant resurgence of sorghum midge in the Fada Ngourma region of Burkina Faso, where the effective introduction of short-duration varieties may have led to the co-existence with native, longer-maturing ecotypes, and promoted the proliferation of pest populations through staggered flowering windows.
- *More generally, overlooking the complexity of the socio-economic context in which smallholder farmers operate* can short circuit efforts to develop appropriate crop varieties. Farmers have to find the adequate balance between changing production environments, market conditions, food preferences, storage characteristics, and various households' needs. Although some 'promising' technologies are proposed, farmers do necessarily adopt them because of the diversity of variables that enter into choice of crop varieties. For example, Totin el al. (2013) reported that despite all the effort that has been put into promoting the short-duration (90-days) rice variety, Nerica-4, farmers in Benin continue to produce their local rice with 120 days growing cycle because of its higher yields, its taste and its market value. This example illustrates the need to account for the complex and dynamic context of

smallholder farming rather than simply developing a variety around how it improves a particular production factor.

A study by Sultan et al. (2013) for West Africa reported that any positive effects on cereal crop yields resulting from a future increase in precipitation would be more than countermanded by yield loss from high temperature stress. The negative effects of high temperatures are expected be stronger in the Savannah than in the Sahel, and impact modern cereal varieties more than landraces. Crop modeling of maize, millet and peanut cultivars adapted for constant crop cycle, improved root distribution and water extraction potential were shown to offset some of the negative impacts of climate change with, in some circumstances, a net positive impact of climate change adaptation (Adiku et al., 2015). These findings highlight the importance of looking at various other traits for adaptation to within-season variability, beyond the misleadingly simple focus on reducing the crop cycle length.

5.2.4 Access to seasonal weather and climate information

Seasonal climate forecasts and long-range weather forecasts are viewed as an important tool for bolstering climate risk management capabilities, particularly in rainfed agriculture and particularly during periods of a strong El Niño or El Niña that tend to conincide with unusually wet or dry years (Sivakumar and Hansen, 2007). Regional climate outlook forums (COFs) for developing concensus seasonal forecasts were developed in the late 1990s and have become commmonplace in Western, Eastern and Southern Africa. However, seasonal climate forecasts generated through the COFs have had notably mixed results with instances of modest success and remarkable failure (Patt et al., 2007). Mostly though seasonal forecasts have not realized their potential in Africa because they are presented in a way that is not actionable (i.e. tercile forecasts of above, normal of below normal rainfall presented probabistically at regional scales); the forecast-development process lacks sufficient input from, and coordination with, end users; and end users lack understanding of, or trust in, the forecasts and thus do not act on the information (Ibid; Roncoli et al., 2008).

Mali is often noted as one of the exceptional countries in West Africa with respect to its use of seasonal climate information in the agricultural sector. For example, the Mali Meteorological Service has had a long-running program in which they give rain gauges to farmers so that farmers can use *in-situ* rainfall measurements in conjunction with weather advisories from the met services to make decisions about planting dates and varieties to plant (USAID, 2014). In turn, the rain gauge data collected by farmers is conveyed back to the met services and to a multi-agency *Groupe de Travail Pluridisciplinaire d'Assistance Agrométéorologique*, which feeds this information to agricultural services agencies within the government. Though this is a good model for use of seasonal climate data, the reality is that use of agrometeorological advisories by farmers in Mali is still quite low, due largely to the persistent mismatch of the quality and type of information supplied to the complex decision making needs of end users (Ibid). Moreover elite capture of technologies, a common problem in Africa, is evident in this case as user groups tend to be heavily skewed towards male farmers with wealth and assets, and women farmers are largely excluded as there are no advisories tailored to crops that women cultivate.

No recent reviews of the Ghana Meteorological Service were available during the period that this RDS was compiled. However, one innovative approach in northern Ghana appears to be helping to advance use of climate information. This program involves bundling climate information with other information needs was introduced by CCAFS through the work of the NGO ESOKO in northern Ghana.

The CCAFS/ESOKO program provides weather forecasts together with recommendations about when to prepare lands and plant, and when to harvest, via mobile phones in all local languages. With a short code of 1900 a farmer can call for information and the call centre of ESOKO can response in local languages at very inexpensive call rates. ESOKO sends text messages to farmers regarding weather forecast and other climate related information as well as prices of commodities and where to buy seeds. Farmers are also allowed to report any agriculture related information to ESOKO. As reported at the focus group discussions with farmers in northern Ghana, it is now common to hear 'what is ESOKO saying today' among farmers. (Information in this paragraph derived through focus group discussions.)

5.2.5 Forest management

(See Section 4.4.2 and Box 2 for an examination of vulnerabilities facing forests and forest-dependent communities.)

Dryland forest management strategies that emphasize fire control, non-timber forest products conservation, and forest genetic diversity provide a link between current risk management and potential adaptation responses to climate change. While adaptation is not an explicit component of forest management in West Africa, Kalame et al. (2009) point to elements of risk management in current forest policies in Burkina Faso and Ghana that are relevant to adaptation in dryland forest ecosystems. These include such measures as enhanced fire management, increased forest genetic resources, non-timber resource conservation, tree regeneration and improved silvicultural practices. The authors note that "Their implementation will require experienced and well-trained forestry personnel, financial resources, socio-cultural and political dimensions, and the political will of decision makers to act appropriately by formulating necessary policies and mainstreaming adaptation into forest policy and management planning."

The positioning of forest management in the overall framing of adaptation extends beyond 'best management practices' for forest health to encompass the integration of communities in sustainable use of forests, to the extent that community-based forest management provides options for expanding livelihoods security particularly for women and the poor (Gyampoh, et al., 2009; Kalame et al., 2008). Land-use conflicts, land tenure insecurity and ambiguities in access to forest resources, and top-down policy directives that are incompatible with localized resource management are important impediments to advancing adaptation within sustainable forest management in West Africa (Brockhaus et al., 2013; Kalame, et al., 2008; Mbow et al., 2008).

Community forest management – embracing various degrees of community involvement, including arrangements such as participatory forest management, joint forest management, co- management and community-based forest management – can contribute to reducing forest degradation and thus stabilizing or enhancing forest carbon stocks and conserving other ecosystem services (Roe et al. 2009). The production and sale of gums and resins, medicinal plants, honey and beeswax, bushmeat and other non-timber forest products contribute considerably to local economies (IFAD 2008). Often it is the poorest groups in rural communities that are most dependent on forests for fruits, seeds and bushmeat, which take on greater importance for food security during periods of famine (Ndao 2014; Lamien & Vognan 2001).

5.2.6 Farming system and livelihoods diversification

Diversification of farming system and livelihoods is another example of a risk management strategy with clear implications for adapting to climate change. In Burkina Faso, for example, communities are diversifying away from high reliance on climate sensitive crop and livestock production (Nielsen and Reenberg, 2010; Traoré and Owiyo, 2013; West et al., 2008), though the extent to which climate is driving this diversification versus that of other socio-ecological and economic factors is not clear. In Burkina Faso, recent agricultural intensification and diversification efforts seem to be motivated more by increasing land scarcity and new market opportunities than by climate risks (Barbier et al., 2009). Similarly in northern Ghana, increasing demand from urban markets, not climate risks, is spurring diversification towards irrigated vegetable production (Laube et al., 2012), and towards trading and other non-farm income sources (Assan et al., 2009). Charcoal production also provides an important source of livelihoods diversification in northern Ghana though one with important environmental downsides (Kalame et al., 2008). As noted by Mertz et al. (2009) in Senegal "[c]hange in land use and livelihood strategies is driven by adaptation to a range of factors of which climate appears not to be the most important. Implications for policymaking on agricultural and economic development will be to focus on providing flexible options rather than specific solutions to uncertain climate."

Following on this observation, the complexities underlying system diversification point to the need for better understanding critical development factors, such as access to roads, markets, extension, and credit, that catalyze or constrain actions towards diversification and other means of risk management and adaptation. There are several examples in the adaptation literature from West Africa that underscore this point. In northern Nigeria, the adoption of drought tolerant maize varieties is constrained by the inability of farmers to afford seed and complementary inputs that would make the use of drought tolerant varieties feasible (Tambo and Abdoulaye, 2012). In the northern Nigeria case and in southern Mali, lack of access to extension services was a key impediment to diversification away from climate sensitive crops (Ebi et al., 2011). In Senegal, improved infrastructure for seed, fertilizer and pesticide distribution, irrigation, functional credit and insurance institutions and market access were identified as critical factors that need to be in place in order to advance climate change adaptation efforts (Dieye and Roy, 2012; Mertz et al., 2011). Similarly in northern Ghana and Burkina Faso, improving transport infrastructure to link food producing areas to markets (Codjoe et al., 2012) and access to credit to spur investment in irrigated vegetable production (Barbier et al., 2009) were viewed as critical. Remittances are also an important livelihoods strategy with implications for diversification(Barbier et al., 2009; Laube et al., 2012; Mertz et al., 2011) though there are significant knowledge gaps as to their relative importance.

The agro-climatic zone has a strong bearing on options that people have for diversifying systems and managing risk. In a study in Senegal, Mertz et al. (2011) noted that "[i]n the driest zone, people resort to prayer as well as increased food purchase and migration, both of which corroborate the trend away from agriculture. People in the intermediate zone have an even stronger focus on migration, but are also engaged in livelihood diversification and reforestation. The latter probably reflects the intensity of agriculture in this zone and the perceived need for more trees in the landscape to assist with the restoration of land productivity. In the wettest of the three areas there is a strong perceived need to improve agriculture by fertilization and soil and water conservation. Only in this zone did household responses indicate a continued potential for profitable agriculture."

5.2.7 Health responses

Responses to climate-sensitive diseases are generally reactive and take the form of mass vaccinations, awareness raising and modification in living environments. For meningitis, Codjoe and Nabie, (2014) note that communities have high acceptance for mass immunization either before or during outbreaks. Some communities also adopt a moderation of cultural practices that usually occur with mass gathering of people (funeral, festival, marriage and birth naming ceremonies) during outbreaks with general restrictions in movement. Autonomous responses by households usually include expansion in the number of windows, addition of fans, and reduction in room occupancy rates. The traditional cooking stocks both for indoor and outdoor cooking generate high amount of heat thereby worsening the conditions for meningitis. Some households in response have adopted an improved clay-based cooking stove that uses small amount of charcoal and processes relatively small heat. There are also other planned adaptations to meningitis in the form of afforestation and preservation of greenery in rural neighborhoods to create cooler microclimates.

For malaria, response strategies take the form of acquisition of mosquito insecticide treated nets (ITNs), indoor and outdoor insecticide applications, case management, and capacity building (President's Malaria Initiative, 2014). Some households also use the indoor residual spraying to control malaria. Surveillance of and control in dry season shelters of *Anopheles* spp. was found to be important in Mali (Lehmann et al., 2014). A recent study reported that the level of formal education is the major mitigation factor to the incidence of malaria in Ghana (Akpalu and Codjoe, 2013). The study also points out that middle-income household are more likely to suffer from malaria. Policies on malaria the require a focus on education and up scaling the distribution of insecticide nets to both poor and middle-income households. More generally (beyond that of malaria) awareness of disease transmission is an important impediment, as in the case of the inland delta of the Niger River in Mali, where local awareness of the relationship between poor water quality, oral-fecal disease transmission, and waterborne disease is low (Halvorson et al., 2011).

In 2002, Government of Ghana adopted technical guidelines for the integration of disease surveillance and responses (Government of Ghana *et al,* 2002). More than a decade later, transportation of meningitis and malaria cases remains a challenge in most rural areas because of limited means of transport. Quite often bicycle- ambulance and donkeys-carts are used as transport carriers (Heyen-Perschon, 2005). A National Malaria Behavior Change Communication strategy was implemented in 2010 as a means for raising awareness about malaria and to mobilize change in how communities and local governments respond.

Currently, there is no holistic and well-established governance architecture for climate change and health. The existing coordination, information flow, and decision-making processes are on project and programme basis. At the local level, major actors in health include the Ghana Health Service (District Health Directorate), District Assembly, EPA, NADMO, Community Water and Sanitation Agency, Traditional Authorities, NGOs (especially CARE International, Plan International), donors (eg. DANIDA, DFID) and private sector, mainly AngloGold Ashanti. However, these actors do not have a common platform for climate change-health dialogues, negotiations and consensus building at the local level. The capacity of both technical and institutional stakeholders at the local level (i.e. Ghana Health Service, District Assembly, EPA) to respond to climate-related health risks and adaptation in local plans and implementation is limited, reactive and isolated (UNDP, 2010). A review of 41 NAPAs (Manga et al., 2010) showed that 39 (95%) countries in Africa consider health as being a key sector that will be impacted by climate change. However, only 23% (9/39) of these NAPAs were considered to be comprehensive in their health-vulnerability assessment. Box 5 describes recommendations to encourage closer links between health and climate science communities.

Box 5

Recommendations for forging closer links between health and climate experts

Given that the distribution and cycle of many infectious diseases in Africa are influenced by climate, incorporating climate information into epidemic response measures could help to reduce the substantial toll that high disease burdens exact on development. Currently, the lack of timely and relevant information about the important seasonal climatic conditions that drive disease dynamics hampers the ability of public health services to respond effectively through epidemic early warning systems and other means. Addressing this critical information gap by integrating relevant and actionable climate information into disease control strategies could help to build foundational capacities for adapting disease control strategies to emerging risks linked to climate change.

A workshop to examine how climate information can be better utilized to inform the management of climate-sensitive diseases in West Africa was held in Ouagadougou, Burkina Faso in 2012 (START, 2012). The workshop involved 35 participants from 10 West African countries, and featured a range of expertise including climatology, meteorology, hydrology, disease epidemiology, public health management, and mass media/communications. Key recommendations from this workshop included:

- Avenues for channeling demand for health-relevant climate data and forecasting products need to be identified, sensitized, and exploited more fully if countries are to move from business as usual tercile probabilities of above-normal, normal, and below-normal seasonal rainfall quantities at regional scales, which are basically useless for disease early warning, to products that provide actionable information. This would include forecasts an bulletins on temperature, humidity, seasonal rainfall characteristics, and wind speed and direction, and at spatial aggregations where disease management decisions are made, such as at district levels as opposed to seasonal forecasts at regional scales.
- The health community in West Africa needs to innovate with respect to the types of data it collects, and how it collects them so that it can use climate information more effectively. As it currently stands, the health community is ill equipped to know what climate information to demand, and to have appropriate and sufficient health data to use climate information effectively.
- Lack of access to relevant sectoral and climatic data presents a significant impediment to developing robust disease management responses. Measures need to be put in place that addresses the need for open data policies.
- A common platform for understanding, communicating and implementing results is needed. Aligning data sets where possible between health and climate would be useful for knowledge generation that supports a platform.
- Institutional structures and arrangements need to be put in place that enable and encourage collaboration between relevant government ministries, which lead to more integrated responses to disease outbreaks. Ministerial silos, such as between national meteorological services and health, create disincentives for coordinated, integrated action.

