ADAPTING TO THE SAHEL'S CHANGING CLIMATE: LOCAL APPROACHES

AN ECONOMIC AND TECHNICAL FEASIBILITY ANALYSIS OF ADAPTATION TECHNIQUES IN NIGER, BURKINA FASO AND MALI

August 2014

UKaid from the British people

DRLA

Tulane University

CRS CATHOLIC RELIEF SERVICES

This study was produced with funding from the UK Department for International Development (DFID) as part of the project development phase for Scaling Up Resilience for Over One Million people in the Niger River Basin of Niger, Burkina Faso, and Mali (SUR1M), one of 10 projects across the Sahel Region for which a Concept Note has been approved by the DFID-funded Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) Programme. The SUR1M consortium is led by Catholic Relief Services, and brings together CAFOD (Catholic Agency for Overseas Development), *Caritas Développement* (CADEV) Niger, Catholic Organisation for Development and Solidarity (*Organisation Catholique pour le Développement et la Solidarité*) OCADES Burkina Faso, Caritas Mali, Farm Radio International (FRI), United Nations Development Programme (UNDP), Agrometeorology, Hydrology, Meteorology (AGRHYMET) Regional Centre, Research Programme on Climate Change, Agriculture and Food Security (CCAFS), and Tulane University. The opinions expressed in this paper are those of the author and do not necessarily represent those of CRS, DFID, or any other organizations mentioned herein.

Cover photograph: Women construct a raised earthen berm to help reduce water runoff and soil erosion in Burkina Faso. Strategies such as this can help mitigate the impacts of heavy rainfall in areas suffering the effects of climate change. 26 April 2012 Photographer: Amidou Traore, CRS

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August 2014

Tulane University's Disaster Resilience Leadership Academy (DRLA) Research Team

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EXECUTIVE SUMMARY

This report has been commissioned as part of a series of studies being undertaken by CRS that is to inform design of new activities under CRS' Consortium SUR1M initiative. SUR1M is one of 10 projects across the Sahel Region provisionally approved by the DFID-funded Building Resiliency and Adaptation to Climate Extremes and Disasters (BRACED) umbrella program. The report assesses climate change threats and their impacts on vulnerable populations and ecosystems, identifies adaptation strategies, and proposes climate smart agricultural (CSA) technologies and strategies to address the overarching objectives of the BRACED program. Analysis includes an economic and technical feasibility study of CSA practices to support recuperation of degraded lands, soil and water management, and sustainable agriculture and pastoralism.

Recommendations are proposed, based on a 45-day study in three targeted zones of high vulnerability to food insecurity in Burkina Faso, Niger, and Mali. The report pays special attention to the most inclusive and appropriate practices to maximize both men's and women's participation and benefits. The study covers 20 villages in 16 communes in the Sahel Region of Burkina Faso, the Tillaberi Region of Niger, and the Gao Region of Mali, using key informant interviews (KII), focus group discussions (FGD), and a structured Village Leaders Survey (VLS). Analyses examine adaptation strategies using three key variables: 1) gender, 2) proximity to markets, and 3) proximity to water sources (rivers or large streams).

KEY FINDINGS

Analysis of Climate Smart Agriculture Techniques by Gender

Among crop and soil management practices identified in the study, men accounted for nearly 60 percent of all practices cited, women accounting for the remaining 40 percent. Water management strategies were notably few, and no significant disparities in water technology use by gender were found. Livestock management practices focused largely on three areas: intensive animal fattening, fodder storage, and fodder production. Men engaged in nearly 64 percent of all livestock management techniques identified, particularly cattle fattening, while women, accounting for 36 percent, specialize primarily in sheep fattening and grass production. The most common forestry adaptation practices were agroforestry, farmer managed natural regeneration (FMNR), and reforestation. Overall, 65 percent of all forestry management techniques cited were undertaken by men, 35 percent by women.

Analysis Climate Smart Agriculture Techniques by Proximity to Markets and Rivers

In comparing market proximity to crop and soil management techniques across the three study areas, a total of 89 practices were cited, of which nearly 61 percent were in villages within relative proximity (5 kilometers) of a market. Thus, market location may play some role in shaping diversification strategies deployed to manage crops, soils, and water. When comparing all agricultural practices (crops, water, livestock, forestry) across the three study regions, nearly 60 percent occurred in villages close to a market.

Proximity to a river appears to influence the diversification of crop and soil management strategies. Nearly 67 percent of crop and soil management practices were in villages close to a river.

Cost Benefit Analysis of Climate Change Adaptation Techniques

Of 35 techniques inventoried, composting provides relatively high economic benefits, relative to costs. In terms of livestock adaptation strategies, intensive goat fattening proves to be a relatively profitable activity when compared to intensive fattening of cows and sheep.

Recommendations

Findings support actionable items to strengthen **ecosystem** and **livelihood resilience**. A large-scale sustainable landscapes approach emphasizing ecosystem resilience should be a guiding principle and cornerstone of SUR1M. Watershed restoration is needed to address the underlying causes that drive environmental decline and land degradation in the study zone. Proposed interventions include the bio-recovery of degraded lands (BDL) through fodder production, a mix of trees, stone bunds, and grass hedges, and non-timber forest products (NTFPs).

Livelihood resilience can be strengthened through the promotion of various CSA practices that should be introduced as an integrated package. These include a mix of zai, compost, stone bunds, and improved seed, composting, fertilizer micro dosage, and inventory credit and warehouse receipts ('warrantage'). Seed access and distribution should be promoted through innovative, decentralized, community-based models such as master/lead farmers, APS (Agents Prestataires de Services), Farmer Field Schools, micro-enterprise based agro-vet dealers who serve as village-based agronomic extension agents, and suppliers of inputs such as seed in small quantities affordable to the farmer

One of the most salient findings of the study is the very low use of, or access to, water resource technologies. Well technology, particularly deep boreholes, would greatly benefit both humans and animals throughout the region. Due to cost limitations, alternative, low-cost manual pump technologies may prove the most cost-effective.

Animal fattening, fodder production, and storage should be supported under SUR1M. Intensive feeding of cows, sheep, and goats serves as one of the primary activities for generating family income, and serving as a social safety net during periods of acute environmental or economic stress. Fodder production has the potential to significantly improve livestock productivity, while also meeting environmental objectives of protecting and enhancing soil quality. Improved fodder storage technology should be researched and promoted as a low cost intervention that could boost feed quality for animals.

Tree crops with a clear NTFP market value should be promoted. FMNR requires very little, if any, capital outlays, builds upon already existing local knowledge and practice, and would be the most technically and economically feasible strategy to pursue in promoting adaptive forestry management capacity.

SUR1M should promote climate 'neutral' livelihood activities that are less dependent on scarce rainfall in a semi-arid region. This might include small-scale artisanal activities, such as soap production and other artifacts or handicrafts that could be marketed to the larger urban centers, skilled trades such as sewing, and other micro-enterprise activities where strong demand for a market product can be identified.

ACRONYMS

A2N	Africa 2000 Network
AGED	Association pour la Gestion de l'Environnement et le Développement
AGRA	Alliance for a Green Revolution in Africa
BDL	Bio-reclamation of degraded land
BRACED	Building Resilience and Adaptation to Climate Extremes and Disasters
CCA	Climate Change Adaptation
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CCAT	Climate Change Adaptation Technique
CFW	Cash-for-Work
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
CLUSA	Cooperative League of the USA
CRS	Catholic Relief Services
CSA	Climate Smart Agriculture
CVD	Conseil Villageois de Développement (Village Development Council)
DAP	Double ammonium phosphate
DFID	Department for International Development
DRM	Disaster Risk Management
DRR	Disaster risk reduction
EWRG	Early Warning/Response Group
FEWS	Famine Early Warning System
FGD	Focus Group Discussion
FMNR	Farmer-managed natural regeneration
(F)RA	(Field) Research Assistant
GIZ	Gesellschaft für Internationale Zusammenarbeit

ICRISAT	International Crops Research Institute for the Semi-Arid-Tropics
iDE	International Development Enterprises
IDRC	International Development Research Centre
INERA	Institut de l'Environnement et Recherches Agricoles
INRAN	Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Intertropical Convergence Zone
KII	Key Informant Interview
LC	Lead Consultant
MOI/AVC	Market Opportunies Identification/ Agriculture Value Chains
NGO	Non-governmental organization
NRM	Natural resource management
NTFP	Non-timber forest product
SILC	Savings and Internal Lending Communities
SUR1M	Scaling Up Resilience for One Million people in the Niger River Basin of Niger, Burkina Faso, and Mali
TU/DRLA	Tulane University Disaster Resilience Leadership Academy
USAID	United States Agency for International Development
USGS	U.S. Geological Survey
VLS	Village Leader Survey

1. INTRODUCTION

In northern central and eastern Burkina Faso, CRS has supported women farmers to rehabilitate previously degraded lands and improve agricultural production through a range of climate-smart agriculture techniques. 16 August 2012
AMIDOU TRAORE, CRS

Catholic Relief Services commissioned Tulane University's Disaster Resilience Leadership Academy to complete this report as part of a series of studies to inform new activities under CRS' Consortium SUR1M initiative. SUR1M is one of 10 projects across the Sahel Region provisionally approved by the UK's Department for International Development (DFID) funded Building Resiliency and Adaptation to Climate Extremes and Disasters (BRACED) umbrella program. SUR1M is designed to reduce one million people's risk to droughts and floods in 30 communes in the Niger River Basin. Project interventions will focus on livelihoods and malnutrition, natural resource management (NRM) and climate adaptation, governance and Disaster Risk Reduction (DRR), women's participation and leadership in community level decision-making structures and bodies, and collective learning and evidence-based decision-making.

The TU/DRLA research team hopes these findings will better empower communes and villages to make behavioral and institutional changes to increase their resilience to climatic changes. This will be evidenced by an uptake in new techniques and timesaving technologies, participation in Savings and Internal Lending Communities (SILC) and Early Warning/Response Groups (EWRG), strengthened market linkages, use of climate data for decision-making, improved nutrition, diversified and improved revenues, more equitable land usage and ownership, a sustainable natural resource base, and more secure assets.

In preparation for the full project implementation phase, SUR1M commissioned this study, entitled **Economic and Technical Feasibility Analysis of Climate Change Adaptation Techniques with a Focus on Climate Smart Agriculture (CSA)**[1]**.** Findings will inform the target communes' leaders and populations about the range of most-appropriate technical options taking into account the agro-ecologies in the study zones, the market context (including existence of support services and expertise in the public and private sectors, suppliers of equipment, all materials required locally, in the region, and in country), and community priorities and needs. The recommendations proposed – based on a 45-day study in three targeted zones of high vulnerability to food insecurity in the West African Sahel – will support a consultative decision making process by CRS and program partners to support investments that build human and environmental resilience to effects of climate change. This study pays special attention to the most-inclusive and appropriate practices to maximize participation by men and women.

The SUR1M objectives and expected outcomes are outlined in the following sections.

1.1 SUR1M OBJECTIVES

CRS elaborated the following program objectives:

1. SUR1M will increase resilience to climate extremes by increasing disaster risk preparedness and climate change adaptation. It will scale impact by reinforcing the disaster risk management capacity of 30 communes through technical assistance, performance-based matching grants for DRR

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1 CSA seeks to increase sustainable productivity, strengthen farmers' resilience, reduce agriculture's greenhouse gas emissions and increase carbon sequestration. It strengthens food security and delivers environmental benefits. Climate-smart agriculture includes proven practical techniques — such as mulching, intercropping, conservation agriculture, crop rotation, integrated crop-livestock management, agroforestry, improved grazing, and improved water management — and innovative practices such as better weather forecasting, more resilient food crops and risk insurance. http://www.worldbank.org/content/dam/Worldbank/document/CSA_Brochure_web_WB.pdf

CSA is an agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation), and enhances achievement of national food security and development goals.

FAO climate-smart website: www.fao.org/climatechange/climatesmart/en planning targeted at strengthening markets and natural resource management (NRM), and mass media campaigns. SUR1M will increase revenue opportunities and financial services while reducing malnutrition. Women's participation in early warning and savings groups will increase, as will integration of gender-responsive DRR. Finally, SUR1M will catalyze DRR and climate adaptation learning and build evidence of impact.

2. Target populations in Niger, Burkina Faso and Mali will increase resilience to climate extremes. SUR1M will work with communes and citizens to increase preparedness, strengthen mitigation practices and build critical government and community assets to reduce existing vulnerabilities. Together, these efforts will create a culture of disaster risk management (DRM) that expands livelihoods, increases food security, reduces malnutrition, improves market and financial access, strengthens participatory governance and empowers women. Early adopters will see immediate resiliency gains, and after three years, SUR1M will benefit the entire population by strengthening the risk reduction system as a whole.

1.2 SUR1M STUDY ZONE

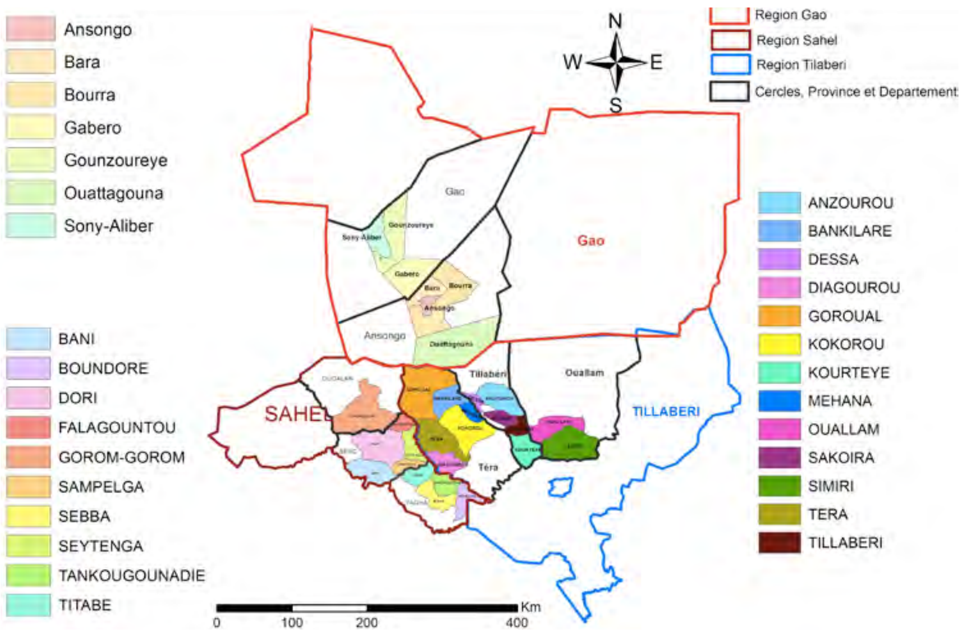
SUR1M operates in 30 communes in three contiguous zones across Burkina Faso, Niger and Mali (Map 1). These include:

- 10 communes in the Sahel Region of Burkina Faso (Seno, Yagha, Oudalan Provinces);
- 13 communes in the Tillaberi Region of Niger (Ouallam, Tillaberi, Tera Departments); and
- 7 communes in the Gao Region of Mali (Ansongo, Gao Circles).

These areas are relatively food insecure and highly vulnerable to climate variability and change, particularly episodes of drought and flooding. SUR1M will target 80 percent of the total population in these communes for a total of 614,125 inhabitants in Niger, 423,789 in Burkina Faso, and 174,514 in Mali.

Map 1: SUR1M Project Zone

SUR1M Communes



Within this zone, CRS selected an opportunistic sample of communes and villages for this study. This includes eight villages in six communes in the Sahel Region of Burkina Faso, eight villages in six communes in Niger, and four villages in four communes in Mali.

Table 1: Sample Study Sites

VILLAGE	COMMUNE	PROVINCE	CRITERIA	DISTANCE FROM DORI
Bani	Bani	Seno	Close to market	43km
Belgou	Falagountou	Seno	Close to river	45km
Titabe	Titabe	Yagha	Close to market	70km
Pagalaga	Bani	Seno	Far from market	57km
Yatakou	Seytenga	Seno	Far from market	42km
Bellare	Seytenga	Seno	Far from river	63km
Gatougou	Titabe/Sebba	Yagha	Close to river	91km
Balliata	Gorom-Gorom	Oudalan	Far from river	32km

Sahel Region, Burkina Faso

VILLAGE	COMMUNE	DEPARTMENT	CRITERIA	DISTANCE FROM DEPT. CAPITAL
Zindigori	Tera	Tera	Close to market	10 Km
Mehana	Mehana	Tera	Close to market	90 Km
Sakoira	Sakoira	Tillaberi	Close to river	10 Km
Daiberi	Tillaberi	Tillaberi	Close to river	5 Km
Simiri	Simiri	Ouallam	Far from river	25 Km
Kabefo	Ouallam	Ouallam	Far from river	73 Km (from Niamey)
Hari Kirey	Ouallam	Ouallam	Far from market	50 Km
Kanda	Simiri	Ouallam	Far from market	36 Km

Tillaberi Region, Niger

VILLAGE	COMMUNE	DEPARTMENT	CRITERIA	DISTANCE FROM GAO
Kariebandia	Soni-Ali-Ber	Gao	Far from market	55 Km
Ansongo	Ansongo	Ansongo	Close to market Far from river	1000 Km
Bara	Bara	Ansongo	Close to market Close to river	55 Km
Tacharane	Gounzoureye	Gao	Close to river	22 Km

Gao Region, Mali

1.3 STUDY OBJECTIVES

This study addresses two principal objectives outlined in the Teaming Agreement and Scope of Work:

1. Carry out an economic and technical feasibility study (including costs and benefits analysis) of CSA practices, including drylands re-greening, land reclamation, land and water management, and sustainable agriculture and pastoralism.
2. Inform the target communes' leaders and populations about the range of most-appropriate technical CSA options taking in account local agro-ecologies, context (including existence of support services and expertise in the public and private sectors, suppliers of equipment, all materials required locally/in the region/in country or not), needs and demand. This focus will support the decision making process on related investments, implementation and sustainable use and management. Particular attention will be dedicated to understanding potential

barriers, limitations or opportunities for access to, control over, participation in, and ownership of CSA practices related to gender and therefore the most appropriate techniques to benefit men and women.

The study will assess climate change threats and their impacts on vulnerable populations and ecosystems, identify adaptation strategies, and propose climate smart agricultural technologies and strategies that address the overarching objectives of the BRACED program.

2. STUDY METHODOLOGY

This section provides an overview of the field methodology, including design of field survey instruments, training and pre-test of field tools, and overview of the field schedule. Findings from this study are based on a triangulation of information from primary field data and an intensive review of the secondary literature, gleaning findings from various project and program reports provided by CRS, as well as government and research institutions. Additional studies related to topical areas were collated from a desktop review as well as reports and documents obtained by the Lead Consultant (LC) and Research Assistants (RA) team members during the course of the study. A repository of all reports and studies relating to this report are archived electronically in a SUR1M Dropbox folder by CRS.

2.1 FIELD SURVEY INSTRUMENTS

Collaborating with a team of research assistants and local interpreters, the TU/DRLA Research Team designed three data collection instruments for use in the target communities. Field instruments designed for primary data collection in each study region included:

1. **Key Informant Interview (KII)** – a key informant interview matrix guide sheet designed for interviewing relevant stakeholders (normally not exceeding 1-2 individuals maximum);
2. **Focus Group Discussion (FGD)** – a data matrix in Word, designed to complement the KII guide sheet, used to facilitate the FGD sessions for men and women;
3. **Village Leaders Survey (VLS)** – a structured informational questionnaire, carried out with the village chief and elders/ leaders (approximately 5 per village), identifying basic features of history, demography, livelihoods, infrastructure, and general perceptions of climate change in the community. Designed as a 45 – 60 minute discussion and orientation to the village upon arrival in each community.

2.2 LITERATURE REVIEW

In addition to the pre-study literature review, a second review of the literature was undertaken to further compliment this study. Approximately 80 documents were scanned as possible background literature for this study, of which approximately 25 were reviewed in-depth and used to contribute to the findings of this report.

Literature fell into four general categories:

1. General background information on climate smart agriculture;
2. General background and/or country/region specific information on livelihoods, agricultural practices, etc.;
3. Specific information on climate change for the countries/regions covered in the study;
4. Specific information on agricultural techniques that serve to triangulate or complement the information collected in the FGDs and KIIs.

Literature referenced in this report can be found in Annex 1 as a bibliography. Additionally, there is a compendium of studies, reports, documents, etc., relevant to this report in a matrix inventory format, as well.

2.3 STUDY TIMEFRAME, TEAM, AND COLLECTION PROTOCOL

This study comprises five methodological phases:

1. **Research design and preliminary literature review** – including development of an initial proposed budget and work plan, carried out in the US over a two-week period (15-31 March);
2. **Field instrument design, training and pre-test** – carried out at the CRS main office in Ouagadougou, Burkina Faso (3-8 April);
3. **Field data collection** – across the three study zones (11 April – 18 May);
4. **Data analysis, synthesis and presentation** – includes data analysis, synthesis and presentation of preliminary findings to CRS staff as a debrief conference call upon completion of each field data phase (24 April – Burkina Faso findings; 8 May – Niger findings; 28 May – Mali findings);
5. **Report write up** – presentation of data findings with recommendations in a preliminary draft report with final draft version completed on June 24.

Activities for each phase are described here:

Research Design and Preliminary Literature Review

A budget and draft work plan was initiated (late February) prior to completion of a Teaming Agreement between CRS and TU/DRLA (effective 15 March). Multiple iterations of budget proposal were shared and vetted with CRS during this time, and the Lead Consultant submitted a preliminary work plan prior to international departure from the US on 30 March. Preliminary drafts of field instruments also were developed and vetted during this phase. A preliminary literature review by the project Research Assistant, based at TU/DRLA, also began during this period.

CRS recruited four host national Field Research Assistants (FRA), organized in two teams for each study (CCAT/CSA, MOI/AVC), through the main country office in Burkina Faso. For purposes of facilitating the study logistically, four Burkinabe RAs were recruited (see names in Annex 2). Subsequent to team selection, two interpreters were recruited in each country to assist the teams with field data collection (see names in same Annex).

Field Instrument Design, Training and Pre-Test

Upon arrival at the CRS main office in Ouagadougou, the Lead Consultant conducted an intensive training of the two field teams from 3-4 April[2]. Training entailed an overview of BRACED and SUR1M, study objectives, key concepts (e.g., livelihoods analysis and asset categories), and introduction to the field instruments (described further below). The content of the training session is found in Annex 3. Design of the field instruments was participatory, involving review, comments, and feedback from CRS staff in the study target countries, and from the RA teams. After multiple revisions, the field instruments were field tested in two villages on 7-8 April at Bourzanga (Kongoussi region), and Rimagouya (Kalsaka region), where CRS has a presence. Substantial revisions were made with the field tools on 9-10 April, prior to departure for the first field visit in the Sahel Region of Burkina Faso on 11 April.

Field Data Collection

The research teams traveled with the Lead Consultant (LC) to each study zone, with the exception of Gao, Mali, where the LC visited only CRS staff and relevant stakeholders in Bamako, due to high insecurity

2 Due to inclement weather and a flight delay from the US, the training session, originally planned over a 5-day period, was truncated into 4 days.

and travel restrictions for Americans in the region. Field visits were conducted in the Sahel Region of Burkina Faso from 12-19 April, the Tillaberi Region of Niger from 26 April – 3 May, and the Gao Region of Mali from 15-18 May. The teams resided in regional centers, departing each day to a village and returning to the regional centers in the late afternoon to continue data entry for the day's session. A total of 20 villages were surveyed (8 Burkina Faso, 8 Niger, 4 Mali), involving two focus group discussions (FGDs) per village. A total of 38 FGD sessions were held in the three country regions, including 15 in Burkina Faso, 15 in Niger, and eight in Mali [3].

FGDs were organized by gender, thus a men's session and women's session was held in each community. FGDs were made up of approximately 15 persons per group[4]. Criteria for participation included: 1) adults residing in the village for at least 10 years, 2) at least 30 years of age (old enough to recall changes in the village during the past 20 years); and 3) representation of all *quartiers*, clans and religious groups in the community. Each FGD was to last no more than two hours[5].

To complement and contextualize information being received in the FGDs, the LC conducted key informant interviews (KIIs) in the regions, as well as in the capital cities of each country (Annex 4). In the Sahel Region, the LC attended the first two village FGD sessions to oversee quality control, and to assure that team facilitation of discussions was sufficient, generating the needed information for data analysis, and to observe the group dynamics of each session. The LC attended three village FGDs in Niger, and none in Mali (for reasons of security), thus totaling five villages out of 20. The LC met with a range of stakeholders to discuss their observations about climate change, adaptation, and their experience with CSA techniques, including any

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3 For reasons of high insecurity, the Mali field session was reduced from 8 to 4 days. In the first two countries, the team conducted only 1 FGD on Fridays, the Muslim day of prayer, and a half work day for the team.

4 Numerous problems arose in adhering strictly to the proposed criteria. In several villages, groups expanded to 30-40 individuals arriving for the FGD. This was often due to natural curiosity of onlookers and passersby, and difficult to control. Despite large numbers in some sessions, the teams managed to facilitate the sessions by actively engaging approximately 15 individuals per group. A second, and fundamental problem, was the lack of true representation of village members of different ethnic groups and from all village *quartiers*. Again, despite measures in advance to identify the core criteria for participation, the teams could not control or assure full representativeness of each group. More in depth advance planning and direct contact with local village officials would be required to assure more robust representation of all social strata in the community.

5 Some sessions, particularly early on in the first field phase in Burkina Faso, lasted up to 3 hours. This was due to multiple factors, including long convoluted discussions, which sometimes required explanation or clarification when introducing the concept of climate change, as well as discussions on costs and benefits of CSA technologies. This topic of the FGD often took considerable time for participants to carry out various cost or benefit calculations (using local measures) and to arrive at a consensus on average yield and market sales figures for the community as a whole. With time, the team increased their mastery in facilitating discussion on these somewhat complex topics.

available information on the costs and benefits of those techniques and approaches used in the study region. In total, the LC conducted 19 KIIs, including nine in Burkina Faso, eight in Niger, and two in Mali.

Data Analysis, Synthesis and Presentation

Data obtained in FGDs was entered each evening by the two RAs into an electronic FGD matrix (Word software). Information on advantages and constraints for each CSA technique were organized by livelihood asset category. Costs and benefits were broken out by basic capital cost categories such as tools/equipment, inputs (seed, fertilizer, etc.), and labor, and estimating benefits as crop yield (including forage crops) per hectare, or the market value of livestock (per head) sold. Both gross and net average earnings were calculated, as well as the range in earnings according to price variations from their low market value at harvest time, to their high during the lean dry season. The CSA FGD matrix guide sheet is submitted under separate cover to CRS. Raw data entered for all FGDs also was submitted under separate cover to CRS to accompany the final version of this report.

The LC used a KII matrix guide sheet to orient semi-structured interviews with various stakeholders working in regional government ministry offices (agriculture, environment, livestock, water resources). Notes from the KIIs were not entered into an electronic version of the KII matrix, but serve as the basis of much of the contextual observation for this report, most notably in the sections that address the feasibility (advantages, constraints, costs, benefits) of each CSA technique.

Data was analyzed and synthesized for each country debrief by entering both qualitative and quantitative information into an Excel spreadsheet with coded categories for each section of the FGD. These include coded responses from the FGDs on: 1) signs or manifestations of climate change (rainfall volume, intensity, and distribution, temperature, high winds and extreme drought and flood frequency), 2) an inventory of CSA techniques practiced in the village, 3) prioritization of the techniques by order of **importance** and **preference**, and 4) feasibility of the techniques (advantages, constraints, costs, and benefits).

Synthesis of this information was conducted during a two-to-three day period per country and involved a close collaboration of the LC with the RA team members in the organization, review and presentation of the findings. Dates of the debrief presentations per country region are noted above, and involved the presence of both the LC and the CSA team, with the exception of the final debrief on the Mali findings (presented by the LC after departure from Mali). Questions and feedback from CRS staff after each debrief session were shared with the LC and team members for further clarification and consideration in preparation for the next phase of country field investigation.

Report Write Up

The TU/DRLA research team scheduled the final phase of data synthesis and write up to be completed in two phases: 1) delivery of a draft report by 31 May, and 2) submission of a final report on 15 July. Dates for completion of the final report have been revised, with final submission on 30 July.

CRS' Program FASO is transforming smallholder agriculture for farming families living on the frontlines of climate change. The program aims to improve access to food of sufficient quantity and quality year-round for 56,126 households. 17 August 2012
AMIDOU TRAORE, CRS

3. RESEARCH CONTEXT

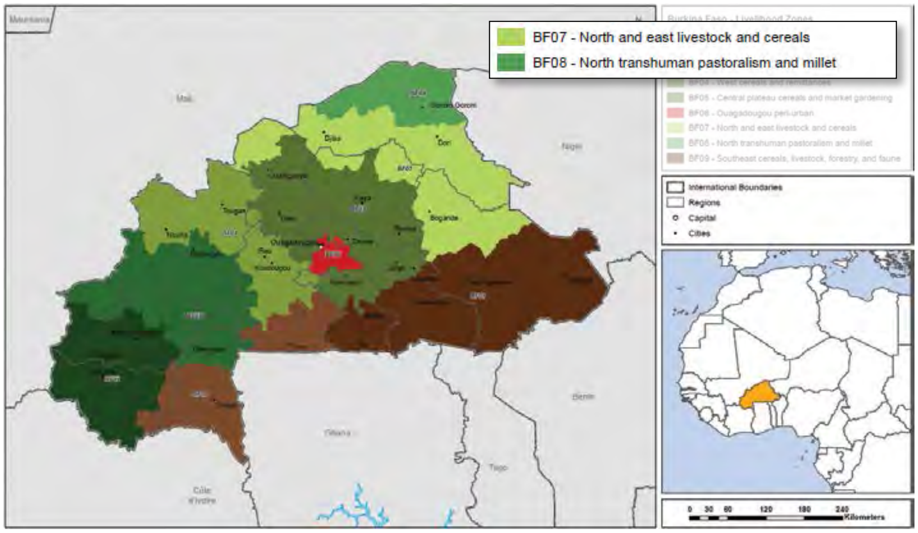
3.1 REGIONAL GEOGRAPHY AND LIVELIHOODS

This section presents an overview of the regional geography and livelihoods of the study areas, presented by study area. This summary draws mainly from the FEWSNET livelihood studies, which provide the most comprehensive general overview of the geography, climate, livelihoods and other pertinent information.

3.1.1 Burkina Faso

The study areas in Burkina Faso (Map 2) cover two identified FEWS livelihood zones; Zone 7 (North and East Livestock and Cereals) in Seno and Yagha Provinces, and Zone 8 (North Transhuman Pastoralism and Millet) in Oudalan Province.

Map 2: FEWS Livelihood Zones in the Study Area (Ouadalan, Seno, Yagha Provinces), Burkina Faso



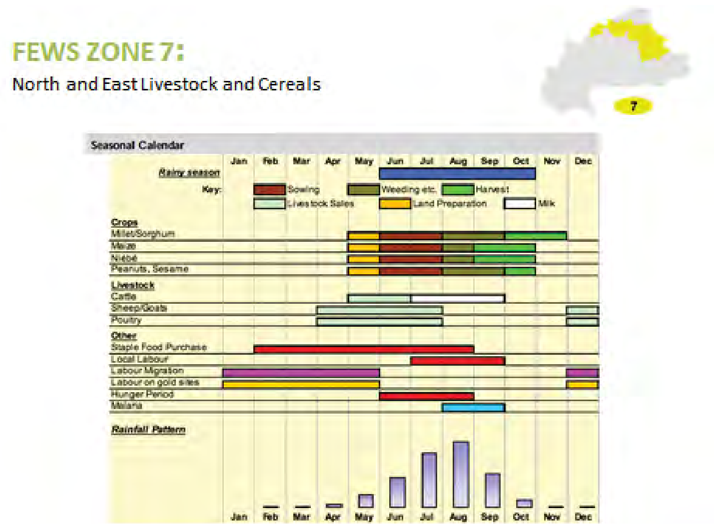
Source: USAID, FEWSNET (2014) http://www.fews.net/sites/default/files/documents/reports/BF_Livelihoods_0.pdf

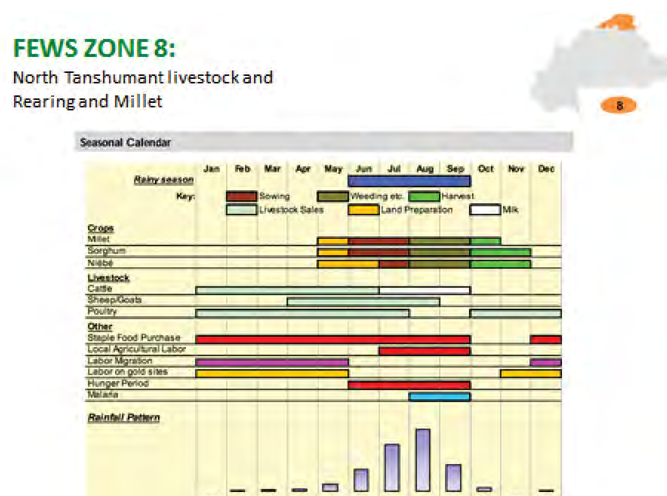
Agriculture and Climate

Zone 8, where Oudalan province is located, has the driest and most-unreliable rainfall in Burkina Faso, at less than 400mm/year. Yagha has slightly more abundant and reliable rainfall than Seno, although both are relatively dry areas (400-700 mm/year). Millet is grown in the drier areas, and sorghum in the slightly wetter areas, particularly in Yagha. Water access, even for people, is problematic.

