PROFILING AND CHARACTERIZATION OF CONSERVATION AGRICULTURE PRACTICES AND ADOPTION IN GUINEA SAVANNAH, SUDAN SAVANNAH AND TRANSITIONAL AGRO-ECOLOGICAL ZONES OF GHANA

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AUTHORITY/DISCLAIMER

This document was prepared for the Ghana Agricultural Sector Investment Programme (GASIP) with funds from the International Fund for Agricultural Development (IFAD), the Government of Ghana (GoG). Technical support was provided by the Food and Agriculture Organization of the United Nations (FAO). The co-leaders of the research team include Eugene Rurangwa, Naaminong Karbo, Benjamin Adjei, Mathias Edetor, Delali Kofi Nutsukpo and Wilhelmina Quaye.

The views expressed and opinions contained in this report are those of the research team and are not intended as statements of policy of either IFAD or the cooperating organizations. As such, the contents do not necessarily reflect the views of Government of Ghana/Ghana Agricultural Sector Investment Programme (GASIP).

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Acronyms

ACDEP	Association of Church Development Projects
ADVANCE	Agricultural Development and Value Chain Enhancement
AGRA	Alliance for Green Revolution in Ghana
AMSEC	Agricultural Mechanization Service Centers
ASNAPP	Agribusiness in Sustainable Natural African Plants Products
AUDA-NEPAD	African Union Development Agency-New Partnership for Africa's Development
BAC	Business Resource Centers
CA	Conservation Agriculture
CAADP	Comprehensive African Agricultural Development Programme
CAPI	Computer Assisted Personal Interviewing
CBOs	Community-Based Organizations
CCAFS	Climate Change Agriculture and Food Security
CGIAR	Consultative Group for International Agricultural Research
CIKOD	Centre for Indigenous Knowledge and Organizational Development
CNTA	Center for No Tillage Agriculture
CSA	Climate Smart Agriculture
CSIR	Council for Scientific and Industrial Research
DFO	Direct Field observation (DFO)
DGM	Dedicated Grant Management
EIA	Environmental Action plan
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
FASDEP	Food and Agriculture Sector Development Policy
FAW	Fall Army Worm
FBO	Farmer Based Organization
GAEPS	Ghana Agricultural Engineering Policy
GASIP	Ghana Agriculture Sector Investment Programme
GDP	Gross Domestic Product
GESSIP	Ghana Extension funded by Hunger Project (GESSIP)
GhAIP	Ghana Agriculture Investment Plan
GIC	Green Innovation Centre
GIZ	Deutsche Gesellschaft fur Internationale Zusammenarbeit
GoG	Government of Ghana
HH	Households
ICT	Information Communication Technology
IDE	International Development and Sustainable Enterprises
IDE	International Development and Sustainable Enterprises
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
IWAD	Integrated Water Management for Agriculture Development
JFFLS	Junior Farm Field and Life School
KNUST	Kwame Nkrumah University of Science and Technology
KOICA	Korea International Cooperation Agency

MAG	Modernizing Agriculture in Ghana
MDA	Ministry Department and Agencies
MMDA	Metropolitan Municipal and District Assemblies
MOAP	Market-Oriented Agriculture Programme
MoFA	Ministry of Food and Agriculture
MoU	Memorandum of Understanding
MSMEs	Micro, Small and Medium Enterprises
NADMO	National Disaster Management Organization
NCCP	National Climate Change Policy
NDCs	Nationally Determined Commitments
NGO	Non-Governmental Organization
PERD	Planting of Export and Rural Development
PESTLI	Political Economic Socio-cultural Technological Legal and Institutional
PFJ	Planting for Food and Jobs
PRA	Participatory Rural Appraisal
R & D	Research and Development
RCC	Regional Coordinating Council
REACH	Resilience Against Climate Change
RELC	Research Extension Linkages Committee
REP	Rural Enterprise Project
RFJ	Rearing for Food and Jobs
SAPIP	Savannah Zone Agricultural Productivity Improvement Project
SARI	Savannah Agriculture Research Institute
SEND	Social Enterprise Development
SDGs	Sustainable Development Goals
SLWMP	Sustainable Land and Water Management project
SR	Small Ruminants
TECAS	Training and Extension for Conservation Agriculture in the Savannahs
TOR	Terms of Reference TOR
TV	Television
VSLA	Village Savings and Loans Associations
WFP	World Food Programme
WIAD	Women in Agricultural Development