5.2.8 Migration

Migration has a long historic relationship with risk management and livelihoods, and has been an important coping strategy in West Africa in response to climate variability and other stressors (Broekhuis et al., 2004; Dietz et al., 2004; Van der Geest, 2004). In Ghana, migration has primarily been from the north to the forest-savannah transition and forest zones (Awumbila and Tsikata, 2007). Seasonal labour migration has served as a temporary coping strategy for drought and other stressors,, especially in the Upper East Region of northern Ghana (Schraven, 2010). The poor performance of the agricultural sector is an important factor in labour migration out of rural areas (Antwi-Agyei et al., 2012). A household survey conducted by Rademacher-Schulz & Mahama (2012) showed that the most important reasons for migration by order of importance are: the decline in crop production for own consumption; shifts in the rainy season; unemployment; longer drought periods followed by unreliable harvest; and increase in drought frequency.

In Ghana, the main destinations for migration are the Brong Ahafo Region and Ashanti Region due to the bimodal rainfall and relatively fertile lands compared with the northern part of Ghana. The main economic activities of the migrants in these new destinations are farming and mining. Gold mining areas across the country in particular attract young seasonal migrants. Also seasonal migrants work as farm labourers, whereas long-term migrants attempt to establish their own farms (Rademacher-Schulz & Mahama, 2012).

In the Lake Faguibine area in Mali migration is an important risk management strategy for men; however women in this area perceive this strategy more as a cause of vulnerability than an adaptive strategy (Djoudi and Brockhaus, 2011). Many of the old established routes still exist, for example labourers and pastoralists migrating seasonally from the north to the south and longer term migrations to mines and plantations (Van der Geest, 2004). Migration has important positive aspects in West Africa related to remittances flows between urban and rural areas (Barbier, 2009; Mertz et al., 2011; Nielsen and Reenberg, 2010; West et al., 2008), though in some areas profitability of migration is decreasing and risks to migrants are increasing (Laube et al., 2012).

While climate may be a factor in stimulating migration, there are a number of important economic, political, demographic, social and environmental dimensions at play as well. Studies from Ghana indicate that seasonal migration can actually be greater in good years than in drought years (Black, et al., 2011), and that environmental resource scarcity, economic factors and conflict can be a larger push factor than drought per se in influencing migration (Lawson et al. 2012; Tschakert and Tutu, 2010; van der Geest, 2011). The role that climate plays in regional migration dynamics may become more prominent as impacts of climate change intensify in the coming decades (Scheffran et al., 2012). However an important challenge in understanding the climate role in migration is in understanding how impacts of a changing climate will interact with a constellation of other migration drivers in both the source and destination areas (Black et al., 2011; Foresight, 2011; Garcia et. al. 2015; Lawson et al. 2012).

Migration and who is left behind was an important point of engagement during the focus group discussions held in northern Ghana in March 2015, as exemplified by the following statements.

When we enter the dry season, the men leave to house and go to the south to work. The women and children will have to stay and getting food is very difficult during the dry season.

A woman from Jirapa, Ghana

The old people in the community suffer the most. The young ones migrate to the south leaving the old people. These old people cannot farm well. When they fall sick there is nobody to send them to the hospital. At time if a thief comes to steal the old man's animals, he cannot fight the thief but to shout. Look at how the houses are scattered. Nobody can hear you shouting.

A man from Nandom, Ghana

5.3 Gender

5.3.1 An examination of gender in vulnerability and adaptation

Low-income women, female-headed households, the elderly and children face significant vulnerabilities that predispose them to climate impacts and limit their abilities to adapt to increasing environmental stresses including those associated with climate change (AAP, 2011; Carr and Thompson. 2013; CARE, 2011; Mensah-Kutin, 2010). Women in rural Africa contend with unique vulnerabilities stemming from historical social inequalities, ascribed social and economic roles that manifest in unequal access to resources and decision-making processes, reduced access to information, ineffective property rights and reduced mobility (AAP, 2011). Specific areas of inequality in relation to adaptation include women's limited access to and control of land, women's high household burdens that include responsibility for water and fuelwood collection, high levels of responsibility for agricultural production, greater economic insecurity and rates of poverty relative to men, and lack of access to formal education (Kutin, 2011; Bugri, 2008a; Rademacher-Schulz and Mahama, 2012; CARE, 2011; MESTI, 2013). The increasing feminization of agriculture in West Africa (resulting from male migration and other societal changes) demands a response to address gendered inequalities in women's access to land, extension and financial services, and other resources to support agriculturally based livelihoods (de Schutter, 2013; World Bank and IFPRI, 2010).

Gender disparities in wage and employment are an important facet of vulnerability (Heintz and Pickbourne, 2012; Hampel-Milagrosa, 2011). For example women agricultural wage labourers are paid between a third and a half of male rates in northeast Ghana (Whitehead, 2009). The higher wage rates for men provide a greater potential to buffer difficult periods and, along with other assets, make it easier for them to invest in alternative livelihoods (CARE, 2011). Gendered social norms obviously play an important role in migration resulting in culture and gender being important barriers to migration for some groups (Nielsen and Reenberg, 2010; Van der Geest, 2004), though in recent years there has been an increase in young females migrating in search of economic opportunities. During the focus group discussion in Jirapa, discussants mentioned that women also migrated to the south to work as head porters during the dry season and returned in time to prepare the land for the next farming season.

Women's inability to own land affects their livelihoods, income, access to credit, food and nutrition security and access to energy, as well as their coping and adaptive capacities (WEDO, 2008). For example, in Mali approximately 5 percent of landowners are women (UNDP, 2012), and in Senegal only 13 percent of landowners are women, despite the fact that over 70 percent of women are involved in agriculture (Dankelman et al, 2008). Women farmers have difficulties accessing high quality lands and irrigation sources (Agana, 2012). However, factors additional to lack of land ownership, including intra-household dynamics and agricultural commodification, play a role in constraining women's participation in irrigated agriculture in West Africa (Nation, 2010). In northern

Mali, increased aridity, leading to loss of arable land, and diminished access to new land allocations, has increased workloads on women and has heightened their vulnerability to drought (Djoudi and Brockhaus, 2011).

Traditional laws dealing with inheritance have contributed to land ownership inequalities, resulting in unequal power relations between men and women in accessing, owning and controlling resources (Agana, 2012; Bugri, 2008a; World Bank, 2005; Carr and Thompson, 2013). The patrilineal system of inheritance is found in many parts of West Africa including Northern Ghana and Mali (Tsikata, 2001; Rademacher-Schulz and Mahama, 2012; Carr and Thompson. 2013; CARE, 2011; Djoudi and Brockhaus, 2011), where access to land is mediated by men who also control the decision-making powers in allocation of resources within the household (Rademacher-Schulz and Mahama, 2012).

In the focus group discussion in Lawra, northern Ghana, the major gender issue concerned access to secure and fertile lands for vulnerable groups. The participants described how women are given bare and low fertile lands to farm. In instances where they improve the agricultural productivity of the land, men are liable to take the land back, though men also suffer the same fate from the hands of landowners. Similarly, in the Jirapa district women are given land in valley bottoms that are only suitable for rice cultivation. In situations where women have bumper rice harvests in the valleys, they are susceptible to having their land taken over by men.

As elsewhere in conservative rural societies, customary practices proscribe norms about what men and women can do on the farm. Millet, an important staple crop in northern Ghana, is viewed as a male crop, and among the Dagombas and Kusasis of northern Ghana, men are obliged to provide starchy staples such as millet, maize, and yams (Baglund, 2013; Padmanabhan, 2004). In Mali, men grow grains and cash crops like cotton, while women grow vegetable crops (Djoudi and Brockhaus, 2011). These cultural distinctions in cropping practices clearly demonstrates the need for gender aware adaptation strategies.

Livelihood strategies complementary to agriculture are also quite gender determined; for example, in northern Ghana women are most likely to be engaged in Shea butter extraction, tailoring and brewing of local alcohol, while men practice carpentry, teaching and weaving to supplement incomes from agricultural activities (CARE, 2011). Financial services such as savings and credit can play an important role in creating opportunities for people to diversify their livelihoods; however, women's access to credit is less than that of men. The result of this "genderification" of livelihoods, combined with men's advantages in accessing land, education and credit, is that men typically have more money and other assets than women, and with it an advantage in buffering risks and investing in alternative livelihoods sources (CARE, 2011).

While changing long-held attitudinal beliefs towards gender inequality is desirable, the significant cultural barriers to initiating systemic measures, such as those related to gender and land tenure, require a pragmatic approach to creating opportunities for alternative income generating activities that consider time and labor management (Resurrección, 2013). At a strategic planning level, changing the starting point for developing gender-responsive climate change policies needs to focus on the analyses of local social, economic and political situations in tandem with generating knowledge on broad adaptation to changes, including but not exclusive to climate change (Okali and Naess, 2013). In West Africa, the CGIAR's Climate Change, Agriculture, and Food Security (CCAFS) initiative, which is operating in Mali, Ghana, Senegal, Burkina Faso and Niger, aims to "increase control by women and other marginalized groups of assets, inputs, decision-making and benefits".

CCAFS together with the FAO have initiated pilot efforts to understand how to tailor climate smart agricultural practices to the needs of different groups. Related to this effort, the focus group discussions in northern Ghana with farmers and women's groups described how most the current forms of modern agriculture implements (e.g. tractors) are not gender sensitive because they are complex, difficult, heavy and otherwise inappropriate for women to operate. Box 6 describes perspectives on gender and climate change that were derived through focus group discussions held in Ghana in conjunction with the RDS.

5.3.2 *Other differentiated forms of vulnerability*

Concerns around gender and development and around gender and adaptation very often fail to account for other forms of differentiation and disadvantage, such as those based on class, age, and ethnicity; as stated by Demetriades and Esplen (2008) "Intersecting inequalities produce differing experiences of power and powerlessness between and among diverse groups of women and men." The issue of youth and climate change has received scant attention relative to that of gender but it is an important concern given the large rate of growth in the next few decades of population under 20 years of age (AFDB, 2012). State interventions in Africa that protect women, youth, and the elderly in the aftermath of extreme events are sporadic and severely under resourced relative to the scope of the problem (Zawedde, 2011). Moreover, many youth are highly dependent on natural resources and are thus sensitive to extreme events. Yet apart from a few blogs (e.g. http://abibimman.blogspot.com/2013/03/climate-change-in-Ghana-has-become.html; http://agricinGhana.com/tag/African-youth-initiative-on-climate-change-ayicc/; http://www.yveGhana.org/?p=112) there is little published information on how youth are adapting to climate change in West Africa. A focus group discussion in northern Ghana held in conjunction with this RDS noted that increasingly limited avenues for food production are contributing to youth being forced to migrate south.

Box 6

Differing perspectives on progress in addressing gender disparities

Participants at the national experts meeting in Accra, Ghana (in conjunction with the RDS) identified the existence of gender mainstreaming strategies in many sectors as a positive contribution to the inclusion of gender in climate change adaptation plans. Most sectors also have gender policies, gender desks and gender focal persons, which have created an enabling environment for the mainstreaming of gender into the various strategies. Ghana has ratified some relevant international treaties such as the UN Convention on the Rights of the Child, and the Convention on the Elimination and discrimination (CEDAW). While progress is being realized, the participants noted the overemphasis on women as victims who are not capable of making decisions for themselves, the low numbers of gender specialists capable of doing gender analyses at the policy level, and the fact that the "gender agenda" was being largely externally driven by those who have little or no knowledge of the cultural setting, leading to conflicts in communities.

At the district level, the examination of gender that took place through the focus group discussions identified the issue of marginalization of women in decision-making processes, as exemplified by the following statements.

When it comes to decision-making; women are separated from the men group. We are not in the same group with the men. When women are asked to join in the decision-making, we come as observers and we are not to say anything.

A woman in Jirapa, Ghana

Climate change has reinforced gender roles in agriculture and as such women work like donkeys in farms but remain the poorest in Nandom.

A gender desk officer in Nandom, Ghana

An analysis of climate change projects and initiatives in northern Ghana indicate that gender concerns are beginning to be integrated into adaptation planning efforts (Table 5); similar efforts are occuring in Mali though are not captured in a table. Greater clarification is needed as to how widespread the integration of gender is across projects and how well policy initiatives for gender are actually being considered.

Table 5: Examples of gender considerations in adaptation planning in Ghana

COMMUNITY PROJECTS	NATIONAL PROJECTS	NATIONAL POLICY INITIATIVES
In northern Ghana, the CARE Community Land Use Responses to Climate Change (CLURCC) Projectis supporting women to assume leadership roles in community and local government organisations by providing training and mentoring, as well as by strengthening the capacity of women's organisations to advocate for women's rights. (http://www.care.org/sites/default/files/documents/CC-2010-CARE_Gender_Brief.pdf)	The national coalition Gender Action on Climate Change for Equality and Sustainability (GACCES) aims to promote gender responsiveness in climate change policy-making. The specific objectives of the Coalition include enhancing the awareness of gendered nature of climate change, promoting women's participation in decision-making on climate change, sensitizing actors on relevance of women's knowledge on climate change, and establishing relationships to ensure continuous engagement on climate change.	The establishment of a focal point on gender and climate change at the Ghana Environmental Protection Agency (EPA).
A women's rights organization, the Centre for Sustainable Development Initiative (CENSUDI) worked to ensure that social inequalities were not widened as a result of the disaster. They focused on meeting the immediate food needs of the most vulnerable women, men and children in each community whose coping capacities in times of crises had been jeopardized.	A United Nations Development Assistance Framework (UNDAF) project focused on integrating climate change into the management of priority health risks in Ghana with two cross cutting themes of gender and HIV/AIDS.	A sector-wide collaboration between EPA and key agencies such as the Ministries of Women and Children's Affairs (MOWAC) and Local Government to incorporate gender-responsive measures in combating desertification in Ghana.
		An early warning system, which is mainstreaming pro-poor gender sensitive climate change adaptation into national development processes, is also on course.
		Through the Reduction in Emission through Degradation and Deforestation (REDD) initiatives, the Forestry Commission is implementing a policy that ensures equitable participation and benefit for both women and men.

5.4 Adaptation policy platforms in Ghana and Mali

The development of national level policy frameworks for adaptation planning is proceeding well in both Mali and Ghana. These national policies provide general guidance for investments and actions aimed at addressing adaptation needs. What is not clear from the available literature is how effectively these policies are being implemented, which sectors are moving forward and which are lagging, and where important pathways and obstacles exist with respect to initiating and supporting adaptation options at district to local levels. Section 5.5 begins to probe these issue through an examination of decentralization in these two countries.

5.4.1 Ghana[5]

Ghana's National Climate Change Policy (NCCP) was developed in 2012 (but formally launched in 2014), as a complementary document to the Ghana Shared Growth And Development Agenda (GSGDA) II, Ghana's medium-term national development policy framework (2014-2017). Its development was led by the National Climate Change Committee (see Section 3.3 for more details), with technical support from the Ministry of Environment, Science, Technology and Innovation (MESTI) and the Environmental Protection Agency (EPA). The vision of the NCCP is "to ensure a climate-resilient and climate-compatible economy while achieving sustainable development through equitable low carbon economic growth for Ghana" (MEST, 2012b, p. 1-8). Five focus areas for action on climate change are identified: agriculture and food security; disaster preparedness and response; natural resource management; equitable social development; and energy, industrial and infrastructural development.

The NCCP comprises ten Policy Focus Areas for addressing Ghana's climate change challenges and opportunities: developing climate-resilient agriculture and food security systems; building climate-resilient infrastructure; increasing resilience of vulnerable communities to climate-related risks; increasing carbon sinks; improving management and resilience of terrestrial, aquatic and marine ecosystems; addressing impacts of climate change on human health; minimizing impacts of climate change on access to water and sanitation; addressing gender issues in climate change; addressing climate change and migration; and minimizing greenhouse gas emissions. Each of these areas has a number of specific programmes for addressing the critical policy actions necessary to achieve the desired objectives. The second phase of this process, which is currently underway, will identify specific actions within these programme areas, as well as timelines and budgets for implementation (MEST, 2012b).