In both areas, the poorest households rely on small areas of cultivated land (1.5 to 2.5 ha) and few livestock (4-6 goats, 6-8 hens). More affluent households enjoy larger cultivated land holdings and greater numbers of livestock. Seasonal calendars for the two zones are provided below.

Figure 1: Seasonal Calendars for FEWS Livelihood Zones 7 and 8





Source: FEWS livelihood report, Burkina Faso

According to FEWS, soil erosion and increasing pressure on the country's natural resources are a problem throughout the country, while land clearance for farming increasingly threatens forest resources.

In the study areas (Zones 7 and 8), the FEWS report states:

> *Crop production in these zones is so limited by rainfall amount and distribution that in most years even the better-off cannot satisfy more than two-thirds of their food needs from their own harvest. This is particularly the case for the transhumant livestock zone (8) whereas in a small number of good rainfall years, zone 7 can produce a*

substantial food surplus, so that a shift from deficit to abundance is seen from one year to the next. (p. 12)

Livelihoods

Zones 7 and 8 and are characterized by agriculture-related activities (selling of cereal crops, agricultural labor), as well as livestock sales. Livestock sales are more commonly the main source of cash for better-off households, while poorer households rely more on a variety of different sources of cash, including agricultural labor, labor migration, wood/charcoal/fodder sales, and in Zone 8, some sales of milk. Zone 8 tends to rely more on cattle, goats, sheep and other livestock than Zone 7.

Beyond agricultural/livestock livelihoods, FEWS identifies gold mining as an increasing source of income for poor and very poor households in Zone 7. Some of the villages visited in this zone participated in small-scale, local artisanal mining of gold, which was observed during the FGD sessions.

Food Sources

Food is primarily sourced through local subsistence production or by purchase. Zones 7 and 8 are the most reliant on markets for their food in a normal year, despite the fact that they are two of the most isolated zones in the country in terms of market access. According to the FEWS study, the poorer households tend to source more of their food through purchase than their own crops, and the richest (better-off) households source more of their food from their own crops.[6]

Food Security Current Outlook

The May 2014 food security outlook update from FEWS[7] indicates a stressed situation in the near and medium term for the northern areas of the country, including all of the study areas. The stress is due to a longer and more difficult lean season than normal, with limited grazing and water resources for agro-pastoralists' animals, as well as market dependent households being confronted with high staple food prices.

3.1.2 Niger

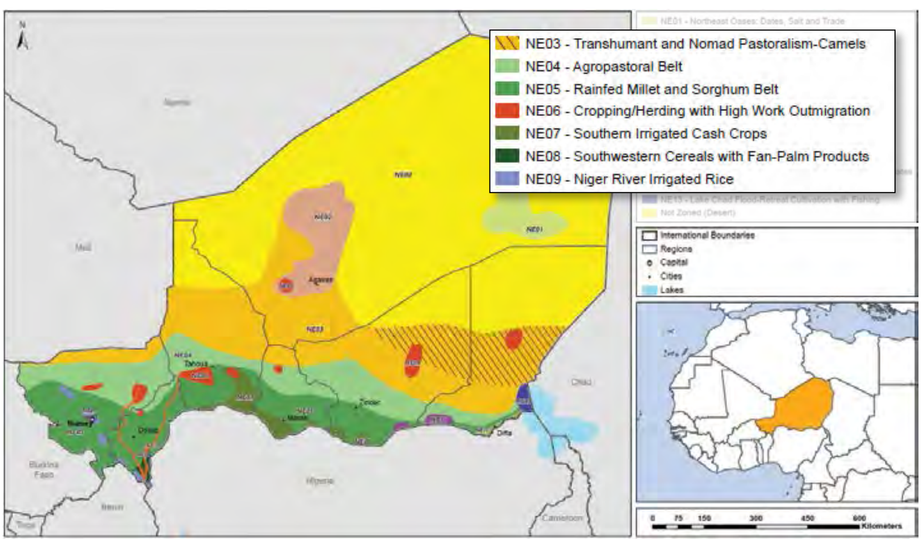
6 This is widely known in the agricultural economic sector. Better-off households have higher crop productivity due to access to several key factor inputs, including land labor and capital. Poorer families have experience poor access to key inputs ; thus, ultimately have a lower crop output and have greater dependence on food purchases, increasing their levels of indebtedness. This increases their vulnerability and food insecurity over time. As a result, when a sever shock hits, these individuals are most vulnerable and suffer the greatest losses.

7 http://www.fews.net/west-africa/burkina-faso

The study area (Oullam, Tillaberi, Tera Departments) covers a large range of FEWS livelihood zones. These zones include:

- Zone 3- Transhumant and Nomad Pastoralism
    - Found in the northern portion of all three departments
- Zone 4- Agro-pastoral belt
    - Found in the center area of all three departments
- Zone 5- Ran fed Millet and Sorghum belt
    - Found in the southern portion of all three departments
- Zone 6- Cropping/Herding with High Work Outmigration
    - Found in small areas in south central Tillaberi and Tera departments
- Zone 9- Niger River Irrigated Rice
    - Found only in Tera Department, along the Niger River

Map 3: FEWS Livelihoods Zones in the Study Area (Ouallam, Tillaberi, Tera Departments), Niger



Source: USAID, FEWSNET (2011) http://www.fews.net/sites/default/files/documents/reports/NE_Livelihoods_2011.pdf

Agriculture and Climate

Zone 3

Zone 3 is the driest zone in Niger's study area. It is covered primarily with sparse grass and bush. There is no major agriculture.

This zone is most vulnerable to drought because of the potential for the loss of the only major livelihood source – livestock. However, FEWS reports that pastoralism is in itself a fairly recent adaption to the arid environment and variation in rainfall.

Zone 4
This zone experiences on average 300-400 mm of rain per year, and high inter-annual variability of rainfall (greater than 20 percent). Locals and immigrants settled the pasturelands for cultivation, bringing many poor people to the area.

Zone 5
Zone 5 enjoys higher rainfall than those to the north, between 400mm in the northern ranges to **600mm/year** or more in the south. Frequent irregular rainfall continues to effect harvests and pastures. Agriculture consists of millet, sorghum and cowpea production. Soil degradation is increasing.

Zone 6
Zone 6, found in just a few small areas, has varied average rainfalls, but can grow large amounts of grains in good years. Even still, it suffers large losses in bad rainfall years. The land is generally low in fertility, and production resource problems prompt more seasonal labor migration.

Zone 9
This zone tends to be more stable in terms of productivity and is less vulnerable to food insecurity. The main crop is irrigated rice (mainly as a cash crop), along with tobacco, as well as sorghum for domestic production. Rice is not dependent on the local rainfall, making it less subject to inter-annual variability.

Livelihoods

Zone 3
Most households in Zone 3 rely on livestock only as their main livelihood. This makes households more resistant to drought (as pastoralism is an adaptation to an arid environment) and the most vulnerable in the case of severe drought (as the loss of livestock is a difficult shock to reverse).

Zone 4
Households in Zone 4 rely on crop cultivation, small stock rearing, cowpea and firewood sales and migrant labor. However, livestock

ownership is more characteristic of wealthier households. In bad years of low rain, the poorer households lose their meager harvests and agricultural labor income, and do not have the buffer of livestock holdings. FEWS describes this as an "imbalanced agro pastoralism."

Zone 5

Cattle and livestock are owned almost exclusively by the wealthier half of the population. Poor people commonly rely on agricultural labor.

Zone 6

This zone enjoys lower livestock holdings and less income variation than neighboring Zones 4 and 5, making them vulnerable to climatic and market shocks. As the name of the zone implies, work-out migration is one of the common livelihood strategies, which is a consequence of production resource problems and subsequent high poverty, coupled with the high risk of absence of rain.

Zone 9

Beyond the agricultural livelihoods (mainly cash crops), paid agricultural labor is more common in this area due to the labor-intensive nature of growing rice. This brings in money for all wealth groups. Fishing (in the Niger River) is also common. There is less livestock in this area, as there is limited pastureland.

Food Sources

Though the FEWS report does not fully detail food sources, most staple foods are sourced through markets, particularly among pastoralist households, making them vulnerable to staple food price fluctuations.

Food Security Current Outlook

FEWS published a food security outlook for April-September of 2014, which predicts a crisis in some of the study area between July and September, and a stressed situation for most of the rest of the study area for that same time period. The area at the greatest risk of food insecurity crisis includes some parts of the agro-pastoral area (Zone 4), primarily in Ouallam.

This insecurity is caused by below average crop stocks, poor pastoral conditions and higher than normal staple food prices (which are expected to be higher than normal from April to June).

However, domestic and cross-border flows are stabilizing and ensuring adequate market supplies.

3.1.3 Mali

The areas of study in Mali, the Ansongo and Gao Cercles, both contain three livelihood zones:

- Zone 2 Nomadic and Transhumant Pastoralism
    - Found to the north
- Zone 3 Fluvial Rice and Transhumant Livestock
    - Found along the Niger river
- Zone 4 Millet and Transhumant Livestock rearing
    - Found in the far southern areas.

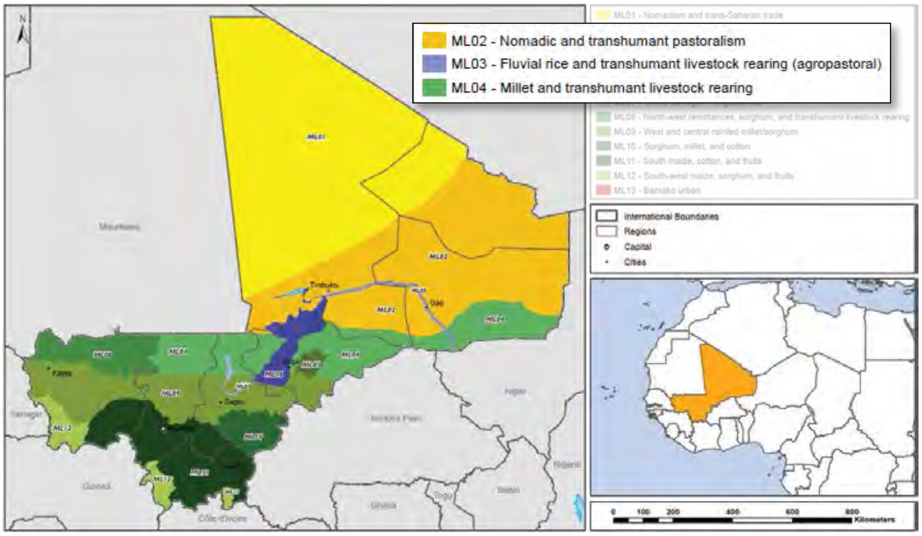
Agriculture and Climate

Zone 2 is characterized by a northern Sahelian ecology, with sparse grass in the near-desert areas. The hot period between March and June is the most-difficult period. Rain-fed agriculture is not possible in this zone due to the rainfall levels less than 200mm/year.

Zone 3 also experiences low rainfall (150-200mm/year). Therefore, agriculture is present only due to the river, allowing for the cultivation of rice, bourgou and market gardening crops. Rice is the main crop, grown on the edge of the river.

Zone 4 enjoys higher precipitation than the other zones in the study area (300-500mm/year). Millet and cowpeas are the main crops grown. The unreliable rainfall, however, means that agriculture is inconsistent, and so transhumant livestock rearing is also a common practice in the zone.

Map 4: FEWS Livelihood Zones in the Study Area (Ansongo and Gao Cercles), Mali



Source: USAID, FEWSNET (2009) http://www.fews.net/sites/default/files/documents/reports/ML_Livelihoods.pdf

Livelihoods

Zone 2 is mainly dependent on livestock, as agriculture is not possible. There is little wealth diversity, and most households are poor or very poor. Conflict has forced animal sales and unusual migration patterns, intensifying conflict between pastoralists and settled populations over water and crop damage. Very poor and poor households rely mainly on local labor for cash resources, whereas the few middle and better off households rely on livestock sales.

Zone 3 is characterized mainly by livestock rearing (cattle, sheep, goats). All wealth groups commonly migrate in search of labor for several months a year. Poor and very poor households source their cash from a variety of sources, including crop sales, agricultural labor, labor migration and other activities. Middle and better off households source most of their cash from crop and livestock sales.

Zone 4 also relies mainly on livestock (cattle, goats, sheep, some camels), particularly as a cash income source for middle and better off households. Poor and very poor households source their cash from local agricultural labor (particularly the very poor households), other local labor, and very little from crop and livestock sales. Middle and better off households source most of their cash from crop and livestock sales, as well as labor migration and petty trade.

Food Sources

Across the different zones, poorer households tend to source their food mainly from purchase, with other sources (own production, payment-in-kind, wild foods, etc.) making up the rest. These households usually produce only one-to-three months of their own food needs. Middle and better- off households source more of their food from their own production, followed by purchase, with more access to milk than the poorer groups.

Food Security Current Outlook

A 2012 study from Oxfam GB[8] indicates that very poor and poor households are the most likely to face deficits and undertake survival and livelihood protection coping strategies. They are at greatest risk of going hungry in addition to not being able to afford basic things such as education, healthcare, inputs for livelihoods and other non-food needs.

The current (May 2014) food security outlook update from FEWS[9] indicates that in the near and medium term, most of the study area has minimal food insecurity, with a small area of northern Tera Department undergoing food security stress in the near term and this area as well as a portion of Ouallam predicted to be under food security stress in the near and medium term. This is due to the lower terms of trade between livestock and cereals because of poor water availability and reduced pasture.

3.2 OVERVIEW OF FIELD STUDY SITES

3.2.1 Burkina Faso – Sahel Region

A brief 45 minute to one hour discussion was held in each community with the village chief and 5-6 elders to gain a quick glimpse of the basic village characteristics, such as history of settlement, demography, religious and ethnic composition, community infrastructure, and livelihood activities. The most pertinent observations are summarized here and provided in a matrix format in Annex 5.

Villages range in population size, from slightly more than 300 inhabitants (Balliata) to nearly 6,000 (Bani). Population has grown over time amongst all the villages surveyed, with the exception of

8 Scenario Analysis for Rural Livelihood Zones, Oxfam GB 2012
9 http://www.fews.net/west-africa/mali

Balliata, where the number of inhabitants has declined due to lack of access to water.

Communities are composed predominantly of sedentarized FulBe (Peuhl) pastoralists who have become primarily agro-pastoralists, carrying out rainfed farming of pearl millet and sorghum. Other ethnic groups include the Bella (former slaves of the FulBe), Gourmantche, Mossi, Sonrai, and Gaobe (Annex 6).

While rainfed agriculture is the principal livelihood, livestock production (cattle, sheep, goats) plays a key role in meeting daily consumptive and economic needs as a primary strategy of capital accumulation[10]. Petty commerce and small-scale artisanal gold mining play a secondary role in generating household income in the long, hot dry season after crops have been harvested.

Livelihood strategies vary to some degree among men and women. Men farm primarily millet and sorghum, and commonly own cattle. Also, some men practice cattle fattening (embouche) as a key source of income generation. Women most frequently cultivate vegetables, gombo (oseille), cowpeas, groundnuts and sesame as their primary source of income, in addition to practicing fattening of sheep. Women, also, often sell cow's milk, although in very small quantities due to very low milk production. Additionally, some women raise and sell chickens, while a smaller number of women also engage in artisanal activities, such as weaving of mats and baskets.

Islam is widespread in the region, with much smaller numbers of Christian and animist groups. Customary land tenure is practiced, in which founding lineages of the village chief and their descendants hold ownership to land. Caste structure is important in the region, and plays an important role in access and control over land. Three general tiers of social strata include a noble caste (generally founding families), and two groups of dependents or patron-clients of the nobles: an artisan caste, and a slave caste. In some communities, such as Belgou, weaver artisans and former slaves (Bella) left their patron FulBe masters long ago to settle and access land as free holding farmers.

Infrastructure is very basic and limited in almost all villages visited. Primary schools were present in all eight villages, but few had

10 One village, Yatakou, has no livestock activity due to the general poverty of the community, thus minimizing livelihood diversification and increasing overall vulnerability to various economic, climatic, political, or other shocks and stresses.

a secondary school. Rural health clinics were found in only two communities. Potable water in the form of boreholes was present in all villages, although in many instances residents were dependent on one water source. This was due to the drying of water sources and progressive drop in water table levels, as well as the lack of maintenance and/or parts for borehole and hand-dug wells, which become inoperable over time.

Access to paved roads and markets is relatively remote and difficult, with only two villages having market infrastructure (weekly markets), and all communities (with the exception of Bani) at a distance of 25-70 kilometers from the nearest paved road.

In terms of community infrastructure, only the larger community of Bani has a cereal bank. **It is salient to note that cereal banks, which serve as an important institutional and infrastructural resource to buffer against severe food shortages during the lean hunger season (soudure) throughout the Sahel, are notably absent in the zone of study.**

Seasonal and long-term migration was characteristic of the villages surveyed. Seasonal migratory activities consist of some transhumance, artisanal mining, and petty commerce in larger towns, as well as some migration to the neighboring countries of Ivory Coast and Niger. Some in migration from outside was limited, but present, in villages with artisanal mining.

3.2.2 Niger – Tillaberi Region

This area of study is characterized primarily by the zone Sahero-Sahel, with 150 to 350 mm of rain per year, which allows for mainly pastoral livelihoods, and the Sahel zone, characterized by 300-400 mm of rain per year, which allows for agricultural livelihoods, including mixed livestock and millet-legume cereal production. In the areas further south of Tillaberi, the Sahelo-Soudain Zone (400-600 mm of rain annually, and the Soudain zone (>600mm of rain annually) allow for mixed livestock and cereal production (mainly millet and sorghum).[11]

Study communities consist of several different ethnic groups, most predominantly Sonrai (4 of 7 interviews), Peuhl (5 of 7), Germa (4 of 7), Bella (4 of 7), as Kourti (1 of 7), Haoussa (1 of 7), Mossa (1 of 7). All villages reported two or more principal ethnic groups, with

11 "Consultation Sectorielle sur l'Environnement et la lutte contre la Désertification » Ministère de l'Hydraulique, de l'Environnement, et de la Lutte Contre la Désertification, 2005.

the exception of Kabefo, which cited only Germa (Kabefo is also the smallest in terms of population). All villages cited Islam as the sole religion, with the exception of Simiri, which cited Christanity and Animism in addition to Islam.

Agriculture is the primary livelihood activity. The practice of raising livestock is a form of diversification of livelihoods, which is historically the case. Agriculture consists mainly of millet, sorghum, niebe, and rice. Other crops mentioned include sesame, okra, peanuts, and Oseille. Village leaders also described the livestock livelihood as generally consisting of sheep and goats, with the mention of cows, fowl, and occasionally fishing. Three village leaders also cited small commerce as one of the main livelihoods in their villages.

When looking at the livelihood activities as practiced by men and women, men were most often cited as practicing the cereal/staple crop production (millet, sorghum, niebe) and livestock raising. Women most often were cited as involved in agriculture as well, but most often cash crops such as sesame, okra, peanuts, and vegetables, as well as occasionally livestock activities (either jointly with men, or specifically the sheep, goats, and fowl).

In terms of infrastructure, one or more primary schools are found in all village, but only a few have a secondary school. Three villages have an Integrated Health Center (dispensary and maternal clinic), two only an dispensary, and two (Kabefo, Dayberi) had no health care facilities, though they mentioned that they made use of nearby Integrated Health Centers 2-3 km away in neighboring villages). Potable water (from boreholes or public taps) were present in all villages with the exception of Kabefo, which had only wells.

Distance to the nearest paved road varied greatly between villages. Dayberi, Sakoira, Zintingori, and Simiry are all found on paved roads. Kanda is about 12km from the nearest paved road, and the other villages were between 45 and 80 km from the nearest paved roads. The road access, however, did not correlate with the presence of a daily food market in the village, though all villages had a food and livestock market within (4 villages) or a maximum of 5km away from (3 villages) their village. However, only Mehana had a permanent market (of minor importance).

In terms of migration, only the village of Zidigori reported significant permanent migration to other regions in the country and to Lybia. All communities reported seasonal migration to other areas of the country and to several neighboring countries. Some minor in-migration was mentioned in a few villages.

3.2.3 Mali – Gao Region

Although 4 villages were included in data collection in Mali, the village chief discussion was not done in one village (Kareibandia). Some information is included for that village; however, this information was gathered in the male FGD.

The village populations are all relatively large, ranging from range from 5,000 to 13,000 people. In the three villages where the village leaders were interviewed, they indicated that the population is growing.

The villages all have the Sonrai (Songhai, Songharai) as one of their main ethnic groups. Tacharane has only one additional ethnic group, the Tamacheques. Kareibandia reports these two ethnic groups as well as the Bella and the Koroboro. Finally, Asongo reports the most diverse number of ethnic groups, with Songhai, Dherma, Bella, Mossi, Bambara, Arabe, Bozo, Dogon, Peuhl, and Haoussa. All villages cited Islam as the main (and only) religion.

All villages where data was collected report that the main livelihood activities are Agriculture and livestock, as well as small commerce (including transport, artisanship). The village leaders in Bara made the particular point that in addition to cultivating rice, they use to produced local varieties of long-cycle sorghum, but the scarcity of rain and the extended dry periods have resulted in their abandoning sorghum cultivation. They also noted that around 5% of the population continues to grow maize in small quantities. The population of Bara noted that the need improved, native seeds that are adapted to the ecology and conditions of the area, and that they'd like to produce millet as well to diversify their cereal cultivation.

While the village leaders all stated that there is no gender or age-specific livelihood activity, they all added that women tend to do more vegetable gardening (maraichere) than men.

In terms of infrastructure, all four villages have at least one primary school. The others have secondary schools (not reported for Kareibandia). In the tree villages where full data were collected, they all have either a health center or a Referral Health Center (CSR). Bara appears to have the best health infrastructure, with a community health center that consists of a dispensary, maternal clinic, and a pharmacy depot.

Electricity is rare in the villages, with only asongo reporting that there was thermic energy available every two days for 3 hours. In terms of water, all villages have multiple boreholes (forages), except for Kareibanda, whose partial data indicate there is no functioning borehold in the village.

The three villages where full data were collected are located directly on paved roads. They all have a weekly market in the village, although only Ansongo had a permanent market in the village.

Of the four villages, only Asongo and Tcharane report having mills. All villages have a cereal bank, except Kareibanda which reported no cereal bank.

Finally, when asked about credit institutions, none of the villages reported having any. The leaders in Asongo reported that there were only the informal credit structures, such as the traditional sharing women grops ('tontines'). Of interest, the village leaders interviewed in Tacharane indicated that although there were the informal credit groups (as in Asongo), the religion condemns credit, and so people don't make use of it.

All three villages interviewed indicated that there is seasonal migration to the neighboring countries, consisting mainly of men roughly between 18 and 40 years of age. Most migration was in search of commercial or labor-related jobs.

3.3 REGIONAL OVERVIEW OF CLIMATE CHANGE

Global and regional climate models have been inconsistent in predicting the future spatial distribution, frequency and quantity of rainfall in the West African Sahel due to problems in modeling the boundaries of the Intertropical Convergence Zone (ITCZ). Thus, the Intergovernmental Panel on Climate Change (IPCC) concludes that projections of changes in precipitation in West Africa must be '… viewed with caution'[12].

Despite present limitations in climate change projections on rainfall in the Sahel, there is broad scientific consensus that the intensity and

12 Stockholm Environment Institute, 2009. Climate Change and Institutions: Niger Inception Report. Stockholm Environment Institute (SEI).

frequency of extreme climate events, such as droughts and floods, will increase across Africa[13]. Arid regions such as the West African Sahel can anticipate more desiccation, a decline in vegetative cover, and a drop in water infiltration and runoff, which will likely have deleterious effects on the hydrological cycle of major watersheds such as the Niger River basin, and recharge of groundwater aquifers[14].

The three regions in this study (Sahel, Tillaberi, Gao) are situated in agro-climatic zones near the threshold for rainfed agriculture and viable pastureland for livestock, making people and animals vulnerable to small decreases in rainfall and/or changes in rainfall patterns that lead to increased aridity.

Climate change projections on temperature indicate that the Sahel will increasingly become warmer over time. With temperatures already near the maximum for plant growth, potential warming of the region may have a large impact on cereal production[15].

The adaptive capacity of populations in the Sahel is challenged not only by technical and economic issues, but also by social norms, values, and rules, including class, gender, and caste social hierarchies. These social norms play a factor in the choice of adaptation strategies in adjusting to climate change and variability[16]. One recent study on the cultural dimensions of climate change adaptation in northern Burkina Faso states:

> *"Adaptation to climate change will never be a homogenous process agreed upon by all parties, but one influenced by factors such as class, gender and culture, to mention but a few. Acknowledging this must be a first step for researchers, policy makers and civil society if adaptation at the local level is to be facilitated, supported and understood[17]."*

3.3.1 Burkina Faso – Sahel Region

Climate is characterized by several key changes in the region that span

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13 IPCC, 2007. Climate change 2007: Synthesis report. Contribution of working groups I, II, and III to the fourth assessment report of the intergovernmental panel on climate change. Geneva, Switzerland: IPCC.

14 Niasse, M. 2007. Elements of a regional climate change adaptation strategy based on the risk sharing approach: West Africa, final draft. Climate Change Adaptation Program (CCAP). Rutashobya, D.G. 2008. Climate change scenarios: Impacts and adaptation strategies in Africa. In T. Petermann (ed), Towards climate change adaptation – building adaptive capacity in managing African transboundary river basins. (pp. 23-40). Zschortau, Germany: InWEnt.

15 Adapting dryland agriculture in Mali to climate change. Norweigian University of Life Sciences.

16 "Cultural barriers to climate change adaptation: A case study from Northern Burkina Faso", Global Environmental Change 20 (2010) 142-152.

17 "Cultural barriers to climate change adaptation: A case study from Northern Burkina Faso", Global Environmental Change 20 (2010) 142-152.

several decades. Several individuals interviewed reference two major droughts, in 1973-1974, and then again in 1984, as the watershed years of the change in climate, with patterns trending toward less rainfall, higher temperatures, and a new phase of increasing aridity throughout the West African Sahel.

Key changes in climate include[18]:

- Increasing inter-annual and seasonal variability in precipitation.
- Marked decline in the number of days of rainfall.
- Increasing irregularity in the temporal and spatial distribution of rainfall.
- Increasing uncertainty in the onset and end of the rainy season.
- Trend of rising temperatures.

The targeted zone of this study in Burkina Faso, the Sahel Region, is located in the Sahelian Climatic Zone, with the following climatic features (see Map, Annex 7):

- Located in the rainfall isohyet band under 600 mm/year;
- Short annual rainy season of approximately 2.5 – 3 months;
- High variability in rainfall distribution;
- High rates of evapotranspiration;
- High amplitude in diurnal and annual temperatures.

In the regional capital of Dori, average annual rainfall from 1981 – 2010 was 457.4 mm, with most rains falling in July and August. Average temperature over the same time period was 29.4C, with temperatures peaking well above 30C in April and May. (Graphs in Annex 8).

Desert encroachment and a decadal drying trend over the past half century, particularly a southward shift in 20 mm isohyet in the Sahel, has been well documented. A renewal of rains during the past decade and an upsurge in the adoption of improved soil and water management practices across the Sahel, including the contiguous boundaries of this study, has sparked debate over a 'greening of the Sahel' and the nature of desertification in the region[19]. Land degradation, whether reversible or not, is taking place due to both demographic and agricultural pressures on the land, exacerbated by significant drying trends over time.

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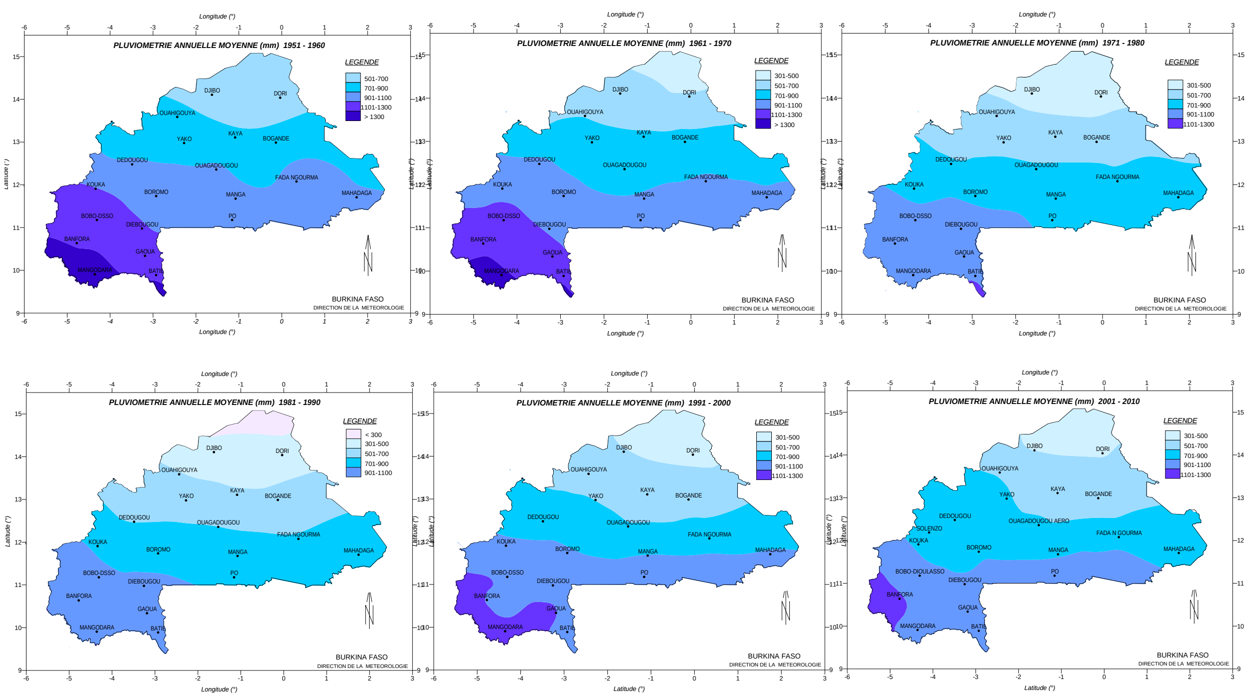
18 Ouedraogo, E. 2014. Climatologie du Burkina Faso. Direction Generale de la Meteorologie, Burkina Faso.
19 Herrmann, S., and Hutchinson, C. 2005. The changing contexts of the desertification debate. Journal of Arid Environments, 63 (3), 538-555.

A trend of southward migration of the Sahelian Zone isohyet has occurred from 1951 – 2010. In the past decade, there has been a slight upward trend in the isohyet band, as annual precipitation has increased mildly (see Annex 9 of decadal isohyets).

On a 30-year decadal time frame, from 1951- 2010, one discerns the southward shift of the 600-900mm isohyet, with a slight turning of the band in a southwesterly direction between the 1971 and 1981 decadal time frames (Figure 2). Overall, the study sites in the Sahel Region have seen a significant southward drift of the 600mm isohyet band over the past 60 years.