DEFINITIONS

TERMS	*DEFINITIONS*
Conservation Agriculture (CA)	The goal and means of achieving CA was defined to include the following elements: **Goal** • Protection of soil structure • Improve nutrient content in the soil • Improve moisture retention in the soil • Improve soil biology (organic matter) • Biodiversity conservation **Means** • Minimum tillage • Mulching • Cover cropping, mixed cropping, rotation, crop-livestock integration • Agro-forestry The classical and working definitions of CA were then proposed as follows: The working definition of CA/CSA adopted in this study is 'resource saving agriculture (crop and livestock) production systems that strive to achieve acceptable profit with high and sustained production levels while concurrently conserving the environment'. In this working definition, CA/CSA practices will include minimum/no till, intercropping, crop rotation, use of manure, permanent soil cover(cover cropping, mulching) and crop-livestock integration. Definition of CA Sustainable improvement of agricultural productivity through practices that promote the improvement and conservation of soil, its structure, nutrient, moisture, biology and biodiversity. This is achieved through practices such as minimum tillage, mulching, crop rotation and crop-livestock integration.
Climate change	Climate change is defined as a change of climatic conditions which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (UNFCCC).
Drought	Agricultural drought was defined to include the lack or insufficiency of precipitation (less than 0.2mm/day) for an extended period that causes considerable hydrological (water) imbalances and consequently water shortages, crop damage, stream flow reduction and depletion of ground water and soil moisture. Drought can last for months or years or may be declared after as few as 15 days.

Dry Spells	Dry spells occur due to inadequate rainfall. Therefore a week of rainfall less than 20mm is considered as a dry week; however during a dry week the crop may meet its water requirement through the moisture available in the soil. Dry spell is shorter than and not as severe as drought. Severity of a dry spell depends on the crop, the time of occurrence during the plant development and the soil type.
Mulching	Mulching is the practice of covering the top soil surface with organic materials like straw, grass as well as inorganic material like plastic to conserve soil moisture, improve fertility and health of the soil and reduce weed growth.

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EXECUTIVE SUMMARY

Background and Study

One of the subcomponents of the Ghana Agricultural Sector Investment Programme (GASIP) is dedicated to mainstreaming climate change resilience and conservation agriculture practices into smallholder agriculture in Ghana. This report profiled Conservation Agriculture (CA) practices in three agro-ecological zones in Ghana and proposed appropriate CA model (s) that could support promotion of adoption of CA by smallholder farmers in the Transitional, Guinea and Sudan Savannah agro-ecological zones of Ghana. The report also proposes institutional arrangements for effective coordination of CA in Ghana. A mixed methodological approach was employed for data and information gathering consisting of literature review, CA related policy review, reconnaissance survey followed with a structured farmer household survey using a questionnaire, and district level rapid participatory CA appraisal sessions involving 780 selected participants with a designed checklist to guide the process. A total of 1560 farmers representing households in the three ecological zones were interviewed in 26 districts by 78 trained enumerators using computer assisted personal interview (CAPI).

Climate change vulnerability of smallholder farmers

Climate hazards including drought, bushfires, floods, unpredictable rainfall, etc. were identified based on the structured farmer household survey. Drought emerged as the most prominent hazard affecting 79.0%, 68.7% and 66.7% of the households in Sudan, Guinea Savannah and Transition Forest-Savannah, respectively. This development was attributed to erratic rainfall pattern and rising temperatures being experienced in these areas in recent times. These findings were in sync with the district level information where the hazards were prioritized in a participatory matrix scoring and ranking. Households in the zones were observed to have quite a number of adaptation strategies. However, food storage, non-farm activities, increased number of livestock emerged as the most frequently employed strategies by the farmers. Crop insurance, water harvesting and soil and water conservation were rarely used by farmers across all the agro-ecological zones. Of the three agro-ecological zones, households in the Sudan Savannah were observed to be more prone to frequently employ strategies involving increasing livestock numbers, crop insurance, food storage, water harvesting, change crop variety and planting dates as well as increase land under cultivation as climate change adaptation strategies. Migration was largely associated with the youth gender group for economic and social change.