While recognizing the potential for Ghana to pursue lower-carbon development pathways and to increase its carbon sinks, the NCCP places significant emphasis on integrating adaptation across a range of different sectors important for the country's development progress. There is potential for this to make a difference both in terms of reducing Ghana's

[5] Source of section 5.4.1: IISD: Review of Current and Planned Adaptation Action in Ghana, report authored by Angie Dazé and Daniella Echeverría, February 2015

vulnerability to climate change and in ensuring that development outcomes are resilient to climate change over time. The inclusion of equitable social development as a theme is also promising, as it suggests that the Government intends to consider differential vulnerability to climate change in its adaptation action. Whether this potential can be realized will depend on the processes put in place to identify and prioritize appropriate responses, as well as the allocation of resources to implement the priority adaptation actions. The NCCP does not provide details on financing mechanisms for implementation, however it does indicate that substantial additional resources will be needed, and that these will come from "a mix of public and private, national and international sources" (MEST, 2012b, p. 2-12).

In parallel with the development of the NCCP, Ghana prepared its National Climate Change Adaptation Strategy (NCCAS), which was released in 2012 and covers the period 2010-2020. Preparation of the NCCAS was supported by the Climate Change and Development – Adapting by Reducing Vulnerability (CC-DARE) programme funded by the Danish Ministry of Foreign Affairs and jointly implemented by the United Nations Environment Program (UNEP) and the United Nations Development Program (UNDP). Its implementation is led by MEST, with support from the National Climate Change Committee. Although it was developed before the NCCP, the two documents are generally aligned in terms of their objectives and types of interventions.

The overarching goal of the NCCAS is "to [protect] Ghana's current and future development [from] climate change impacts by strengthening its adaptive capacity and building resilience of the society and ecosystems" (MEST, 2012a, p. 17). This is to be achieved through five key objectives:

- Improving society's awareness of and preparedness for future climate change;
- Mainstreaming of climate change into national development to reduce climate risks;
- Increasing the robustness of infrastructure development and long-term investments;
- Increasing the flexibility and resilience of vulnerable ecological and social systems to enhance their adaptive capacity; and
- Fostering competitiveness and promoting technological innovation.

These objectives are to be achieved through interventions in the following key areas: livelihoods, energy, agriculture, health, early warning, fisheries management, land use and water.

The NCCAS is designed to be implemented through a series of programmes that address Ghana's urgent adaptation priorities, namely (MEST, 2012a):

- Strengthening early warning systems
- Supporting alternative livelihoods for the poor and vulnerable
- Improved land use management
- Research and awareness creation on climate change adaptation
- Environmental sanitation strategies for adaptation to climate change
- Managing the impacts of climate change on water resources
- Agricultural diversification
- Improved access to health care to minimize climate change impacts on human health

- Demand- and supply-side measures to adapt national energy systems
- Enhanced fisheries resource management.

It is as yet unclear how and when the NCCAS will evolve into a formal National Adaptation Plan (NAP) under the United Nations Framework Convention on Climate Change (UNFCCC) process established in the Cancun Adaptation Framework in 2010 (CCAFS, 2014).

Looking across the different policy documents, there is a convergence of priorities in the sectors identified as most vulnerable, namely agriculture, water resources, fisheries, energy and health. Table 6 summarizes the key actions identified for different sectors in the NCCAS and key sectoral policies that address adaptation (MEST, 2012a; MWRWH, 2007). Box 7 describes national-level perspectives on adaptation plannikng that were derived through focus group discussions held in conjunction with the RDS.

Table 6: Key adaptation actions by sector identified in the NCCAS and key sectoral policies (MEST, 2012a; MWRWH, 2007)

SECTOR	ADAPTATION PRIORITIES
Agriculture	• Build farmer awareness of climate issues • Strengthen farmer capacity to increase agricultural productivity • Build capacity of extension officers to better support adaptation by farmers • Promote alternative livelihood strategies, particularly for vulnerable groups • Promote agricultural biodiversity • Promote crop and livestock production practices that are climate-resilient • Promote post-harvest technologies to minimize losses • Identify and document indigenous adaptation strategies
Water Resources	• Water preservation and conservation • Increase accessibility and availability of water for domestic, agricultural, industrial, and commercial use and energy production, for example through rainwater harvesting • Improve and sustain quality of water resources • Build capacity in water resource management • Construct flood protection and water conservation structures • Develop buffer zones along river banks • Strengthening and enforcement of land use planning regulations for waterways and flood zones
Fisheries	• Promotion of fish farming • Design and implementation of programmes on fisheries management and disease control • Develop alternative livelihood strategies for fisherfolk
Energy	• Increase the use of off-grid alternative energy resources • Expand the use of efficient domestic appliances • Develop low-head run of river hydroelectricity schemes • Encourage energy conservation on a large scale • Increase use of natural gas
Health	• Raise public awareness on climate change and its impacts on health, livelihoods and environmental sanitation • Improve waste management systems and provide new and affordable technologies for environmental sanitation • Reduce incidence of water and air-borne diseases • Increase capacity and knowledge of health care workers on climate change-related health problems • Improve and increase existing health facilities and equipment

Box 7

National level perspectives on adaptation planning in Ghana

Ghana is clearly making strides in adaptation planning at the national level. This sense of progress was "groundtruthed" at a national experts meeting in March 2015. Present at this meeting was an array of experts from government ministries and agencies (e.g. *Ministry of Environment, Science, Technology and Innovation, Ministry of Gender, Children & Social Protection, Ghana Irrigation Development Authority, National Development Planning Commission, Ministry of Food and Agriculture. Ghana health service*), NGOs and CSOs (e.g. *Oxfam, WaterAid, Ghana Red Cross Society, CARE-International, Peasant Farmers Association, Ghana News Agency*), research institutions (e.g. *the University of Ghana and the CSIR-Animal Research Institute*), and the *FAO* and *African Development Bank* representing multilateral organizations.

The purpose of the expert meeting was to explore and debate the strengths, weaknesses of, and opportunities and challenges facing, the national platform on adaptation as represented through the various policies, strategies and committees described in this section. The participants noted many strengths of the platform, including strong leadership by key ministries and cross-sectoral institutions, political will, and the establishment and staffing of climate change units within government. The group saw strong opportunities for funding through the GEF and others in the donor community, possibilities for scholarships and fellowships for capacity building and training, and the increasing availability of geospatial data. There were also a number of weaknesses identified in the adaptation planning and implementation spheres. These include lack of solid baseline data (and obsolete or disjointed data), unwillingness or inability to share data across institutions, poor communication and weak coordination, low human and institutional capacities, and limited funding that is mostly donor driven. The issue of donor agendas carried into the examination of challenges, which in addition included unfair global governance systems and the narrow political interests of major actors including the United States and China that impede urgent global action on climate change.

5.4.2 Mali

At the national level, priorities for addressing vulnerability and adaption to climate change hold an important position within Mali's national policy documents. Mali's NAPA (also referred to as national policy for adaptation to climate change, or NAPCC) was completed in 2007 and the process was led by the Ministry of Environment, supported by UNDP (République du Mali, 2007). The NAPCC identified agriculture (farming, fishing and pastoralism); food security, health, energy and water resources as the most vulnerable sectors and priorities for adaptation. Advancing adaptation in these sectors is expected to be achieved through planning activities to build resilience. In addition, the NAPA report is used by NGOs and others to plan related projects and activities (SIDA, 2013).

According to the Elements of National Policy for Adaption to Climate Change released by the Ministry for Environment and Sanitation in 2008, the vision of the NAPCC is to define a sustainable socioeconomic development trajectory that enhances the wellbeing of vulnerable populations. It is articulated around the following major objectives:

- Securing agricultural production and productivity through better management of surface and ground waters in order to cope with food security and poverty alleviation;
- Promoting sustainable development through the sustainable exploitation and management of natural resources (water, forests, soils, fauna, and fish resources);
- Ensuring energy security and sovereignty through the implementation of the household energy strategy and the construction of hydroelectric structures;
- Setting up a system for monitoring diseases associated with climate change;
- Developing environment friendly infrastructure that is better adapted to climate change.

These major objectives are translated into the strategic axes aimed at:

- Improving and disseminating knowledge on adaptation to climate change;
- Improving the institutional and legislative framework for a better adaptation to climate change;
- Improving the management of information at all levels, through sensitization;
- Undertaking research and conducting studies and long term observation of support decisions; and,
- Building and strengthening skills and capacities.

The management of climate change concerns is distributed among various sectoral agencies. These include:

5.4.2.1 Agriculture sector

Policy elements are translated through:

- The implementation of the Agricultural Orientation Law;
- The modernization of agriculture through the introduction of equipment that is better adapted to a more challenging climate;
- Sensitization and training of farmers in the use of agro-meteorological information and counseling;
- Training in proper management techniques for surface waters and for soil and water conservation within agriculture;
- Training in natural resources management techniques (forests, rangelands, and soils), including vegetative restoration;
- Strengthening of research in the field of improved seeds adapted to drought;
- The use of crop varieties adapted to climate change, including increased valuation and conservation of local genetic resources, mainly their adaptability to changes in farming conditions that include photo period sensitivity (adapted to variable length rainy seasons)
- Diversification of agricultural systems away from climate sensitive activities;

- Strengthening of the early warning system and cereal banks for ensuring food
- security;
- Use of non-perennial surface waters and ground waters for irrigation; and,
- Development and intensification of crop and livestock production.

5.4.2.2 Water resources sector

- The NAPCC elements in the water resources sector include the following:
- Improved water management through irrigation and bore-hole development; deepening of wells and ponds;
- Construction of dams for regulating the flow of permanent water streams;
- Promotion of farming practices and techniques aimed at conserving soil moisture;
- Development of operational systems for elaborating and disseminating agro-meteorological information and counseling in rural communities;
- Development of a rainwater harvesting system where feasible;
- Construction of gutters for evacuating run-off waters in sensitive areas; and,
- Elaboration of a water evacuation plan in risk prone zones.

5.4.2.3 Heath sector

The NAPCC elements in the health sector focus on three main areas:

- Bolstering efforts at training, information generation, and communication regarding harmful effects of climate change on the health and well-being of the population;
- Building capacities for the prevention of and response to climate-sensitive diseases with endemic and lethal potential; and,
- The elaboration of plans for warning about extreme meteorological conditions with a view to preventing against their effects on the population.

5.4.2.4 Energy sector

The national policy with regards to the energy sector takes into consideration diminution of water sources and thus promotes the:

- Enhanced protection and management of watershed areas;
- Upstream construction of water catchments for hydroelectric structures in order to better regulate water courses and avoid the discharge of water surpluses;
- Construction, wherever possible, of hydro-electric micro-dams;
- Exploitation of groundwater for reducing pressure on surface waters;
- Innovation and promotion of energy saving technologies; and,
- Promotion of renewable energies as a substitute for firewood.

In 2010, the National Agency for Environmental and Sustainable Development (*Agence de l'Environnement et du Développement Durable*) was established to coordinate the implementation of national climate change policies and facilitate the integration of climate consideration in the national policies. The government has also made a broad attempt to green the CSCRP *(Cadre stratégique pour la croissance et la réduction de la pauvreté;*

strategic framework for growth and poverty reduction) for 2012-2017, which emphasizes environmental considerations in its policies.

The CSCRP defines three strategic areas: (i) promoting accelerated and sustainable growth that benefits the poor and creates jobs and revenue; (ii) reinforcing the long-term bases of development and equitable access to good-quality social services; and (iii) strengthening institutions and governance. The government-funded projects are required to be embedded in these strategic areas to support social and economic development in the country.

In addition to the CSCRP, the government set policies for agricultural development that also emphasize environmental dimensions: i) the *Loi d'Orientation Agricole* (agricultural guidance law), which establishes a long-term vision for the agricultural sector based on the promotion of a sustainable, modern and competitive agricultural sector based primarily on family farms; and, ii) the *Stratégie Nationale de Sécurité Alimentaire* (national food security strategy), and the *Plan National d'Investissement du Secteur Agricole* (national agricultural sector investment plan), which focuses on strategic investments in the majors agricultural value chains, including rice, maize, millet and sorghum. The strong links between environment, climate change and thematic sectoral priorities blur important distinctions between environmental and climate change policies. Boxes 8 and 9 describe perspectives on adaptation planning in Mali that were derived through focus group discussions at the national and district-level, respectively, held in conjunction with the RDS.

Box 8

National level perspectives on adaptation planning in Mali

Planning for climate change in Mali is gaining momentum in important climate-sensitive sectors. This box highlights findings from a national experts meeting held in Bamako, Mali in March 2015 to explore the process around the design of policies and strategies related to climate change based onthe experience and perception of participants on the implementation of these policies and strategies. Present at this meeting was an array of experts from government ministries and agencies (e.g. *Directorates of Civil Protection, Agriculture, Fisheries, Animal Production and Hydrology*), research institutes (*ICRISAT* and the *Institute of Economic Research*) and NGOs represented by the *Malian Association for Environment and Sustainable Developement-AMEDD*, and farmers organizations (*The Permanent Assembly of Malian Chambers of Agriculutre-APCAM* and *the National Coordination of Producers Organizations*) .

The responsibility for developing national planning is led by the relevant line ministries and the process it carried out through expert consultancies. The consultations involve dialogues with national, regional and local stakeholders from within and outside (civil society organizations, producer's organizations and the chambers of agriculture, commerce, and mines) government, followed by a process of technical and political validation. Incorporating the needs of vulnerable groups (including gender considerations) is an important focus of the consultations though gender is not fully fledged in the implementation process. The implementation of climate change policies and strategies is most advanced in the agriculture sector and it was noted that several national extension programs and development projects have been implemented in the agriculture sector to enable the uptake of climate change adaptation responses.

The critique of the policy and strategy formulation and dissemination process surfaced concerns that paralleled those voiced at the district level focus group discussion described in Box 9. Namely, that there are formal channels for information dissemination, such as through government hierarchies and through civil society and producers' organizations but these channels are not well supported due to weak institutional capacities, paltry financial resources, and lack of sensitization of material to local contexts including local languages. Also, the consultation process was criticized as being overly normative and dominated by national experts resulting in community representatives and civil society organizations being only nominally involved in the consultation process and their knowledge and perspectives largely sidelined.

Box 9

Perspectives on adaptation planning at the district level in Mali

The abovementioned initiatives are increasing visibility of climate change issues within the government. However, the extent to which these initiatives have contributed to raising awareness about climate change and the formulation of adaptation measures at district and local levels is unclear, particularly given the lack of financial resources and generally poor institutional capacities in Mali. The broad issue of how well national policies are reaching district level planners was explored in focus group discussions and key informant interviews carried out in the Koutiala district in the Sikasso Region of southern Mali.

The general sentiment emerging from this focus group discussion centered around the lack of communication and support from national policy levels to district levels for implementation of adaptation measures. Participants (farmers, extension officers and NGO representatives) had heard about the development of a national climate change policy on radio and TV but were unaware of specific details. They noted that the local representatives of farmer organizations are not well equipped or endowed with financial resources to dispatch information about national policies to local communities, and the technical details contained within the strategy are not translated into local languages that would allow farmers to internalize them. Moreover, formal information channels utilized in the past by the central administration to reach remotes villages are no longer active. Also, there is also no visible coordination between public and private sectors for implementing the national adaptation strategy.