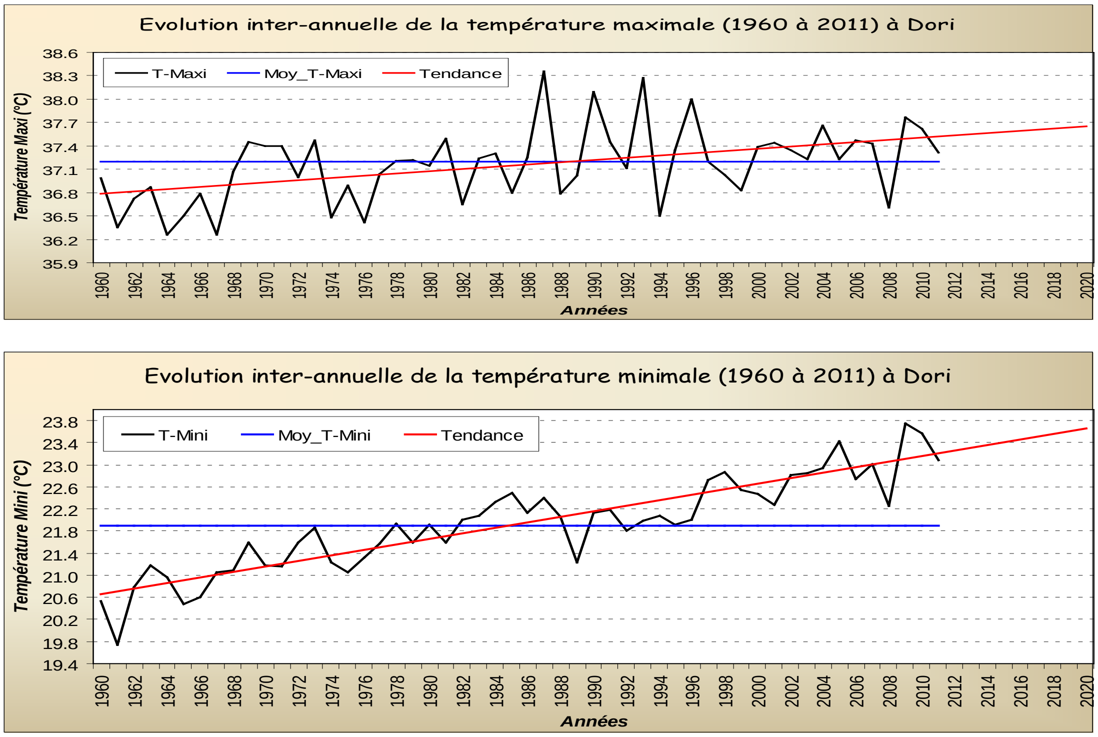
Figure 2: Decadal Change in Rainfall Isohyets, 1951-2010. Burkina Faso



Source: Ouedraogo, E. 2014

In the Sahel Region study area, average annual temperatures have slowly risen over time. A rise of nearly 1C in maximum annual temperature has occurred in Dori from 1960 – 2011, while minimum annual temperature has risen more than 2C (Figure 3).

Figure 3: Inter-annual Evolution of Minimum and Maximum Temperatures at Dori, 1960-2011.



Source: Ouedraogo, E. 2014

Extremes in maximum and minimum daily temperature in Dori include a high reading of 46.4C recorded three times, in 1981, 1998, and 2001, and an historical low of 6.8C recorded in 1977. The seasonal high in rainfall was 753.2mm in 2003, and a low of 259.1 in 1987 (Tables 2 and 3).

As noted, the distribution of rainfall has become increasingly variable and uneven over time. Long dry spells of weeks or months may now be followed by intense monsoon downpours over a 24-48 hour period. A record rainfall of 117.7mm was recorded on June 25, 2008. Other recent years of extreme rainfall recorded at Dori in one day include 2005 (112.7mm), 2011 (60mm), and 2012 (50mm)[20]. These intense rains cause severe flooding, particularly in low lying areas, and often destroy crops such as sorghum, that are often grown in depressions to better capture rainfall.

20 Personal communication, TOUGUMA, E., Meteorologist, Dori, Burkina Faso.

In summary, the Sahel region of Burkina Faso has seen a steady secular decline in rainfall since the 1950s, and a notable rise in minimum and maximum temperatures. Impacts on agricultural production (crops, livestock, trees, vegetation) have been severe, as crop phenology and plant growth is affected by declines in rainfall and rising temperatures.

Table 2: Maximum and Minimum Daily Temperature in Dori, 1960-2011

STATION	MAXIMUM DAILY TEMPERATURE			MINIMUM DAILY TEMPERATURE		
	Day	Year	Record	Day	Year	Record
Dori	Apr 27 Apr 17 May 12	1981 1998 2001	46.4	Dec 29	1977	6.8
Ouahig	Apr 21	1983	45.5	Jan 6	1966	7.2
Fada	Apr 18	1998	44.5	Dec14	1961	10.7
Ouaga	Apr 23	1994	44.5	Jan 3	1989	10.1

Source: Adapted from Ouedraogo, E. 2014

Table 3: Maximum and Minimum Annual Temperature in Dori, 1960-2011

STATION	MAXIMUM ANNUAL RAINFALL		MINIMUM ANNUAL RAINFALL	
	Year	Rainfall (mm)	Year	Rainfall (mm)
Bobo	1968	1412.9	1983	778.1
Boromo	2008	1134.7	1961	539.3
Dédougou	1962	1149.5	1981	395.6
Dori	2003	753.2	1987	259.1

Source: Adapted from Ouedraogo, E. 2014

3.3.2 Niger – Tillaberi Region

The area of study is characterized primarily by the zone Sahero-Sahel, with 150 to 350 mm of rain per year, which allows for mainly pastoral livelihoods. The Sahel zone, characterized by 300-400 mm of rain per year, allows for agricultural livelihoods, including mixed livestock and millet-legume cereal production. In the further south areas of Tillaberi, the Sahelo-Soudain Zone (400-600 mm of rain annually, and the Soudain zone (>600mm of rain annually) allow for mixed livestock and cereal production (mainly millet and sorghum)[21] [22].

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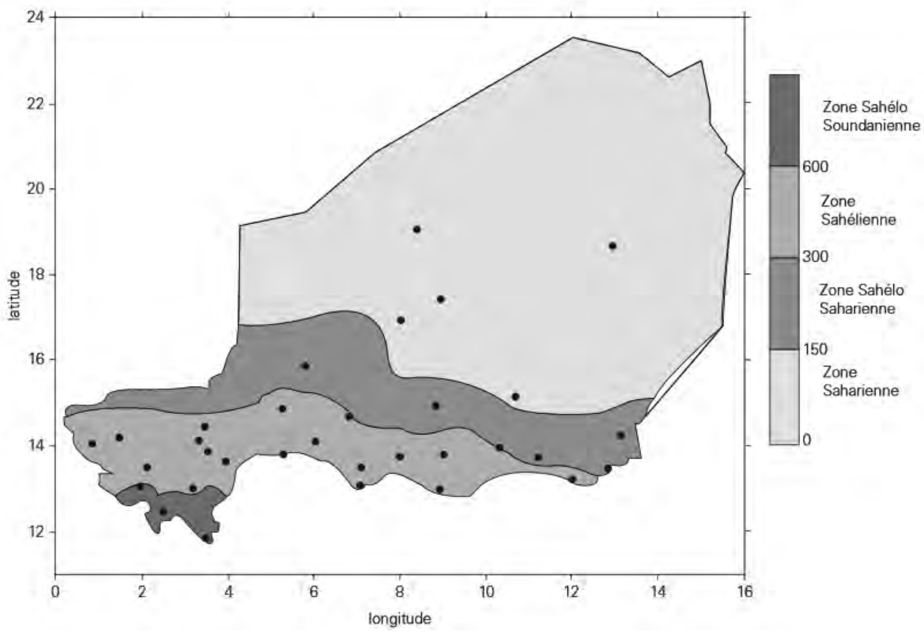
21 "Consultation Sectorielle sur l'Environnement et la lutte contre la Désertification » Ministère de l'Hydraulique, de l'Environnement, et de la Lutte Contre la Désertification, 2005.

22 Agricultural Sector Risk Assessment in Niger, World Bank

Map 5: Agro-climactic Zones of Niger



Source: Agricultural Sector Risk Assessment in Niger, World Bank (taken from the Comite Interministerial de Pilotage de la Strategie de Developpement Rural, Secretariat Executif. September 2004)

This means that as the rainfall isohyets shift south, there is a loss of agricultural land in the areas of study because of the decreased rainfall. According to AGRHYMET, 15 percent of the land in Niger allows for rain fed agriculture, decreased from 25 percent 30 years ago, due to the descent south of the isohyets.

However, a report by the World Bank[23] indicates that following a decline in rainfall and a shift south of the isohyets from 1950-1990, the trend has reversed since the 1990s, and the isohyets are shifting north again. Regardless, the erratic rainfall and changing trends means that these areas living on the edges of these zones continue to be at risk from changing climate.

In addition to the annual rainfall, the patterns of rainfall have changed over the past several decades in two other important ways: regularity and severity.

The periods of long dry periods have increased in number. For example, In Tillaberi and Kollo, in the month of September, the periods of at least 10 days of no rainfall have become more numerous over time, which affects the maturation of millet[24].

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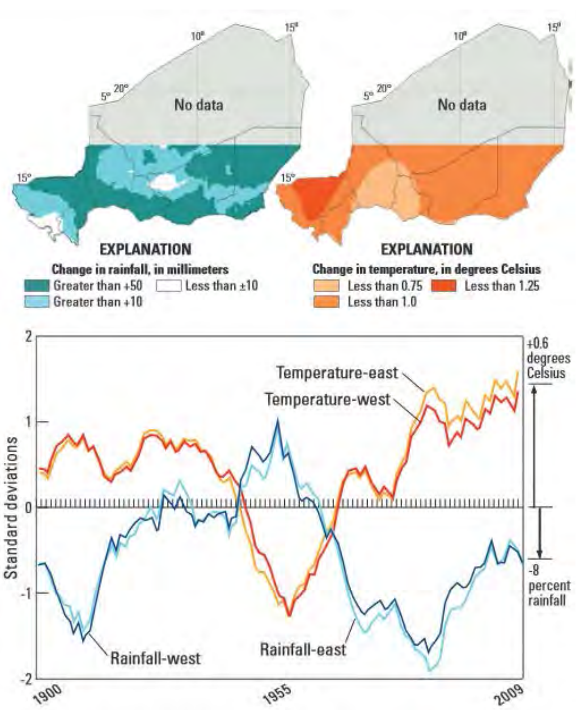
23 Agricultural Sector Risk Assessment in Niger, World Bank (Document 140)
24 AGRHYMET

Additionally, the aggressiveness of the rains (as measured by the Fournier index, which measures the erosive force on the rain on soil) has increased between the period of 1971-200 and 2003-2012. Specific data exist for the Stations at Bogande, Dori, and Fada[25]. These aggressive rains lead to soil degradation and increased erosion.

Temperatures in Niger have also increased, on average by more than 0.7C from the average, with the recent warming unprecedented within the past 110 years. The transition to even hotter temperatures will have a negative impact on crop harvests and harvest availability, and will amplify the impact of drought and/or increase rainfall requirements to compensate for the increased temperatures.[26]

Map 6: A Climate Trend Analysis of Niger

Observed and Projected change in June-September rainfall and temperature for 1960-2039 (top) and rainfall and air temperature series for June-September for eastern and western Niger (bottom).



Source: A Climate Trend Analysis of Niger, USGS/USAID, FEWS (Document 141)

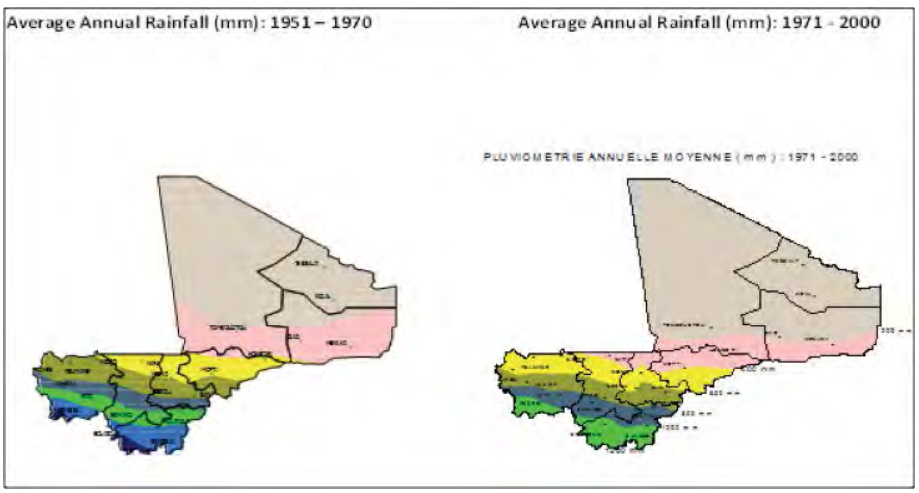
25 AGRHYMET
26 A Climate Trend Analysis of Niger, USGS/USAID, FEWS (Document 141)

3.3.3 Mali – Gao Region

High temperatures are already a constraint to cereal production in Mali, particularly dry land crops of pearl millet and sorghum. Temperatures in the Sahel are expected to increase by between 1 and 2.75 degrees Celsius by 2030, with less certain predictions for rainfall[27].

As in the Sahel Region of Burkina Faso, there has been a steady decline in rainfall in Mali. From 1951-2000, rainfall declined by 20 percent (Map 7) with isohyets shifting southward. In the Gao Region, average annual rainfall fell below 200 mm from 1971-2000. Thus, rainfed agriculture, requiring a minimum of 250 mm for pearl millet, has been under extreme water stress during this time period.

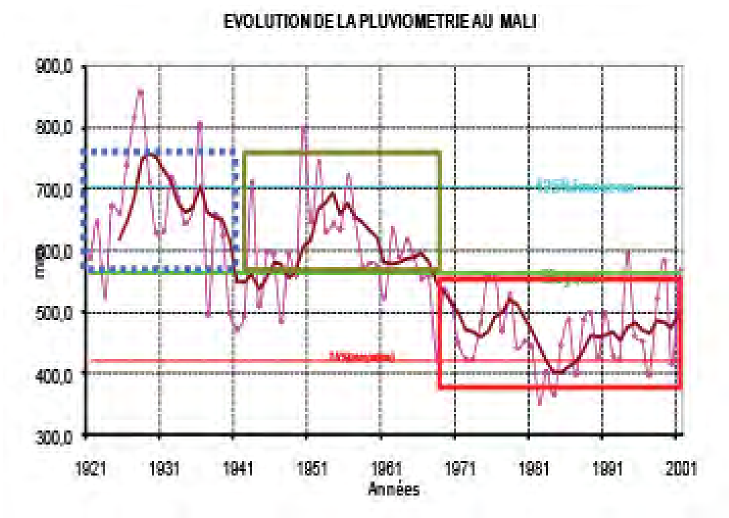
Map 7: Southward Shift of Rainfall in Mali, 1951 – 2000.



Source: Tandia, F. 2014. Division Agrométéorologie, Agence Nationale de la Météorologie, Mali

27 Adapting dryland agriculture in Mali to climate change. Norwegian University of Life Sciences (document 124).

Figure 4: Decadal Decline in Rainfall in Mali, 1921 – 2001.



Source: Tandia, F. 2014. Division Agrométéorologie, Agence Nationale de la Météorologie, Mali

4. KEY FINDINGS

The use of improved seed varieties is a critical innovation for making smallholder agriculture more durable in the face of unpredictable weather patterns. 17 August 2012
AMIDOU TRAORE, CRS

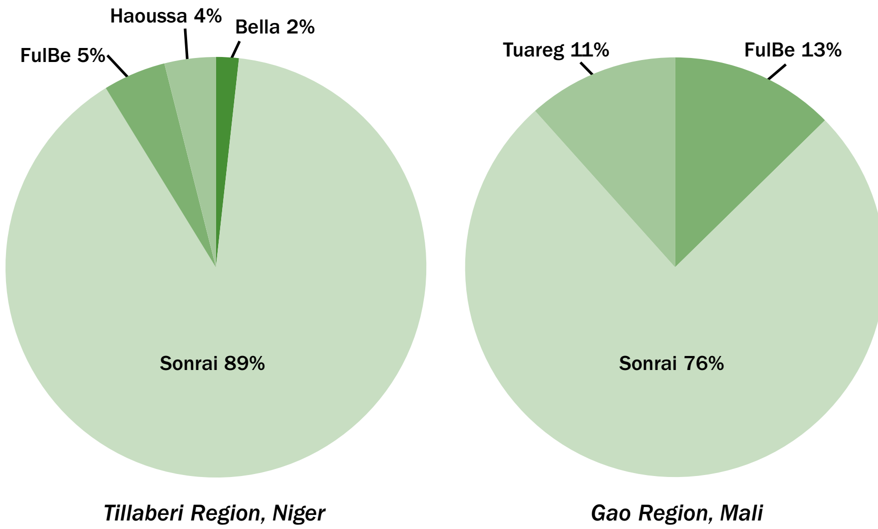
4.1 FGD PARTICIPANT PROFILES

The profile of FGD participants across all three-country study zones was largely uniform in terms of low levels of literacy and education, and low to moderate diversification of livelihoods. From Section 3.2 (Overview of Field Study Sites), agro-pastoral production is the primary livelihood activity throughout the three-country region, with little variance in production systems across all three sub-regions. Only in villages in close proximity to the Niger River did gardening and rice production play a more important role in meeting the consumptive and economic needs of households.

4.1.1 Ethnic Composition of Focus Groups

Figures on ethnic composition of the focus groups were not collected for the first study phase in Burkina Faso. The large majority of FGD participants in the Sahel region study in Burkina Faso were FulBe (Peuhl), with a substantial number of Bella in some communities. Smaller numbers of Gourmantche, Mossi, Sonrai, and Gaobé were present in several villages. The Sonrai (Figure 5) were the predominant ethnic group in Niger (89 percent) and Mali (76 percent). Much smaller numbers of FulBe, Haoussa, and Bella were present in the FGDs in Niger, and FulBe and Tuareg in Mali.

Figure 5: Ethnic Composition of FGD Participants



4.1.2 Educational Level of Focus Groups

Profiles of educational level attained for all three-country regions (Figure 6) illustrate very low levels of literacy and formal education among the study villages[28]. In Mali, primary and secondary education amongst both genders is noticeably higher than in the other countries. Informal levels of education[29], particularly Koranic school attendance, are higher in the Tillaberi Region (Niger) than in the Sahel (Burkina Faso) and Gao (Mali) regions. Levels of formal education for both men and women were higher in Mali than in Niger and Burkina Faso[30].

Overall, participants in the FGDs in Burkina Faso had the lowest levels of education (3 percent formal education), while formal schooling in Niger was 16 percent, and highest in Mali at 38 percent. The most noticeable disparities in education by gender are in Mali, where women had slightly higher levels of informal and primary schooling than men.

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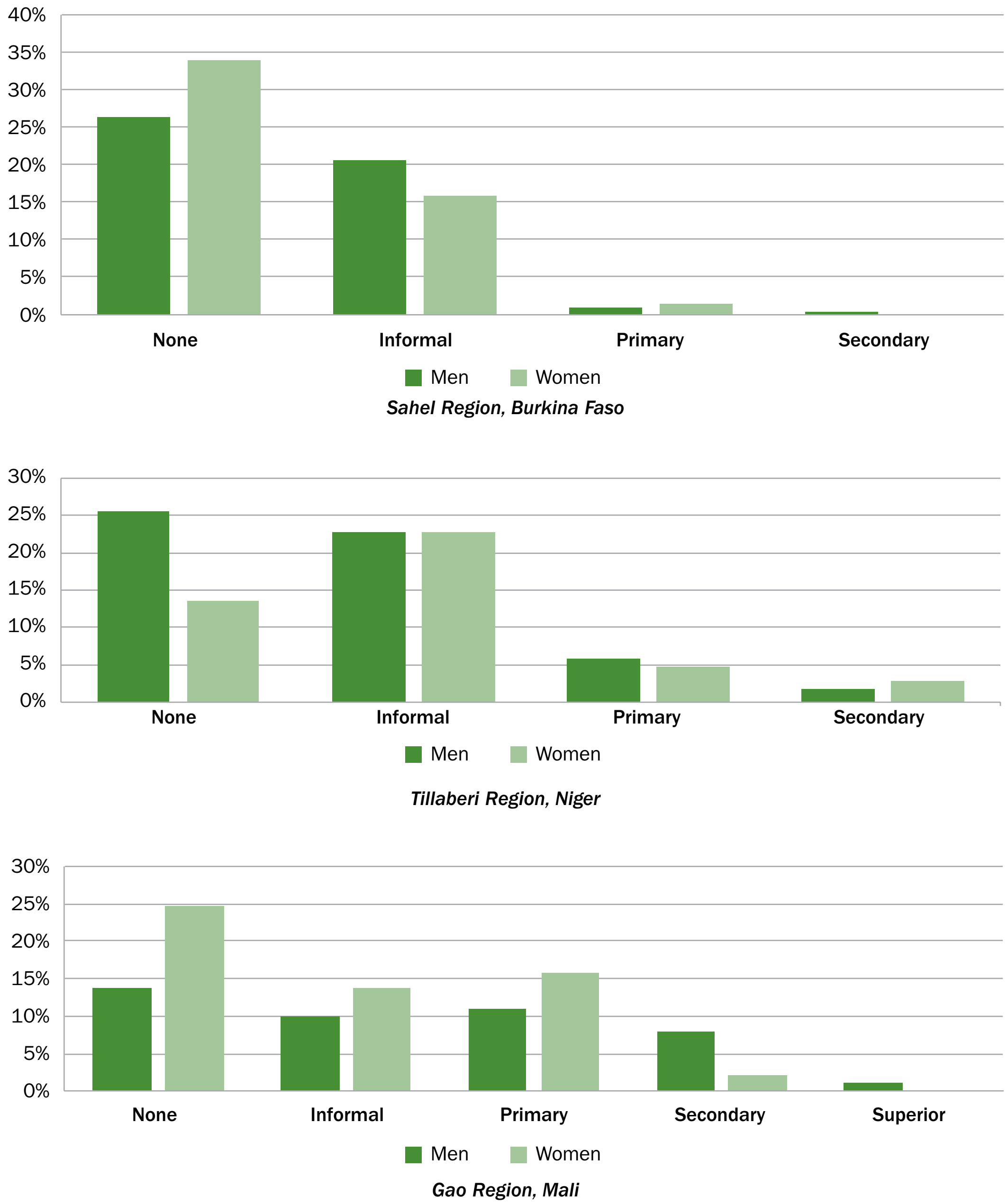
28 Observations across the three study regions have limitations in drawing broad comparisons and conclusions due to small sample size, particularly in Mali, covering only four villages.

29 Informal education includes both adult literacy programs and Koran schools. In Niger, most respondents in this category attended Koranic schools for both genders.

30 The differences noted across the regions in levels of school attendance, including differences between and within gender (eg, women in Niger versus women in Burkina Faso and Mali) may possibly be explained by the small sample size, divergent cultural views or attitudes toward formal education among different ethnic groups, or other factors that should be explored further in the design phase of SUR1M.

Figure 6: Educational Level by Gender



4.2 LOCAL PERCEPTIONS OF CLIMATE CHANGE

Focus group discussions were initiated by asking participants if they have an understanding of the term 'climate change', and if so, to cite examples of manifestations, or 'signs' of how the climate has changed over the past 20 to 30 years. Signs include changes in rainfall, temperature, and winds. Follow up, probing questions were posed to generate a more refined or nuanced discussion on the frequency, duration, and amplitude of these changes.

Responses were recorded and organized under three general categories:

1. **Extreme weather events** – to include sudden intense storms or monsoon floods; droughts of a severe or protracted nature resulting in loss of crops, animals, or other assets; and extreme high winds causing damage to crops, housing, or other resources;
2. **Changes in temperature** – to include either a slow, gradual rise in temperature, or sudden change in temperature such as heat waves or cold fronts;
3. **Changes in precipitation** – to include slow or sudden changes in timing, distribution, and intensity of rains such as: a) unpredictable start and end to the rainy season; 2) erratic, unpredictable distribution of rainfall during the rainy season; and 3) an increase in the intensity of rainfall, such as severe thunder storms or showers occurring over a brief time period.

Due to a small divergence in perceptions of climate change across the three study sites, a comparative analysis of observations for all three regions is presented in this section (Figure 7).

Perceptions of climate change were somewhat uniform across all three regions, with gender observations being largely congruent. The most commonly cited signs of change in order of frequency of response were: 1) reduced rainfall, 2) seasonal changes (particularly in onset and end of the rainy season), 3) increases in temperature, and 4) episodes of severe drought. Only in Burkina Faso, did respondents note seasonal and inter-annual variability in rainfall as a significant change[31]. Changes in high winds were less frequently reported, and flooding was noted less frequently in Burkina Faso, where sample villages were located near streams

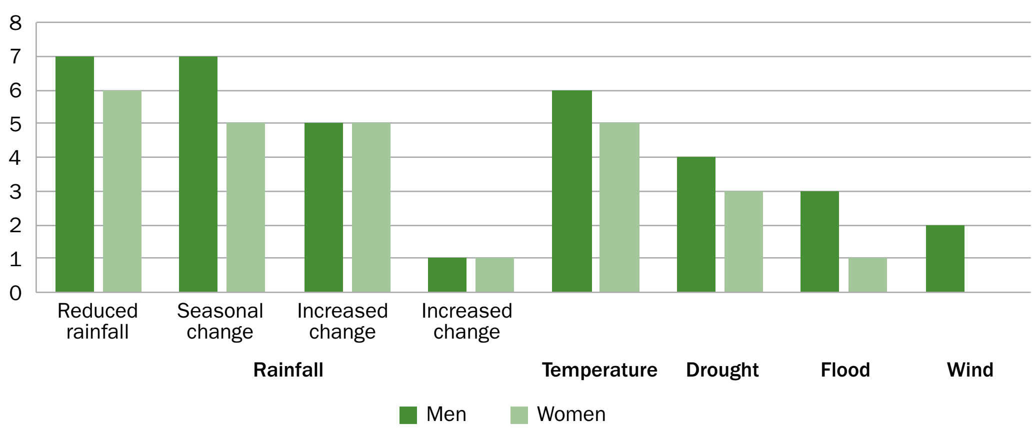
31 Response categories for this section of the report are somewhat subjective, as differences observed such as variability, seasonality, and intensity of rainfall can be very subtle or nuanced in interpreting the content of the discussions. This may account for a higher response rate of increased variability in the Burkina Faso sessions.

that are seasonal and much smaller in hydrological flow than the Niger River, where more of the Niger and Mali sample communities were located.

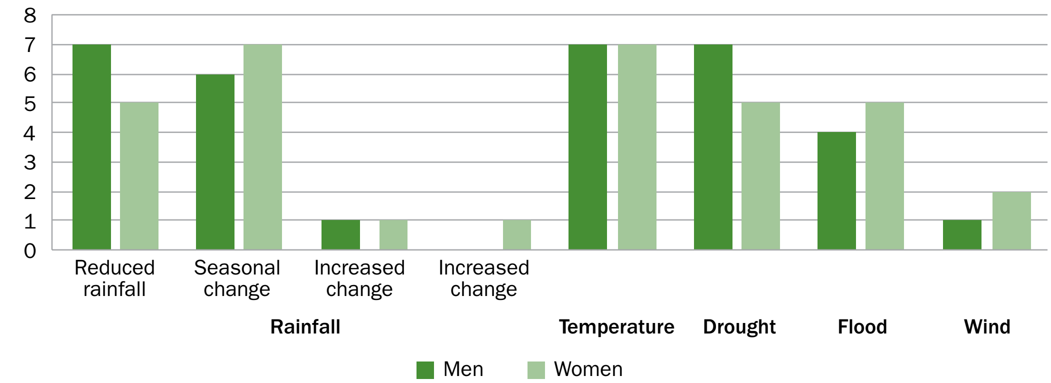
As anticipated, participants in all three regions most frequently cited a decline in rainfall as the primary sign of climate change. This included discussions about drought, and more specifically, changes in the frequency and duration of extended dry spells. A typical change in frequency would be three out of five years as very dry, whereas before, three out of five years would be relatively good, with sufficient rainfall. These observations are consistent with climate change research in the West African Sahel region, where inter-annual distribution and variability in rainfall has increased for more than three decades since the advent of the great Sahelian drought of the 1970s (Jalloh et al 2013).

Respondents also often identified impacts of climate change, such as the loss of trees and vegetation, or barren, dry soils, confusing impacts with signs of climate change.

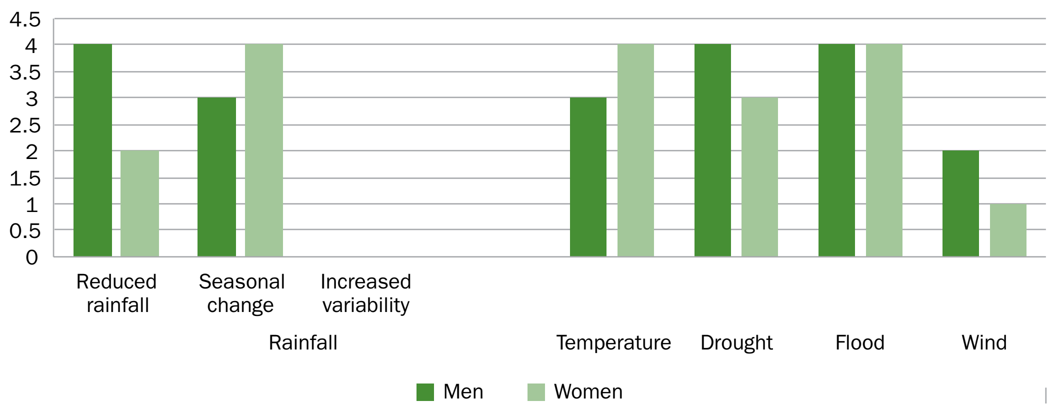
Figure 7: Local Perceptions of Climate Change by Gender



Sahel Region, Burkina Faso



Tillaberi Region, Niger



Gao Region, Mali

Changes in rainfall accounted for nearly one-half of all observations (47.6 percent) on signs of climate change. Participants most often noted a reduction in rainfall (18.7 percent), and a change in the season (19.2 percent), particularly a late onset of the rainy season and a premature end of rains, truncating the growing season for rainfed millet and sorghum. Historically, according to one key informant, the rainy season in the Sahel region used to extend over five months, from May to September. Today, however, the wet season has shortened to roughly 2.5 to 3 months of rain, from late June or early July until the end of August or early September (INERA communication).

Increasing irregularity in the onset and distribution of rains was frequently noted. Long dry spells of at least 2-4 weeks have become common in recent years. Increasing unpredictability in the start of the rainy season poses challenges for local farmers who indicated that they are now forced to sometimes plant seed on multiple occasions, as rains may begin and abruptly stop for a period weeks. In Belgou (Burkina Faso), women noted that the unpredictable onset of the rainy season forces families to remain in fields longer to protect small seedlings from livestock and other predators after planting. They also prepare their fields for cultivation earlier in the season than previously, due to uncertainty in the onset of rains. Thus loss of seed stocks and an increase in labor time allocation has resulted due to increasingly 'capricious' rains. Session participants in Belgou noted that the decline and unpredictability in rainfall has forced them to rely more on herding as a major livelihood.

Increases in temperature, particularly arriving early by the end of February or early March, and extending well into June with the first rains were noted (19.2 percent). Observations of increased drought were slightly less reported (15.7 percent). Participants observe that extremes in temperature between seasons, such as hotter days in the dry season, and cooler evenings during the harmattan season are becoming more frequent. As one participant noted, "…tout est violant maintenant…" A deleterious impact of increasing temperatures in the dry season noted by some women was on the loss of poultry (particularly chickens), due to their low tolerance of extreme high temperatures.

An increase in high winds was noted only about 5 percent of the time. However, a few observations were made about the loss of trees and vegetation due to climate change over the years; thus, enabling winds to become more turbulent, carrying more sand from denuded landscapes. High winds occur most often during the rainy season in the form of turbulent sand storms. Villagers in the community of Zindigori, Niger noted that sand storms have become more frequent early in the rainy season, covering up small seedlings and resulting in crop loss and destruction. They also noted that strong winds also damage their millet crop at harvest time. Impacts may be more severe than earlier decades due to the progressive loss of trees and vegetation.

Discussants also noted that storm winds, as well as torrential monsoon rains, occur more frequently now than in the past. Storm winds pose a problem for water courses and river beds where heavy siltation is occurring, affecting stream flow during the rainy season. These observations corroborate the opinion of one NRM expert interviewed in Niger, who believes that environmental degradation in terms of loss of soil fertility, severe erosion of top soils and gullies, sheet run off, and a steady decline in agricultural productivity must be understood at a landscape level as primarily a watershed management problem (CLUSA International, personal communication). The source of watersheds on high plateaus in Niger are now severely denuded of plants, trees, vegetative cover and other natural or manmade barriers (such as stone bunds) to impede the heavy flow of silt into small gullies and streams, and the washing way of top soil nutrients from low lying farm land areas.