Profile of CA practices

Overall, approximately 87 percent of the farmers interviewed were practicing CA. Among the key pillars of CA practices, crop rotation was the most commonly practiced with over 80 percent of the entire sample interviewed engaged in the practice. No/zero tillage and minimum tillage were discovered as age long practices in the Transition zone. Similarly, minimum tillage and tractor tillage were the age long practices in the Guinea Savannah zone, whereas crop-livestock integration and minimum tillage (bullock) were the age long practices in the Sudan Savannah agro-ecological zone of Ghana. CA practices offered smallholder farmers numerous opportunities including (i) reduction in soil erosion and maintenance of soil moisture reported by 61 percent of respondents, (ii) improvement in crop yields overtime as reported by 63 percent, and improvement

in household food security reported by fifty eight percent of the total sample interviewed among others. Although no-till using herbicides is one of the CA technologies found to be popular, farmers identified the challenge of inappropriate use of the chemicals resulting in decreasing biodiversity within farming systems and attendant human health hazards among others.

Proposed CA models and profitability

Five key CA models were identified in the three zones but each of the districts surveyed selected two (2) most suitable CA models with their respective profitability analysis done for scaling up and for investment decisions.

1. Medium /Large Tractor Operated
2. Small Holder Manual Operated
3. Crop-Livestock Integration
4. Integrated Tree-Crop-Livestock
5. Irrigated Cereal-Vegetable-Livestock

All the chosen models are economically and financially viable with the highest net profit (Gh₵39,610.00 or USD7188 equivalent) attributed to Cashew-Yam-Plantain-Small Ruminant associated with the tree crop livestock integration model. The profitability of the systems is however linked to the availability of a marketing system that provides for payment of fair prices to farmers. Less than 20 percent of respondents across the three zones practiced any form of irrigation.

Proposed CA coordination structure and mechanisms

A coordination structure for scaling up CA practices in Ghana has been proposed and recommendations made to address challenges with CA practices such as indiscriminate bush burning, lack of CA equipment and irrigation facilities, post-harvest losses and marketing difficulties. The Political, Economic, Social, Technological, Environmental and Legal and Institutional (PESTELI) analysis downscaled to the district level identified the factors and actors for the promotion of CA at those levels.

Conclusion and Recommendations

The study has provided evidence-based grassroots level baseline information thus illuminating the stage and paths for actors in CA including GASIP and farmers to take the process forward in the development of sustainable food systems in transitional, Guinea and Sudan Savannahs zones of Ghana. Various conclusions have been drawn from the study and outlined. Recommendations emerging from the conclusions are quite instructive and point to existing policies and their enforcement at all levels, social learning-based extension education for farmers and extension agents and consistent participatory action research to aid CA promotion and adoption. Areas of low hanging fruits for potential CA interventions to accelerate awareness creation and adoption of the systems of practices for sustainable agricultural development have also been identified and suggested in this study.

CHAPTER ONE
INTRODUCTION AND BACKGROUND

1.1 Background

Agriculture continues to be a major contributor to the national economy despite decreases in its proportional share of the Gross Domestic Product (GDP). Despite the sector's importance to socio-economic development, its structure has remained basic over the years. The sector is dominated by small-scale operators with land holdings of not more than 2 ha using rudimentary practices that are mostly exploitative of the natural resources and heavily dependent on rainfall. The nature of the production systems is exerting pressure on the natural resources thus threatening their sustainability. In addition to the above, external factors including population increases and climate change effects are further exacerbating the pressure on the agriculture system.

Climate change and its variability with much uncertainties remain one of the major threats hanging over Ghanaian's agriculture. The extreme occurrences include drought and floods, increasing population of invasive species, pests and diseases often resulting in severe yield reductions, loss of livelihoods and climate- induced migration, among others likely to undermine efforts towards the achievement of related SDGs. There is therefore the need for various adaptation, resilience building and mitigation actions to address climate change and its devastating effects.