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5.4.3 Climate finance in West Africa

Climate financing for adaptation in West Africa faces many challenges stemming from lack of institutional strength and reliable funding sources. Denton (2010) suggests that LDCs in West Africa can partly compensate for these institutional and funding weaknesses " by first creating a burden-sharing mechanism that will facilitate the mobilization of additional funding streams and coherently address a number of priority sectors in their own current NAPAs and national communications." This will require close institutional cooperation across countries within the region.

The last few years has witnessed an increase in activity around climate financing in Africa. Among these funding mechanisms, the Green Climate Fund (GCF) is emerging as a priority climate finance mechanism for Africa. The GCF sits within the UNFCCC and is a mechanism to channel funds from developed to developing nations for green development encompassing adaptation and mitigation. In an analysis of how to better position the GCF in Africa, Afful-Koomson (2014) argues for new mechanisms and incentives and better policy and institutional alignments. Specifically, he points to the need for:

- Incentives to enable investment from the domestic private sector;
- Aggregation of small projects to enhance scalability and reduce transaction costs;

- Diversification of financial instruments from predominately 'goodwill' grants-based financing to loans and equity investments;
- Improvement of finance predictabilities by diversifying funding sources away from an over reliance on public funds; and,
- Strengthening of institutional capacities in Africa to absorb funds.

Mali is one of a handfull of developing countries that has moved forward with a "readiness" request to the GCF. (The only other country in West Africa currently preparing a readiness plan is Togo.) In doing so, Mali has nominated the National Environment and Sustainable Development Agency (AEDD) as its National Designated Authority (NDA), according to the GCF Readiness Newsletter, October 2014. Through this process, Mali will work with the GCF to deepen its consultations with national and international stakeholders that will allow for strategic priorities for GCF funding to be identified. The GCF Secretariat is working with the NDA to develop an "investable pipeline of programs and projects." In addition to these efforts under the GCF, Mali has a National Climate Fund, developed through UNDP, that would combine financing from bilateral and multilateral sources and enable more effective alignment with Mali's National Strategy on Climate Change. The National Climate Fund seeks to enhance national research capacities that will foster more anticipatory capacities to deal with climate emergencies; increase water supply and strengthen food security; reduce risks of crop failure and shore up support for more sustainable livestock and fisheries management; diversify food and livelihoods sources for highly vulnerable populations; and, develop renewable energy sources (Mali Climate Fund Factsheet, UNDP).

In Ghana, the government has moved forward in creating a Ghana Green Fund (GGF) that is designed such that it can be accredited as a GCF National Implementing Entity. The objectives of the GGF are to enable investments and co-financing in more effective adaptation and mitigation, waste management, biodiversity conservation, and natural resources management, as well as stengthen domestic institutional capacities in project preparation, appraisal and financial management so as to enhance absorptive abilities for climate investment finance. In terms of other sources of climate finance, Ghana has a successful track record of receiving grants from the GEF and is a pilot country under the World Bank's Forest Investment Program (Würtenberger et al., 2011). The UNDP African Adaptation Program, which ended in 2012, analyzed in-country climate finance mechanisms in Ghana to identify institutions prepared to effectively manage climate finance (Tutu, 2012). That analysis suggested that the National Climate Change Committee (NCCC), the National Environmental Fund (NEF), and the Electoral Commission could be merged in order to meet the needs of a climate finance mechanism. The NCCC could serve as the overall umbrella and the NEF and the Ecological Fund would be devoted to climate change activities relevant to their mandate.

5.5 Governance aspects of adaptation related to decentralization

Effective, efficient and equitable governance across scales is crucial to successful adaptation and building resilient development. One of the key governance questions that recurs in current literature in West Africa in general, and Ghana and Mali in particular, is the advantages and constraints associated with decentralized governance. Decentralization, at least in theory, empowers local governments and enables public participation while also enhancing efficiency and effectiveness of service delivery by reducing bureaucracy and increasing accountability (Ribot, 2002; Weingast 1995; Agrawal and Ribbot 1999). However, because resources tend to be concentrated in the central government, especially in the sub-Saharan Africa context, capacity constraints often lead to bad policy outcomes. West Africa in general, Ghana and Mali in particular, have been undergoing decentralization, albeit for different set of reasons. Sections 5.5.1 and 5.5.2 focus on Ghana and Mali though the application of this information is relevant throughout the region.

5.5.1 Ghana

In Ghana, decentralization has led to some "formal transfer of authority to elected officials at sub-national levels, along with modest fiscal transfers" (Ayee and Dickovick, 2010). Yet, there are factors that prevent meaningful decentralization from thriving. For example, while Ghana has put in place a robust legal framework for devolved governance, transfers of authority to local governments has been incomplete and ineffective, as the autonomy of local governments is often hindered by revenue and resource constraints. Also, there are concerns regarding the accountability of national and local governments to local populations and civil society. Most importantly, lack of human and institutional capacity at the local level is a serious challenge, both in fiscal and administrative terms. Thus, while Ghana has made strides in devolution, the process is far from complete and efficient (Ayee and Dickovick 2010).

With the institutional transition from the state to local-level governance, local initiatives on climate change adaptation are strongly influenced by the ongoing decentralization effort. Major stakeholders at the local level include NGOs, communities, community based organizations (CBOs), farmer-based organizations (FBOs), traditional authorities, government agencies, women, youth, local politicians and, to a limited extent, media. Whereas governance is not explicit in some of the initiatives, the few that do address governance usually take the form of stakeholder participation in decision making processes, land tenure change, land rights, and public awareness raising. Many of the studies in northern Ghana are contextualized under the framework of rural development with considerably less attention to urban concerns. As such, there are limited contributions from urban markets, private sector, and urban institutions in climate change governance.

The major challenge to governance in climate change adaptation across all sectors is poor institutional structure and weak institutional capacity (MESTI, 2013; Nelson and Agbey, 2005) as well as limited network platforms for climate change adaptation dialogue. The means of knowledge acquisition, information flow, and sharing are quite limited in northern Ghana (Schiffer, et al., 2008). Since most of the initiatives are driven by NGOs and CBOs through their funding, governance is viewed through a lens of participation between beneficiary communities, traditional institutions (i.e. Chiefs, taboos, norms), and the local governance structure (metropolitan, municipal and district assemblies). NGOs in northern Ghana exert significant influence on rural communities and have a mixed record of success. The proliferation of NGOs, some of which are created by local politicians to channel international donor funds, has led to concern that NGO operations are marginalizing rural communities in decision-making processes in cases where project goals are predetermined (Marchetta, 2011).

Moreover, there are many overlapping national sectoral policies but little effort towards integration of policy implementation between state institutions, NGOs and local communities (Adaba, 2005). In northern Ghana, the National Development Planning Commission (NPDC) provides few resources and guidelines on how to integrate local communities and climate change in the decision-making processes of agricultural development (CARE, 2009). In addition, local governance structures for disaster risk reduction (DRR) in Ghana are limited. In 2006, NADMO established the National Platforms for DRR and climate change but has yet to decentralize it into local or community platforms for DRR and climate change. Although NADMO has created local zonal offices across northern Ghana, they do not have the capacity to record, store, receive, and disseminate information (Assani, 2014). In an effort to improve governance of DRR in northern Ghana, CARE through the Adaptation Learning Programme initiated the establishment of Community Information Centres (CICs) as platforms to share information on climate change and DRR (Assani, 2014). Through the CIC, community members and farmers can send and receive disaster and climate related information locally. Disaster issues relating to flooding from dams in Burkina Faso are addressed through the Ghana- Burkina Faso local committee and the White Volta Basin Board (WVBB). However, WVBB lacks sufficient enforcement authority (Schiffer, et al., 2010; Blau and Fingerman, 2010).

The governance of land-use change at the local level is under the auspices of the Lands Commission, Town and Country Planning Department (TCPD), traditional authorities and district assemblies. However, many areas in northern Ghana are not governed by any local planning schemes because district assemblies are not willing to bear the cost of preparing local plans, the TCPD do not have enforcement capacity and cannot prepare a local plan for a community without approval of the custodians of the land, and most chiefs in the region perceive that preparation of a local plan to guide land use change and development automatically confers ownership to land to the state agencies. Poor institutional capacities also hamper land-use planning. For example, the Upper West Region as of 2014 has only four physical/spatial planners, very limited spatial data, and low technical capacity to integrate climate change into land use planning. EPA, which has knowledge and information on climate change, does not interact with current land use planning processes at the local level. Several years ago, CARE initiated a Community Land Use Response to Climate Change effort in selected communities in northern Ghana. The project has accumulated local knowledge on climate change adaptation but much of this has not made its way into district level development and land use planning processes (CARE, 2009). Box 10 describes local perspectives on NGOs and decentralization that were derived through focus group discussions held in conjunction with the RDS.

Box 10

Local adaptation planning: NGOs and decentralization

The focus group discussion held in Jirapa, Lawra, and Nandom in northern Ghana noted the importance of NGOs in helping to advance adaptation planning, while at the same time calling into question the ultimate sustainability of the NGO-led approach. An important concern revolved around the fact that NGOs are implementing programs without community input or without sufficiently considering local protocols and structures, which is undermining trust and credibility of NGO efforts. Sustainability concerns resulting from a lack of community ownership over an NGO-led effort are further amplified by a common issue of NGOs lacking an adequate exit strategy from communities with inadequate consideration given to continuity of efforts. Similarly, with focus group discussions in the Koutiala district of southern Mali participants noted the presence of local NGOs who were active across different intervention areas but they expressed concerns that the NGOs have a tendency to reproduce the same interventions in different locations without due consideration to local conditions and contexts.

NGO programs are increasingly filling the 'adaptation space' as local governments largely lack the mandate and resources to implement comprehensive programs. Farmers groups noted the diminished role of agricultural officers that used to teach farmers about new methods. There was a call for a return of demonstration farms and greater involvement of agricultural specialists and agriculture research stations in sensitizing farmers to new methods.

According to a Development Planning Officer who participated in an interview in Lawra: "Decentralization below the District Assembly has not moved and decentralization between the central government and the district Assembly is wobbling." Climate change and the National Climate Change Plan are often mentioned in assembly meetings during the planning process of the district development plans but there have been no concrete projects. Because of the National Development Planning Commission (NDPC) guidelines call for preparation of development plans at the local level, district assemblies find it difficult to initiate their own projects that do not fall within the purview of the thematic areas ordered by the NDPC. If any initiative doesn't fall within the NDPC thematic areas, funding that project is difficult. This is why currently the district depends on the NGOs to address climate change issues. The NDPC guidelines and thematic areas do not address the realities of the diverse districts in Ghana but we are all forced to follow the same steps noting that our problems are different. Current initiatives are all top down from the centralized government or NGOs with already fixed goals and projects.

5.5.2 Mali

Mali has made similar strides in decentralized governance, which is evident by over 24 pieces of legislation that aim for greater devolution of power to local governments (Wing and Kassibo 2010). However, a weak national government has led to weak local governments. For example, civil service at the local government levels is characterized by chronic human capacity handicaps – for example competent people are reticent to commit to civil service with local governments due to lack of financial resources (Wing and Kassibo 2010). (Refer to Section 4.3 for an examination of decentralization in the context of natural resource governance.)

The presence of decentralized participatory governance structures may have a positive impact on adaptation and disaster risk reduction but it is not enough in itself to enable effective adaptation (see Scott and Tarazona 2011). Linked to the question of decentralization is also the need for better understanding of the power dynamics and underlying factors (e.g. the role of traditional authority in Ghana and endogenous and exogenous pushes for greater democratization in Mali) that drive devolution of power and how this affects adaptation in the long term. Both issues will need further scrutiny to articulate the upsides and downsides of decentralization and more generally institutions responses and how devolution of power plays into enabling or constraining adaptation.

The need for effective horizontal and vertical policy coordination among sector agencies and local actors is another key governance question that may have significant impact on development planning as a whole as well as adaption. Ghana and Mali have made good strides in ensuring environmental coordination. Ghana, for example, put in place an Environmental Action Plan (EAP), which seeks to ensure integration and coordination in government action for the environment sector, a desirable departure from the sectoral approach that used to be common place prior to the adoption of the EAP. However, there is still lack of effective coordination, especially between the central-local governments. Similarly, Mali has put in place improved the legislative and institutional framework and mainstreamed environment and climate in the country's national development plan. Yet, among the key underlying drivers of environmental degradation in the country is "insufficient planning and coordination and weak regulations" (Sida 2013). Adaptive efforts in both countries would benefit a lot from effective interagency and local-central coordination.

Questions of transparency and accountability of institutions with public funds has a direct effect on large-scale adaptation. It is essential that existing governance processes and institutions are accountable and democratic. This aspect of adaptation is nonetheless understudied in the African context (Lockwood 2013). Mali does not have a good record with corruption, as it ranks 115th out of 175 countries in the Transparency International Corruption Perceptions Index (CPI) (Transparency International 2014). Ghana is much better but there are areas for improvement. In both cases, there is a need to examine existing evidence of the link between more accountable governance and ongoing adaptive efforts.

5.6 Conclusions

5.6.1 Barriers to and enablers of adaptation

This RDS report concludes with an examination of key barriers and enablers to adaptation, which are derived from findings in Chapters 4 and 5 of this report. The barriers and enablers are grouped by development, gender and governance factors reflecting important themes that are examined in this report. These barriers and enablers are strongly rooted in a multi-stressor environment in which is implicit multiple development drivers acting across different scales. Thus the barriers and enablers do not neatly align with a simplistic duality of 'autonomous' or 'planned' adaptation to climate change. Rather they reflect wide array of actions that different institutions and actors are taking—decentralization of government authority, actions that conserve and overexploit the natural resource base, inclusion or exclusion of different land users, new policy levers, etc.—that have clear implications for enabling or constraining adaptive capacities and adaptation outcomes.

The main question that motivates ASSAR concerns understanding key barriers and enablers for effective adaptation in the medium term (out to the 2030s) and identifying critical response levers that can trigger more widespread, sustained adaptation. The focus on *responses* implicitly recognizes that societies are facing multiple interlocking stresses that generate differential vulnerabilities depending on where in society an individual or group is positioned. In turn, this multi-stress environment creates an imperative to adapt to multiple drivers (i.e. land-use change, urbanization, population pressures and demographic change, environmental degradation, etc.) that interact in varying degrees with climate change and the adaptation efforts therein.

A responses framing allows for a bidirectional examination of the development-adaptation spectrum. One direction concerns how societal responses to important development drivers— outside of the formal, 'planned' climate change adaptation realm— might enhance or hinder capacities to deal with climate change, including possibly leading to maladaptation to climate change. The other direction considers whether planned adaptation to climate change in Africa, which is presently being heavily driven by the global agendas of northern industrialized regions, is adequately considering societal needs and priorities with respect to important development drivers and trajectories. Thus, to what extent does the climate change adaptation agenda compliment or shortchange development?

The West Africa ASSAR partners are considering this development-adaptation 'dialectic' in the context of regional food security and the inevitability that wherever possible, agriculture will need to intensify in the next 20 years and beyond to meet rising food security needs (Ringler et al., 2014), and that this will unfold through both public and private investments. As described in Chapters 1 and 2, the regional research program (RRP) will focus on the dry sub-humid area that extends from northern Ghana through southern Mali, which is a drought prone but agriculturally important area poised to undergo agro-intensification. This development driver will strongly influence the 'adaptation space' in this region, and could alleviate or intensify vulnerabilities of different groups. The barriers and enablers identified in this section (Tables 7 and 8) help to identify important points of entry for the regional research.