FGD respondents provided relatively detailed observations of the temporal changes in climate over time, referring often to the number of months of absence of rain, or hot temperatures, etc. An illustrative list of typical contextual responses of perceived change, as well as impacts, is provided in the tables below.

Table 4: Local Perceptions and Impacts of Climate Change

ILLUSTRATIVE SIGNS OF CLIMATE CHANGE
Late onset of rains
Insufficient rain
Before – onset of rains in May – now, in late June, early July
Before, 3 months of heat; now, 5 months of heat
Lack of rain, desertification, silting of rivers
Before, 5 month rainy season; now 2 months
Severe floods in 2004, 2005, 2008
Extreme drought in 2002, 2005, 2010, 2013
Before, high winds in 2/5 years; now 5/5 years

CLIMATE EVENTS	IMPACTS OF CLIMATE CHANGE
Drought	Insufficient rains Late onset of rains Premature end of rains Reduced soil moisture
Flooding	Water erosion Increased land degradation
High Winds	River siltation
Extreme Heat	Increase in evapotranspiration Early depletion of water sources Increased water stress

4.3 CLIMATE CHANGE ADAPTATION TECHNIQUES

This section addresses climate change adaptation techniques and methods that are commonly used throughout areas of the West Africa Sahel region, including the three regions studied. Summary descriptions of the most well-known techniques are first introduced. Then, a delineation of the range of agricultural practices deployed across the study sites is introduced, looking comparatively at similarities and differences across the three regions.

This section is followed by a feasibility analysis of the various techniques that examines the advantages and constraints of the most widely practiced techniques, succeeded by an economic analysis of their costs and benefits. Information is drawn from the FGD discussions, and compared with several research studies that have been undertaken in the three countries. Gaps in economic data from the secondary sources, particularly benefits (expressed as crop yields or animal sales), are substantial; thus, limiting to a large degree comparisons and triangulations of data to accurately assess real costs for households and communities. A caveat is also in order, as analyses, particularly of an economic nature, are highly site specific, and must take into account a myriad of factors – social, environmental, political, and cultural – that shape economic behavior, investments and outcomes. Therefore, economic calculations and analyses presented in this study are provided as a general estimate or rule of thumb, recognizing that further detailed, robust economic studies are critical prior to design and implementation of actionable program strategies and interventions at the community level. Given this major concern, recommendations generated from this study explicitly acknowledge limitations in the data being used, both in terms of small sample size, and in terms of a limited, cursory understanding of the gendered dynamics of economic behavior and decision making among smallholder households in the study zone.

Analyses below are stratified according to several variables that shaped the selection of sample villages, and the analytical framework for this study. These include: 1) gender, 2) proximity to a market, and 3) proximity to a water source (river or large stream).

4.3.1 Summary Description of Climate Change Adaptation Techniques

This section gives brief descriptions of climate change adaptation techniques that were included in the survey. They are divided into four broad categories: 1) crop and soil management, 2) water management, 3) livestock management, and 4) forestry management[32].

4.3.1.1 Crop and Soil Management

Zai

Known as zai in Burkina Faso, and tassa in Niger, this practice, based on an indigenous farming practice as an adaptation to the local regional agro-ecology and arid climatic conditions, is a treatment of the surface of the soil. It involves creating pockets or shallow pit holes in the soil, which are designed to capture surface runoff water and maximize water infiltration into, otherwise, encrusted soils. It involves digging of infiltration pits with a hoe, approximately 25-35cm wide and 10-15cm deep[33]. They are often accompanied by the application of compost or fertilizer (300g of manure or compost) in each pit, or a 'micro dose' of NPK fertilizer at 65kg/ha. The process can also be mechanized using a tillage tool (draught power), making crossed furrows in dry soil[34].

Half-Moon (Demi-lune)

The half-moon is a physical structure composed of a half-circle (semi-open) depression in the soil that allows for the collection of surface runoff water, favoring its infiltration. It differs from a zai in that the half-moon is larger, creating a larger surface for planting and water collection. It is used on land that has little slope (0-3 percent).

Bio-reclamation of degraded lands – BDL (Bio-récupération des terres dégradées)

According to ICRISAT[35], BDL is an integrated system aimed at increasing food production and income through the utilization of degraded lands for production of fruit trees and vegetables. The approach combines half-moons, zais, and the use of compost/manure to improve degraded land. Drought-resistant trees and vegetables (egs., okra, roselle, pomme du Sahel, moringa) are often planted in these reclaimed lands.

Anti-Erosive Dikes (Diguettes antiérosives)

A simple anti-erosive dike is a manual construction of earth, stones, or earth/stone mixture into small dikes (bunds) that follow the

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32 The descriptions of these techniques are drawn from two key documents (unless otherwise cited), the Niger PAC document, and the IUCN Burkina Faso Document.

33 Presentation "Les techniques d'agriculture de conservation peuvent-elles faire mieux que le Zai manquele ou mechanise dans le Sahel?", INERA. CIRAD

34 Presentation "Les techniques d'agriculture de conservation peuvent-elles faire mieux que le Zai manquele ou mechanise dans le Sahel?", INERA. CIRAD

35 « Biorecuperation of degraded Lands », ICRISAT 2009 http://www.icrisat.org/impacts/impact-stories/icrisat-is-bio-reclamation-land.pdf

contours of the land. The process can be mechanized using land-grading machinery.

Improved Seed (Semence améliorée)
This practice consists of the introduction of improved seed varieties adapted to the conditions of specific ecological zones, increasing tolerance of heat and low rainfall, resistance to some plant diseases, and reduced growing cycles. In Burkina Faso, improved seeds are mostly used for corn, sorghum, millet, sesame, manioc, and cotton. Improved seeds may be better adapted to variations in rainfall, other climactic changes, and can improve production, standardize crops and modernize production chains as a result.

Integrated Pest Management – IPM (Gestion intégrée des parasites- GIP)
According to FAO[36], integrated pest management (IPM) is an ecosystem approach to crop production and protection that combines different management strategies and practices to grow healthy crops and minimize the use of pesticides.

Crop Rotation (Rotation des cultures)
This is the practice of successively planting cereals and legumes on the same field, which helps improve soil fertility (similar to the use of nitrogen-fixing cover crops).

Cover Crops (Cultures de couverture/Fixateurs d'azote)
This technique is an improvement on fallow fields. It consists of integrating fast-growing, nitrogen fixing species into the cropping system to improve/restore soil fertility.

Stone Bunds (Cordon pierreux)
This is an anti-erosion technique consisting of stones/rocks placed in a line following the contour of the land. It is appropriate only in areas with available stones/rocks.

Hedges, Live Fencing (Bande enherbée, haies vives)
Hedges/live fencing consists of herbaceous plants installed parallel to the contour lines in the fields either alone or uphill of anti-erosion structures.

Mulch (Paillage/Mulching)
This technique involves covering bare soil with organic material, particularly vegetative material such as stalks from millet or sorghum,

36 http://www.fao.org/agriculture/crops/thematic-sitemap/theme/pests/ipm/en/

small branches, or straw, with the goal of improving the retention of soil humidity and bioactivity, increasing water infiltration, and improving soil fertility. Mulching is very effective in rehabilitating bare or encrusted soils.

Compost (Compostage)
Compost is a technique to produce organic fertilizer from organic refuse and certain mineral additives. Compost is often used in conjunction with other techniques, and most effective when applied with animal manure.

Bio-Intensive Gardens (Bio-jardinage)
Bio-intensive gardening is the practice of intense cultivation of a small plot of land to restore the productivity of the soil. It can increase the fertility of the soil, improve productivity, and diversify crops over multiple harvests per year.

4.3.1.2 Water Management

Drip Irrigation (Irrigation goûte à goûte)
This is a technology to optimize irrigation and minimize water use, particularly in arid and semi-arid zones. The irrigation system delivers water to the foot of each plant individually through a system of pipes with emitters at regular intervals. The system feeds water drip-by-drip, in small doses, over long periods of time.

Water Storage (Récupération/stockage de l'eau)
Garden-based basins (système de bassins liés pour le jardin) are systems of water storage, consisting of small basins of water spread throughout the garden. Each basin is fed by a PVC pipe, and holds about 1,078 liters of water. There are usually about 4 basins per 0.16 ha. This system reduces the time and hardship of irrigation, and reduced water loss as compared to irrigation canals.

Rainwater Harvesting (Ruisellement de l'eau de pluies)
Rainwater harvesting involves a variety of techniques that harvest water from roofs and ground surfaces for agricultural irrigation (or other) uses. Note that 'floodwater harvesting' is a related practice that collects water from intermittent or ephemeral watercourses.[37]

Water Pumping Technology (Technologie de pompage de l'eau)
Water pumping technology includes different ways to convey or move

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37 http://www.fao.org/docrep/u3160e/u3160e03.htm#1.2

water Pedal powered pumps are human powered pumps that can be used to extract water for vegetable plots. Motor powered pumps are another water pumping technology, often used to move water from a well or other source for irrigation, human, or animal use.

4.3.1.3 Livestock Management

Fattening (Embouche)
The practice of fattening is an intensive livestock rearing technique, usually involving sheep or cows, and involves the purchase of young animals and keeping them on tethers and feeding them until they are fattened, and then selling. This is also a method to produce more manure.

Fodder Production (Culture fourragère), Silage (Ensilage), Fodder Storage (conservation du fourrage)
These three techniques were surveyed separately, but are all related to each other; in the literature they are often described jointly/in some combination as a single technique.

Fodder production is done by harvesting naturally occurring plant matter for feed at an opportune time, and conditioning it for use by drying it. The plant matter can be grassy (hay) or can consist of stems and leaves as well as woody parts of plants (including certain bushes and trees).

Silage differs in that the storage of the plant material is done green (not dried), relying on the acidifying power of lactic bacteria that lower the pH to around 4, at which all chemical reactions and fermentation cease, and the material produced is stored as silage.

Bourgou Fodder (Bourgouculture)
"Bourgou" is a common name for a type of perennial grass (*Echinocloa stagnina*) that grows on riverbanks and in wetlands of the Niger River, and has been used traditionally for a long time. Bourgou is very palatable to livestock. In irrigated areas, it grows back well after cutting or grazing, except in the colder months (January, February). It also has a good market value. However, the high demand for water and water management must be considered[38].

Water Boreholes (Hydraulique pastorale)
Water boreholes are one type of pastoral hydraulics. Boreholes are

38 For more information on the plant science characteristics of bourgou, see: http://www.feedipedia.org/node/453

vertically dug holes that allow access to the aquifer in order to provide water for livestock. Extraction of this water can be done through manual pumps, solar pumps, and other methods.

Similar to boreholes, wells are holes in the ground made of masonry to reach the aquifer to provide drinking water for livestock.

Water Basins/Ponds (Boulis)

Water basins are small surface water pools/ponds that store water for at least part of the year. They are smaller than damns, which are larger projects that create permanent water sources. These basins/pools/ponds are made by dredging natural ponds/pools to increase their depth and thus the volume of water stored, and/or by digging such pools.

Dune Stabilization (Fixation des dunes)

Dune stabilization is a technique that helps the recuperation and stabilization of dunes, by stopping the movement of sand first by mechanical means and then by biological means. Dune stabilization seeks to stop the source of the sand and to fix the dunes in site.

One method described involves installing 'fences' of the plant *Leptadenia pyrotechnica*, and using stalks of millet and stabilizing bands of the plant *Euphorbia balsamifera.* Other plants are also used in the biological step of dune stabilization, depending on the availability in the region.

One risk to consider is the adverse effects of the abusive cutting of the stand of *Leptadenia*.

Herd Composition (Composition du troupeau)

Herd composition involves adjustments in the mix of animal species in order to adapt to changing environmental and climatic conditions. Over several decades of extreme, recurrent drought episodes, some herders in the Sahel region have been forced to reduce the herd size of cattle and shift more toward management of smaller ruminants, largely sheep and goats, due to greater tolerance of heat and water scarcity than cattle.

4.3.1.4 Forestry Management

Agroforestry (Agro-foresterie)

Agro-forestry encompasses a large number of techniques to conserve, improve, and use forestry resources, and involves the intercropping of trees with cereals, legumes, and other agricultural or horticultural crops. Several of these techniques are described in more detail below.

Fire Management (Feu précoce)

Fire management refers to a preventive strategy of setting a fire deliberately outside a field perimeter prior to the cropping season. Intentional fires set early on help burn off bush grass and vegetation in order to protect crops from larger bushfires during the growing season.

Farmer Managed Natural Regeration -FMNR (Régénération Naturelle Assistée, RNA)

This agro-forestry approach aims to stimulate/encourage the natural regeneration of woody plant species, and/or develop their integration into agricultural fields in a way that they can increase the total return of the fields. One key characteristic of this technique is the presence in the field of a certain number of species following a variable and acceptable density. Certain species can be selected for, particularly those that produce non-timber forest products (NTFPs).

Another simpler description of this technique is simply the practice of leaving 1-3 plants from each of the different trees and shrubs during clearing (in the dry or rainy season) to allow them to continue their growth.

Wind Breaks (Brises vent)

Wind breaks are linear structures, often living woody species (and sometimes herbaceous) placed so that they can protect cultivated areas, grazed areas, or housing against the adverse effects of prevailing winds.

Live Fencing (Haies Vives)

Live fencing consists of dense lines of trees, shrubs, or bushes of one or more rows and one or more species, located around a perimeter, to protect against animals and other attacks. They can also serve to delineate properties, protect gardens, produce timber and non-timber products, and help fight erosion.

Reforestation (Reboisement)

Reforestation is the planting of trees on degraded surfaces or deforested lands. This requires the production of nursery plants, selection of the proper site and appropriate species, as well as proper planting techniques. Beyond serving as carbon sinks, reforestation also contributes to the protection of soils, infiltration of water into the soil and the replenishment of groundwater.

NTFPs – Non-Timber Forest Products (PFNL – Produits forestiers non ligneux)

NTFPs are one aspect of many agro-forestry techniques, which attempts to encourage the use of forestry products other than wood. This tends to be more sustainable. Trees such as Baobab, Moringa, gum trees, and types of palms are used for their non-timber forest products, for example.

4.4 COMPARATIVE ANALYSIS OF AGRICULTURAL ADAPTATION TECHNIQUES BY GENDER

FGD participants were queried to first establish an inventory of climate smart agricultural strategies that are currently practiced in the community. This includes a list of 13 crop and soil management strategies that are well documented in the West African Sahel, 5 agricultural water management strategies, 9 livestock management practices, and 7 forestry management methods. A contextual description of these various techniques, consolidated in a feasibility matrix, is presented in more detail in the following section of this report.

4.4.1 Crop and Soil Management Practices

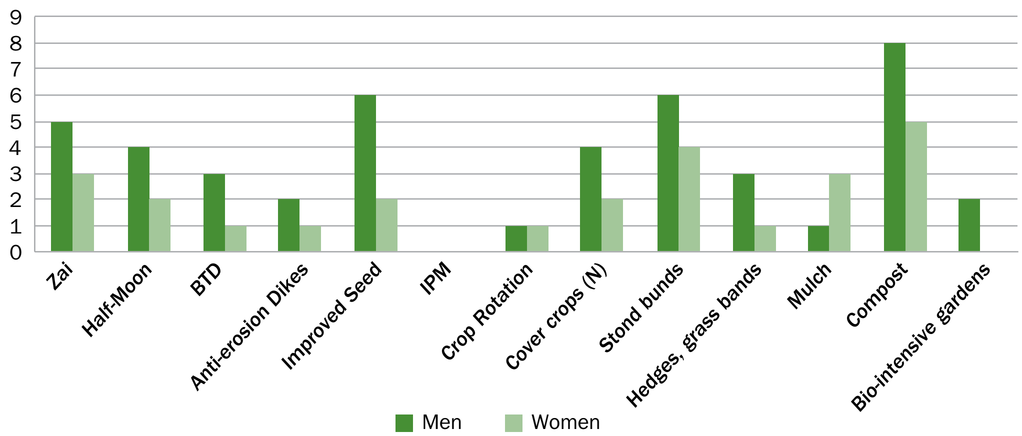
Across a sample of 20 villages (38 focus groups), 166 crop and soil management practices were identified (average of 8.3 practices per village). Of these, composting (18 percent), improved seed (12.7 percent), and stone bunds (11.4 percent) were the three most common techniques recorded (Figure 8). Composting (which actually entails manuring of fields with little organic matter), and improved seed (often distributed free or at highly subsidized rates) are relatively low capital investment strategies in comparison with other technologies, and may explain their higher levels of practice.

Crop and soil management practices are fairly well diversified in the study zones of Burkina Faso and Niger, whereas such practices are markedly absent in the Mali sample.

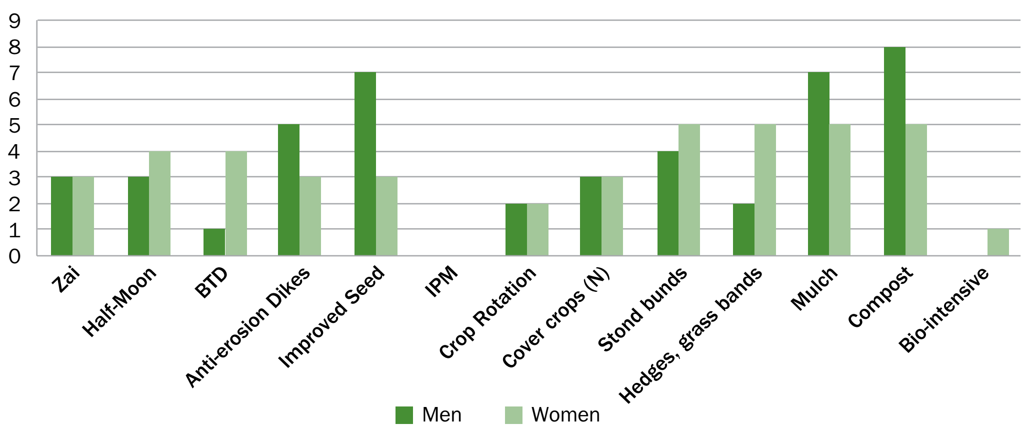
Given a smaller sample size, only three crop and soil management practices were documented – improved seed, composting, and bio-intensive gardening. These practices serve as an integrated approach to intensive gardening, which serves as the principal livelihood among four sample communities in relatively close proximity to the Niger River.

Men are most noticeably more diversified than women in their agricultural management practices in Burkina Faso (63.2 percent of all practices). While women have near parity with men in their practices in Niger (48.9 percent), practicing half-moons, bio-recovery of degraded lands (BDL), stone bunds, hedge rows/live fencing, and gardening more often than men. Men engage in 60 percent of all agricultural adaptation techniques recorded in the Mali sample. For the three regions, men account for 56.6 percent of all agricultural practices.

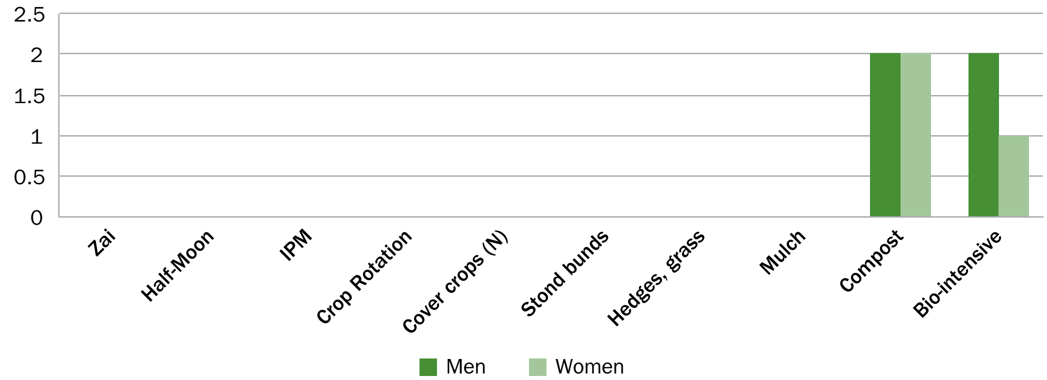
Figure 8: Comparison of Crop and Soil Management Practices by Gender



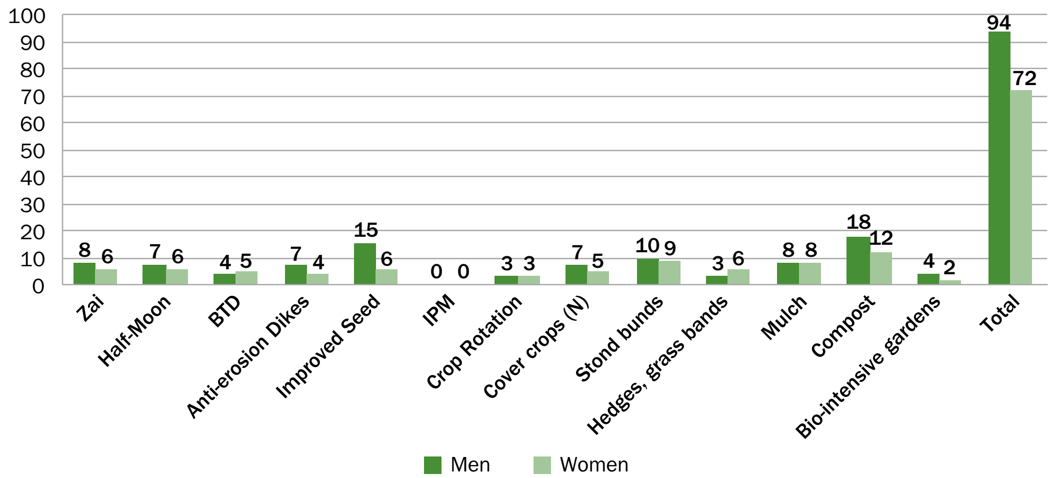
Sahel Region, Burkina Faso



Tillaberi Region, Niger



Gao Region, Mali



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4.4.2 Comparison of Water Management Practices

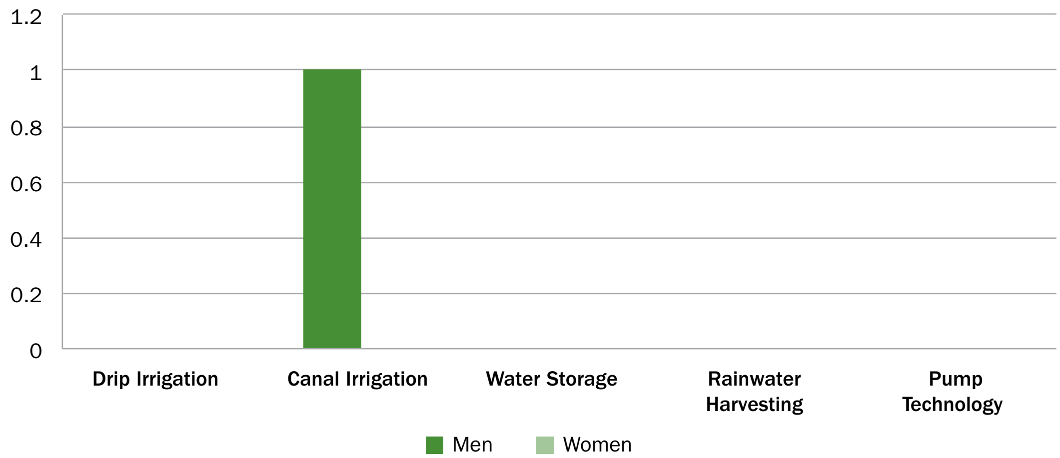
Water management strategies are notably few in a region of chronic water scarcity. Only 14 water management practices were recorded across 20 villages, or less than 1 technique (.7 average) per village. This is due in part to the lack of proximity to major water sources (streams, rivers), and to the high capital cost of most agricultural water management technologies.

Pump technology, used primarily for irrigation and garden production, constitutes 86 percent of all technologies used across the study sites, of which nearly 60 percent was in Niger (Figure 9). Only one instance of water management (canal irrigation) was cited in the Burkina Faso study, while Niger and Mali accounted for all other technologies, due to their closer proximity to a year round water source, in this case the

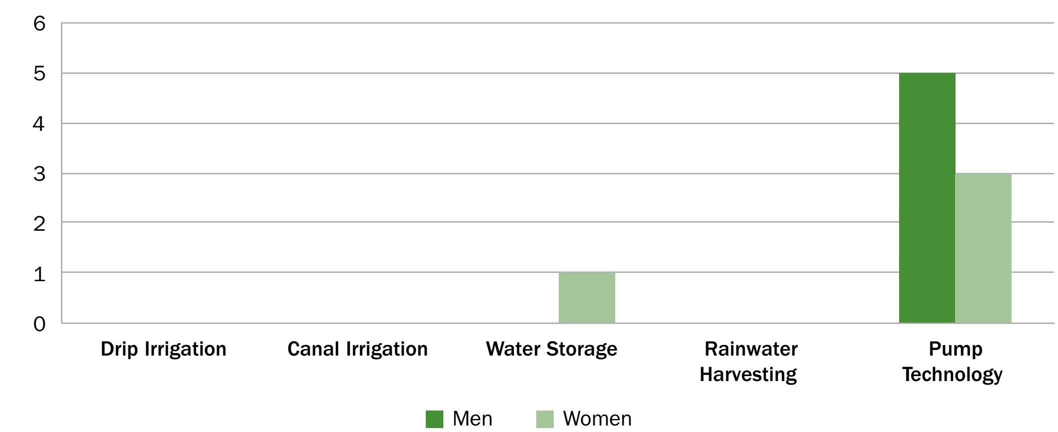
Niger River.

Disparities in water technology use by gender were not significant, men accounting for 57 percent of all water management techniques. This is due to the active participation of women in gardening, and some irrigated rice farming as well.

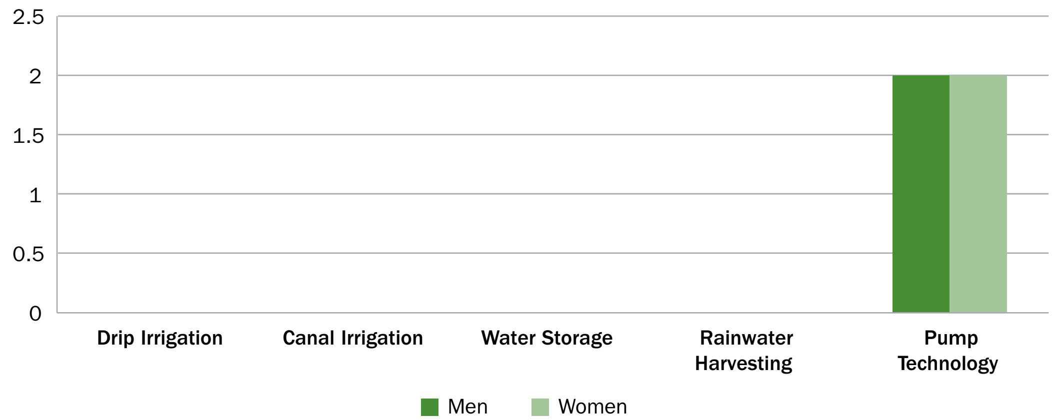
Figure 9: Comparison of Water Management Practices by Gender



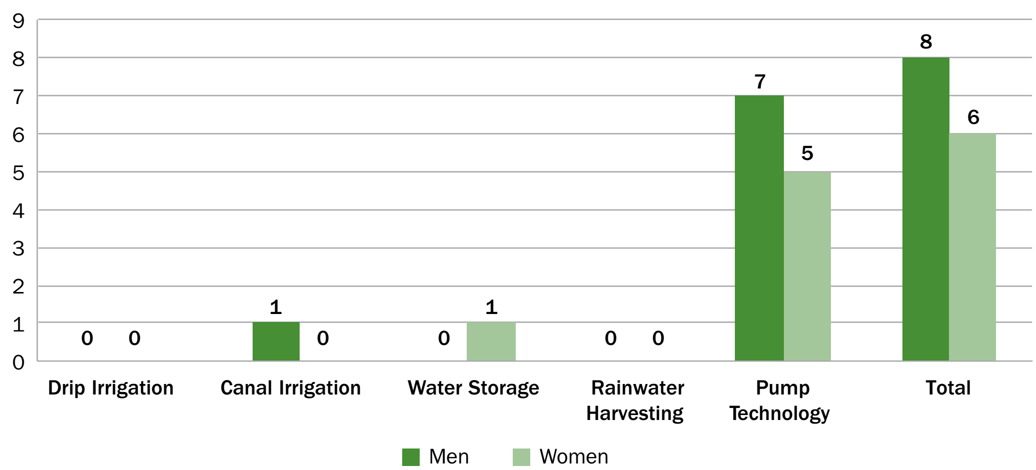
Sahel Region, Burkina Faso



Tillaberi Region, Niger



Gao Region, Mali



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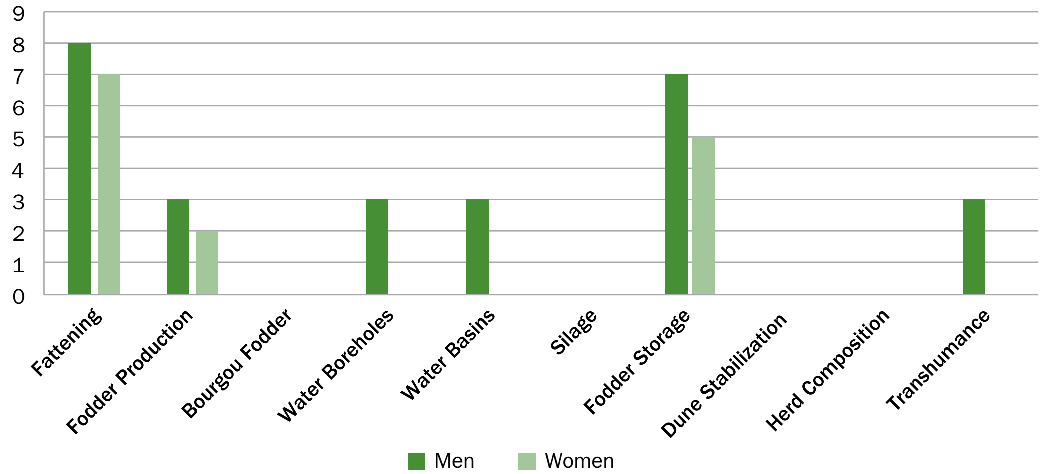
4.4.3 Comparison of Livestock Management Practices

A total of 105 livestock management practices were cited in the study sample, or an average of 5.3 practices per village. In general, there was relatively low diversification of practices, with animal fattening accounting for 32.4 percent of all practices, fodder storage 27.6 percent, and fodder production 12.4 percent (Figure 10). Bourgou production was not evidenced in Burkina Faso, and was practiced only in close proximity of the Niger River in Niger and Mali.

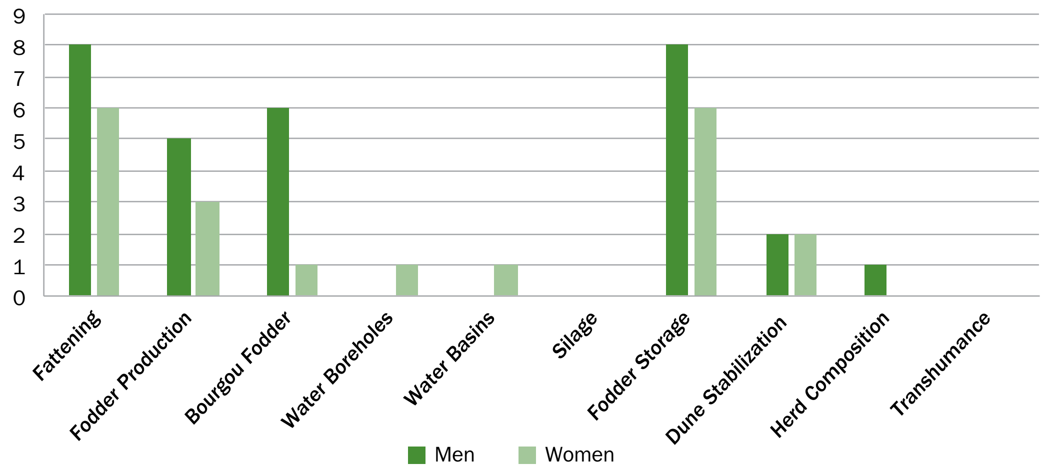
Overall, men engaged in nearly 64 percent of all livestock management techniques, particularly the fattening of cattle, while women specialize primarily in sheep production. No notable differences in livestock management practices were found between

Burkina Faso and Niger, with the exception of bourgou production in Niger.