Most African countries including Ghana have successfully put in place climate change policy documents including the Nationally Determined Contributions (NDCs) and National Climate Change Policy (NCCP). These alone may not be enough as there are financial investment challenges as a result of limited government resources with competing demands. Beyond these policies and interventions, there is the aspect of mobilizing adequate human resources of men, women and youth at all levels for implementation employing best systems and practices for innovation. A well capacitated human resource base, and a dedicated and systematic application of technologies (technical and institutional) are required. Conservation agriculture (CA) is one such system of practices identified within the climate smart agriculture approach for productivity enhancement, farmer resilience and adaptation capacitation while sustaining the environment.

The Ghana Agricultural Sector Investment Programme (GASIP) is a Government of Ghana (GoG) programme designed to provide a framework for long-term financing arrangement for private sector-led, pro-poor agricultural value chain development in Ghana. It is being financed by the International Fund for Agricultural Development (IFAD) and the Government of Ghana (GoG). The Ministry of Food and Agriculture (MoFA) is the lead implementing Ministry. In order to build resilience of value chain stakeholders or actors against the negative impacts of climate change, one of the subcomponents of GASIP is dedicated to mainstreaming climate change resilience across selected agricultural value chains. GASIP in collaboration with FAO is supporting the promotion and adoption of CA practices /technologies as a sustainable approach for smallholder farmers to undertake adaptation, build resilience and mitigate effects of climate change.

1.2 Objectives and Terms of Reference (TOR)

In order to ensure successful adoption and scaling up of CA, the partners stated above commissioned a study to conduct a comprehensive profiling of CA practices in the Transitional, Guinea Savannah and Sudan Savannah agro-ecological zones to identify existing practices as well as gaps aimed at meeting the full CA principles. The broad objective of the assignment was to characterize the level of CA practices and adoption in these agro ecologies and propose or recommend the institutional arrangement and appropriate CA model (s) that promote adoption by smallholder farmers.

Overall, the specific objectives of the CA/CSA Profiling study were to:

- Ascertain vulnerabilities of CA/CSA small-holder farmers in achieving food security, resilience and emission reduction from agricultural activities
- Assess the effects (gains and draw backs) of CA/CSA technologies and practices adopted by farmers on their livelihood, the natural resource base
- Characterize the (existing/new) institutional structure/arrangement for promotion of CA/CSA adoption and practice and design a framework for coordination and collaboration among various CA/CSA promoters necessary for effective promotion of CA/CSA adoption and practice for priority value chains
- Assess the potential irrigation options for CA/CSA taking into consideration, climate change mitigation and adaptation needs
- Assess and recommend the kinds and levels of CA/CSA equipment, tools and mechanization appropriate for the 3 agro-ecological zones taking into account gender and ecological diversity
- Develop appropriate CA/CSA model (s) that meet the needs of smallholder actor for adoption and practice taking into account gender and ecological diversity; and
- Conduct a Political Economic Socio-cultural Technological and Institutional (PESTI) Analysis to assess strengths and weaknesses in promoting the adoption and practice of CA/CSA among smallholder (including youth and women) farmers (See further details in Appendix 1)

1.3 Organisation of Report

This report is made up of four main chapters. Chapter 1 provides the introduction and the background to the commissioned study. Chapter 2 gives a description of the processes of design and methods in the conduct of the investigation to deliver needed result outputs. Chapter 3 examines the compelling evidence co-generated in the study by way of the findings. These have been presented in various sub-chapters that answer the terms of reference given for the study and at the same time serve as a one-stop-shop in the report for most of the deliverables required. Conclusions and recommendations backed by stakeholder visioning of their agriculture futures can be found in Chapter 4 which marks the end of the report.

CHAPTER TWO
METHODOLOGY

The design of the study consisted of three key steps namely: Multi-disciplinary team formation, reconnaissance survey and District and Household Level Co-generation of Information. A detailed description of the steps is provided below in this chapter.