Table 7: Key barriers to adaptation in West Africa

Development factors	Gender and cultural factors	Governance factors
Lack of studies on urban systems in dryland areas; and on the urban-rural continuum that would allow for better understanding of migration dynamics in dryland areas.	Traditional gender norms that manifest in unequal access to resources and decision-making processes, reduced access to information, lack of land ownership and weak usufruct arrangements and reduced mobility.	Incomplete government decentralization. Transfers of authority to local governments has been ineffective; local institutions are under-resourced and lack jurisdictional authority to effectively govern and adjudicate local natural resource decisions.
Lack of integrated water resource planning, particularly at watershed and river basin scales to better manage negative impacts of water extraction on downstream users.	High labour burden of women and lack of female access to education that constrain women's ability to diversify livelihoods.	Top-down policy interventions for managing natural resources that lack local incentives and lock local communities out of resource access.
Land degradation that is increasing droughtiness of soils; extensification of agriculture onto drought prone soils; high pest pressure (e.g. *Striga*) that amplify drought stress on crops.	Gender disparities in wage and employment that hamper abilities to buffer shocks. Livelihood or technologic options for women are limited thus constraining women's range of responses for managing risk and adapting to change.	Lack of land tenure security that disincentivize land users to adopt new practices; traditional communal land tenure system giving way to formalized arrangements that marginalize smallholders.
Reduced access to pastoral corridors; increased encroachment of farming onto rangelands; conflict between pastoralists and farmers.	Predominance of male migration that leave women, children, elderly and disabled dependents more vulnerable to shocks, particularly where remittance flows are weak or nonexistent.	Large-scale land leases to external private sector organizations in which affected smallholders lack agency over the outcomes and face displacement from the land.
Under investment in dryland areas that manifest through lack of access to credit and markets, inadequate educational opportunities,	Externally driven gender agendas that do not adequately consider cultural norms and that lack flexibility in addressing	Lack of communication and coordination within national-level institutions and across national to district scales. Lack of, or ineffective,

inadequate infrastructure, lack of rural employment opportunities.	gender disparities.	mechanisms or funds for implementing national adaptation policies.
High dependency on donor community for funds to implement adaptation projects; lack of continuity.	Predominant focus of women in gender, which diverts attention and resources away from other vulnerable groups, especially youth, disabled and the elderly.	Lack of sufficient community engagement/ buy-in by NGOs; NGO use of cookie-cutter approaches to addressing adaptation needs; NGOs lack an exit strategy.
Lack of solid baseline sectoral data; data obsolete and disjointed.	Traditional belief systems (i.e. will of God) that hamper management of climate sensitive diseases.	Lack of data sharing across institutions. Weak expertise in important areas such as gender.
		Weak institutional capacities and lack of mechanisms for climate finance.

Table 8: Key enablers of adaptation in West Africa

Development factors	Gender and cultural factors	Governance factors
Research agendas are increasingly emphasizing participatory processes for knowledge co-generation.	Adaptation provides an entry point for better addressing the needs of differentially vulnerable groups though local input is essential to ensure sustainability of the effort.	Potential to leverage decentralization efforts to increase local adaptive capacities *if* local institutional capacities and authorities can be strengthened.
Appropriate technologies for soil and water conservation, natural resource management, etc. are gaining greater prominence.	Traditional authorities and religious institutions are viewed as credible sources for mobilizing actions on adaptation.	Significant increase in national policy development around climate change. Leadership emerging in key ministries and political will is increasing.
Adoption of early maturing crop varieties has increased, though there are risks in overreliance on these varieties given interannual climate variability.	Opportunities to promote greater peer-to-peer learning through adaptation efforts. .	Evidence of mainstreaming of climate into different sectoral policies and strategies.
Efforts are increasing to better channel weather information to local communities, through radio and mobile phones.	Promotion of civil society platforms.	Staffing of climate change units within government. Limited but beginning.
The Green Climate Fund and other opportunities for climate finance are gaining momentum.	The youth are relatively more educated and engaged in environmental education and awareness raising, planting trees and promoting renewable energy.	Increasing recognition within governments of the need to put in place mechanisms that ensure effective, equitable and transparent use of climate finance.

5.6.2 Knowledge gaps and needs

The in-depth examination of vulnerability and adaptation in this West Africa diagnostic study helped to identify important knowledge gaps and needs that span climatic, biophysical, socio-economic, cultural, and political realms. The gaps and needs identified in this section are not exhaustive though they are indicative of critical issues that need greater research attention in order to foster more informed planning. These knowledge gaps and needs include:

- *Understanding of shifts in the quality of the rainy season:* The increasingly widespread but still largely anecdotal reports of an increase in intense rainfall events and of changes in the timing and distribution of rainfall are weakly corroborated (or not corroborated) with meteorological data. It is unclear as to the extent to which the relative lack of corroboration is real or is a function of incomplete meteorological data and inadequate human and institutional capacities to gather and analyse such data.
- *Lack of agreement between climate models as to the future magnitude and direction of change in precipitation over the region:* The extent to which the region will become wetter or drier is highly uncertain. Climate variability at interannual to multi-decadal scales will continue to exert a dominant influence on regional precipitation. However the extent to which variability may intensify with increased atmospheric warming is poorly understood.
- *Urban-rural connectivity and urban vulnerabilities:* The dearth of studies on vulnerability and adaptation concerns in secondary cities of interior dryland areas creates an incomplete picture of how the urban poor are responding to vulnerabilities and how the dynamics of rural-urban connectivity influences the adaptation space.
- *Extensification of agriculture and its relation to drought susceptibility*: Agricultural extensification onto increasingly marginal lands is likely interacting with changes in seasonal rainfall characteristics and warming temperatures to magnify drought impacts. However, the extent to which these climate and land-use changes are interacting is unclear; greater clarity is needed on these land-use change dynamics to better inform research and policy development for adaptation.
- *Multiple changing baselines*: The tendency to seek ever-finer resolution on how climate will change in the future is not being matched with serious efforts to understand and quantify other future drivers of change. This information dissymmetry could potentially short change adaptation planning. Important external (e.g. large-scale land leases to and private sector investment from extra-regional actors) and regional (e.g. pending completion of a continuously paved corridor from Accra to Bamako) drivers need to be better understood and incorporated into vulnerability reduction and adaptation planning frameworks.
- *Role of national government within the decentralization trend:* There is a lack of substantial empirical data on the enabling and constraining role of national government in the context of adaptive capacity and disaster preparedness. Concrete

case studies are needed that more closely examine decentralization from the vantage point of local to national government (as well as interagency) relations, coordination, and resources, and its impact on adaptation and disaster preparedness.

- *A limited gender focus:* The focus on gender within the adaptation discourse remains largely centered on women's unique vulnerabilities. While this is a critical consideration, the focus needs to broaden in scope to encompass other differentially vulnerable groups, particularly youth, in these demographically young regional populations, as well as the elderly and disabled. Also, the tension that exists between traditional and western outlooks in defining how to address gender inequities requires better understanding of flexible yet effective approaches for empowering women.
- *Adaptation planning across scales:* Given the sharply increasing demand placed on surface water resources in West Africa, there is a strong need to better understand tradeoffs in adaptation across scales with respect to surface water use by upstream and downstream communities. In this regard, research and institutional capacities need to be strengthened for conducting integrated water resource management.

CHAPTER 6

References

References

Africa Economic Outlook – 2014: Mali. Retrieved from:

http://www.Africaneconomicoutlook.org/fileadmin/uploads/aeo/2014/PDF/CN_Long_EN/Mali_EN.pdf

Africa Economic Outlook – 2014: Ghana. Retrieved from:

http://www.Africaneconomicoutlook.org/fileadmin/uploads/aeo/2014/PDF/CN_Long_EN/Ghana_ENG.pdf

AAP. (2011). *Climate change: Ensuring equal opportunities for men and women.* (Policy Advice Series No. 18).

Adaba, G.B. (2005). *The role of agroforestry for sustainable forest use - case study of community-based agroforestry initiative in the Kassena-Nankan District of northern Ghana*. Master's thesis submitted to the Centre for Transdiciplinary Research on the Environment, CTM, Stockholm University.

Adiku, S. G. K., MacCarthy, D. S., Hathie, I., Diancoumba, M., Freduah, B. S., Amikuzuno, J., . . . Valdivia, R. O. (2015). Climate change impacts on west African agriculture: An integrated regional assessment . *Handbook of climate change and agroecosystems* (pp. 14-52)

AFDB. (2012). *Africa's demographic trends.* (Briefing Notes for AFDB's Long-Term Strategy No. 4).

Afful-Koomson, T. (2014). The Green Climate Fund in Africa: what should be different? *Climate and Development*. doi:10.1080/17565529.2014.951015

Agana, C. (2012). Women's land rights and access to credit in a predominantly patrilineal system of inheritance: case study of the Frafra Traditional Area, Upper East Region. Master of Philosophy (MPhil.) Thesis. Department of Land Economy, Kwame Nkrumah University of Science and Technology, Ghana.

Agrawal, A., & Ribot, J. (1999). Accountability in Decentralization: A Framework with South Asian and West African Cases. *The Journal of Developing Areas 33*(4): 473-502.

Akpalu, W., & Codjoe, S. N. A. (2013). Economic analysis of climate variability impact on malaria prevalence: The case of Ghana. *Sustainability, 5*, 4362-4378.

Anderson, J. M., Samake, S., Jaramillo-Gutierrez, G., Sissoko, I., Coulibaly, C. A., Traoré, B., . . . Kamhawi, S. (2011). Seasonality and prevalence of leishmania major infection in phlebotomus duboscqi neveu-lemaire from two neighboring villages in central Mali. *PLOS Neglected Tropical Diseases, 5*(5) doi:10.1371/journal.pntd.0001139

Antwi-Agyei, P., Fraser, E. D. G., Dougill, A. J., Stringer, L. C., & Simelton, E. (2012). Mapping the vulnerability of crop production to drought in Ghana using rainfall, yield and socioeconomic data. *Applied Geography, 32*(2), 324-334. doi:10.1016/j.apgeog.2011.06.010

Antwi-Bediako, R. (2013). Land grabbing and jatropha boom in Ghana. Retrieved from: http://beahrselp.berkeley.edu/blog/land-grabbing-and-jatropha-boom-in-Ghana/

Armah, F. A., Odoi, J. O., Yengoh, G. T., Obiri, S., Yawson, D. O., & Afrifa, E. K. A. (2011). Food security and climate change in drought-sensitive savanna zones of Ghana. *Mitigation and Adaptation Strategies for Global Change, 16*, 291-306. doi:10.1007/s11027-010-9263-9

Assan, J. K., Caminade, C., & Obeng, F. (2009). Environmental variability and vulnerable livelihoods: Minimising risks and optimising opportunities for poverty alleviation. *Journal of International Development, 21*, 10-14. doi:10.1002/jid

Assani, T. M. (2014). How can communities be involved and contribute to early warning systems: Sharing experiences from the field. *Report of Proceedings on CLIM-WARN Second National Meeting: Improving Efficiency in Delivery of Climate Data to Users,* Mac-Dic Royal Plaza Hotel, Koforidua, Ghana.

Awumbila, M., & Tsikata, D. (2007). *Migration dynamics and small scale gold mining in north-eastern Ghana: Implications for sustainable rural livelihoods*

Ayee, J., & Dickovick, J. T. (2010) Comparative Assessment of Decentralization in Africa: Ghana Desk Study. USAID

Ayivor, J. S. (2012). Evaluation of management effectiveness of protected areas in the Volta Basin of Ghana. PhD Thesis submitted to the School of Graduate Studies, University of Ghana. Legon.

Baglund, A.M. (2013). Gender and empowerment in Bawku West District, Ghana. Master of Philosophy (MPhil.) Thesis. Norwegian University of Science and Technology Trondheim, May 2013.

Bah, M., Cissé, S., Diyamett, B., Diallo, G., Lerise, F., Okali, D., Okpara, E., Olawoye, J., & Tacoli, C. (2003). Changing rural–urban linkages in Mali, Nigeria and Tanzania. *Environment & Urbanization 15*(1).

Barbier, B., Yacouba, H., Karambiri, H., Zoromé, M., & Somé, B. (2009). Human vulnerability to climate variability in the sahel: Farmers' adaptation strategies in northern burkina faso. *Environmental Management, 43*(5), 790-803. doi:10.1007/s00267-008-9237-9

Barron, J., Enfors, E., Cambridge, H., & Moustapha, A. M. (2010). Coping with rainfall variability: Dry spell mitigation and implication on landscape water balances in small-scale farming systems in semi-arid niger. *International Journal of Water Resources Development, 26*(4) doi:10.1080/07900627.2010.519519

Barron, J., Rockström, J., Gichuki, F., & Hatibu, N. (2003). Dry spell analysis and maize yields for two semi-arid locations in east Africa. *Agricultural and Forest Meteorology 117*, 23–37.

Bassett, T. J., & Turner, M. D. (2007). West Africa sudden shift or migratory drift ? FulBe herd movements west Africa to the sudano-guinean region of. *Human Ecology, 35*(1), 33-49. doi:10.1007/s

Batterbury, S. (2001). Landscapes of diversity: a local political ecology of livelihood diversification in south-western Niger. *Cultural Geographies, 8*, 437-464.

Batterbury, S., & Warren, A. (2001). The African Sahel 25 years after the great drought: assessing progress and moving towards new agendas and approaches. *Global Environmental Change, 11*, 1-8.

Bayala, J., Sileshi, G. W., Coe, R., Kalinganire, A., Tchoundjeu, Z., Sinclair, F., & Garrity, D. (2012). Cereal yield response to conservation agriculture practices in drylands of west Africa: A quantitative synthesis. *Journal of Arid Environments, 78*, 13-25. doi:10.1016/j.jaridenv.2011.10.011

Be´ ne´, C., Evans, L., Mills, D., Ovie, S., Raji, A., Tafida, A., Kodio, A., Sinaba, F., Morand, P., Lemoalle, J., & Andrew, N. (2011). Testing resilience thinking in a poverty context: Experience from the Niger River basin. *Global Environmental Change 21*, 1173–1184.

Benjamin, E. (2008). Legal pluralism and decentralization: Natural reseource management in Mali. *World Development, 36*(11), 2255-2276.

Bharati, L., Rodgers, C., Erdenberger, T., Plotnikova, M., Shumilov, S., Vlek, P., & Martin, N. (2008). Integration of economic and hydrologic models: Exploring conjunctive irrigation water use strategies in the volta basin. *Agricultural Water Management, 95*(8), 925-936. doi:10.1016/j.agwat.2008.03.009

Biasutti, & Sobel. (2009). Delayed Sahel Rainfall and Global Seasonal Cycle in a Warmer Climate. *Geophysical Research Letters* 36, L23707.

Black, R., Bennett, S. R. G., Thomas, S. M., & Beddington, J. R. (2011). Climate change: migration as adaptation. *Nature, 478*(7370), 447-449.

Blau, M., & Fingerman, K. L. (2010). *Consequential strangers: Turning everyday encounters into life-changing moments* W. W. Norton Press.

Boardman, J. (2006). Soil erosion science: Reflections on the limitations of current approaches. Catena. 68(2-3), 73-86.