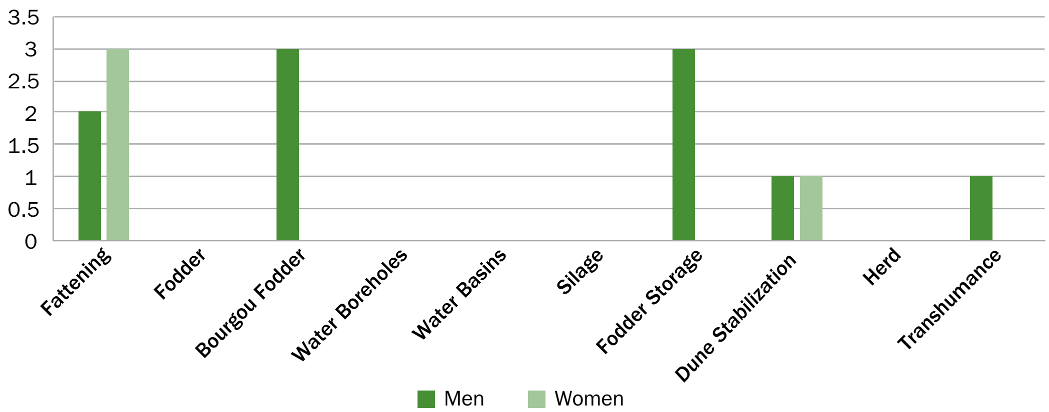
Figure 10: Comparison of Livestock Management Practices by Gender



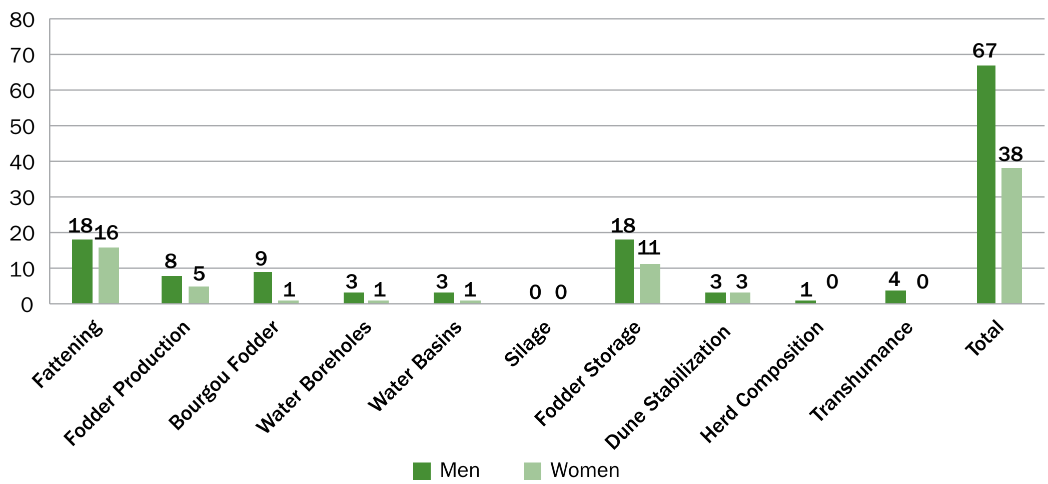
Sahel Region, Burkina Faso



Tillaberi Region, Niger



Gao Region, Mali



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4.4.4 Comparison of Forestry Management Practices

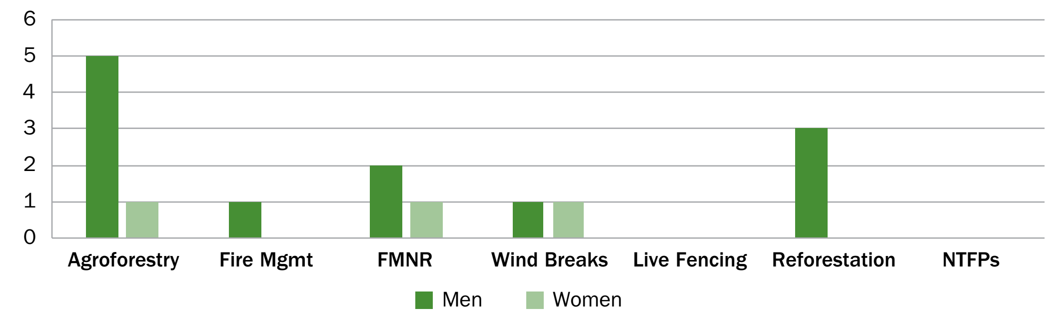
A total of 60 forestry management practices were cited across the 20 sample villages, an average of 3 practices per village (Figure 11). The most common practices were agroforestry (31.7 percent), FMNR (21.6 percent), and reforestation (16.6 percent). As noted earlier, differences among these practices are not always easy to discern, as an FMNR or reforestation practice may exist within an agroforestry farming system[39].

Gender differences are most discernible in Mali, where men engage almost exclusively in forestry management practices. Ultimately, men perform 65 percent of all forestry management techniques cited.

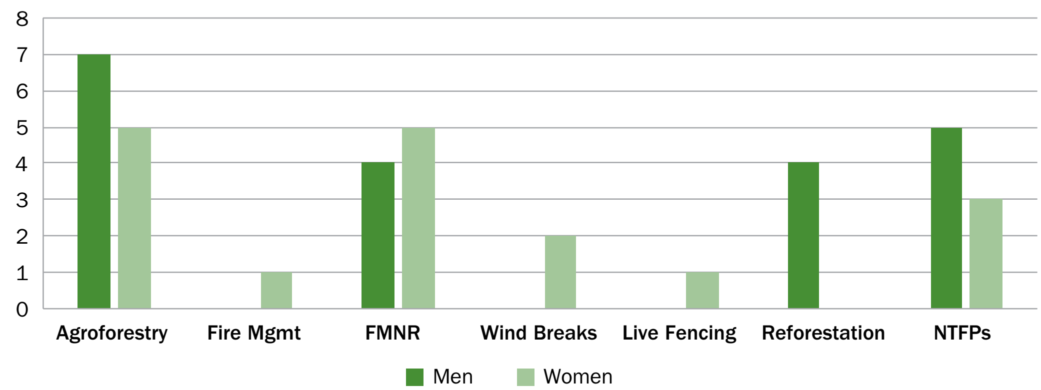
39 In Niger, scaling up FMNR on non-cultivated, degraded land where animals are left roaming would require hiring a guard for 6 months to protect the young trees. The solution to this constraint is a pre-requisite to scaling up FMNR on large degraded areas.

This gendered distinction may be the result of a number of factors, including male ownership and control of key resources in land and trees, as well as more market oriented production of forest resources such as gum and date palm trees.

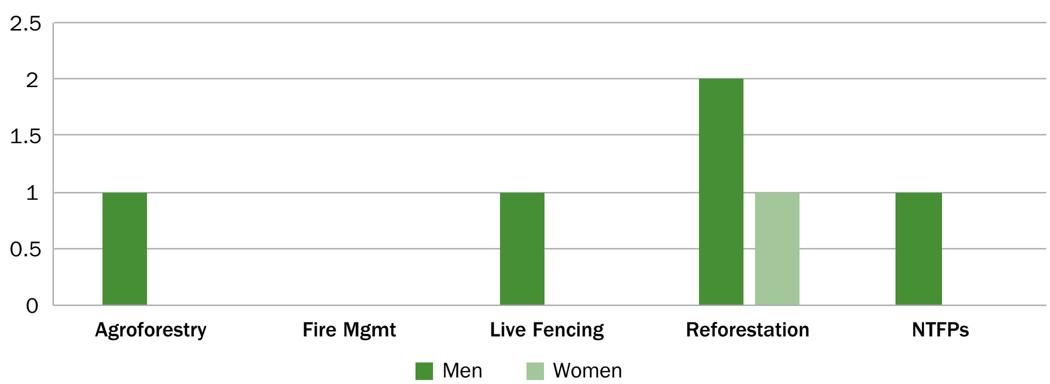
Figure 11: Comparison of Forestry Management Practices by Gender



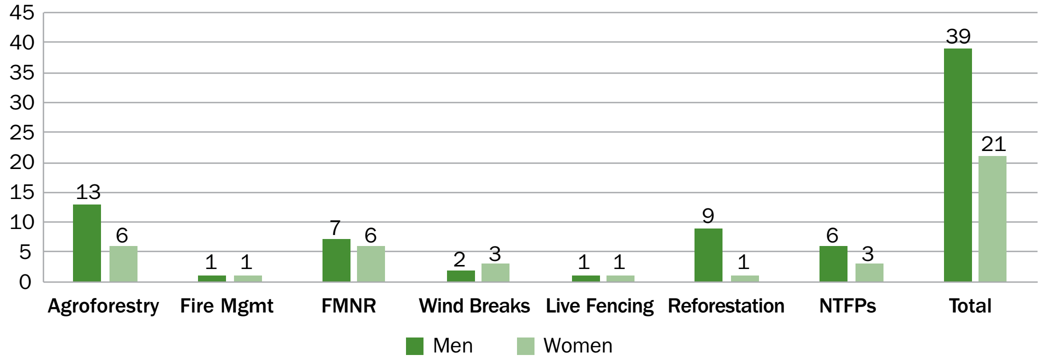
Sahel Region, Burkina Faso



Tillaberi Region, Niger



Gao Region, Mali



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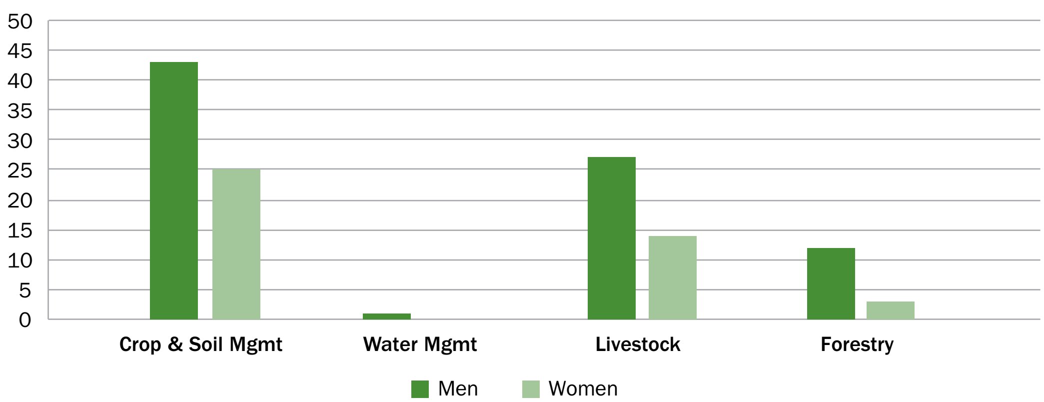
4.4.5 Comparison of Agro-Silvo-Pastoral Management Practices

A total of 345 agro-silvo-pastoral management practices were identified in the study sample, an average of 17.3 practices per village (Figure 12). Crop and soil management practices comprise nearly one-half (48.1 percent) of all practices, followed by livestock (30.4 percent), forestry (17.4 percent), and water management (only 4 percent).

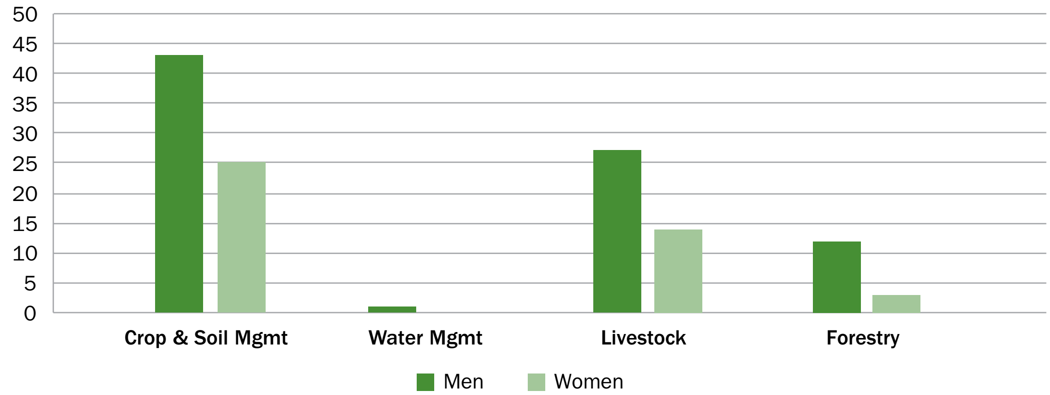
Crop and soil management practices are the principal adaptive dimension of agricultural production systems in Burkina Faso and Niger, while in Mali livestock management plays a primary role.

Overall, men engage in just over 60 percent of all adaptation management practices.

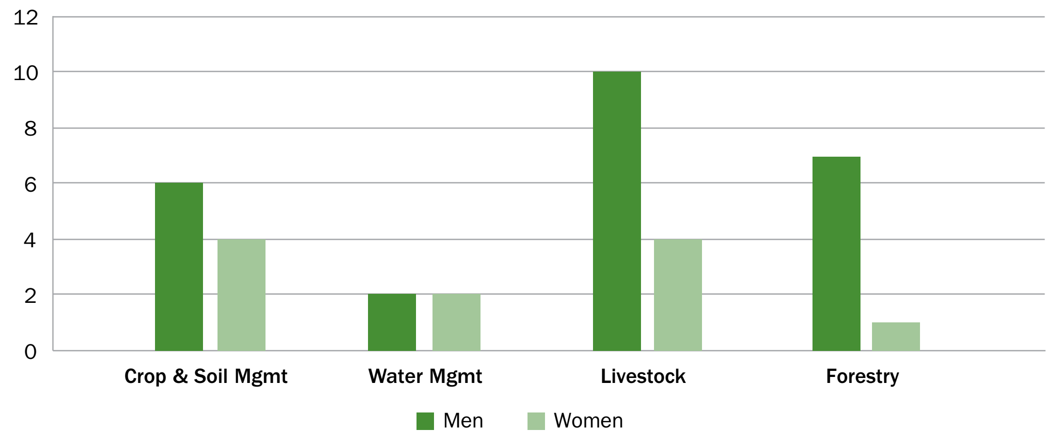
Figure 12: Total Agro-Silvo-Pastoral Adaptation Practices by Gender



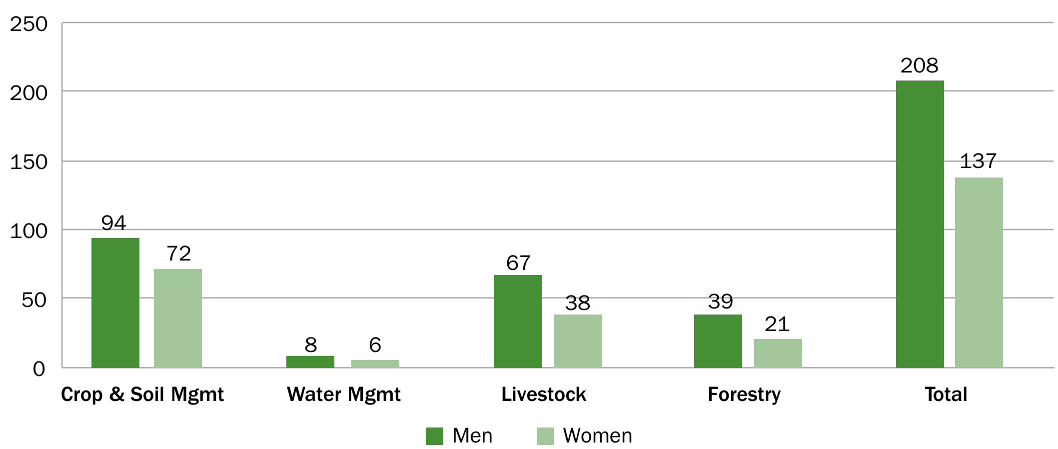
Sahel Region, Burkina Faso



Tillaberi Region, Niger



Gao Region, Mali



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4.5 COMPARISON OF AGRICULTURAL ADAPTATION TECHNIQUES BY PROXIMITY TO MARKET

This section provides a brief analysis of the degree to which proximity to markets shapes strategies of CSA adaptation techniques deployed across the three study sites. Again, a caveat is in order due to the unrepresentative nature of the sample frame in terms of any robust validation of correlations or relationships from a statistical point of view. Observations are preliminary and contextual in nature, requiring a much more rigorous, large sample size. Only crop and soil management practices, and a global comparison of all agricultural production categories (agro-sylvo-pastoral) are examined in this section[40].

4.5.1 Comparison of Crop and Soil Management Practices

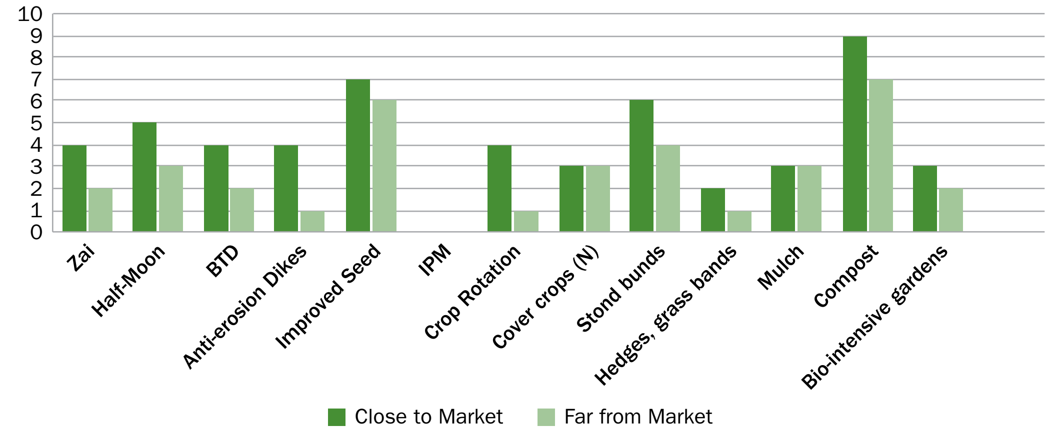
In comparing market proximity to crop and soil management techniques across the three study areas, a total of 89 practices were cited, of which nearly 61 percent (N=54) were in villages within relative proximity (5 kilometers) of a market. Thereby, market location may play some role in shaping diversification strategies deployed to manage crops soils, and water. Further research, on a larger scale, will be needed to verify this preliminary finding. This finding was consistent across all three regions studied. In Burkina Faso, of 40 practices recorded, 65 percent (N= 26) were in villages close to a market. In Niger, where 42 practices were recorded, 55 percent (N=23) were in villages close to a market. And in Mali, where 7 practices were recorded, 71 percent (N=5) were in villages close to a market.

While practices are relatively diverse in Burkina Faso and Niger, only three practices are noted in Mali, all relating to bio-intensive gardening, with the use of improved seed and compost[41].

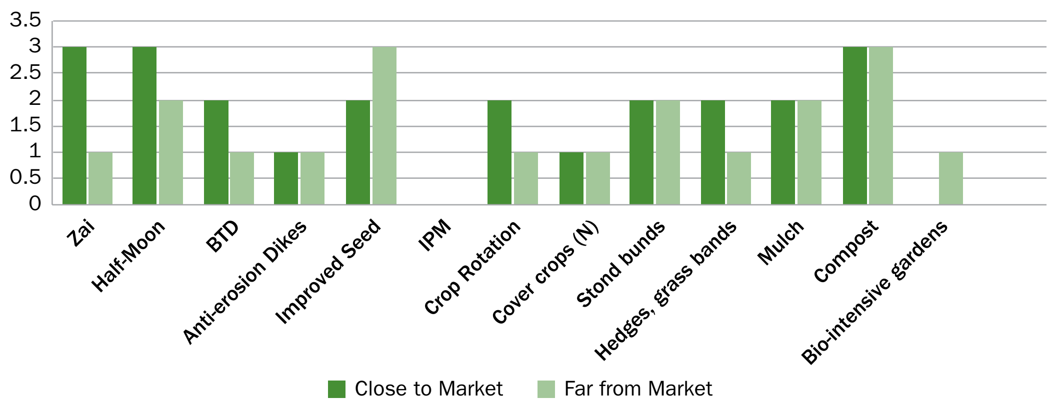
40 Comparisons of market access and water, livestock and forestry management techniques are not presented here due to limitations of time and report size. However, all primary field data for this study are available to CRS for further analysis, should variables such as market access require further examination.

41 Again, this finding is very limited due to the very small sample size (4 villages) and the opportunistic selection of communities deemed to be of lowest security risk for the field time to access.

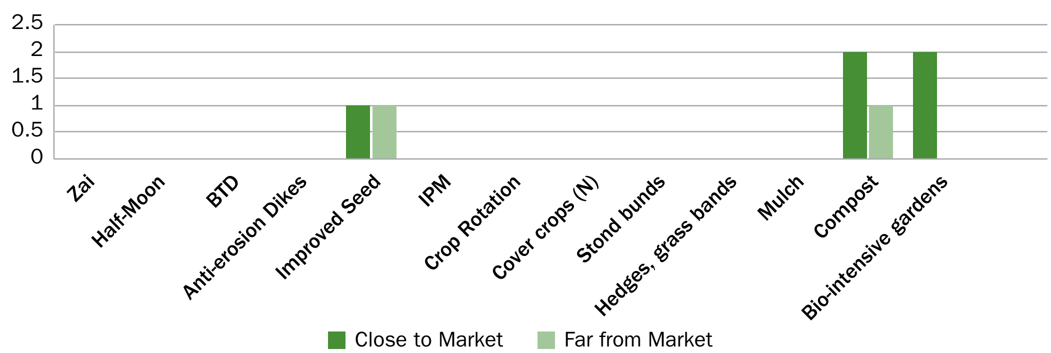
Figure 13: Comparison of Crop and Soil Management Practices by Proximity to Market



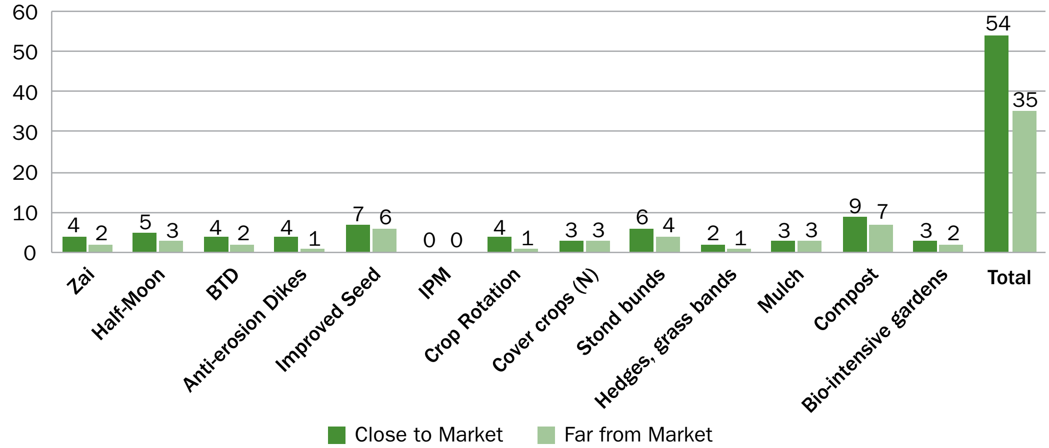
Sahel Region, Burkina Faso



Tillaberi Region, Niger



Gao Region, Mali



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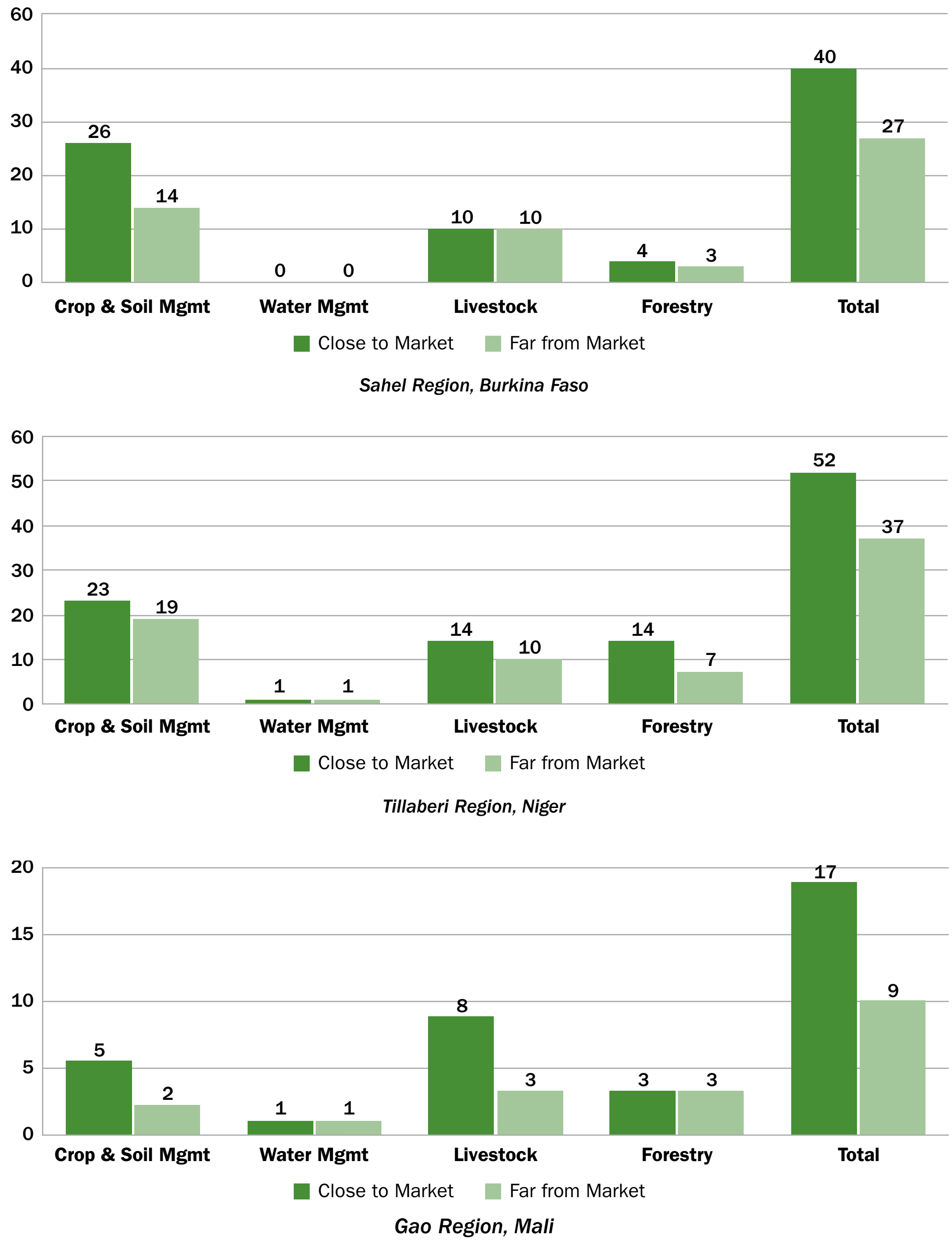
4.5.2 Comparison of Total Agro-Silvo-Pastoral Adaptation Practices by Proximity to Market

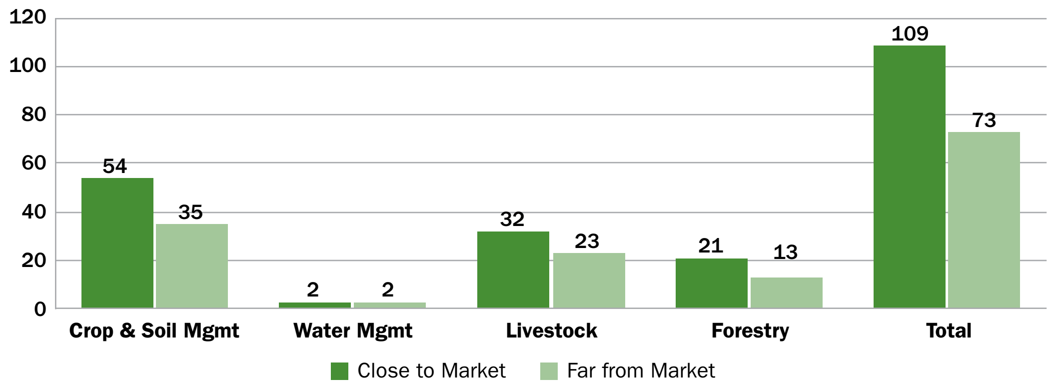
When comparing all agricultural practices (crops, livestock, forestry) across the three study regions, of 182 practices recorded, nearly 60 percent (N=109) were in villages close to a market. This finding is consistent with the observation noted above on crop and soil management practices. In terms of the relative order of all practices, crop and soil management techniques constitute nearly 50 percent (N=89) of all adaptation techniques recorded. Livestock practices are the second most frequently practiced, making up 30 percent (N=55) of all adaptation techniques. Forestry practices comprise nearly 19 percent (N=34) of all practices, while water management practices make up only 2 percent (N=4).

Across all three-country regions, the majority of practices recorded were in close proximity to a market. In Burkina Faso, roughly 60 percent (N=40) of all adaptation practices were in villages close to a market, while in Niger it was 58.4 percent (N=52), and in Mali, 65 percent (N=17).

The data findings suggest that distance to market plays some role in the diversification of livelihood adaptation practices. Confirmation of this hypothesis will require further investigation as CRS refines their program design strategy and conducts a baseline survey under SUR1M.

Figure 14: Comparison of Total Agro-Silvo-Pastoral Adaptation Practices by Proximity to Market





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4.6 COMPARISON OF AGRICULTURAL ADAPTATION TECHNIQUES BY PROXIMITY TO RIVER

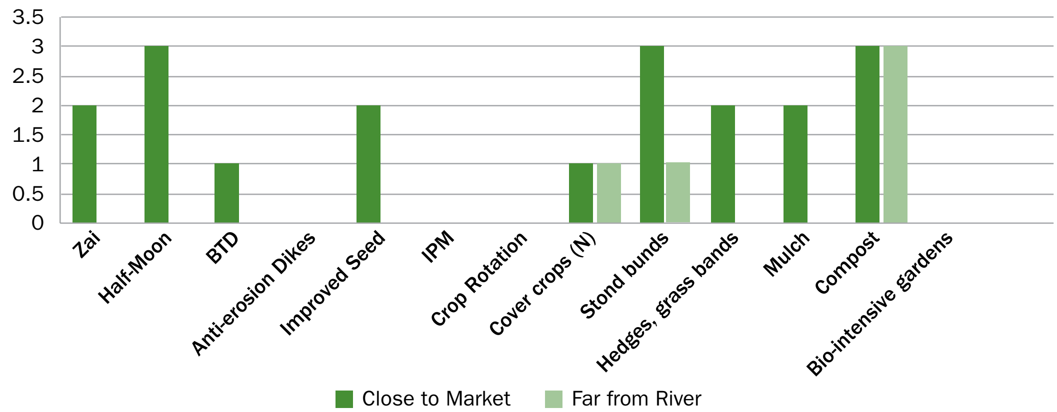
Similar to Section 4.5 above, this section examines distance or proximity to a river, rather than market, as a key variable that may shape agricultural management strategies. A plausible hypothesis would suggest that access to a major watercourse, such as a river or large stream, should correlate to the use of water management techniques and possibly influence agricultural diversification strategies as well. Like the previous section, only crop and soil management practices, and a global comparison of all agricultural production categories (agro-sylvo-pastoral) are explored.

4.6.1 Comparison of Crop and Soil Management Practices by Proximity to River

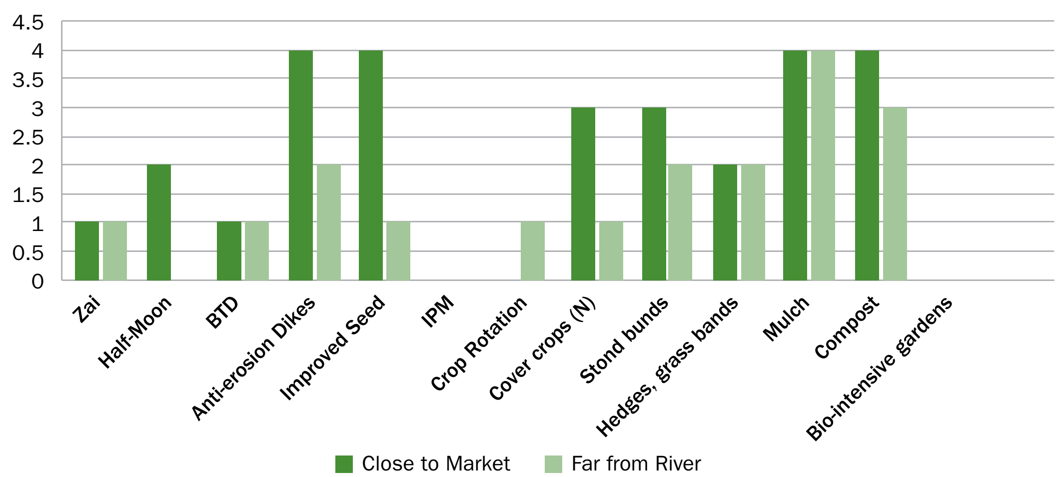
Findings here are consistent with those observed previously in the section above. Proximity to a river appears to influence the diversification of crop and soil management strategies. For the three study regions, of 78 crop and soil practices recorded, nearly 67 percent (N=52) were in villages close to a river. Composting is the most frequent practice, making up 20.5 percent (N=16) of all crop & soil management techniques recorded. Mulch was the second most frequently cited practice, at nearly 13 percent (N=10), while improved seed and stone bunds were nearly 12 percent (N=9) of all practices noted.