2.1 Team Formation and Literature Review (Getting Started)

Apart from the three consultants assigned the work, a multidisciplinary core team of experts in the areas of policy, economics/agribusiness and agriculture value chains was formed (See Appendix 2) for the purpose. However, MoFA staff at the selected locations were coopted in district workshops, mobilization and questionnaire instrument administration for cogeneration of data. Secondary literature searches and review from relevant key sector ministries, research organizations, government and non-governmental projects databases was conducted. Some key policy and programme/project documents reviewed include the following: Gender in Agriculture, Ghana Agriculture Sector Investment Plan (2018-2021/METASIP III, National CSA and Food Security Action Plan, Youth in Agriculture, Agriculture Engineering/Mechanization, Market-Oriented Agriculture Programmes, Modernising Agriculture in Ghana, Soil, Land and Water Conservation, CSA investment frameworks, Irrigation policy, Seed policy, Extension policy, etc. A draft report by the consultants was edited by a team member on policy and development. This enabled the articulation of CA policy and sectorial synergies, the identification and mapping of CA projects, institutions, their actor analysis, the linkages and coordination mechanisms.

2.2 Reconnaissance for Scoping and Designing Ground Level Activity

A reconnaissance visit was undertaken in August 2019 to the eight administrative regions of the designated study domain. This allowed for the team of three consultants to sensitize heads of the departments of agriculture and other actors on the CA project, interact with key opinion leaders and key informants on smallholder farming and conservation agriculture. It also provided an opportunity to observe the farming systems, policy action implementation evidence of past and on-going CA projects at that level and CA-CSA related agronomic, irrigation, mechanization and market infrastructures. Information generated in the earlier step was used as a guide to inform any checklist design for the purpose. The scoping study visits report was used to validate the proposed criteria (Table 1) for selection of districts and also informed the design of the in-depth investigations of CA at district community and household level in the three agro-ecological zones.

2.3 District/Community and Household Level Co-generation of Information

Defining Population for the Study

The population for the research survey was crop farmers who also may be rearing livestock in the regions of Bono (#7), Bono East (#6) and Oti (# 8), representing transitional zone regions, Savannah (#5), Northern (#4) and Upper West (#1) representing Guinea Savannah zone and parts of North East (#3) and Upper East (#2) representing Sudan Savannah of Ghana who have been in

the farming business for not less than three years. These farmers are assumed to have had experience in conservation agriculture for a period long enough to be able to observe possible changes in climatic conditions and productivity, if any.

In the implementation of the survey for the study, Ahafo region was left out with the justification that there are appreciable pockets of forest which probably do not fit for characterization as part of the transitional zone. Figure 1 shows the Map of Ghana indicating regions and their capitals including the selected administrative regions for the study.

The farmers referred to here are smallholder farmers mostly with landholding up to 2ha and dwell mostly in rural areas in the study area. The sample frame for these farmers at the household level was generated from a list of farmers with the assistance from the office of the Department of Agriculture at the various districts.

Figure 1: The Map of Ghana showing study administrative regional capitals

2.4 Sampling Technique for the selection of districts and households

The sample of any research study is a subset of the total population which is randomly selected and possesses characteristics of and represents the population. The sampling frame for the study was generated for each district. The study sampled 30% of districts within each agro-ecological zone. This yielded 9 out of 31 districts from the transitional zone, 12 out of 40 districts from the Guinea Savannah and 5 out of 15 from the Sudan Savannah. The purposive sampling of these districts was guided by the set of criteria as presented in Table 1. For a district to be selected, it must have met at least two or more of the points in the given criteria.

Sampling farmers/households from the selected districts, was done such that one should be able to identify characteristics that are found in the overall population. The sample size determination for a given population by Krejcie and Morgan (1970) was used as a basis to delineate the sample size for the study. Three hundred and eighty four (384) sample size represent the extreme population size of over 1000000 according to Krejcie and Morgan (1970). However since 'more is better', the study considered 1560 sample size and assumed an average sample size of 60 farmers for each district within each agro-ecological zone. The farmers were sampled employing the multistage sampling technique done hierarchically across different stages (i.e. Districts → Agricultural zones →Towns/villages → Farmers). In the process, purposive sampling according to the criteria established in Table 1 as well as series of simple random sampling was done at each stage to arrive at the sample size that represents conservation agriculture practicing communities and farmers in consultation with the Departments of Agriculture at the district level. At least a minimum of 30% of the respondents will be female in the households.