Brockhaus, M., Djoudi, H., & Locatelli, B. (2013). Envisioning the future and learning from the past: Adapting to a changing environment in northern Mali. *Environmental Science \& Policy, 25*, 94-106. doi:10.1016/j.envsci.2012.08.008

Broekhuis, A., de Bruijn, M., & de Jong, A. (2004). Urban-rural linkages and climatic variability. In A. J. Dietz, R. Ruben & A. Verhagen (Eds.), *The impact of climate change on drylands: With a focus on west Africa* (pp. 301-321). Kluwer, Dordrecht.

Brooks. (2004). Drought in the African Sahel: long term perspectives and future prospects. Tyndall Centre for Climate Change Research, Working Paper 61.

Bugri, J. T. (2008a). Gender issues in Africa land tenure: Findings from a study of north-east Ghana. *Journal of the Ghana Institution of Surveyors, 1*(1), 21-35.

Bugri, J. T. (2008b). The dynamics of tenure security, agricultural production and environmental degradation in Africa: Evidence from stakeholders in north-east Ghana. *Land use Policy, 25*(2), 271-285. doi:10.1016/j.landusepol.2007.08.002

Camberlin et al. (2001). Seasonality and atmospheric dynamics of the teleconnection between African rainfall and tropical sea-surface temperature: Atlantic vs. ENSO. *International Journal of Climatology* 21(8), 973–1005.

CARE. (2009). *Participatory and inclusive planning for adaptation to climate change in northern Ghana.*

CARE. (2011). *Understanding vulnerability to climate change: Insights from application of CARE's climate vulnerability and capacity analysis (CVCA) methodology.* CARE International Poverty, Environment and Climate Change Network (PECCN).

Carr, E. R., & Thompson, M. C. (2013). *Gender and climate change adaptation in agrarian settings.* Washington: USAID.

CDKN. (2012). Managing climate extremes and disasters in Africa: Lessons from the SREX report. Climate and Development Knowledge Network. Retrieved from www.cdkn.org/srex

Challinor, A. J., Wheeler, T. R., Garforth, C., Craufurd, P., & Kassam, A. (2007). Assessing the vulnerability of food crop systems in Africa to climate change. *Climatic Change*, *83*, 381-399.

Codjoe, S. N. A., Atidoh, L. K., & Burkett, V. (2012). Gender and occupational perspectives on adaptation to climate extremes in the Afram Plains of Ghana. *Climatic Change 110*, 431–454.

Codjoe, S. N. A., & Nabie, V. A. (2014). Climate Change and Cerebrospinal Meningitis in the Ghanaian Meningitis Belt. *International Journal of Environmental Research and Public Health* 11, 6923-6939.

Cook, K. H., & Vizy, E. K. (2006). Coupled Model Simulations of the West African Monsoon System: Twentieth- and Twenty-First-Century Simulations. *J. Climate* 19, 3681–3703.

Cook, K. H., & Vizy, E. K. (2012). Impact of climate change on mid-twenty-first century growing seasons in Africa. *Climate Dynamics, 39*, 2937-2955. doi:10.1007/s00382-012-1324-1

Cooper, P., Dimes, J., Rao, K., Shapiro, B., Shiferaw, B., & Twomlow, S. (2014). Coping better with current climatic variability in the rain-fed farming systems of sub-saharan Africa: An essential first step in adapting to future climate change? . *Agriculture, Ecosystems, and Environment, 126*, 24-35.

Cotula, L., Vermeulen, S., Leonard, R., & Keeley, J. (2009). *Land grab or development opportunity? agricultural investment and international land deals in Africa.* London/Rome: IIED/FAO/IFAD.

Crane, T. A. (2010). Of models and meanings: Cultural resilience in socio-ecological systems. Centre for Climate Change Economics and Policy. *15*(4).

Dankelman, I., Alam, K., Ahmed, W. B., Guete, Y. D., & Fatema, N. (2008). *Gender, climate change and human security: Lessons from bangladesh, Ghana and Senegal.*

Daron et al. (2014). The role of regional climate projections in managing complex socio-ecological systems. *Regional Environmental Change* doi: 10.1007/s10113-014-0631-y

Daron, J. D. (2014). Regional Climate Messages: West Africa. Scientific report from the CARIAA Adaptation at Scale in Semi-Arid Regions (ASSAR) Project, December 2014.

Dazé, A. (2007). *Climate change and poverty in Ghana*. CARE International.

de Schutter, O. (2013). The agrarian transition and the 'feminization' of agriculture. *Food Sovereignty: A Critical Dialogue,* Yale University. (Conference Paper 37)

Deen-Swarray, M., Adekunle, B., & Odularu, G. (2014). Policy recipe for fostering regional integration through infrastructure development and coordination in west Africa. *Regional economic integration in west Africa* (pp. 29-56) Springer.

Demetriades, J., & Esplen, E. (2008). The gender dimensions of poverty and climate change adaptation. *IDS Bulletin, 39*(4).

Demont, M., Jouve, P., Stessens, J., & Tollens E. (2007). Boserup versus Malthus revisited: Evolution of farming systems in northern Côte d'Ivoire. *Agricultural Systems 93*, 215–228.

Denton, F. (2010). Financing adaptation in Least Developed Countries in West Africa: is finance the 'real deal'? *Climate Policy 10*(6). 655-671.

Descroix et al. (2013). Impact of Drought and Land-Use Changes on Surface Water Quality and Quantity: The Sahelian Paradox. In: Current Perspectives in Contaminant Hydrology and Water Resources Sustainability, chap. 10, edited by: Bradley, P. M., 243–271.

Dietz, T., Ruben, R., & Verhagen, A. (2004). *The impact of climate change on drylands with a focus on west Africa*. Kluwer, Dordrecht.

Dieye, A. M., & Roy, D. P. (2012). A study of rural Senegalese attitudes and perceptions of their behavior to changes in the climate. *Environmental Management, 50*(5), 929-941. doi:10.1007/s00267-012-9932-4

Dingkuhn, M., Singh, B. B., Clerget, B., Chantereau, J., & Sultan, B. (2006). Past, present and future criteria to breed crops for water-limited environments in west Africa. *Agricultural Water Management, 80*(1-3), 241-261. doi:10.1016/j.agwat.2005.07.016

Diouf et al. (2000). Lutte contre la sécheresse au Sahel : résultats. *Centre regional Aghymet* 11(4), 257-66.

Djoudi, H., & Brockhaus, M. (2011). Is adaptation to climate change gender neutral?: Lessons from communities dependent on livestock and forests in northern Mali *International Forestry Review* 13(2), 123-135.

Dosu, A. (2011). *Fulani-farmer conflict and climate change in Ghana.* (ICE Case Studies No. 258).

Douxchamps, S., Ayantunde, A., & Barron, J. (2012). *Evolution of agricultural water management in rainfed crop-livestock systems of the volta basin.* (CPWF R4D Working Paper Series No. 04). Colombo, Sri Lanka: CGIAR Challenge Program for Water and Food.

Druyan. (2011). Studies of 21st-century precipitation trends over West Africa. *Int. J. Climatol.* 31(10), 1415–1424.

Dugje, I. Y., Kamara, A. Y., & Omoigui, L. O. (2006). Infestation of crop fields by striga species in the savanna zones of northeast nigeria. *Agriculture, Ecosystems \& Environment, 116*(3-4), 251-254. doi:10.1016/j.agee.2006.02.013

Duku, M. H., Gu, S., & Hagan, E. B. (2011). A comprehensive review of biomass resources and biofuels potential in Ghana. *Renewable and Sustainable Energy Reviews, 15*(1), 404-415. doi:10.1016/j.rser.2010.09.033

Ebi, K. L., Padgham, J., Doumbia, M., Kergna, A., Smith, J., Butt, T., & McCarl, B. (2011). Smallholders adaptation to climate change in Mali. *Climatic Change, 108*(3), 423-436. doi:10.1007/s10584-011-0160-3

ECOWAS Republic of Mali_ECOWAS country profile. Retrieved from: http://www.ecowas.int/member-states/Mali/

ECOWAS Republic of Ghana_ECOWAS country profile. Retrieved from: http://www.ecowas.int/member-states/Ghana/

Environmental Protection Agency (EPA). (2003). *National action programme to combat drought and desertification.* Environmental Protection Agency (EPA) Accra-Ghana.

Evans, A. E. V., Giordano, M., & Clayton, T. (2012). *Investing in agricultural water management to benefit smallholder farmers in Ghana. AgWater solutions project country synthesis report.* (IWMI Working Paper No. 147). Colombo, Sri Lanka: International Water Management Institute (IWMI).

Favreau, G., Cappelaere, B., Massuel, S., Leblanc, M., Boucher, M., Boulain, N., & Leduc, C. (2009). Land clearing, climate variability, and water resources increase in semiarid southwest niger: A review. *Water Resources Research, 45*, 1-18. doi:10.1029/2007WR006785

Ferry, L., Coulibaly, N., Muther, N., Martin, D., Paturel, J.-E., & Mietton, M. (2011). *Impact du changement climatique sur les écoulements modification des régimes hydrologiques due à des facteurs anthropiques? une confusion possible sur le bassin versant du bani (niger supérieur).*

Folliard, A., Traoré, P. C. S., Vaksmann, M., & Kouressy, M. (2004). Modeling of sorghum response to photoperiod: A threshold–hyperbolic approach. *Field Crops Research, 89*(1), 59-70. doi:10.1016/j.fcr.2004.01.006

Food and Agricultural Organization of the United Nations, Statistics Division (FAOSTAT). (2014). Retrieved from: http://faostat3.fao.org/home/E

Forbes, R. H. (1929). The desiccation problem in west Africa: The capture of the sourou by the black volta. *Geographical Review, 22*(1), 97-106.

Foresight. (2011). *Migration and global environmental change.* (). London: The Government Office for Science, Department for Business, Skills and Innovation.

Forest Research Institute of Ghana (FORIG). (2003). *Final technical report: Forest fire management in Ghana, Forest Research Institute of Ghana*. FORIG, Kumasi.

Fossi, S., Barbier, B., Brou, Y. T., Kodio, A., & Mahé, G. (2012). Perception sociale de la crue et réponse des pêcheurs à la baisse de l'inondation des plaines dans le delta intérieur du niger, Mali . *Territoire En Mouvement, 14-15*, 23 January 2014.

Galvin, K. A. (2009). Transitions: Pastoralists living with change. *Annual Review of Anthropology, 38*(1), 185-198. doi:10.1146/annurev-anthro-091908-164442

Garcia, A. J., Pindolia, D. K., Lopiano, K. K., & Tatem, A. J. (2014). Modeling internal migration flows in sub-saharan Africa using census microdata. *Migration Studies, 3*(1), 89-110. doi:10.1093/migration/mnu036

Garrity, D. P., Akinnifesi, F. K., Ajayi, O. C., Weldesemayat, S. G., Mowo, J. G., Kalinganire, A., . . . Bayala, J. (2010). Evergreen agriculture: A robust approach to sustainable food security in Africa. *Food Security, 2*, 197-214. doi:10.1007/s12571-010-0070-7

Ghile et al. (2014). Bottom-up climate risk assessment of infrastructure investment in the Niger River Basin. *Climatic Change* 122, 97–110.

Goulden, M., & Few, R. (2011). *Climate change, water and conflict in the niger river basin.* USAID.

Government of Ghana, Ministry of Health and National Surveillance Unit. (2002). *Technical Guidelines for Integrated Disease Surveillance and Response in Ghana*. Accra.

Green, V. (2008). *Household water treatment and safe storage options for Northern Region Ghana: consumer preference and relative cost*. MS thesis submitted to Department of Civil and Environmental Engineering. MIT, US.

Gueneau, A., & Robinson, S. (2014). *Is Irrigation in Northern Ghana a Good Adaptation Strategy to Climate Change*: A CGE-W Study. Working Paper, International Food Policy Research Institute (IFPRI), Washington, D.C.

Gyampoh, B. A., Amisah, S., Idinoba, M., & Nkem, J. (2009). Using traditional knowledge to cope with climate change in rural Ghana. *Unasylva 231/232, 60*, 70-74.

Halvorson, S. J., Williams, A. L., Ba, S., & Dunkel, F. V. (2011). Water quality and waterborne disease in the niger river inland delta, Mali: A study of local knowledge and response. *Health & Place, 17*(2), 449-457. doi:10.1016/j.healthplace.2010.10.002

Hampel-Milagrosa, A. (2011). *The role of regulation, tradition and gender in doing business.* Bonn: German Development Institute.

Harris, D. (2006). Development and testing of 'on-farm' seed priming. *Advances in Agronomy 90*, 129-178.

Harris, F. (1996). Intensification of Agriculture in Semi-Arid Areas: Lessons from the Kano Close-Settled Zone, Nigeria. IIED Gatekeeper Series no. SA59. International Institute for Environment and Development. Sustainable Agriculture and Rural Livelihoods Programme. 18 p.

Haussmann, B., Rattunde, F., Weltzien, E., Traore, P. C. S., & K. vom Brocke, H. Parzies. (2012). Breeding strategies for adaptation of pearl millet and sorghum to climate variability and change in west Africa. *Journal of Agronomy and Crop Science, 198*(5), 327-339. doi:10.1111/j.1439-037X.2012.00526.x

Hawkins, & Sutton. (2009). The potential to narrow uncertainty in regional climate projections. *Bulletin of the American Meteorological Society, 90*(8), 1095–1107.

Heintz, J., & Pickbourne, L. (2012). The determinants of selection into non-agricultural self-employment in Ghana. *Margin: Journal of Applied Economic Research, 6*(2), 181-209.

Held et al. (2005). Simulation of Sahel drought in the 20th and 21st centuries. *Proceedings of the National Academy of Science* 102(50), 17891-17896.

Hessel, R., van den Berg, J., Kabor\'e Oumar, van Kekem, A., Verzandvoort, S., Dipama, J. M., & Diallo, B. (2009). Linking participatory and GIS-based land use planning methods: A case study from burkina faso. *Land use Policy, 26*, 1162-1172. doi:10.1016/j.landusepol.2009.02.008

Heubes et al. (2013). The projected impact of climate and land use change on plant diversity: An example from West Africa. *Journal of Arid Environments* 96, 48-54.

Heyen-Perschon, J. (2005). *Report on current situation in the health sector of Ghana and possible roles for appropriate transport technology and transport related communication interventions.* Institute for Transportation Development and Policy, Germany.

Hilhorst, T. (2008). *Local governance institutions for natural resource management in Mali, burkina faso and niger.* (KIT Working Papers Series No. G1). Amsterdam: KIT.

Hounkonnou, D., Kossou, D. K., Kuyper, T. W., Leeuwis, C., Richards, P., R\oling, N. G., . . . Van Huis, A. (2006). Convergence of sciences: The management of agricultural research for small-scale farmers in benin and Ghana. *NJAS - Wageningen Journal of Life Sciences, 53*(3-4), 343-367. doi:10.1016/S1573-5214(06)80013-8

Hwang, Y., Frierson, D. M. W., & Kang, S. M. (2013). Anthropogenic sulfate aerosol and the southward shift of tropical precipitation in the late 20th century. *Geophysical Research Letters 40*, 1-6.

Ibrahim et al. (2014). Changes in rainfall regime over Burkina Faso under the climate change conditions simulated by 5 regional climate models. *Clim Dyn* 42, 363–138.