Country region figures are consistent, with 79 percent (N=19) of all adaptation practices in Burkina Faso in villages close to a river, while in Niger it was nearly 61 percent(N=28), and in Mali approximately 63 percent (N=5).

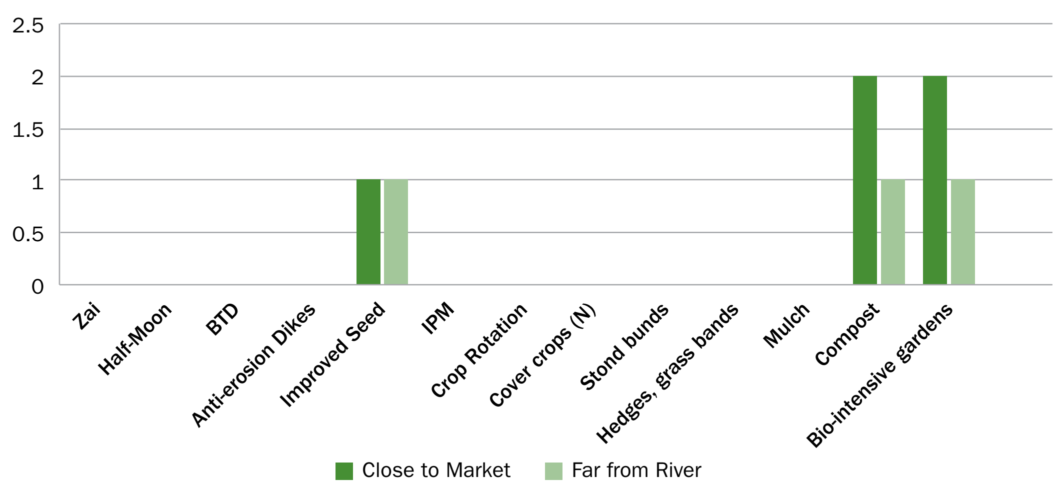
Figure 15: Comparison of Crop and Soil Management Practices by Proximity to River



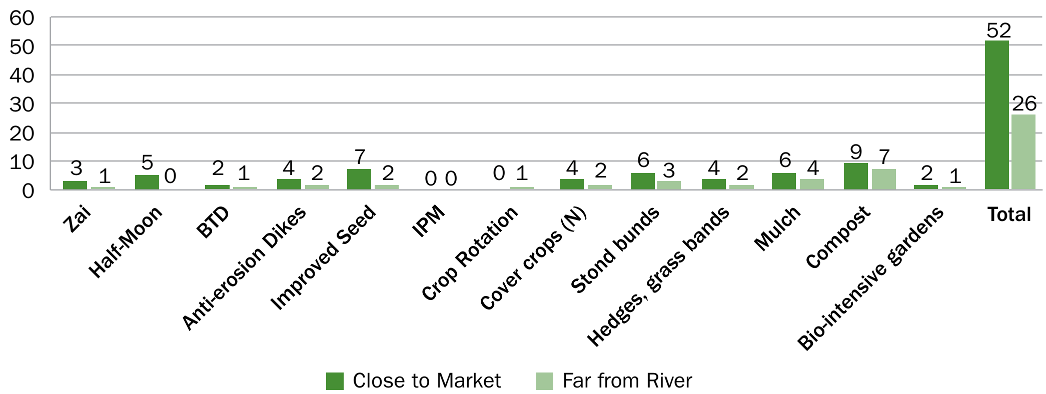
Sahel Region, Burkina Faso



Tillaberi Region, Niger



Gao Region, Mali



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4.6.2 Comparison of Total Agro-Sylvo-Pastoral Adaptation Practices by Proximity to River

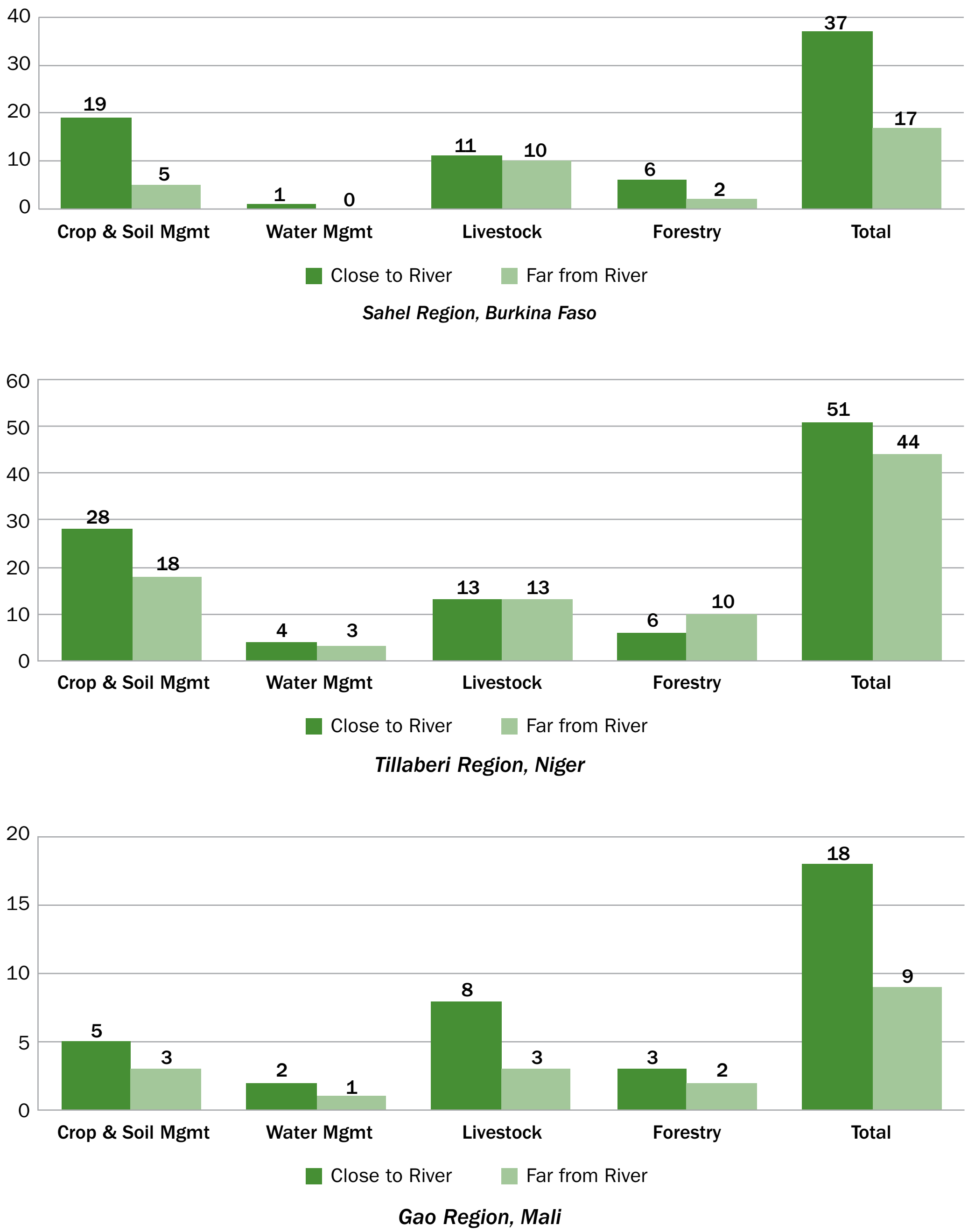
For all agricultural management practices across the three study sites, of 176 practices recorded, nearly 60 percent (N=106) were in villages close to a river. Crop & soil management practices constitute 44 percent (N=78) of all adaptation techniques, while water management practices comprise only 4 percent (N=11). For all three regions, proximity to a river is associated with the diversification of practices. In Burkina Faso, nearly 69 percent (N=37) of all adaptation practices were in villages close to a river. In Niger, it is just over one-half (53.7 percent, N=51), while in Mali it is two-thirds (66.6 percent, N=18).

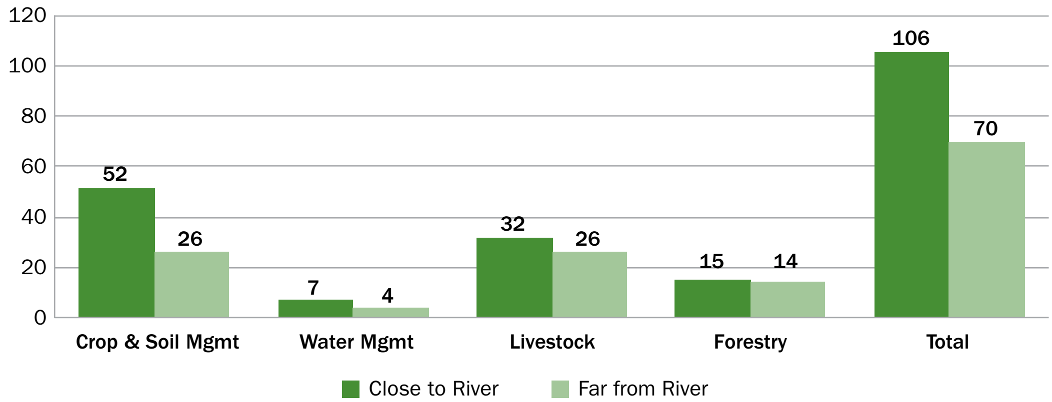
As one would anticipate, the table below suggests that water management techniques are used more frequently in villages that are closer to a river. This is obviously due to water availability and access throughout most, or all of the year. While figures are quite small, it confirms the adoption of water management practices in riparian areas in a very small sample.

Table 5: Water Management Practices by Country Region and Proximity to a River

Country Region	Close to River	Far from River
Sahel, Burkina Faso	1	0
Tillaberi, Niger	4	3
Gao, Mali	2	1
Total	7	4

Figure 16: Comparison of Total Agro-Sylvo-Pastoral Adaptation Practices by Proximity to River





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4.7 ADVANTAGES AND CONSTRAINTS OF CLIMATE CHANGE ADAPTATION TECHNIQUES

Discussions were held on the advantages and constraints of those CSA techniques that were prioritized by order of importance in each village visited. This was followed by a discussion of the costs and benefits associated with each technique. Due to sessions that often ran for two or more hours, it was not possible to facilitate a detailed discussion of each prioritized technique under the four CSA categories (crop and soil, water, livestock, forestry). Responses on advantages and constraints were coded and organized by the five asset or resource categories of the sustainable livelihoods framework – 1) natural (or environmental), 2) physical (infrastructure, including inputs), 3) economic (livelihood activity), 4) human (knowledge, capacity building), and 5) social (institutions, networks).

Responses were recorded and entered in an Excel template by livelihood category for each FGD by gender. The range of most frequently recorded responses are found in a series of matrix tables in Annex 10, organized by country and by agricultural adaptation category (crop and soil, water, livestock, forestry). Discussions on advantages and constraints of the prioritized CSA techniques elicited no significant differences by gender. Therefore, information is not disaggregated by gender in the matrix tables.

Responses were relatively uniform across the three country regions and very general in nature[42]. As anticipated, discussions focused primarily

42 A highly detailed discussion of advantages and constraints of each CSA technique, such as specificity of environmental conditions (eg., soil typology, water conditions) was not possible due to time constraints and the long list of techniques being surveyed, in addition to a rank order/prioritization exercise carried out for each CSA agricultural category.

on economic advantages and constraints. Environmental and physical advantages and constraints also arose, but with less frequency. Human advantages and limitations were much less common, and references to social benefits and disadvantages were not cited[43].

4.7.1 Advantages of CSA Management Techniques

A summary of the most frequently identified advantages of CSA management techniques is presented in this section.

Economic advantages cited were relatively uniform for most all CSA techniques. Common responses for crop and soil management, water, and livestock management techniques included:

- Increases in productivity of crops (yield, plant growth cycles) or animals (weight from fattening and access to forage)
- Increases in discretionary income for schooling of children, purchase of clothing, and for social investments (marriages, naming ceremonies)
- Improved access and availability of food (food security) through improved subsistence production and market sales
- Improved forage production for animals
- Autonomous source of revenue for women (animal fattening)
- Increases in milk production

The most frequently cited responses for forestry management techniques included:

- Forage for animals
- Crop protection from high winds
- Improved crop yields
- Income source for women
- Revenue source from fuelwood sales
- Live fencing as protection against predators (animals)

43 FGD participants did not cite social constraints, such as the lack of local institutions or networks in the community as a major constraint. In order to solicit more information of this nature, a more extended discussion on the nature of social resources/assets would have been necessary, and was not possible due to limitations of time.

Environmental advantages frequently identified when using crop and soil, water and livestock adaptation techniques include:

- Enhanced retention of soil moisture, improved humidity
- Increased soil fertility

Environmental advantages identified for forestry management strategies include:

- Increased shading for animals
- Improved soil fertility
- Sheltering of crops against high winds
- Reduced sand erosion

The physical (infrastructural) advantages of water management techniques include:

- Water source for animals and gardens
- Water availability year round

Few **human advantages** of improvements in labor efficiency, knowledge, or human health were identified in the adoption of CSA techniques. These included:

- Labor saving technology for women (pumps)
- Shading, shelter in fields (forestry management methods)

4.7.2 Constraints of CSA Management Techniques

Similar to advantages, constraints identified in the adoption of CSA management techniques were largely economic in nature. Few environmental, physical, or human constraints were discussed. A summary of the most frequently identified constraints of CSA management techniques are summarized below.

Economic constraints cited most often for crop and soil management, water, and livestock management techniques included:

- Shortage of capital to purchase tools and equipment (donkeys, carts, wheelbarrows, shovels, picks, etc.) and key inputs (manure, compost, seed, fertilizer, pesticides)
- Lack of capital to purchase animal fodder, feed supplements, and veterinary services
- High cost of animal forage in the dry season
- Lack of capital to build fodder storage infrastructure

- Lack of capital for pump technology, fuel, and maintenance

The **physical constraints** of water management techniques include:

- Lack of storage facilities for forage crops

Human constraints included:

- Significant labor intensity, high physical exertion
- Lack of training, technical capacity, knowledge

Key informant interviews on the feasibility of adoption or non-adoption of various CSA techniques elicited highly idiosyncratic observations that are defined by local parameters of geography, the environmental setting, local market conditions, etc. Some of the key observations obtained on the most commonly practiced CSA techniques are summarized here[44].

4.7.2.1 Crop and Soil Management Adaptation Techniques

The use of many of the crop and soil management adaptation techniques described in this report, such as zai, half moons, stone bunds, composting, mulching, etc., generally require rudimentary hand tools such as axes, picks, and shovels, as well as transport equipment such as donkey carts, to haul manure, large rocks, crop residues, etc.

In both KIIs and FGD sessions, several observations were made about resource competition among men and women in terms of their ability to access agricultural tools and equipment. For example, in Zindigori, Niger, women stated that male farmers do not share their tools to carry out composting, digging of zai pot holes, or coppicing of small trees and bushes, as these tasks are carried out simultaneously by both genders in their own fields. Thus, men are in competition with women over the use of physical implements and agricultural resources (tools, equipment), which men own or control, and are often unable to share due to synchronous cropping calendars. In another example in Simiri, Niger, women noted they were unable to access donkey carts to transport compost due to their use by men in their own fields.

A second critical observation on differential access to resources by gender is perhaps the most obvious, that of land tenure status and ownership of land. Women frequently observed that they do not hold

44 This section draws from key informant interviews (KII) held by the Lead Consultant. As noted, while information obtained in one KII may be idiosyncratic and thus difficult to extrapolate or present as a representative finding across all three country regions, it nonetheless provides some context that may assist in better determining which CSA techniques may be most feasible for CRS to consider scaling up under a new SUR1M initiative.

formal or customary title to land, thus they must cultivate small parcels of land given to them by their husbands or other family members. The small plots are generally less productive, as inferior quality, degraded lands are often reserved for women in a community. This, along with other important cultural variables that shape resource access and control, such as caste structure in the three regions, are critical in determining the productivity and sustainable management of natural resources, crops, livestock, forest resources, etc. Thus, a range of socio-cultural variables including gender, caste, ethnicity, religion, and age must all be thoroughly understood and given careful consideration in the effective design of feasible CSA adaptation strategies. Issues of resource constraint by women, particularly access to land, are addressed in the recommendations section of this report.

Zai

Zai, based on local knowledge and practice in the Sahel region (most notably Burkina Faso and Niger), were generally viewed as being highly feasible and effective as an adaptive response to climate change, particularly when combined with other supporting practices (compost, improved seed, stone bunds, fertilizer inputs). With improved seed varieties of millet, sorghum, and cowpeas alone, CLUSA International noted a 30 percent increase in crop yields when using zai. They should be used in areas of gravelly soil and little sand to be most effective in retaining water and soil nutrients. They are commonly practiced on eroded high plateaus, or gently sloping inclines with smooth surfaces ('glacis').

To be effective, zai pot holes should be accompanied by compost that is a mix of decomposed organic matter with animal manure. Figures vary on the recommended quantity to apply, from 2-5 tons per hectare[45]. Due to the high labor and water requirements to dig and maintain a compost pit, one observer felt that only the use of manure is feasible, in which only 1 ton per hectare is needed. This is because higher recommended quantities of manure burn the small plants. Proper manuring in a zai requires adequate rain and two months for manure to decompose properly before use. Another expert on NRM methods observed that zai are feasible technically as they do not require contour leveling which is complex to master, as in the case of stone bunds and anti-erosion dikes (digettes, banquettes).

Zai best benefit from micro dosage applications of NPK, urea, and DAP

45 According to CCAFS, the quantity of manure in zai holes could be reduced from current 300 gr/ha to 157 gr/ha without for the same yields (See article by Albert Barro et al in Cahiers agricultures vol 14 n0 6 nov-dec 2005).

(double ammonium phosphate). However, farmers do not have the cash liquidity to assume the cost of fertilizer inputs, and rarely access to an effective micro credit facility to assume the capital investment required. Ready access to such inputs rarely exists, as few, if any, effective agro-input supply dealers or other service provision systems (government, NGO/CBO, private sector, local community structures) are operational in the study zones.

Stone Bunds

Stone bunds are designed to retain water in farm fields or for erosion control on sloping lands. They are not effective or practical to use on sandy soils, such as those found in some areas of Tera Department in the Tillaberi Region of Niger. Many of the bunds that presently exist throughout the study zones are improperly constructed and highly ineffective, according to one highly experienced NRM specialist. They are generally not built properly to follow contour lines, and very poor construction techniques are used. The use of cash and food for work programs as a strategy to promote improved NRM techniques in the region has been called into question, particularly poor mastery of bund construction by local communities. This finding, while not based on a systematic survey or representative sample, is addressed in the recommendations section of this report, and should be further explored in the design/baseline phases of the SUR1M strategy.

Half-Moons

Half-moons require 'glacis', or smooth, sloping clay soils to capture rainwater runoff from an upward slope. They are used almost exclusively for fodder and tree production, and less so for crops, in the region. They have frequently been introduced as a component of BDL, and entail considerable physical effort and investment in hand tools. One estimate on the labor requirement for half-moons with stone bund perimeters is 40 person days per hectare. Thus, their adoption should take into account labor availability, and the capital required for tools and paid labor (in some instances). They appear to be most effective for fodder and tree production, according to some experts interviewed.

Compost

As noted, composting with organic detritus is not widely practiced in the study sample. Respondents reported using manure only, as organic crop residues are almost universally harvested and stored as livestock forage. Manure is most commonly collected in corral areas in close proximity to family compounds.

To be most effective, manure and organic matter should be deposited in a pit dug in the ground (3 meters wide and 1 meter deep). Those interviewed (KII, FGD sessions) rarely employ the technique, which requires some labor to dig a pit, seal the pit with cement, and apply sufficient water for proper decomposition of the compost. Due to the labor input required and scarce water supply, farmers often build small mounds of manure in their fields that is later spread across the soil, or used in zai pot holes.

As noted, manure must decompose properly in order to maximize crop yields. For those smallholders without sufficient livestock, they often must purchase manure from other neighboring farmers, or barter with area pastoralists, accessing cow manure in exchange for millet.

The only area where composting with organic matter was practiced was in rice cultivation areas along the Niger River, where typha grass (*cynchres bifloris)* is harvested and decomposed to mix with manure.

Mulching

The use of mulch as ground cover to improve soil composition and retain soil moisture is not widely practiced in the study zones due to high demand for organic matter as animal forage. Mulching is most effective when done early in the harvest season ('mulching precoce'), using crop stalks, vines and other field residues. However, sorghum stalks and cowpea vines are also used as fodder, thus competing with their use as mulching in the fields.

Improved Seed

Improved seed varieties, such as finger millet HKP (*Haini Kirei Precoce*) have been introduced in the region by ICRISAT since 1999. FGD participants universally acknowledged improve crop yields using improved short cycle seed varieties that are more heat and drought tolerant. Seed is propagated and distributed through the National Agricultural Research System (NARS) in each country, such as INERA, INRAN, and CNRA. Select communities are given improved seed varieties on loan or at subsidized rates to cultivate and grow the seed stock, which is then paid back to the NARS who market the seed through government and private sector agro-input dealers.

Unless provided with seed directly by a NARS source distributor, access to seed through local, community-based agro-input dealers or other small-scale distributors was not existent in the study sample. Also, smallholders often could only produce enough for their own subsistence consumption. For example, in Simiri, Niger, FGD women respondents noted that improved millet and cowpeas seed varieties given to them were only sufficient for consumption, as they were unable to produce enough surplus of seed to save for reseeding their fields the following year. Thus, a viable supply chain of improved seed for propagation, distribution and purchase through market channels was not evident. Limitations in improved seed production, distribution, access, and marketing are addressed in the recommendation section of the report.

Cover Crops

As noted, the shortage of adequate forage for livestock poses a major challenge in promoting CSA techniques such as mulching and composting. This also applies to the cultivation of leguminous cover crops, such as cowpeas and groundnuts, which are rarely turned back into the soils or left on fields to build soil composition and improvement soil moisture retention capacity.

Crop Rotation

No communities in the study identified crop rotation as a current practice. Respondents note that this practice has largely been abandoned due to population pressure and the scarcity of arable land.

BDL

Bio-recovery of degraded lands is a labor and capital-intensive investment on a larger scale, requiring sufficient surface area for strategies such as fodder production to be effective. Such a strategy has the potential to reduce pressure on crop harvest residues as a fodder source. Various plant and grass varieties used as forage, and tree species, some with high NTFP market value, have been introduced in BDL projects, some with success. Some of these species, integrated as a bundle of CSA techniques, are identified in the recommendation section of the report.

Due to near total ‘mining’ of fields of post-harvest crop residues and green organic matter/ vegetation as a fodder source that is stored to feed animals through the dry season, fields are rapidly denuded and exposed to severe wind and soil erosion during intense monsoon rains. As a result, large grazing reserves are needed to help reduce pressure on smallholder plots, where little mulching or green manuring is practiced due to competition for scarce vegetation as an animal food source. Highland plateaus that serve as watershed sources now look like barren moonscapes, with severe loss of trees and vegetative cover. A new mini ‘re-greening’ of the study zone needs to focus on

BDL strategies that rehabilitate watersheds, slowly restoring these lands as primary reserves for fodder production.

Anti-Erosion Dikes

Anti-erosion dikes are labor and capital intensive, and were rarely identified as a practice in the sample communities. Unless introduced by an external source, such as an NGO or government service project; such practices were not initiated by communities themselves. Thus, the longer-term sustainability of larger scale CSA techniques such as anti-erosion dikes should be called into question.

4.7.2.2 Livestock Management Adaptation Techniques

Fattening

Intensive feeding of cows and sheep is widely practiced in the study sample, and holds practice as a feasible income-earning strategy. However, access to feed supplement is in short supply and a viable microcredit system is required if scale up of the practice is to be effective. Costs of production are particularly high, and some of the opportunities and constraints in promoting the practice are highlighted in the recommendations section.

Fodder Production

Due to shortages of animal fodder, farmers harvest entire plants including stalks and crop residues, and leave little organic material to decompose on the soil, thus denuding the landscape. Proper weeding procedures at harvest is not followed by farmers in the Sahel region, as weeds are entirely removed and stored as dry season animal forage. Thus, little residual weed or plant growth remains on the topsoil, exposing it to wind and water erosion.

One livestock expert noted that an adequate stock of forage must be available well in advance of the dry season in order to have an adequate feed source throughout the year. It was also noted that forage production is most effective when combined with gardening, during which vegetables and short cycle forage crops can be harvested in October.

Bourgou

Bourgou production is limited to low lying wetland or marsh areas, and was only observed in a few of the Niger and Mali sample villages, in close proximity to the Niger River. Thus, widespread adoption is limited, based on agro-ecological conditions and sufficient access to water. It is discussed further in the recommendations section.

4.7.2.3 Forestry Management Adaptation Techniques

The forestry management practices surveyed for this study are closely interrelated, thus distinctions among them are somewhat blurred. A number of tree species with potential market value are integrated within local farming systems through agroforestry, NTFP, FMNR and reforestation practices. Specific tree species are identified and discussed in the recommendation section of the report.

Live Fencing, Wind Breaks

Live fencing and wind breaks are sometimes combined with other practices noted above, and are most effective when introduced in sandy soils and areas of high wind erosion, such as along riverine areas where large rocks or stones are not available to create natural stone barriers or bunds around field perimeters. One NGO in Niger has promoted the use of *andropogon gayamus* as a plant that is effective in stabilizing sandy soils. Some tree species, such as *acacia albida*, and *acacia nilotica*, can be used for live fencing and wind breaks, while also providing seed pods that are consumed as nutrient-rich forage by sheep and goats.

One limitation noted with live fencing is that they are often used as field boundaries, which may not be well accepted by some farmers, as the demarcation of field borders raises concerns about land tenure.

4.8 COST BENEFIT ANALYSIS OF CLIMATE CHANGE ADAPTATION TECHNIQUES

After recording an inventory of climate change adaptation techniques and a prioritization of those practices by order of importance (in meeting food security needs) and by preference, discussions concentrated on highlighting the advantages and constraints of those prioritized strategies, as well as an estimation of the costs and benefits that each practice entails.

Cost-benefit figures are presented below (Table 6), and are averaged for men and women. Out of 35 techniques inventoried, 18 were listed as priority strategies in the communities. Thus cost-benefit data were not collected on nearly one-half of the techniques (17) in the FGD guide sheets. In the absence of economic information on these techniques, cost-benefit figures, where available, are drawn from various secondary sources, most notably from two key studies in

Burkina Faso and Niger[46]. Details on cost-benefit figures, comparing findings of the FGD field data (in table below) with other secondary sources, may be found in matrix format in Annex 11. Analyses from other sources are very limiting in terms of calculating benefits for each technique, and generally focus on technical descriptions (fiches teqhniques) of each adaptation method. Benefit figures from the field data are based on production yields of crops and fodder, as well as animal sales in the livestock management category.

Many techniques do not easily translate into an obvious or direct yield output for crops, animals, trees, or other agriculture-based products. Thus, attempts were made to provide a market-based estimate of benefit where possible, given limitations of the FGD methodology. This, along with the small sample size, must be taken into account in the summary observations below. Thus, information below should be used with some caution, the cursory, qualitative nature of FGD field methodology used to calibrate the data findings[47].

Composting

The most frequently cited and prioritized crop and soil management technique, composting, provides relatively high economic gains, relative to costs. The application of animal manure on farm fields is a ubiquitous practice among the villages surveyed across all three regions, on both men's and women's field crops. However, as noted in the section above, composting in this study largely entails only the use of animal manure, with organic matter in the form of crop residues (stalks, vines, leaves, etc.) notably absent. Thus crop yields and economic benefits could be boosted with the proper adoption and application of effective composting methods. With the use of animal manure alone, men stated a net gain of over ten-fold, investing approximately 60,000 CFA/hectare, with an estimated net gain for millet and cowpea fodder of greater than 700,000 CFA. For women, gains were roughly four times the cost, investing just over 50,000 CFA, and netting benefits of circa 200,000 CFA. Labor, running 40,000 CFA – 50,000 CFA/hectare (at 20 person days), is the principal capital

46 These include a 2009 provisional report by IUCN (*Capitalisation des informations sur les pratiques d'adaptation aux changements climatiques au Burkina Faso*), and a study by the Ministry of Agricultural Development in Niger (*Programme d-actions communautaires – Recueil des fiches techniques en gestion des ressources naturelles*. no date given).

47 Among the challenges confronted in generating figures in the table, data were obtained from general recall of estimated crop yields by converting local measures (weight, surface area) into standardized metric measures, as well as using estimated annual averages for a community population. This includes crop and livestock data based on the seasonal spread in market sales from harvest to dry season, which represent the high and low range of market sales.

outlay, generally requiring a donkey cart to transport manure to fields for those who are lacking animals and/or equipment to for manure application in their fields.[48]

Table 6: Cost Benefit Analysis of Climate Change Adaptation Techniques

TECHNIQUE	MEN			WOMEN		
Crop & Soil Management	**Cost**	**Labor**	**Net Benefit**	**Cost**	**Labor**	**Net Benefit**
Zai	130,000	60,000	153,250	142,625	35,000	83,000
Half Moon	50,750	35,000	312,500	219,000	35,000	331,000
Stone Bunds	285,125	143,333	557,275	71,208	63,000	391,583
Improved Seed				95,500	92,500	246,250
Compost	61,389	30,000 20 person days	709,819	53,938	40,000	200,958
Mulching	42,500		569,625	28,000		167,500
Cover crops (N)	1,000		174,000			
Hedges, grass bands	63,000	63,000				
Bio-intensive gardens	766,667		385,417	553,333		-595,000
Water Management						
Pump Technology	684,300	218,000	2,615,700	651,333	280,000 20 person days/mo*4	11,682,000
LIVESTOCK MANAGEMENT						
Fattening						
Cow	481,365		-31,365	382,250		59,000
Sheep	107,475		8,489	71,678		853
Goat	22,200		40,300	22,767		31,667
Fodder Storage	75,050	60,000 20 person days	100,575	75,233		137,267
Fodder Production	60,000	60,000 20 person days	127,500	70,000	60,000 20 person days	230,000
Water Basins/Ponds	43,563			331,375		
Bourgou	521,438	140,000 20 person days	756,688			
Dune Stabilization	103,750	100,000 20 person days				
Forestry Management						
Reforestation	725,000		1,275,000	34,000	25,000	26,000
NTFP	30,000		40,000			

48 In sections with no data, estimated figures could not be obtained in the FGD sessions, or data provided were too flawed to use for analysis. Costs were obtained by asking for all expenditures required to undertake a given technique (equipment, tools, cost of animals, paid labor, transport of crops/fiber, inputs in seed, fertilizer, technology) over the past production season. Net benefit was calculated by subtracting totals costs (including labor) from the estimated market value of field crops and fodder sold over the past season.

Stone Bunds
Stone bunds, although requiring the availability of large rocks and sufficient labor to transport and build stone contours on field perimeters, also appear to be effective in boosting crop yields as a relatively positive return on investment. Men nearly doubled their economic gains, with labor, tools, and donkey carts to transport large stones costing approximately 285,000 CFA/hectare, while estimated millet (or sorghum) and cowpea fodder sales netted nearly 560,000 CFA. For women, benefits were more than five times the investment, with costs at roughly 70,000 CFA/hectare and net gains of nearly 400,000 CFA. Labor costs averaged over 140,000 CFA for men, while only 63,000 CFA for women. Further investigation and a larger sample size are needed to verify or refute the figures obtained for this study, and to explain the higher return and lower cost estimate provided by women.

Mulching
Mulching is a relatively low cost NRM practice, improving retention of soil moisture, while adding soil nutrients and reducing erosion and sheet runoff during intense during monsoon rains. While mulch only requires spreading organic matter from post-harvest crop residues on farm fields, the practice has not been widely adopted in the communities surveyed. This is due primarily to competition of crop residues and organic matter, which are collected and stored as animal forage, rather than being left on the ground or tilled back into the soils. For men, the relatively low cost of applying mulch to fields (42,000 CFA/hectare) provided significant net gains (570,000 CFA) in millet or sorghum crops and forage. For women, benefits were approximately six times the required investment (28,000 CFA/hectare), accounting for market sales of nearly 170,000 CFA.