Table 1: Proposed Criteria for selection of the Districts

No.	Criteria	Remarks
1	Agro-ecology	CA is site-specific, hence the need for a representation of the 3 agro-ecological zones in northern Ghana and matching these zones with the 8 administrative regions
2	Peace and Security	Security concern in some districts
2	Existing CSA practices and success cases from interventions	Fast track development success factors
3	Participation in CSA investment framework development	Building on existing knowledge bases for sustainable development
3	Proximity to demonstration research facilities	Identification of technologies
4	Regional Equity or balance	Administrative region representation
5	Presence of CA-CSA groups and or climate change platforms	Ease to mobilization of groups for participation
6	Agricultural Project Beneficiaries	Beneficiary of RTIP and Northern Rural Growth Project and other government projects

Table 2: Selected study Districts/Municipalities by Agro ecological zones

	Agro-ecological Zone	District	Capital Town
1	**Forest Savannah Transitional**	Banda	Banda Ahenkro
		Dormaa Central Municipal	Dormaa Ahenkro
		Jaman South Municipal	Drobo
		Tain	Nsawkaw
			Kintampo
		Nkuranza South Municipal	Nkuranza
		Techiman Municipal	Techiman
		Krachi East	Dambai
			Kpassa
2	**Guinea Savannah**	Sagnarigu Municipal	Sagnerigu
			Savelugu
		Tolon	Tolon
			Gushiegu
		West Mamprusi Municipal	Walewale
		East Mamprusi Municipal	Gambaga
		Nanumba South	Wulensi
		North Gonja	Daboya
		Sawla-Tuna-Kalba	Sawla
		Wa Municipal	Wa
		Lawra Municipal	Lawra
			Nandom
3	**Sudan Savannah**	Bongo	Bongo
			Tongo
		Bawku West	Zebilla
			Garu
		Bawku East Municipal	Bawku

Characteristics of the Studied Agro-ecological Zones

Transition Zone

- **Area (km^2)** – 8400
- **Mean annual rainfall (mm)** – 1300
- **Annual rainfall range (mm)** – 1100 – 1400
- **Average mean Temperature (°C)** – 26.7
- **Major rainy season** – March to July
- **Minor rainy season** – September to October
- **Length of growing season (Days)** – Major season: 200-220, Minor season: 60
- **Dominant land use systems** - annual food and cash crops
- **Main food crops** - maize, roots, plantain
- **Tree crops** – Cocoa, mango and cashew

- **Vegetation** – Medium to large trees (including timber species), shrubs interspersed with tall grasses
- **Major challenge** – Bushfires
- Climate change effects include; erratic rainfall, increasing dry spells, high temperatures, merging of two seasons and increasing pest and disease incidences

Guinea Savannah

- **Area (km^2)** – 147900
- **Mean annual rainfall (mm)** – 1100
- **Annual rainfall range (mm)** – 800 -1200
- **Average mean Temperature (°C)** – 27.6
- **Major rainy season** – May to September
- **Length of growing season (Days)** – 180-200
- Vegetation – Medium sizes drought and fire-resistant trees interspersed with tall grasses
- **Dominant land use systems** - annual food and cash crops, livestock
- **Main food crops** - sorghum, maize, rice, groundnuts, cowpeas and yams
- Tree crops include Shea, dawadawa, mango and cashew
- Livestock include; small ruminants, cattle and poultry mainly guinea fowls
- Major challenges: Recurrent annual bushfires, long dry season with high temperatures
- Climate change effects – delay in onset of rains, longer dry spells increasing temperatures and high intensity rains

Sudan Savannah

- **Area (km^2)** – 2200
- **Mean annual rainfall (mm)** – 1000
- **Annual rainfall range (mm) :** 655 – 1320
- **Average mean Temperature (°C)** – 28.0
- **Major rainy season** – May to September
- **Minor rainy season** – N/A
- **Length of growing season** – **(Days)** 150-160
- **Vegetation:** Open grass with scattered short drought and fire-resistant trees
- **Dominant land use systems** - annual food crops, livestock
- **Main food crops** - millet, sorghum, cowpea
- **Livestock:** mainly small ruminants and guinea fowl
- **Major challenges**: long dry season with high temperatures
- **Climate change** effects include; erratic rainfall, delay in start of season, increasing dry spells, high intensity rains early cessation of rains, and increasing temperatures

The distribution of the study locations in the given agro-ecological zones have been visualized in a map and presented in Figure 2.