ICARDA. (2012). CRP 1.1 Dryland Systems: Integrated Agricultural Production Systems for Improved Food Security and Livelihoods in Dry Areas. A proposal submitted to the CGIAR Consortium Board. International Center for Agricultural Research in the Dry Areas, Aleppo, Syria. 201 p.

IFAD. (2008). *Gender and non-timber forest products: Promoting food security and economic empowerment.* ().International Fund for Agricultural Development (IFAD).

Imamura, F., et al. (2015). Dietary quality among men and women in 187 countries in 1990 and 2010: a systematic assessment. *The Lancet Global Health 3*(3), e132-e142.

IPCC. (2012). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Field, C.B. et al. (eds), Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

IPCC. (2013). Climate Change 2013: The Physical Science Basis. Stocker T et al. (eds). In: IPCC Fifth Assessment Report (AR5), Cambridge University Press, Cambridge, UK, and New York, NY, USA.

Jankowskaa, M. M., Lopez-Carr, D., Funk, C., Husak, G. J., & Chafe, Z. A. (2012). Climate change and human health: Spatial modeling of water availability, malnutrition, and livelihoods in Mali, Africa. *Applied Geography, 33*(0), 4-15. doi:10.1016/j.apgeog.2011.08.009

Joly, & Voldoire. (2009). Influence of ENSO on the West African Monsoon: Temporal Aspects and Atmospheric Processes. *Journal of Climate* 22, 3193–3210.

Kalame, F. B., Idinoba, M., Brockhaus, M., & Johnson, N. (2008). *Forest policies and forest resource flow in burkina faso, Ghana and Mali: Conflicting or consistent for adaptation to climate change?* (TroFCCA Brief, No. 1) Center for International Forestry Research (CIFOR).

Kalame, F. B., Kudejira, D., & Nkem, J. (2009). Assessing the process and options for implementing National Adaptation Programmes of Action (NAPA): a case study from Burkina Faso. *Mitig Adapt Strateg Glob Change 14*, 135–151.

Kalame, F. B., Nkem, J., Idinoba, M., & Kanninen, M. (2009). Matching national forest policies and management practices for climate change adaptation in burkina faso and Ghana. *Mitigation and Adaptation Strategies for Global Change, 14*(2), 135-151. doi:10.1007/s11027-008-9155-4

Kamga et al. (2005). Evaluating the National Center for Atmospheric Research climate system model over West Africa: Present-day and the 21st century A1 scenario. *J. Geophys. Res.* 110, D03106.

Lagger, A. (2011). *Access to affordable and effective irrigation technology for small farmers in northern Ghana.* (). Dzorwulu, Accra: iDE-Ghana.

Lahmar, R., Bationo, B. A., Dan Lamso Nomaou, Gu\'ero, Y., & Tittonell, P. (2012). Tailoring conservation agriculture technologies to west Africa semi-arid zones: Building on traditional local practices for soil restoration. *Field Crops Research, 132*, 158-167. doi:10.1016/j.fcr.2011.09.013

Lamien, N., & Vognan, G. (2001). Importance of non-wood forest products as source of rural women's income in western burkina faso. In D. Pasternak, & A. Schlissel (Eds.), *Combating desertification with plants* (pp. 69-79)

Larwanou, M., & Saadou, M. (2011). The role of human interventions in tree dynamics and environmental rehabilitation in the sahel zone of niger. *Journal of Arid Environments, 75*(2), 194-200. doi:10.1016/j.jaridenv.2010.09.016

Laube, W., Schraven, B., & Awo, M. (2012). Smallholder adaptation to climate change: Dynamics and limits in northern Ghana. *Climatic Change, 111*, 753-774. doi:10.1007/s10584-011-0199-1

Lawson, E. T., Mensah, A. & Gordon, C. (2012). Policy brief on climate change in relation to migration and global environmental change. Submitted to UK Foresight Programme.

Lebel, & Ali (2009). Recent trends in the Central and Western Sahel rainfall regime (1990–2007). *J. Hydrol.* 375, 52–64.

Leblanc, M. J., Favreau, G., Massuel, S., Tweed, S. O., Loireau, M., & Cappelaere, B. (2008). Land clearance and hydrological change in the sahel: SW niger. *Global and Planetary Change, 61*, 135-150. doi:10.1016/j.gloplacha.2007.08.011

Lehmann, T., Dao, A., Yaro, A. S., Diallo, M., Timbiné, S., Huestis, D. L., . . . Traoré, A. I. (2014). Seasonal variation in spatial distributions of anopheles gambiae in a sahelian village: Evidence for aestivation. *Journal of Medical Entomology, 51*(1), 27-38.

Lockwood, M. (2013). What can climate-adaptation policy in sub-saharan Africa learn from research on governance and politics? *Development Policy Review, 31*(6), 647-676. doi:10.1111/dpr.12029

Madzwamuse. (2010). Climate Governance in Africa: Adaptation Strategies and institutions. Heinrich Böll Stiftung (HBS).

Mahé, G., & Olivry, J. C. (1999). Assessment of freshwater yields to the ocean along the intertropical atlantic coast of Africa. *C.R. Acad. Sci. Paris, série IIa 328*, 621-626.

Mahé, G. (2009). Surface/groundwater interactions in the bani and nakambe rivers, tributaries of the niger and volta basins, west Africa. *Hydrological Sciences Journal, 54*(4), 704-712. doi:10.1623/hysj.54.4.704

Mahé, G., et al. (2013). The rivers of Africa: witness of climate change and human impact on the environment. *Hydrol. Process.* 27(15), 2105–2114.

Mali Climate Fund MPTF Office GATEWAY-UNDP.

Mali Country Profile: Library of Congress.

Manga, L., Bagayoko, M., Meredith, T., & Neira, M. (2010). Overview of health considerations within national adaptation programmes of action for climate change in least developed countries and small island states.

Marchetta, F. (2011). On the move: Livelihood strategies in northern Ghana.

Marrioti et al. (2014). Seasonal and intraseasonal changes of African monsoon climates in 21st century CORDEX projections. *Climatic Change* 125, 53–65.

Maynard et al. (2002). Impact of greenhouse warming on the West African summer monsoon. *Climate Dynamics* 19, 499–514.

Mbow, C., Mertz, O., Diouf, A., Rasmussen, K., & Reenberg, A. (2008). The history of environmental change and adaptation in eastern Saloum-Senegal-Driving forces and perceptions. *Global and Planetary Change, 64*(3-4), 210-221. doi:10.1016/j.gloplacha.2008.09.008

Mdemu, M. V., Rodgers, C., Vlek, P. L. G., & Borgadi, J. J. (2009). Water productivity (WP) in reservoir irrigated schemes in the upper east region (UER) of Ghana. *Physics and Chemistry of the Earth, 34*(4-5), 324-328. doi:10.1016/j.pce.2008.08.006

Mensah-Kutin, R. (2010). Gender and Climate Change Issues: the Challenge for Policy Advocacy In Ghana. Paper presented at Ghana Research and Advocacy Programme (G-RAP) National Gender Forum on Civic Engagement for Gender Equality and Good Governance in Ghana: Sharing Experiences, Contesting Spaces, Renewing Commitments. 16th and 17th March 2010, Airport West Hotel, Accra.

Mertz, O., Mbow, C., Reenberg, A., & Diouf, A. (2009). Farmers' perceptions of climate change and agricultural adaptation strategies in rural sahel. *Environmental Management, 43*, 804-816. doi:10.1007/s00267-008-9197-0

Mertz, O., Mbow, C., Reenberg, A., Genesio, L., Lambin, E. F., D'haen, S., . . . Sandholt, I. (2011). Adaptation strategies and climate vulnerability in the sudano-sahelian region of west Africa. *Atmospheric Science Letters, 12*, 104-108. doi:10.1002/asl.314

MESTI. (2013). *Ghana national climate change policy.* (). Accra, Ghana: Ministry of Environment, Science, Technology and Innovation.

MoFA. (2007). *Food and agriculture sector development policy II.* (). Accra, Ghana:

Morand, P., Kodio, A., Andrew, N., Sinaba, F., Lemoalle, J., & B\'en\'e Christophe. (2012). Vulnerability and adaptation of African rural populations to hydro-climate change: Experience from fishing communities in the inner niger delta (Mali). *Climatic Change, 115*, 463-483. doi:10.1007/s10584-012-0492-7

Namara, R. E., Horowitz, L., Kolavalli, S., Kranjac-Berisavljevic, G., Dawuni, B. N., Barry, B., & Giordano, M. (2010). *Typology of irrigation systems in Ghana.* (IWMI Working Paper No. 142). Colombo, Sri Lanka: International Water Management Institute. doi:10.5337/2011.200

Namara, R. E., Horowitz, L., Nyamadi, B., & Barry, B. (2011). *Irrigation development in Ghana: Past experiences, emerging opportunities, and future directions.* (Ghana Strategy Support Program Working Paper No. 27). Accra: IFPRI.

Nation, M. L. (2010). Understanding women's participation in irrigated agriculture: A case study from Senegal. *Agriculture and Human Values, 27*, 163-176. doi:10.1007/s10460-009-9207-8

Ndao, L. M. (2014). The socioeconomic importance of the gathering of non timber forest products in the rural community of niaguis. *Merit Research Journal of Agricultural Science and Soil Sciences, 2*(10), 130-137.

Nelson, W., & Agbey, S. N. D. (2005). *Linkages between poverty and climate change: Adaptation for livelihood of the poor in Ghana.* ().The Netherlands Climate Assistance Programme.

New et al. (2006). Evidence of trends in daily climate extremes over southern and west Africa. *Journal of Geophysical Research* 111, D14102.

Niang, I., Ruppel, O. C., Abdrabo, M. A., Essel, A., Lennard, C., Padgham, J., & Urquhart, P. (2014). Africa. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.) Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1199-1265.

Nicholson. (2013). The West African Sahel: A Review of Recent Studies on the Rainfall Regime and Its Interannual Variability. *ISRN Meteorology*, Article ID 453521

Nielsen, J. Ø., & Reenberg, A. (2010). Temporality and the problem with singling out climate as a current driver of change in a small West African village. *Journal of Arid Environments 74*, 464–474.

Obioha, E. E. (2009). Climate variability, environment change and food security nexus in nigeria. *J Hum Ecol, 26*(2), 107-121.

OECD. (2007). Atlas on Regional Integration in West Africa: Demographic Trends. Retrieved from: http://www.oecd.org/swac/publications/39802965.pdf

Okali, C., & Naess Otto, L. (2013). *Making sense of gender, climate change and agriculture in sub-saharan Africa: Creating gender responsive climate adaptation policy.* (Future Agricultures Working Paper No. 057).

Osman-Elasha, B., et al. (2008). Community development and coping with drought in rural Sudan. *Climate Change and Adaptation*, 90-108.

Oyebande, L., & Odunuga, S. (2010). Climate change impact on water resources at the transboundary level in West Africa: the cases of the Senegal, Niger and Volta Basins. *Open Hydrology Journal 4*(1), 163-172

Padgham, J. (2009). Agricultural Development under a Changing Climate: Opportunities and Challenges for Adaptation. Joint Discussion Paper, Agriculture and Rural Development & Environment Departments. The World Bank. 169 pp.

Padmanabhan, M. A. (2004). The making and unmaking of gendered crops in northern Ghana deutscher tropentag. *Conference on International Agricultural Research for Development,* Berlin.

Paeth, H. & Thamm, H. P. (2007). Regional modeling of future African climate north of 15° S including greenhouse warming and land degradation. *Climatic Change 83*, 401-427.

Patt, A. G., Ogallo, L., & Hellmuth, M. (2007). Learning from 10 years of Climate Outlook Forums in Africa. *Science, 318*, 49-50.

Paturel et al. (2003). Modelling the impact of climatic variability on water resources in West and Central Africa from a non-calibrated hydrological model. *Hydrolog. Sci. J.* 52, 38–48.

Philippon, S., Broutin, H., Constantin de Magny, G., Toure, K., Diakite, C. H., Fourquet, N., . . . Guégan, J. (2009). Meningococcal meningitis in Mali: A long-term study of persistence and spread. *International Journal of Infectious Diseases, 13*(1), 103-109. doi:10.1016/j.ijid.2008.05.1223

Piccolino, G., & Minou, S. (2014). The EU and Regional Integration in West Africa: What Effects on Conflict Resolution and Transformation? (Working Paper Series Working Paper No. 5). University of Pretoria.

Population Reference Bureau (PRB) 2014. Retrieved from: http://www.prb.org/DataFinder/Geography/Data.aspx?loc=256

President's Malaria Initiative. (2014). *Malaria Operational Plan FY 2015.* Accra, Ghana.

Rademacher-Schulz, C., & Mahama, E. S. (2012). *"Where the rain falls" project. case study: Ghana. results from nadowli district, upper west region, Ghana.* (Report No. 3). Bonn: United Nations University Institute for Environment and Human Security (UNU-EHS).

Rasmussen, L. V., Rasmussen, K., Birch-Thomsen, T., Kristensen, S. R. B. P., & Traoré Oumar. (2012). The effect of cassava-based bioethanol production on above-ground carbon stocks:

A case study from southern Mali. *Energy Policy, 41*, 575-583. doi:10.1016/j.enpol.2011.11.019

Raynaut, C. (2001). Societies and nature in the Sahel: ecological diversity and social dynamics. *Global Environmental Change 11*(1), 9-18.

Reij, C. P., & Smaling, E. M. A. (2007). Analyzing successes in agriculture and land management in sub-saharan Africa: Is macro-level gloom obscuring positive micro-level change? *Land use Policy, 25*(3), 410-420. doi:10.1016/j.landusepol.2007.10.001

Republic of Mali embassy US, Mali Factsheet. Retrieved from http://www.maliembassy.us/index.php/about-Mali/government-a-politics

Republic of Ghana embassy US Ghana factsheet. Retrieved from http://www.Ghanaembassy.org/index.php?page=population

Republic of Ghana (2011). Ghana's Second National Communication to the UNFCCC. Retrieved from http://unfccc.int/resource/docs/natc/ghanc2.pdf

Republique du Mali, GEF, UNDP. (2007). Plan d'Action National d'Adaptation aux Changements Climatiques (PANA). Ministère de l'Equipement et des Transports. Bamako. Retrieved from www.adaptationlearning.net/sites/default/files/mli01f.pdf

Resurrección, B. P. (2013). Persistent women and environment linkages in climate change and sustainable development agendas. *Women's Studies International Forum, 40*, 33-43.

Ribot, J. C. (2002). African Decentralization: Local Actors, Powers and Accountability. United Nations Research Institute for Social Development Programme on Democracy, Governance and Human Rights Paper no. 8. Geneva: UNRISD.

Ringler, C., Cenacchi, N., Koo, J., Robertson, R. D., Fisher, M., Cox, C. M., . . . Rosegrant, M. W. (2014). Sustainable agricultural intensification: The promise of innovative farming practices. In A. Marble, & H. Fritschel (Eds.), *2013 global food policy report* (pp. 43-52). Washington, D.C.: International Food Policy Research Institute (IFPRI).

Roberts, B., & Peter Hohmann, R. (2014). *The system of secondary cities: The neglected drivers of urbanising economies.* (CIVIS series No. 7).Cities Alliance. Retrieved from http://citiesalliance.org

Roe, D., Nelson, F., & Sandbrook, C. (2009). *Community management of natural resources in Africa: Impacts, experiences and future directions.* (Natural Resource Issues No. 18). London, UK: International Institute for Environment and Development.