Bio-intensive Gardens
Intensive small garden plots, most often located on the banks of the Niger River (in the case of the Mali study area), or in close proximity to a small water channel, have the potential to generate significant household revenue. However, capital outlays for pump systems, fencing, pipe, and wells (further from the river) are considerable. When amortized, production costs ranged from approximately 550,000 CFA for women, to nearly 770,000 CFA for men[49]. Net gains for men averaged 385,000 CFA, whereas for women significant net losses

49 More expensive farm equipment such as pump technology, animal carts, plows, and wheelbarrows were amortized over 5 years, while small hand tools including picks, axes, hammers, and hoes were amortized over 2 years.

averaging nearly 600,000 CFA/hectare were recorded. The most profitable garden crops grown were onions and potatoes. Costs of production for women generally entailed more and higher costs for pumps and other field equipment, while men may have more ready access to garden technologies. Women consistently reported significantly lower estimated yields than men for onions, potatoes and other garden crops, which may also explain the high net loss figure.

Pump Technology

Pump technology, used primarily for rice cultivation in the small number of communities where it was identified, provided significantly greater economic benefits than any other technology, with men averaging 2.6 million CFA/hectare while women's earnings averaged nearly 11.7 million CFA. Costs ranged from about 650,000 CFA for women, to nearly 685,000 CFA for men. This included paid labor of 218,000 CFA for men, and 280,000 CFA for women. Women paid 160,000 CFA for 20 person days of labor per month (4 month growing season) to cultivate potatoes. Labor costs to run and maintain pumps during the garden season are also significant. The cost of a mechanized pump (generally diesel) averaged 500,000 CFA. However, a wide range in the cost of pump technology, from 350,000 CFA to 2,500,000 CFA was recorded.

In comparing net profit in general by gender, men consistently had higher net gains than women for all technologies, with the exception of half-moons.

Livestock

Goat production proves to be a relatively profitable animal fattening activity, requiring low capital investment and relatively high net gains when compared to cows and sheep. Unfortunately, market demand for goats is low in comparison with other livestock. Costs for goat fattening were similar for men and women, averaging about 22,000 CFA per head, while netting 30,000 CFA to 40,000 CFA in profit. Cattle and sheep require significantly higher inputs for animal forage and feed supplements, as well as veterinary costs for vaccinations and prevention of illnesses and disease. Thus, sheep fattening averaged 107,000 CFA for men and 71,600 CFA for women, while earning much less per head, only 8,4000 CFA for men, and a meager 853 CFA for women. Cattle fattening is the most expensive, at a cost of 481,000 CFA for men, and 382,000 CFA for women. Men had losses of -31,000 while women managed much better, at 59,000 CFA per head.

Fodder Production and Storage
Production of forage for livestock, particularly cowpeas, provide relatively high net gains, as capital costs to plant a forage crop and store crop residues are low. Proper technical storage of fodder is markedly absent, as smallholders resort to the most rudimentary measures and technology for storing crops in trees, on thatch roofs of huts and shelters, and only occasionally in an enclosed pen or fenced off area, to protect from animals. Per acreage production of a cowpea variety for livestock was 60,000 CFA for men, and 70,000 CFA for women. Net gains were over fourfold (127,500 CFA) for men, and more than threefold (230,000 CFA) for women. Labor averaged 60,000 CFA for 20 per days per hectare. Storage costs were the same for both men and women, at 75,000 CFA and the net value of the stored fodder was just over 100,000 CFA for men, and 137,000 CFA for women.

Bourgou Production
Bourgou production holds promising potential as a cost-effective food source for livestock, selling for as high as 700 CFA/kg in the dry season in Mali. It is grown in low-lying marsh areas, and competes with growing demographic pressure for expansion of agricultural land. It was only practiced in the Niger and Mali study zones, and only practiced by men. Costs averaged 521,000 CFA/hectare and produced 756,000 CFA in net sales. Labor cost was 140,000 CFA, or 20 person days per hectare.

Reforestation
Reforestation was the most frequently cited forestry practice, and was most prevalent among men. A number of tree species are planted or protected through natural regeneration (FMNR), serving multiple functions. Several species were noted for their use in building shelter or for fencing, as fuel sources for cooking, as sources of nutrient-rich fodder for animals (leaves, pods, seeds), and most importantly, as sources of fruit and medicine. The most commonly cited species include Faidherbia albida, acacia Senegal (gum Arabic, very limited to Yagha Province), zizyphus, balanites, palmier doum, eucalyptus, nime, and acacia nilotica.. Costs ranged widely, with men incurring significantly higher costs (725,000 CFA) than women (34,000 CFA), and netting considerably higher economic benefits (1,275,000 CFA vs 26,000 CFA).

The reintroduction and modification of traditional land restoration techniques such as zaï and half-moons has been a successful strategy for transforming agricultural livelihoods in the Sahel region. 26 April 2012
AMIDOU TRAORE, CRS

5. RECOMMENDATIONS

This section proposes strategies for SUR1M program design, based on the findings of this study. A range of factors – geographical, cultural, environmental, economic, etc., – will need to be taken into account in identifying appropriate interventions. The mix of CCAT practices should be site-specific, based on soil typology (sand, laterite, clay vertisol, etc), elevation (plateau, bottom lands, riparian/riverine river banks and slopes, etc), water access, and other agro-ecological factors. Overall, project activities can be proposed as general CCAT typologies or categories, some of them entailing a bundle of methods, similar to what is being promoted by INERA, INRAN, CLUSA, GIZ, AGED, A2N, and other key stakeholders interviewed for this study.

Below is list of low and high capital-intensive investments. Both are appropriate according to the broader objectives and problems they seek to address. They are organized under two overarching thematic categories addressing resilience –ecosystem and human resilience. These two intervention categories are not mutually exclusive, as activities in each domain are closely interrelated, reinforcing one another.

5.1 ECOSYSTEM RESILIENCE

Sustainable Landscapes – Highland Plateau Watershed Management

A fundamental, overarching construct of **ecosystem resilience** using a **sustainable landscapes** approach is needed to address the underlying causality that drives much of the environmental decline and land degradation in the study zone and throughout the Sahel region in general. Such an approach is needed to remedy the symptomology of low crop productivity, impoverished soils, severe erosion, and an overall secular decline in the natural resource base that has been occurring slowly over time. This will require a large scale, capital-intensive investment strategy of the part of the CRS-led consortium, as well as other key stakeholders carrying out actionable development interventions in the region. To be truly effective, this will require a long term vision, and well-coordinated multi-year investment strategy (beyond three years) involving an array of donor institutions, supporting a well-defined consortium of government, private sector and civil society stakeholders.

Scale up and far reaching impact can best be achieved by creating synergies and well-defined roles, drawing on complementary capabilities among development actors with a common vision for the region. Resources will need to be leveraged from other consortium partners with concordant program objectives and a cohesive, unified mission. Thus, INRAN, INERA, GIZ, government ministries, and NGOs (egs, A2N, AGED, CLUSA International) can all potentially play a critical role in achieving the overall goals of a well-articulated development strategy under the leadership of CRS and the SUR1M program umbrella. A key challenge will be to carve out a vital role for small-scale private sector actors in the form of rural-based micro-enterprises supplying efficient delivery of agricultural products and services, such as input packages of improved seed, fertilizer, and low-cost technologies (eg., family garden drip irrigation kits), as well as community-based agronomic training and innovative micro-credit instruments. This includes a key role for formal and informal community structures, such as local CBOs and village associations, farming and herding groups, and existing or new men's and women's producer collectives.

Many institutions in the region are engaged in watershed management strategies, which are critical and need to be addressed if the underlying causes of agricultural stagnation and environmental decline are to be addressed. Thus, partnering and building on the work of others in this area, a large-scale sustainable landscapes approach emphasizing ecosystem resilience should be a guiding principal and cornerstone of SUR1M. This serves as a twin pillar of the program, complementing and operating mutually to ultimately reinforce a second core objective – strengthening **human and livelihood resilience** through effective CSA adaptation interventions.

The deteriorating status of the natural resource base is fundamentally a problem occurring on a large watershed scale. Thus, the watershed source and catchment zones in the study region should be a high order priority for effective management and restoration. Most all problems of agricultural productivity and environmental decline are the result directly or indirectly, of poor watershed management at the catchment source on the peaks of the high plateau areas. These areas of higher elevation are highly denuded landscapes, with major vegetative and tree cover loss, and the source of severe sheet runoff into severely eroded gullies which ultimately carry silt and sand downstream into low lying rivers, streams, and farmer fields. On numerous occasions, FGD participants and key informants spoke of problems of siltation of watercourses and low lying farmlands, exacerbating the poor growth of cereal and forage crops.

Recommended CSA Interventions for Highland Plateau Areas

BDL – Bio-recovery of Degraded Lands

Highland plateau watersheds in the study zone should be targeted for urgently needed large-scale re-greening and anti-erosion initiatives. A BDL strategy, should target tree planting and the reconstitution of vegetation in the form of forage crops and grasses, to allow for reduced pressure on lower lying croplands as a source of animal fodder. An array of crop and soil management methods, most importantly stone bunds and larger scale anti-erosion dikes should be built, properly following natural contour lines. In this regard, food for work (FFW) and cash for work (CFW) programs have not been effective in properly training communities to construct stone bunds, dikes and other erosion control structures[50]. Thus, one option to consider may be a **pay for**

50 This observation draws on the opinions of one NRM expert interviewed with years of experience working in the Sahel, and should therefore be followed up with further investigation and evaluation of CFW and FFW programs and their efficacy in properly training individuals to build anti-erosion structures such as those noted here.

performance model that has been piloted with some success in similar arid settings[51]. Such an approach may be needed if lasting effects in sustainable NRM practice and maintenance are to be achieved.

BDL should be introduced as a longer term, capital-intensive CSA strategy. To be effective, it should be undertaken with other partners who have extensive watershed management experience in the region. Due to the level of economic investment required and the large spatial scale of intervention that is needed over a sustained period of time (ideally a minimum of 6-10 years), financial resources will need to be leveraged among several partners in order to achieve scale up and long lasting impact on a regional landscape level. In addressing the root causes of natural resource degradation, underlying and multivariate drivers such as population pressure should be well understood, and supplemental programming funds sought to build synergies with the environmental and livelihood objectives of SUR1M.

A BDL strategy should involve a number of bundled CSA practices that have been evaluated in this study. High priority interventions include:

1. Fodder Production

Large-scale introduction of fodder production on degraded highland plateau watersheds is needed to reduce the chronic shortage of high quality, nutrient-rich forage for livestock, and to alleviate pressure on rain fed croplands where harvesting of crop and plant residues for animal fodder is intense..

A number of plant/tall grass forage varieties have been identified in KII discussions with NRM and livestock experts, some of which have high market value, such as 'secko' (*cenchrus*), which is used as matting and in high demand in large urban centers such as Niamey. Another tall grass, *cympopogon,* is highly valued and being promoted in banquettes by INRAN. Other promising varieties include *andropogon gayanus, leptadenia hastate,* and *panicum maximum,* which is being piloted by INERA in the Sahel Region (Tougouri, Namatenga, and Oursi

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51 Pay for performance here refers to '….payments for ecosystem services (PES), also known as payments for environmental services (or benefits), [which] are incentives offered to farmers or landowners in exchange for managing their land to provide some sort of ecological service. http://en.wikipedia.org/wiki/Payment_for_ecosystem_services

This approach is currently being piloted in the environment/ NRM sector in various international development programs and has been proposed as a way to incentivize the use of improved NRM methods in a sustainable manner, in which communities master the proper methods of CSA that are identified in this study. For more information on PES, see: http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/ENVIRONMENT/EXTEEI/0,,contentMDK:20487926~menuPK:1187844~pagePK:210058~piPK:210062~theSitePK:408050,00.html.

in Oudalan Province, and Batibougo in Yagha Province)[52]. Further research into the most cost-effective, and well adapted plant and tall grass forage varieties should be undertaken in consultation with plant science and range management experts.

2. Tree-Stone Bund-Grass Hedge Bundle

A package of combined CSA practices, including tree planting (using FMNR where possible), the extensive use of stone bunds, and live fencing/grass hedges as anti-erosion measures should be introduced, adhering closely to the technical specifications of proper contour lines. This should include the introduction of well-adapted local tree and grass hedge plant varieties that can also serve as forage sources for livestock. Forage residues could also be used as mulch to help improve soil quality and provide vegetative cover to reduce severe sheet erosion that is occurring on highland plateaus. The bundling of these methods serves collectively to improve soil moisture retention capacity, restore soil health, and reduce sheet runoff through effective channeling of water through watercourses to reduce severe siltation into rivers and streams.

3. NTFPs

Several tree species, many used to market NTFPs, should be introduced to address severely degraded watershed plateaus. One possible innovative model to consider is the piloting of women's access to land, which has been successfully undertaken by an INGO in Niger, introducing various NTFP tree varieties. Highland plateau areas will require appropriate tree species that are adapted to soil and moisture conditions, as well as temperature, shade, and other biophysical requirements. A number of tree species with high NTFP market value were identified in FGD and KII discussions. These include: *acacia radiana*, *ziziphus mauritiana, balanites aegyptiaca*, *faidherbia albida,* *chamaerops humilis* (palmier doum), *azadirachta indica* (nime), *acacia nilotica* and *acacia senegal* (gum Arabic)[53]. Some of these varieties are used for house construction, while *balanites* is highly valued for making a local, artisanal soap by women.

52 *Panicum* is highly effective in building soil structure and improving soil fertility, and grows best in sandy clay soils. It should be planted after the first several rains so that seedlings will be well established. As with all new forage crops, it requires protection from animals during the first year for full propagation to take place. Yields and market value of this particular variety are very high according to discussions with INERA. Access to seed, effective training, and protection of the plant from grazing animals in the first year must be addressed.

53 Gum Arabic was found only in Yagha Province during the study. Those interviewed note that the tree is associated with problems of land tenure and ownership on communal lands due to its high commercial value.

5.2 LIVELIHOOD RESILIENCE

Agro-Pastoral Production Systems

A second proposed strategy, complementing ecosystem resilience, addresses human or livelihood resilience. CSA practices are recommended that focus on improving human resilience and adaptation to climate change primarily through improved crop and soil management practices in the agro-pastoral livelihood zones of this study. These practices should be integrated in a synergistic manner with water, livestock, and forestry management techniques that are discussed further below.

5.2.1 Crop and Soil Management Strategies

Essentially all of the 13 CSA techniques inventoried that address building resilience and adaptive capacity of crops and soils to climate variability and change, have various limitations in terms of the five resource or asset categories that have been identified in this report. As noted, several institutions interviewed (INERA, INRAN, CLUSA International, GIZ) are promoting NRM packages involving several CSA techniques that when used together prove the most effective in boosting crop productivity and restoring environmental quality, along with enhanced ecosystem services and functions. Most communities in the FGDs noted major constraints with any given CSA technique. The bundling of NRM practices increases levels of capital investment, labor time allocation, and capacity development needed to assure effective adoption and uptake of sound CSA practices. Thus, recommendations here on bundled NRM techniques recognize that sustainable adoption of multiple practices will not be achieved unless resource constraints are addressed in terms of innovative project design. Proven, effective models of decentralized service delivery and training will need to be piloted for scale up in the project target zone. Thus, more recent developments in agricultural extension and uptake, particularly non-conventional, market-based strategies are briefly noted in the recommendations, and will require further in-depth research and analysis.

Recommended Crop and Soil Management Techniques for Agro-Pastoral Production Systems

1. Zai-Compost-Stone Bund-Improved Seed Bundle

As noted, several CSA techniques, when introduced as an integrated package, prove more effective in boosting crop productivity and improving environmental quality, such as degraded soils. The combination of techniques will vary by agro-ecological and climatic zone, based on soil conditions, water availability, and access to key resources such as rocks for stone bunds. Two of the most widely promoted CSA packages include: 1) zai, with compost and stone bunds; and 2) live fencing, with zai and compost (when stones are not available). These are combined with improved seed varieties of heat and drought tolerant pearl millet, sorghum, and cowpeas. Seed access and distribution should be promoted through new innovative, decentralized, community-based models such as master/lead farmers, APS (Agents Prestataires de Services) Farmer Field Schools, and micro-enterprise based agro-vet dealers, who serve as village-based agronomic extension agents, and suppliers of inputs in small quantities affordable to the farmer (seed, fertilizers, IPM, etc.).

2. Compost

As noted, FGD discussants practice manuring of their fields with little or no organic matter. This was identified as one of the most widely practiced NRM technique in the study, due to easy accessibility, low cost, and ease of application. It should continue to be promoted as part of an NRM package if possible. However, composting with organic matter will remain a challenge due to demands on labor time and the cost of properly constructing and maintaining a composting pit. Proper composting with organic matter may only be successfully practiced in areas in close proximity to a river or large water body (swamps, ponds) due to the ease of growing and harvesting high grasses or reed plants like typha. Nonetheless, use of manure, when applied sparingly, based on recommended applications, has proven highly effective as a low-cost CSA technique that does not require extensive levels of training or capacity building to master properly.

3. Fertilizer Micro Dosage

While not identified as a CSA technique during the study, fertilizer micro dosage in the form of NPK, urea, and DAP (double ammonium phosphate) is being piloted by INERA, and also promoted through AGRA (Alliance for Green Revolution in Africa) with ICRISAT in Niger since 2009, and IDRC since 2011. The impact in boosting crop yields has proven significant. Using a service delivery model noted above, micro dosage could serve as a highly effective supplement to the NRM bundles proposed here.

4. Inventory Credit and Warehouse Receipts (Warrantage)

Again, while not a CSA technique, warrantage has been piloted in Niger with encouraging results. It was designed to address multiple constraints of access to micro-credit, post-harvest crop loss due to pests and poor quality storage, lack of access to improved seed, fertilizer and inputs in small quantities, and the absence of community cereal banks to serve as safety net and buffer to reduce food insecurity during the lean season. Thus the CSA bundles proposed here should be integrated with innovative pilots based on lessons learned and promising practices documented from other programs on state-of-the-art practice in inventory credit and warehouse receipts.

5.2.2 Water Management Techniques

In a region of chronic water scarcity, one of the most salient findings of the study is the very low use of, or access to, water resource technologies across all three-study zones. These include community-based irrigation systems, water harvesting technologies, and pump technology, all of which normally entail a substantial capital investment. Thus it is not surprising that most communities in the study, which are located in very remote areas, have little or no access to large-scale agricultural water management technology.

Recommended Water Management Techniques for Agro-Pastoral Production Systems

1. Drip Irrigation and Manual Pump Technology

Well technology, particularly deep boreholes, would greatly benefit both humans and animals throughout the region. Due to cost limitations, alternative, low-cost manual pump technologies, such as rope and washer pump systems, may prove the most cost-effective, particularly when coupled with low-cost, small-scale family drip irrigation garden systems that can be easily expanded in size over time[54].

54 International Development Enterprises (iDE), a US-based INGO with country programs in Ghana and Burkina Faso, promotes the local manufacture of low-cost, affordable manual pump technologies using a market-based value chain approach to smallholder market development of high value horticultural and agricultural crops. iDE's technologies and smallholder market development approach can be found at www.ideorg.org.

Small-scale drip irrigation technology addresses multiple factor input constraints in land, labor, water, and capital. Intensive small plot drip irrigation produces significantly higher crop yields (crop per drop), requires less surface area than rain fed agriculture, and is highly efficient in the use of water and labor. All of these advantages address the key resource constraints facing impoverished families throughout the study zones. Most importantly, horticultural production of high value vegetables, fruits, and other horticultural crops (eg., spices, medicinal plants) can prove highly lucrative to growers when viable commercial supply chains and effective market facilitation is provided through external development support. Drip has the potential to extend horticultural production well into the dry season, thus maximizing economic benefits to the smallholder through provisioning of local markets with fruits and vegetables at very lean periods of the year.

A potential entry point for the piloting of such technology could be school-based lunch feeding programs in the study zone for primary and secondary school students. An educational curriculum introducing a more varied diet of fruits and vegetables with staple cereal crops could slowly affect dietary changes outside the classroom within villages and rural communities. School-based programs piloting such technology could have a spillover effect for adoption of the technology by local households. Community wells would be needed to introduce family garden drip kits as small as 20 m^2 that could be installed in close proximity to the community center, with small garden plots attached to family compounds. As families master use of drip technology and earn income from garden crops, systems can easily be scaled up to 500 or 1,000 m^2 and beyond.

Drip systems are most effective in dry season garden bottomlands, where groundwater may be accessible at more shallow depths. However, small plot drip irrigation may be introduced to families in the high plateau areas with no access to fertile valley garden plots. They may also be introduced to the most vulnerable households that are landless.

The development of intensive drip technology alone will not suffice to assure that families boost farm income. Garden production must be integrally linked to vibrant market systems with a well-integrated chain of commercially viable products and micro enterprise service providers. Building strong market infrastructure and linking farmers to remunerative markets opportunities requires specific expertise in market research and development and analytical capacity in subsector mapping and value chain analysis. To be most effective, partners with market research capacity should be identified[55].

Affordable, small-scale drip systems that may be customized and expanded as producer need for more capacity grows are rare to come by in the market place.[56]

5.2.3 Livestock Management Techniques

Recommended Livestock Management Techniques for Agro-Pastoral Production Systems

1. Fattening

Intensive feeding of cows, sheep, and goats (on a very limited scale) is one of the most widespread livestock management practices across all three-study sites. It serves as one of the primary activities for generating family income, and fulfills two functions: 1) as an ongoing, long-term revenue generating strategy in meeting daily cash needs through livestock sales, and 2) as a social safety net, providing income through distress sales during periods of acute environmental, economic, or other natural and human-induced shocks that arise over time. While cost-benefit analyses in this report do not demonstrate cattle and sheep fattening as an economically viable enterprise, closer scrutiny of production data is needed, drawing from a much larger study sample. Access and supply constraints in animal feed concentrates (eg. Cotton seeds cakes) need to be addressed, but market demand for such supplement sources appears to be strong. According to one livestock expert, effective fattening programs require an adequate feed stock reserve in advance, as well as ongoing microfinance in order to build livestock assets over time[57]. A number of animal fattening programs have been undertaken

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55 These may include iDE in Burkina Faso, or GIZ in Niger, who has launched a new program, PROMAP (Promotion d'Agriculture Productive), that will promote small-scale irrigation (from 2012-2018). A companion project funded by KfW, PISA (Programme d'Irrigation et Securite Alimentaire, 2014-2018), also supports irrigation agriculture. A 10-year project piloted by CNRST/DPF, Jardin Potage, involves the use of drip technology for date palms and grafted jujubier, a high value tree crop now being promoted by INERA in the Sahel Region of Burkina Faso.

56 The global leader in drip technology, Netafim, has introduced a family garden system (African Market Gardens) that remains relatively unaffordable without subsidy support, and is promoted only within cooperative producer groups. iDE promotes more affordable, albeit inferior quality, drip technology that is oriented toward individual or household-level production. Other drip systems based in Israel and Europe are almost universally cost prohibitive for the poor smallhold farmer in the Sahel. Information on drip technology may be found on the following web sites: www.ipalac.org; www.ideorg.org; www.chapindrip.com.

57 One micro-finance funding stream for sheep fattening by women is FAARF (Fonds d'Appui aux Activites Remuneratrices des Femmes), promoted by the Burkinabe government.

in the West African Sahel for quite some time. Lessons can be drawn from researching promising practices from a number of projects[58].

1. Fodder Production

Due to shortages of animal fodder, farmers harvest entire plants including stalks and crop residues, and leave little organic material to decompose on the soil, thus denuding the landscape. Farmers, in the study regions, do not follow proper weeding at harvest time is generally not followed, as most vegetation and crop residues are removed and stored as dry season animal forage. Thus little residual weed or plant growth remains on the topsoil, exposing it to wind and water erosion. Thus fodder production, if designed and implemented properly, has the potential to significantly improve livestock production, while also meeting environmental objectives of protecting and enhancing soil quality.

Bourgou, as well as other perennial grasses and plants discussed as an important element of BDL above have high commercial value. While agro-ecological conditions needed for growing bourgou were limited in the study sites visited, bourgou has market potential as a revenue source for animal and human consumption (juice, syrup, and 'secko' as thatch for urban housing).

A local variety of sorghum, *olysicapus ovaris*, serve as a good forage crop and should be considered as one local crop variety for potential fodder production.

Dolique (*vigna unguiculata)*, another fodder crop mentioned, should be further researched to understand opportunities and constraints, such as a longer 5-6 month growth cycle[59].

2. Fodder Storage

As noted in the cost-benefit section of this report, fodder storage technology is very rudimentary, involving storage in trees and rooftops,

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58 One such program, evaluated by this consultant, involved a three-year project partnership (2005-2008) between World Neighbors (WN) and Heifer International (HI) in the departments of Koalla, Liptougou, and Manni in the Gnagna region of Burkina Faso. Entitled "From Hunger to Hope (FHtH)," the program assisted 500 families to build sustainable livelihoods through improved methods of livestock and dairy production, and the adoption of regenerative methods of soil restoration intended to significantly boost crop productivity. Innovative use of micro-credit and the sharing of heifers, based on traditional FulBe herd dairy management practices, could be an effective model for improving intensive animal feeding in the SUR1M zones of intervention.

59 One source noted that dolique is not well adapted to the Sahelian climate. Another observer noted an improved cowpea variety, KVX11P, as an ideal source as livestock forage, and should be combined with dolique. Further research on the advantages and constraints of these and other forage crops will need more in-depth investigation in the early design stage of SUR1M.

or small enclosed areas with very poor quality fencing. Fodder is best preserved for nutrient quality when raised off the ground, and not exposed to direct sunlight. The use of simple, low cost 100 kg sacks, on a simple platform built off the ground in a well shaded enclosure would help to improve the nutrient value of fodder for animals. Simple storage technology should be researched and promoted as a low cost intervention that could boost feed quality for animals.

5.2.4 Forestry Management Techniques

Recommended Forestry Management Techniques for Agro-Pastoral Production Systems

1. FMNR

The section above on ecosystem resilience and the practice of BDL on highland plateaus, proposes tree crop varieties, particularly those with NTFP market value, to be promoted. Tree crops with a clear NTFP market value should be promoted throughout the SUR1M project zone, and not exclusively in the highland plateau watershed areas. FMNR requires very little, if any, capital outlays and builds upon already existing local knowledge and practice. Therefore, FMNR would be the most technically and economically feasible strategy to pursue in promoting forestry management and production. More research will be required to understand the gendered dimensions of FMNR and resource tenure concerning access to and ownership of trees. A number of high value products with income generating potential for women, such as soap production from *balanites*, should be given further consideration.

5.2.5 Climate 'Neutral' Livelihoods

A brief observation and recommendation here concerns the nature of agrarian livelihood systems in the study zone and the need to promote more climate 'neutral' livelihood activities that are less dependent on nature, particularly rainfall in an arid/semi-arid desert region. SUR1M should seek to support a shift away from climate-dependent livelihoods toward micro-enterprise activities that rely less on the primary elements of nature. This might include small-scale artisanal activities, such as soap production noted above (although this activity as well relies on adequate rainfall for tree growth), other artifacts or handicrafts that could marketed to the larger urban centers, skilled trades such as sewing, and other micro-enterprise activities where strong demand for a market product can be identified.

ANNEXES

ANNEX 1. LITERATURE REVIEW

Please see attached Annex 1 – BRACED Literature Review for full details.

ANNEX 2. FIELD RESEARCH TEAM AND INTERPRETERS

TEAM	RESEARCH ASSISTANT
CCAT/CSA	HIEN, Gaston NEYA, Tiga
MOI/AVC	KARAMBIRI, Mawa PALE, Remy
Team	Interpreters Burkina Faso
CCAT/CSA	DIALLO, Hamadou
MOI/AVC	DICKO, Hamidou
Team	Interpreters Niger
CCAT/CSA	YAYE, Oumar
MOI/AVC	ADAMOU, Salamatou
Team	Interpreters Mali
CCAT/CSA	TIDIANI, Boubacar
MOI/AVC	AG ALITINY, Sidi Elmoctare

ANNEX 3. TRAINING AGENDA

SUR1M AGENDA FORMATION

Stratégies d'Adaptation aux Changements Climatiques – Agriculture Intelligente face au Climat
Climate Change Adaptation Techniques (CCAT)/Climate Smart Agriculture (CSA)
L'Identification d'Opportunités de Marchés et d'Analyse des Chaines de Valeurs Porteuses

Market Opportunities Identification (MOI)/Agricultural Value Chains (AVC)

Ouagadougou, Burkina Faso
3-8 April 2014
JOUR 1 – CCAT/CSA

JEUDI, 3 AVRIL

Matin

I. Introduction à l'étude

1. Introductions et l'esprit d'équipe
2. Objectifs de SUR1M
3. Programme de terrain
4. Logistique

II. Aperçu de la méthodologie

1. Revue de la littérature secondaire
2. Collecte de données primaires – 3 outils (Enquête du Village (EV), Interview des Informateurs Clés (IIC), Discussion Thématique de Groupe (DTG)
3. Protocole d'analyse des données
4. Facilitation, l'interview, et l'observation
5. Présentation de l'étude aux participants et déclaration d'éthique

JEUDI, 3 AVRIL

Après-midi

III. Introduction à l'outil 1: EV et l'outil 2 : CCAT/CSA IIC (KII)

1. But
2. Sélection de groupe

3. Examen, l'analyse, la révision de l'outil
4. Entrée de données
5. L'analyse des données

JOUR 2 – CCAT/CSA

VENDREDI, 4 AVRIL

Matin

IV. Introduction à l'outil 3: CCAT/CSA DTG (FGD)

1. But
2. Sélection de groupe
3. Examen, l'analyse, la révision de l'outil
4. Entrée de données
5. L'analyse des données

VENDREDI, 4 AVRIL

Après-midi

V. Introduction à l'outil 3: CCAT/CSA DTG (FGD)

1. Continuation a la revision complète de l'outil
2. Discussion
3. Q & A

JOUR 3 – MOI/AVC

SAMEDI, 5 AVRIL

Matin

VI. Introduction à l'outil 4: MOI/AVC FGD

1. But
2. Sélection de groupe
3. Examen, l'analyse, la révision de l'outil
4. Entrée de données
5. L'analyse des données

SAMEDI, 5 AVRIL

Après-midi

VII. Introduction à l'outil 4: MOI/AVC FGD

1. Continuation a la revision complète de l'outil
2. Discussion
3. Q & A

JOUR 4 – MOI/AVC

DIMANCHE, 6 Avril

Matin

VIII. Introduction à l'outil 5 : MOI/AVC KII

1. But
2. Sélection de groupe
3. Examen, l'analyse, la révision de l'outil
4. Entrée de données
5. L'analyse des données

DIMANCHE, 6 Avril

Après-midi

IX. Introduction à l'outil 5 : MOI/AVC KII

1. Continuation a la revision complète de l'outil
2. Discussion
3. Q & A

FERMETURE

DAY 1 – CCAT/CSA

1. Introduction à l'étude

Session I.1: Introductions et l'esprit d'équipe

- Introduction personnelle brève
- Nom d'état, ville natale et de district
- Occupation actuelle et l'expérience en recherche.
- Citer au cours des cinq dernières années comment un événement climatique a affecté votre vie ou la vie de votre communité, et comment vous avez adapté.

Session I.2: Objectives of SUR1M

SUR1M

- Un projet approuvé dans le context de BRACED – l'Initiative Renforcement de la Résilience et Adaptation aux Phénomènes Climatiques Extrêmes et aux Catastrophes – financée par le DFID. SUR1M vise à réduire le risque d'exposition d'un million de personnes à la sécheresse et aux inondations dans 30 communes situées dans le bassin du fleuve Niger.
- Deux Volets **:**

1. **CCAT/CSA** – Analyse de **faisabilité économique et technique** (y compris l'analyse des **coûts et des avantages**) d'adaptation aux changements climatiques en mettant l'accent sur l'agriculture intelligente face au climat pour informer les dirigeants et les populations des communes cibles sur les diverses options techniques les plus appropriées en tenant compte de leurs **zones agro-écologiques**, du **contexte** (notamment l'existence de services de soutien et l'expertise dans les secteurs public et privé, les fournisseurs d'équipements, de tout le matériel requis au niveau local/régional/national ou non), de la **demande et des besoins**, afin de soutenir leur processus de prise de décision concernant les investissements relatifs, la mise en œuvre, ainsi que l'utilisation et la gestion durables. L'analyse permettra de tenir compte des pratiques les plus inclusives et les plus appropriées pour augmenter au maximum la participation des hommes et des femmes.
2. **MOI/AVC** – une étude sur deux etapes :
    - **MOI** – l'identification des opportunités de marché
    - **AVC** – l'analyse des chaînes de valeur pour documenter les éventuelles options de moyens de subsistance diversifiées pour les :
    - **groupes segmentés (très vulnérables, vulnérables mais viables et commercialisables/orientés vers le marché**) ;
    - **des migrants saisonniers** (dont la plupart sont des hommes) ;
    - des **agriculteurs-éleveurs** et des **éleveurs**, en identifiant les compétences professionnelles demandées, non agricoles et les opportunités dans les domaines de l'élevage et des produits forestiers non ligneux, et
    - faciliter leur accès aux marchés rentables en les mettant en relation avec les acteurs des chaînes de valeur de ces produits, notamment les différentes catégories **d'acheteurs, les acteurs de soutien, les fournisseurs d'intrants, etc.**, afin d'accroître leurs revenus.

- Couverture Géographique des Programmes
    - SUR1M intervient actuellement dans 30 communes – au Niger (13 communes) : Dépts d'Ouallam, de Tillabéri et de Tera, région de Tillabéri ; au Burkina Faso : Seno (10 communes), provinces de Yagha et Oudalan, région du Sahel ; au Mali (7 communes) : cercles d'Ansongo et de Gao, région de Gao. Celles-ci ont été identifiées comme étant les plus exposées aux sécheresses et aux inondations. Dans ces communes, 80% de la population totale sont ciblés : Niger : 640.000 ; Burkina Faso : 228.800 ; Mali : 131.200.

Session I.3: Programme de Terrain

- Formation – 3-6 avril
- Pre-test – 7-8 avril
- Recherche au terrain BF – 12-19 avril
- Restitution de l'etude BF – 24 avril
- Recherche au terrain Niger – 26 avril -3 mai
- Restitution de l'etude Niger – 8 mai
- Recherche au terrain Mali – 11-18 mai
- Termination d'etude pour l'equipe – 19 mai

2.	Output	Due Date
1.	Review of existing relevant literature for the categories of target populations *and* the 3 target sites in Niger, Burkina and Mali	17-20 March 2014
2.	Finalize the methodology and tools and the planning per country with the assistants	21-22; 24-29 March
3.	Travel to BF	30-31 March
4.	CRS Planning meeting (skype with team)	1 April
5.	Training: Feasibility of Climate Change Adaptation Techniques	2-3 April
6.	Training Prep	4 April
7.	Training: MOI/VC	5-6 April
8.	Pre-test CSA	7 April
9.	Pre-test MOI/VC	8 April
10.	Tool revisions with teams	9 April
11.	Printing; JM to Ouaga KIIs	10 April
12.	Travel to site	11 April
13.	FG/KIIs Sites 1-8 BF	12-19 April
14.	Travel to Niamey from BF field sites	20 April
15.	Meet with CRS Niger	21 April
16.	Debrief prep CSA	22 April
17.	Debrief prep AVC	23 April
18.	CRS BF Debrief with Core team via skype in Niamey A **draft report** and **a PowerPoint presentation on methodology including a gender and barrier analysis, key findings and recommendations** are sent to PM and SWA RTA Ag. (Provide soft copies), followed by a presentation to the Core Team (*via Skype is if face to face presentation is not feasible)*	24 April
19.	Travel to site Niger/ KII in Niamey	25 April
20.	FG/KIIs Sites 1-8 Niger	April 26- May 3
21.	Travel back to Niamey	May 4
22.	KII in Niamey	May 5
23.	Debrief prep CSA	May 6
24.	Debrief prep AVC	May 7

25. CRS Debrief Niger with Core team via skype in Niamey A **draft report** and **a PowerPoint presentation on methodology including a gender and barrier analysis, key findings and recommendations** are sent to PM and SWA RTA Ag. (Provide soft copies), followed by a presentation to the Core Team (*via Skype is if face to face presentation is not feasible*	May 8
26. Travel to Bamako (JM)	May 9
27. Field Team travel to Mali site	May 10
28. JM meet with CRS	May 10
29. FG/KIIs Sites 1-8 ML	May 11-18
30. KIIs in Bamako (JM)	May 11
31. Debrief CSA	May 12
32. Debrief AVC	May 13
33. CRS debrief Mali with Core team via skype A **draft report** and **a PowerPoint presentation on methodology including a gender and barrier analysis, key findings and recommendations** are sent to PM and SWA RTA Ag. (Provide soft copies), followed by a presentation to the Core Team (*via Skype is if face to face presentation is not feasible*	May 14
34. JM Travel to Dakar	May 15-16
35. RAs Travel to Gao to home (NE, BF, ML)	May 19
36. Draft writing	May 20-30
37. Submit draft to CRS	May 31
38. CRS Review	1-7 June
39. CRS submits comments	8 June
40. Final draft revisions	9-14 June
41. Final draft submitted to CRS	15 June

Session I.4: Logistiques

- CRS – gestion de contrats (logement, per diem, transport, etc.)
- Laptops
- Communication – téléphone
- Autres

2. Aperçu de la méthodologie

II.1 Revue de la littérature secondaire

II.2 Collecte de données primaires

Collecte des données primaires se fondera principalement sur l'observation qualitative impliquant trois instruments de données:

1. **Enquête du Village (EV)** – une enquête structurée initiale de chefs de village (environ 5 par village) identifier les caractéristiques démographiques, économiques et historiques de base de la communauté, ne doit pas dépasser 30 minutes pour chaque communauté visitée par les deux groupes d'étude.

2. **Interview des Informateurs Clés (IIC/KII)** – avec les parties prenantes impliquant des individus (à ne pas dépasser 2-3 personnes)

3. **Discussion Thématique de Groupe (DTG/FGD)** – impliquant des groupes distincts d'hommes et de femmes

   - CCAT/CSA – 16 discussions de groupe par pays, organisées selon le sexe (les discussions de groupe de de 8 femmes, 8 hommes FGD), seront réalisées dans huit communautés dans chaque pays.
   - MOI/AVC – 8 focus group discussions per country, with: 1) agricultural/agro-pastoral producer associations, or groups of agriculturalists; 2) pastoral associations, or groups of pastoralists; and 3) seasonal migrants.

4. **Village Survey Questionnaire** – an initial structured survey of village leaders (approximately 5 per village) identifying basic demographic, economic, and historical features of the community, not to exceed 30 minutes for each community visited by both study teams.

6. Collecte de données primaires – 3 outils (Enquête du Village (EV), Interview des Informateurs Clés (IIC), Discussion Thématique de Groupe (DTG)
7. Protocole d'analyse des données
8. Facilitation, l'interview, et l'observation
9. Présentation de l'étude aux participants et déclaration d'éthique

II.3 Data Analysis Protocol

- Daily data entry and synthesis of observations in FGD and KII data matrix sheets, working together in 2 teams (CCAT/CSA, MOI/AVC)
- Submission of data sheets to the TLC end of each day (email) or flashdrive
- Preparation of preliminary findings with TLC for country debriefings

II.4 Facilitation, Interviewing, and Observation

- Discussion on facilitation methodology, establishing rapport, building trust among respondents
- Tip sheet for FGDs:
  - Sit at the same level and as part of the circle of participants
  - Do not write down peoples' names

    - Agree on how the facilitator and note taker will communicate prior to the session
    - The note taker writes – not the facilitator
    - Never tell someone that their response was not correct or reject their response
    - Foster discussion by helping the participants to understand the context and help them "tell a story" about their experience or the information they want to share
    - Never dominate the discussion
    - Don't keep the participants waiting – arrive prepared and on time
    - Do not forget to ask at the end of session if they have anything else they want to say or if they have questions of the facilitator
- Interviewing – KIIs

Session II.5: Introduction of Study to Participants and Ethics Statement

Study Statement

Greetings. We are here representing two organizations, Catholic Relief Services (CRS) and Tulane University, to undertake a study to learn about your farming and herding practices in the region. This study will help CRS develop future programs for agriculture and livestock management in the country. CRS is an NGO working in the Sahel region. Tulane University is located in the US and is a partner assisting CRS with this study.

This study does not assure or promise any direct funding to the community. However, it will help CRS and its partners plan activities across the country that we hope will be beneficial and improve the quality of life for many communities in this region.

What are the study procedures?

We will be asking you about questions related to climate and/or markets in your community and the types of problems you and people in your community are facing. The research is taking place in your community as well as other communities in Burkina Faso, Mali and Niger.

We want to be sure you know that any information you give is confidential. We will not be asking or sharing any personal information about you, such as your name, with government or other authorities. We wish to respect and protect your personal rights and assure any information we receive is used in a positive way to benefit your lives and others in this region. Therefore, we will not record your names in our notes during this discussion.

If you decide at any time that you do not wish to participate in this study, you are welcome to leave. There are no penalties or consequences of any kind if you decide that you do not want to participate. Also, you do not have to answer any question that you do not want to answer.

This interview and discussion should take around 2 hours of your time. Do you have any questions before we begin? If not, we will now begin the session.

THURSDAY, APRIL 3

Afternoon

III. Introduction to Field Tool 1: CCAT/CSA KII

3.1 Purpose

3.2 Group selection

3.3 Review, Analysis, Revision of Tool

Final data review

Data analysis

ANNEX 4. CSA KEY INFORMANT INTERVIEWS, MEETINGS, AND CONTACTS

DATE	ACTIVITY	CONTACT	LOCATION
Burkina Faso			
Friday 4/11/14	OCADES Meeting	SAWADOGO, Abbe Bertrand COMPAORE, Donald	Dori, Burkina Faso
Saturday 4/12/14	Field Site – Village 1, Bani	CSA Focus Group Discussions	Bani, Seno Province Burkina Faso
Sunday 4/13/14	Field Site – Village 2, Belgou	MOI/AVC Focus Group Discussions	Belgou, Seno Province Burkina Faso
Monday 4/14/14	KII INERA – Director, Research Scientists; KII – Retired extension agent and son of the Imir of Liptako	SANA, Youssoufou DICKO, Amadou DICKO, Hanafi	Dori, Burkina Faso
Tuesday 4/15/14	KII INERA – Research Scientists KII – Ministry of Agriculture	SAMANDOULGOU, Yaya SOHORO, Adama KAGAMBEGA, Ouamtinga NABIE, Bekouanan	Dori, Burkina Faso
Thursday 4/17/14	KII – AGED KII – DPRAH – Sahel	BOKOUM, Assane HAMA, Hassane	Dori, Burkina Faso
Friday 4/18/14	KII – METEO Sahel KII – A2N	TOUGUMA, Emile MAIGA, Amadou Nouhoun	Dori, Burkina Faso
Niger			
4/26/14	Field Site – Village 1, Zindigori	CSA Focus Group Discussions	Zindigori, Tera Department
4/27/14	Field Site – Village 2, Mehana	MOI/AVC Focus Group Discussions	Mehana, Tera Department
4/28/14	KII – Plan International	LAOUALI, Issa OUMAROU, Ali	Tillaberi, Tillaberi Department
4/29/14	KII – Ministry of the Environment KII – Ministry of Agriculture KII – CLUSA International KII – METEO, Tillaberi	SALE, Mahamoudine TOURE, Adamou Ali NANZIR, Abdou Arzika HABI, Bassirou YAHAYA, Adoum AGALI, Alher AMADOU, Mamune KOULOUKOYE, Zakara	Tillaberi, Tillaberi Department
4/30/14	Field Site – Village 5, Simiri	CSA Focus Group Discussions	Simiri, Ouallam Department
5/1/14	KII – CLUSA International	HERRMANN, Cecilia	Niamey, Niger
5/2/14	KII – INRAN	SABIOU, Mahaman GARBA, Maman	Niamey, Niger
5/5/14	KII – GIZ	MAMADOU ADBOU GAOH, Sani SCHINDLER, Solveig	Niamey, Niger
Mali			
5/12/14	KII – National Meteorological Service	TANDIA TRAORE, Fanta	Bamako, Mali
5/14/14	KII – ICRISAT, CCAFS	MOUSSA, Abdoulaye OSIRU, Moses	Bamako, Mali

Individuals Contacted

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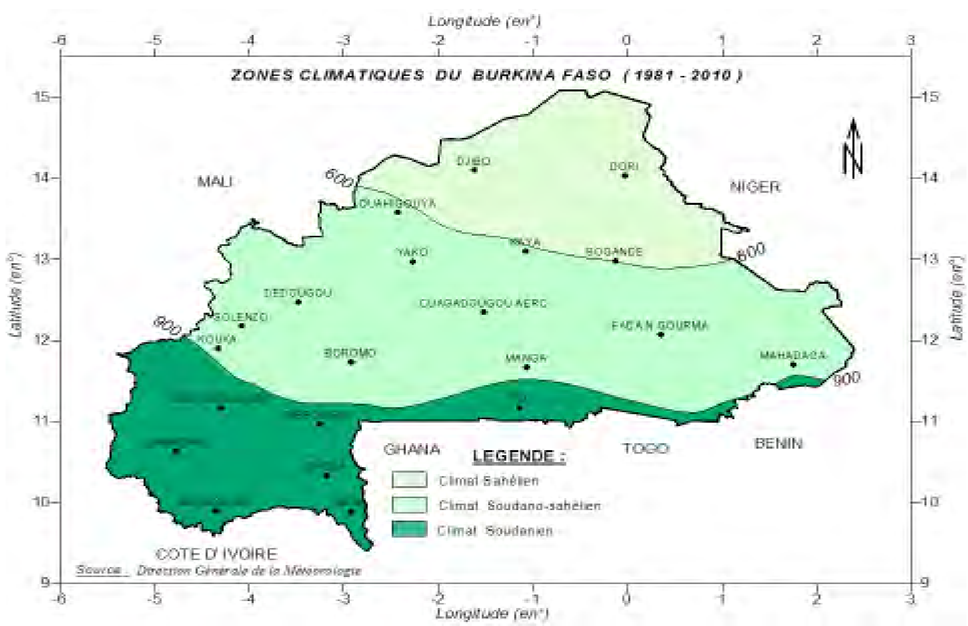
ANNEX 5. VILLAGE LEADER SURVEY – SUMMARY DESCRIPTION

Please see attached Annex 5 – BRACED Village Leader Survey for full description.

ANNEX 6. FGD COMPOSITION BY ETHNICITY AND LIVELIHOOD, BURKINA FASO

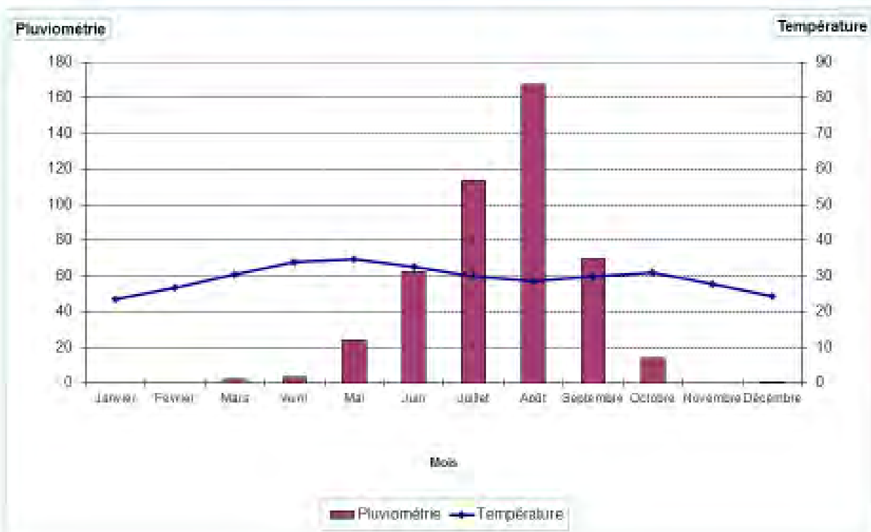
ETHNICITY	BANI	BELGOU	TITABE	PAGALAGA	YATAKOU	BELLARE	GATOUGOU	BALLIATA
	Peuhl	Peuhl	Peuhl	Peuhl	Peuhl	Peuhl	Peuhl	Peuhl
	Mossi	Bella	Bella	Gourmantché	Gourmantché	Bella	Bella	Bella
	Sonrai	Gaobè	Mossi	Bella	Mossi	Gourmantché		Gourmantché
			Gourmantché					
Livelihoods	Agro-pastoral	Agro-pastoral	Agro-pastoral	Agro-pastoral	Agro-pastoral	Agro-pastoral	Agro-pastoral	Agro-pastoral
			Commerce		Gold mining		Commerce	Commerce
							Gold mining	

ANNEX 7. SAHELIAN CLIMATE ZONE, BURKINA FASO



ANNEX 8. AVERAGE MONTHLY DISTRIBUTION OF RAINFALL AND TEMPERATURE, 1981-2010. DORI, BURKINA FASO

Diagramme ombrothermique (1981- 2010) de Dori



Pluviométrie de DORI (mm) moyenne pour la période 1981-2010

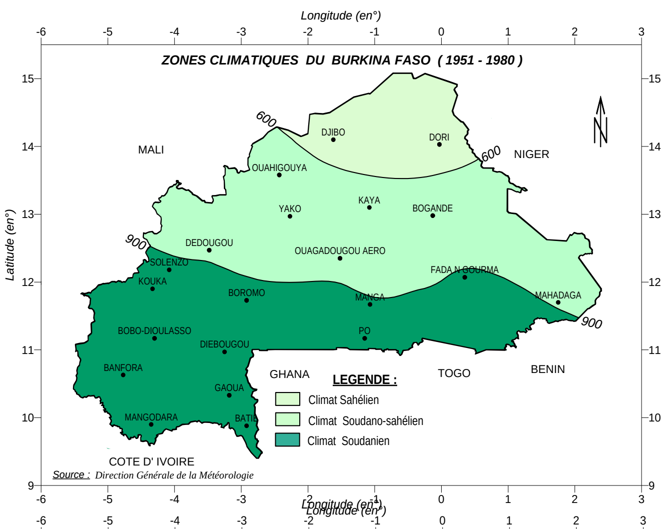
Janvier	Février	Mars	Avril	Mai	Juin	Juillet	Août	Septembre	Octobre	Novembre	Décembre	Total
0	0	2.1	3.2	23.9	62.4	113.6	167.7	70.2	14.1	0	0.1	457.4

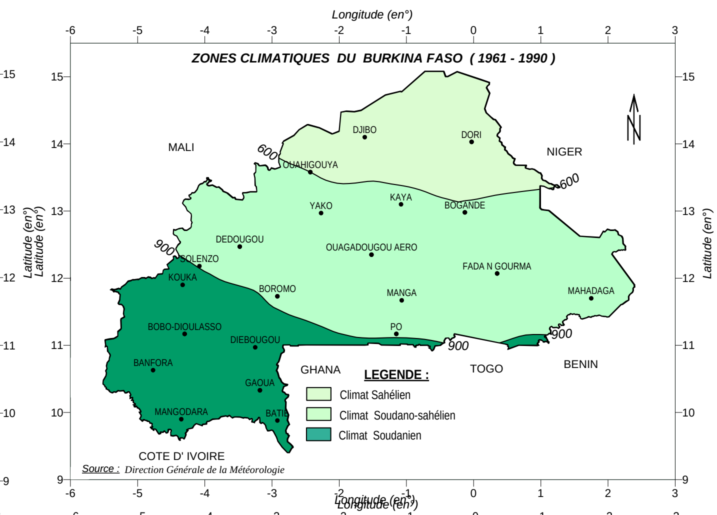
Température de DORI (°C) moyenne pour la période 1981-2010

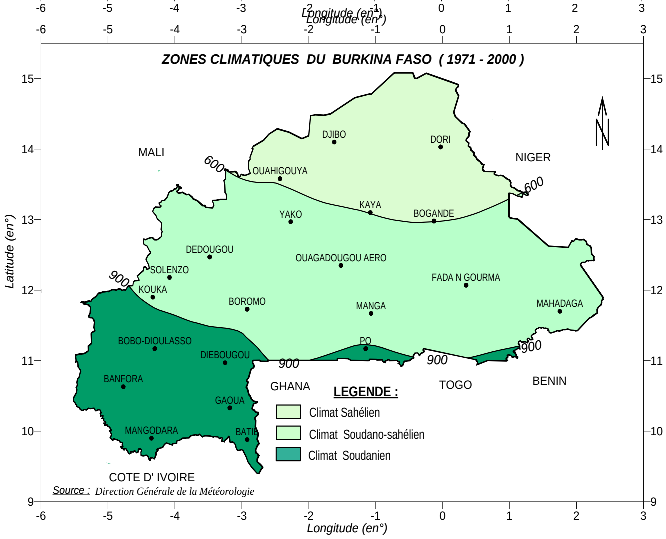
Janvier	Février	Mars	Avril	Mai	Juin	Juillet	Août	Septembre	Octobre	Novembre	Décembre	Moyenne
23.4	26.6	30.5	33.8	34.6	32.6	30.0	28.7	29.9	31.1	27.7	24.3	29.4

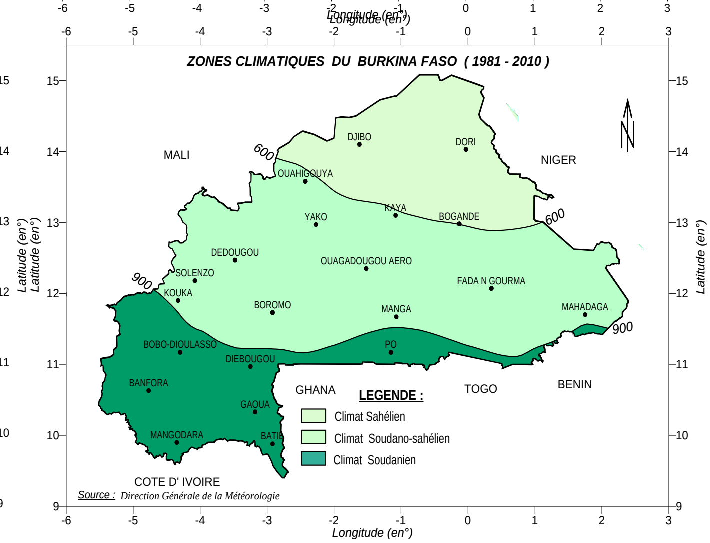
Amplitude Thermique: 11.2 °C

ANNEX 9. DECADAL SHIFT OF CLIMATE ZONES, 1951-2010. BURKINA FASO









ANNEX 10. CSA TECHNIQUES – SUMMARY OF ADVANTAGES AND CONSTRAINTS

1. Burkina Faso – Crop and Soil Management Techniques – Advantages and Constraints

CROP & SOIL MANAGEMENT	ADVANTAGES					CONSTRAINTS				
	Economic	Physical	Environmental	Human	Social	Economic	Physical	Environmental	Human	Social
Zai	Increase in yield		Water retention Adapted to clay soils			Shortage of capital for tools, equipment			Labor intensive	
Half Moon	Increase in yield Increase in revenue					Shortage of capital for equipment (donkey, cart, wheelbarrow) and inputs (manure, compost)			Labor intensive	
Improved Seed	Increase in yield Income for education of children Source of forage for animals		Short cycle crop adapted to climate conditions Rapid seed germination			High cost				
Stone Bunds	Rapid plant growth		Water retention Conservation of soil moisture Favors vegetative regrowth			Shortage of capital for equipment, tools (cart, wheelbarrow, pick)			Lack of training Labor intensive	
Mulch	Increase in yield		Conservation of soil moisture Rapid seed germination Increased soil fertility			Shortage of capital for equipment (donkey and cart)			Labor intensive	
Compost	Increase in yield Rapid crop growth		Better grain quality Conservation of soil moisture			Shortage of capital for equipment (donkey and cart)				
Cover Crops	Increase in yield Crop diversification								Labor intensive Lack of training	
BDL	Increase in yield		Water retention Improves soil permeability Increases soil fertility							

1. Burkina Faso – Livestock Management Techniques – Advantages and Constraints

LIVESTOCK MANAGEMENT	ADVANTAGES					CONSTRAINTS				
	Economic	Physical	Environmental	Human	Social	Economic	Physical	Environmental	Human	Social
Fattening	Rapid increase in weight/productivity Increase in income Autonomous source of revenue for women Contributes to household food security Revenue for marriages, birthing ceremonies					Shortage of capital for animal feed, veterinary care High cost of forage during the dry season				
Fodder Storage	Source of food security for animals during the dry season Reduces cost of forage Improvement in living standard					Shortage of capital for equipment (donkey and cart) Shortage of capital for storage infrastructure				
Water Boreholes	Increase in yield	Water source for animals				High access fees to water livestock				
Water Basins/ Ponds	Increase in herd size Increase in revenue Increase in milk production	Water source for animals Water source for gardening		Savings in labor time						

1. Burkina Faso – Forestry Management Techniques – Advantages and Constraints

FORESTRY MANAGEMENT	ADVANTAGES					CONSTRAINTS				
	Economic	Physical	Environmental	Human	Social	Economic	Physical	Environmental	Human	Social
Reforestation	Forage for animals		Increased shading for animals Improved soil fertility							
Agroforestry	Forage for animals		Improved soil fertility Enhances micro-climate for rains Increased shading for animals Shelters crops against winds	Shading/ shelter during field labor						
Wind Breaks	Crop protection		Impedes sand erosion				Scarcity of plants	Scarcity of water to manage plants		
FMNR	Increase in yield		Reduces erosion			Shortage of capital for tools				

2. Niger – Crop and Soil Management Techniques – Advantages and Constraints

CROP AND SOIL MANAGEMENT	ADVANTAGES					CONSTRAINTS				
	Economic	Physical	Environmental	Human	Social	Economic	Physical	Environmental	Human	Social
Pump Technology	Increase in yield Source of income Opportunity for gardening Supports large-scale irrigation	Water availability year-round		Labor saving technology for women		Shortage of capital for equipment and inputs (pump, fuel) High pump maintenance costs	Lack of storage for potatoes		Lack of training in pump maintenance	
Compost	Increase in yield Rapid crop growth		Conservation of soil moisture Improved soil fertility Better grain quality			Shortage of capital for equipment (donkey, cart, wheelbarrow, shovel), construction of composting pit		Low drought tolerance	Lack of training	
Bio-intensive gardening	Increase in yield Revenue source for women Improvement in food security Income for education and clothing of children					Shortage of capital for equipment, and pesticides		Shortage of water Shortage of fertile land		
Zai	Increase in yield		Conservation of soil moisture Water retention Adapted to clay soils			Shortage of capital for equipment High cost			Labor intensive	
Mulch	Increase in yield		Conservation of soil moisture Water retention Increases soil fertility Rapid germination of plants			Shortage of capital for equipment (donkey, cart)			Labor intensive	
Half Moon	Increase in yield Increase in revenue					Shortage of capital for equipment (donkey, cart, wheelbarrow) and inputs (manure, compost)			Labor intensive	
Improved Seed	Increase in yield Income for education of children Source of forage for animals		Short cycle crop adapted to climate conditions Rapid seed germination			High cost				

2. Niger – Crop and Soil Management Techniques – Advantages and Constraints (cont'd)

CROP AND SOIL MANAGEMENT	ADVANTAGES					CONSTRAINTS				
	Economic	Physical	Environmental	Human	Social	Economic	Physical	Environmental	Human	Social
Stone Bunds	Rapid plant growth		Water retention Conservation of soil moisture Favors vegetative regrowth Improves soil structure			Shortage of capital for equipment, tools (cart, wheelbarrow, pick)			Lack of training Labor intensive	
Hedges/Grass Bands	Protection of gardens against animals Source of revenue		Forage for animals				Lack of availability of andropogone	Nesting of grain-eating birds		
Cover Crops	Increase in yield Crop diversification								Labor intensive Lack of training	
BDL	Increase in yield		Water retention Improves soil permeability Increases soil fertility							

2. Niger – Livestock Management Techniques – Advantages and Constraints

LIVESTOCK MANAGEMENT	ADVANTAGES					CONSTRAINTS				
	Economic	Physical	Environmental	Human	Social	Economic	Physical	Environmental	Human	Social
Fattening	Rapid increase in weight/ productivity Increase in income Autonomous source of revenue for women Contributes to household food security Revenue for marriages, birthing ceremonies		Fuel source for cooking (goat manure)			Shortage of capital for animal feed, veterinary care High cost of forage during the dry season				
Fodder Storage	Reduces cost of forage Improvement in living standard Source of food security for animals during the dry season					Shortage of capital for equipment (donkey and cart) Shortage of capital for storage infrastructure				
Bourgou **Fodder**	Increases livestock production Source of income Human consumption of juice Source of animal forage Used for treating parasites					Shortage of capital for inputs				
Transhumance	Effective herd management strategy Minimizes animal mortality							Absence of water points Rapid drying of water points		
Fodder Production (Niébé)	Increase in yield Source of income Source of animal forage					Shortage of capital for equipment (plow, oxen)		Plant parasites		

2. Niger – Forestry Management Techniques – Advantages and Constraints

FORESTRY MANAGEMENT	ADVANTAGES					CONSTRAINTS				
	Economic	Physical	Environmental	Human	Social	Economic	Physical	Environmental	Human	Social
Reboisement	Income for women Source of revenue from fuelwood sales Forage for animals		Provides shade Improves soil fertility			Shortage of capital for nursery fencing				
Agroforestry	Forage for animals		Protection against wind Improves soil fertility Enhances micro-climate for rains Increased shading for animals	Shading/ shelter during field labor						
Dune Stabilization			Reduces sand encroachment to the village Reduces sand erosion			Shortage of plants	Shortage of water to manage plants			
Wind Breaks	Reduces crop damage due to strong winds							Nesting of grain-eating birds		
NTFPs	Source of income Food source Forage for animals							Overharvesting of *Palmier doume*		
FMNR	Increases crop productivity		Reduces soil erosion			Shortage of capital for materials				
Live Fencing	Protection of gardens against animals							Nesting of grain-eating birds		

3. Mali – Crop and Soil Management Techniques – Advantages and Constraints

CROP & SOIL MANAGEMENT	ADVANTAGES					CONSTRAINTS				
	Economic	Physical	Environmental	Human	Social	Economic	Physical	Environmental	Human	Social
Pump Technology	Increase in yield Source of income Opportunity for gardening	Water availability year round				Shortage of capital for equipment and inputs (pump, fuel)	Lack of storage for potatoes		Hard physical labor required	
Compost	Increase in yield Rapid crop growth		Conservation of soil moisture Improved soil fertility Better grain quality			Shortage of capital for equipment (donkey and cart), construction of composting pit		Low drought tolerance	Lack of training	
Bio-intensive gardening	Increase in yield Revenue source for women Improvement in food security Income for education and clothing of children					Shortage of capital for equipment, and pesticides		Shortage of water Shortage of fertile land		
Improved Seed (Niébé)	Increase in yield Increase In income					Shortage of capital for equipment (cart, wheelbarrow, picks)	Shortage of inputs		Hard physical labor required Lack of training	

3. Mali – Livestock Management Techniques – Advantages and Constraints

LIVESTOCK MANAGEMENT	ADVANTAGES					CONSTRAINTS				
	Economic	Physical	Environmental	Human	Social	Economic	Physical	Environmental	Human	Social
Fattening	Rapid increase in weight/ productivity Source of income Milk production Autonomous source of revenue for women Contributes to household food security Revenue for marriages, birthing ceremonies		Fuel source for cooking (goat manure)			Shortage of capital for animal feed, veterinary care High cost of forage during the dry season				
Fodder Storage	Reduces cost of forage Improvement in living standard Source of food security for animals during the dry season					Shortage of capital for equipment (donkey and cart) Shortage of capital for storage infrastructure				
Bourgou Fodder	Increases livestock production Source of income Human consumption of juice Source of animal forage Used for treating parasites					Shortage of capital for inputs				
Transhumance	Effective herd management strategy Minimizes animal mortality							Absence of water points Rapid drying of water points		

3. Mali – Forestry Management Techniques – Advantages and Constraints

FORESTRY MANAGEMENT	ADVANTAGES					CONSTRAINTS				
	Economic	Physical	Environmental	Human	Social	Economic	Physical	Environmental	Human	Social
Reforestation	Income for women Source of revenue from fuelwood sales					Shortage of capital for nursery fencing				
Wind Breaks	Reduces crop damage due to strong winds							Nesting of grain-eating birds		
NTFPs	Source of income Food source Forage for animals							Overharvesting of *Palmier doume*		
Live Fencing	Protection of gardens against animals							Nesting of grain-eating birds		

ANNEX 11. COST BENEFIT MATRIX OF CLIMATE CHANGE ADAPTATION TECHNIQUES

Please see attached Annex 11 – CSA Feasibility Analysis for full details.

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