Roncoli, C., Jost, C., Kirshen, P., Sanon, M., Ingram, K. T., Woodin, M., . . . Hoogenboom, G. (2008). From accessing to assessing forecasts: An end-to-end study of participatory climate forecast dissemination in burkina faso (west Africa). *Climatic Change, 92*(3-4), 433-460. doi:10.1007/s10584-008-9445-6

Rondinelli, D. A., Nellis, J. R., & Cheema, G. S. (eds.). (1983). Decentralization in Developing Countries: a Review of Recent Experience. Washington, D.C.: World Bank.

Roudier, P., & Mahé, G. (2010). Calcul des pluies et débits classés sur le bassin du bani (Mali): Une approche de la vulnérabilité des ouvrages et de la population depuis la sécheresse. *Hydrological Sciences Journal, 55*(3), 351-363. doi:10.1080/02626661003683280

Roudier et al. (2014). Climate change impacts on runoff in West Africa: a review. *Hydrol. Earth Syst. Sci.* 18, 2789–2801.

Sahel and West Africa Club. (2006). Atlas on Regional Integration in West Africa, SWAC/OECD.

Samimi, C., Fink, A. H., & Paeth, H. (2012). The 2007 flood in the Sahel: causes, characteristics and its presentation in the media and FEWS NET. *Natural Hazards and Earth System Sciences 12*, 313-325.

Sarr, B., & Lona, I. (2009). Les fortes pluies et les inondations enregistrées au sahel au cours de l'hivernage 2007: Variabilité et/ou changement climatique, 14 ème Colloque International SIFEE Changement climatique et évaluation Environnementale, Niamey, 29.

Sarr, B. (2012). Present and future climate change in the semi-arid region of west Africa: A crucial input for practical adaptation in agriculture. *Atmospheric Science Letters, 13*, 108-112. doi:10.1002/asl.368

Savory, E. C., Cuevas, L. E., Yassin, M. A., Hart, C. A., Molesworth, A. M., & Thomson, M. C. (2006). Evaluation of the meningitis epidemics risk model in Africa. *Epidemiology and Infection, 134*(5), 1047-1051. doi:10.1017/S0950268806005929"

Scheffran, J., Marmer, E., & Sow, P. (2012). Migration as a contribution to resilience and innovation in climate adaptation: Social networks and co-development in northwest Africa. *Applied Geography, 33*(0), 119-127. doi:10.1016/j.apgeog.2011.10.002

Schiffer, E., Hartwich, R., & Monge, M. (2010). *Who has influence in multi-stakeholder governance systems? using the net-map method to analyze social networking in watershed management in northern Ghana.* (IFPRI Discussion Paper 00964 No. 00964).Environment and Production Technology Division, IFPRI.

Schiffer, E., McCarthy, N., Birner, R., Waale, D., and Asante, F. (2008). *Information Flow and Acquisition of Knowledge in Water Governance in the Upper East Region of Ghana.* IFPRI Discussion Paper 00820, Environment and Production Technology Division, IFPRI.

Schoneveld, G. C., German, L. a., & Nutako, E. (2011). Land-based investments for rural development? A grounded analysis of the local impacts of biofuel feedstock plantations in Ghana. *Ecology and Society, 16*(4) doi:10.5751/ES-04424-160410

Schraven, B. (2010). Irrigate or migrate? Local livelihood adaptation in Northern Ghana in response to ecological changes and economic challenges. PhD thesis. Center for Development Research, University of Bonn.

Scott, Z., & Tarazona, M. (2011). Study on Disaster Risk Reduction Decentralization and Political Economy. ISDR, UNDP, OPM.

Shapland, P., Prihodko, L., & Hana, N. (2013). Climate change, pastoral resources and livestock in the Sahel, Research brief, Feed the Future Innovation Lab for Collaborative Research on Adapting Livestock Systems to Climate Change. Retrieved from http://lcccrsp.org/wp-content/uploads/2013/10/RB-11-2013.pdf

Sida. (2013). Mali Environmental and Climate Change (Policy Brief). Retrieved from: http://sidaenvironmenthelpdesk.se/wordpress3/wp-content/uploads/2013/05/Mali-Environmental-and-Climate-Change-Policy-Brief-Final-draft.pdf

Simonsson, L. (2005). *Vulnerability profile of Mali.* Stockholm: Stockholm Environment Institute.

Singh, P., Nedumaran, S., Traore, P. C. S., Boote, K. J., Rattunde, H. F. W., Prasad, P. V. V., . . . Bantilan, M. C. S. (2014). Quantifying potential benefits of drought and heat tolerance in rainy season sorghum for adapting to climate change. *Agricultural and Forest Meteorology, 185*(0), 37-48. doi:10.1016/j.agrformet.2013.10.012

Sivakumar, M. V. K., & Hansen, J. (2007). Climate prediction and agriculture: summary and the way forward. Pp. 1-14. *In* M. V. K Sivakumar and J. Hansen (Eds.) Climate prediction and Agriculture, Advances and Challenges. (*WMO, START, IRI*) Springer. New York. Pp. 306.

Skutsch, M. M., & Ba, L. (2010). Crediting carbon in dry forests: The potential for community forest management in west Africa. *Forest Policy and Economics, 12*(4), 264-270. doi:10.1016/j.forpol.2009.12.003

Speranza, C. I., Kiteme, B., & Wiesmann, U. (2008). Droughts and famines: The underlying factors and causal links among agro-pastoral households in semi-arid Makueni district, Kenya. *Global Environmental Change 18*(1), 220-233.

Stone, G. D. (1994). Agricultural Intensification and Perimetrics: Ethnoarchaeological Evidence from Nigeria. *Current Anthropology 35*(3), 317-324.

Stringer, L. C., Twyman, C., & Thomas, D. S. G. (2007). Learning to reduce degradation on Swaziland's arable land: Enhancing understandings of striga asiatica. *Land Degradation & Development, 18*, 163-177.

Sultan, B., Labadi, K., Guégan, J., & Janicot, S. (2005). Climate drives the meningitis epidemics onset in west Africa. *PLOS Medicine,* doi:10.1371/journal.pmed.0020006

Sultan, B., Roudier, P., Quirion, P., Alhassane, A., Muller, B., Dingkuhn, M., . . . Baron, C. (2013). Assessing climate change impacts on sorghum and millet yields in the sudanian and sahelian savannas of west Africa. *Environmental Research Letters, 8*, 014040. doi:10.1088/1748-9326/8/1/014040

Tambo, J. A., & Abdoulaye, T. (2012). Climate change and agricultural technology adoption: the case of drought tolerant maize in rural Nigeria. *Mitigation and Adaptation Strategies for Global Change 17*, 277–292.

Thornton, P. K., Jones, P. G., Ericksen, P. J., & Challinor, A. J. (2010). Agriculture and food systems in sub-saharan Africa in a 4\textdegreeC+ world. *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences, 369*(1934), 117-136. doi:10.1098/rsta.2010.0246

Totin, E., Stroosnijder, L., & Agbossou, E. (2013). Mulching upland rice for efficient water management: A collaborative approach in benin. *Agricultural Water Management, 125*(0), 71-80. doi:10.1016/j.agwat.2013.04.012

Transparency International (2014). Transparency International Corruption Perception Index (CPI). Retrieved from http://www.transparency.org/cpi2014

Traoré, P. C. S., Lamien, N., Ayantunde, A. A., Bayala, J., Kalinganire, A., Binam, J. N., Carey, E., Emechebe, A., Namara, R., Tondoh, J. E., Vodouhe, R. (2013). Sampling the vulnerability reduction – sustainable intensification continuum: a West African paradigm for selection of Dryland Systems sites. 11th International Conference on Development of Drylands, March 18-21, 2013, Beijing, China.

Traoré, S., & Owiyo, T. (2013). Dirty droughts causing loss and damage in northern burkina faso. *International Journal of Global Warming, 5*(4), 498-513. doi:10.1504/IJGW.2013.057288

Tschakert, P. (2007). Views from the vulnerable: Understanding climatic and other stressors in the sahel. *Global Environmental Change, 17*, 381-396. doi:10.1016/j.gloenvcha.2006.11.008

Tschakert, P., Sagoe, R., Ofori-Darko, G., & Codjoe, S. N. (2009). Floods in the Sahel: an analysis of anomalies, memory, and anticipatory learning. *Climatic Change*. doi:10.1007/s10584-009-9776-y.

Tschakert, P., & Tutu, R. (2010). Solastalgia: environmentally induced distress and migration among Africa's poor due to climate change. In: Environment, Forced Migration and Social Vulnerability. Afifi, T. and J. Jägger (eds.). Springer-Verlag, Berlin Heidelberg, Germany, pp. 57-69.

Tschakert, P., van Oort, B., Lera St. Clair, A., & LaMadrid, A. (2013). Inequality and transformation analyses: A complementary lens for addressing vulnerability to climate change. *Climate and Development, 5*(4), 340-350. doi:10.1080/17565529.2013.828583

Tsikata, D. (2001). *Gender training in Ghana: Politics, issues & tools.* ().Woeli Publication Services.

Ubink, J. M., & Quan, J. F. (2008). How to combine tradition and modernity? regulating customary land management in Ghana. *Land use Policy, 25*(2), 198-213. doi:10.1016/j.landusepol.2007.06.002

UNDP. (2010). *Integrating climate change into the management of priority health risks in Ghana*. Environmental Finance Services, UNDP, NY.

UNDP. (2012). *Gender, climate change and food security.* (Gender and climate change Africa Policy Brief No. 4).

UNDP. (2014). The 2014 Human Development Report - Sustaining Human Progress: Reducing Vulnerabilities and Building Resilience. Retrieved from http://hdr.undp.org/en/2014-report

UNEP. (2004). African environment outlook: past, present and future perspectives. Geneva. ISBN No. 92-807-2458-4, 16 pp.

UNEP. (2011). *Livelihood security: Climate change, conflict and migration in the sahel.* United Nations Environment Programme (UNEP).

USAID. (2014). Assessing Mali's Direction Nacionale de la Météorologie Agrometeorological Advisory Program. Preliminary report on the climate science and farmer use of advisories. Prepared for the United States Agency for International Development, Global Climate Change Office, Climate Change Resilient Development Project. Prepared by: Engility Corporation, Washington, DC. Edited by Edward Carr. 168 pages.

UT-Battelle. (2001). LandScan 2001™ High Resolution global Population Data Set. Copyright: UT-Battelle, LLC, operator of Oak Ridge National Laboratory under Contract No. DE-AC05-00OR22725 with the United States Department of Energy. Retrieved from www.ornl.gov/landscan

van de Giesen, N., Liebe, J., & Jung, G. (2010). Adapting to climate change in the Volta Basin, West Africa. *Currentscience, 98*(8), 1033-1037.

van der Geest, K. (2004). *''We are managing!'' climate change and livelihood vulnerability in northwest Ghana.* Leiden: Afrika-Studie Centrum.

van der Geest, K., (2011). North-South migration in Ghana: what role for the environment? *International Migration, 49*(Suppl.1), e69-e94.

van Mele, P., et al. (2011). Attitude counts: engaging with rice farmers in West Africa. *Development in Practice 21*(6), 806-821.

Vlek, P. (1995). The soil and its artisans in sub-Saharan African agriculture. *Geoderma 67*, 165-170.

Vohland, K., & Barry, B. (2009). A review of in situ rainwater harvesting (RWH) practices modifying landscape functions in African drylands. *Agriculture, Ecosystems \& Environment, 131*(3-4), 119-127. doi:10.1016/j.agee.2009.01.010

Ward, J., & Kaczan, D. (2014). Challenging hydrological panaceas: Water poverty governance accounting for spatial scale in the niger river basin. *Journal of Hydrology, 519*(C), 2501-2514.

Washington, R., Harrison, M., Conway, D., Black, E., Challinor, A., Grimes, D., . . . Todd, M. (2006). African climate change: Taking the shorter 10 route. *Bulletin of the American Meteorological Society, 87*(10), 1355-1366.

WEDO. (2008). *Gender, climate change and human security lessons from bangladesh, Ghana and Senegal.* ().

Weingast, B. (1995). The Economic Role of Political Institutions: Market Preserving Federalism and Economic Development. *Journal of Law, Economics, and Organization 20*(1), 1-31.

West, C. T., Roncoli, C., & Ouattara, F. (2008). Local Perceptions and Regional Climate Trends on the Central Plateau of Burkina Faso. *Land Degradation and Development 19*, 289–304.

Westerhoff, L., & Smit, B. (2008). The rains are disappointing us: Dynamic vulnerability and adaptation to multiple stressors in the afram plains, Ghana. *Mitigation and Adaptation Strategies for Global Change, 14*(4), 317-337. doi:10.1007/s11027-008-9166-1

Whitehead, A. (2009). The gendered impacts of liberalization policies on African agricultural economies and rural livelihoods. In S. Razavi (Ed.), *The gendered impacts of liberalization: Towards'embedded' liberalism?* (pp. 37-62). London: Routledge.

Wing, S. & Kassibo, B. (2010). Comparative Assessment of Decentralization in Africa: Mali Desk Study. USAID.

Wood, E. C., Tappan, G. G., & Hadj, A. (2004). Understanding the drivers of agricultural land use change in south-central Senegal. *Journal of Arid Environments, 59*, 565-582. doi:10.1016/j.jaridenv.2004.03.022

World Bank. (2005). Gender issues and best practices in land administration projects. A synthesis Report prepared for Gender and Rural Development Thematic Group (PREM/ARD) and the Land Policy and Administration Thematic Group (ARD) of the World Bank.

World Bank, & IFPRI. (2010). *Gender and governance in rural services: Insights from india, Ghana, and ethiopia*. Washington, D.C.: The World Bank. doi:10.1596/978-0-8213-7658-4

WRI in collaboration with UNDP, UNEP, and World Bank. (2008). Turning back the desert: How farmers have transformed Niger's landscape and livelihoods. *World resources 2008: Roots of Resilience—Growing the wealth of the poor* (pp. 142-157). Washington, DC: WRI.

Würtenberger, L., Bunzeck, I. G., & van Tilburg, X. (2011). Initiatives related to climate change in Ghana: Towards coordinating efforts. CDKN.

Yamana, T. E., & Eltahir, A. B. (2012). Projected impacts of climate change on environmental suitability for malaria transmission in west Africa. *Environmental Health Perspectives, 121*(10), 1179-1186.

Yiridoe, E. K., Langyintuo, A. S., & Dogbe, W. (2006). Economics of the impact of alternative rice cropping systems on subsistence farming: Whole-farm analysis in northern Ghana. *Agricultural Systems, 91*(1-2), 102-121. doi:10.1016/j.agsy.2006.02.006

Zawedde, S. (2011). *Outcomes of the African development forum (VII) on climate change, gender and youth: The way forward acting on climate change for sustainable development in Africa.* Malabo Equatorial Guinea: United Nations Economic Commission For Africa.

Zhang, R., & Delworth, T. L. (2006). Impact of Atlantic multidecadal oscillations on India/Sahel rainfall and Atlantic hurricanes. *Geophysical Research Letters 33*, L17712.

Zomer, R. J., Trabucco, A., Bossio, D. A., van Straaten, O., & Verchot, L. V. (2008). Climate Change Mitigation: A Spatial Analysis of Global Land Suitability for Clean Development Mechanism Afforestation and Reforestation. *Agric. Ecosystems and Envir. 126*, 67-80.