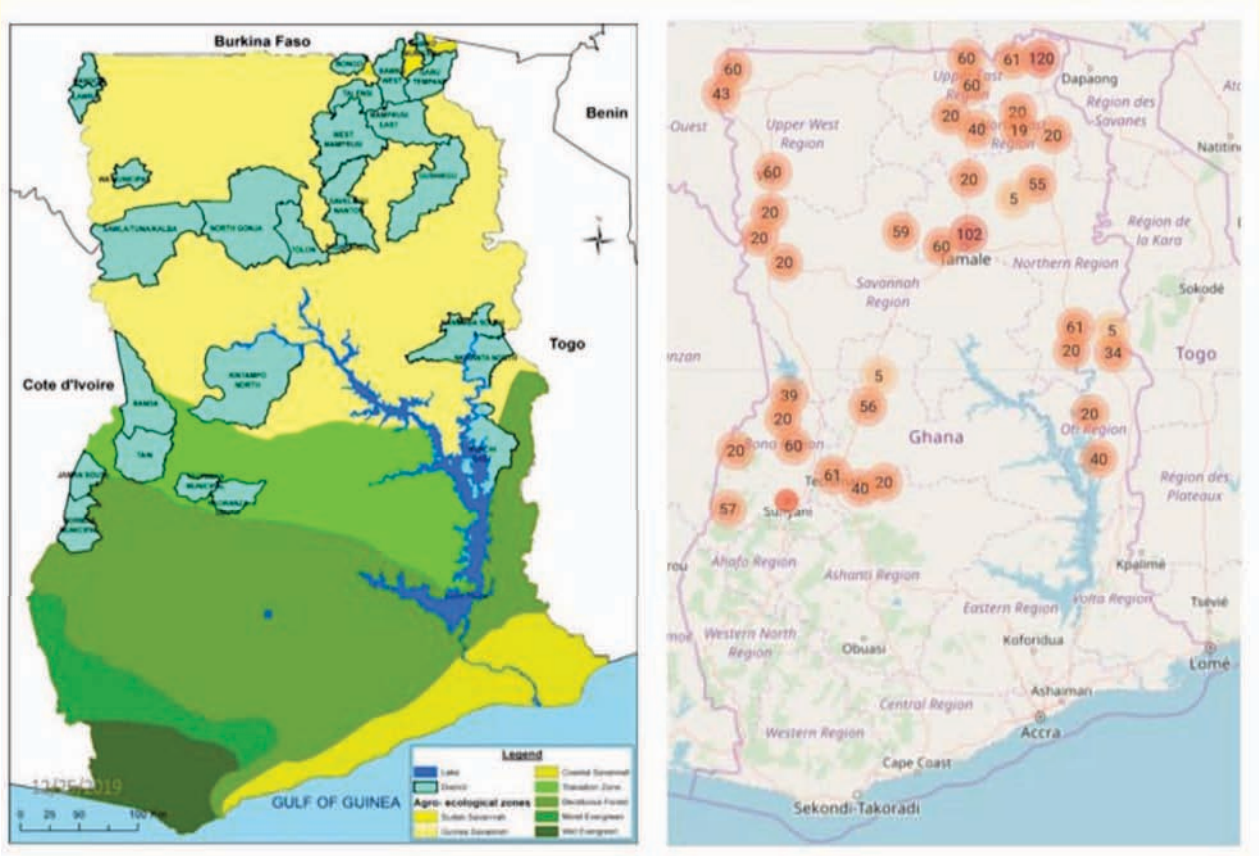

Figure 2: Study Locations and farmer households in the three agro-ecological zones
Source: FAO field study, 2019

Field work in the selected districts consisted of two main actions, which include the administration of a pre-tested survey questionnaire instrument at the household level and participatory rapid CA appraisal with selected stakeholders at the district level. The household question was designed to harvest data on household demographics, value chain commodities (crops/livestock), CA farm sizes, types of CA practices, tools and equipment, production, climate change vulnerability, adaptation for resilience and environmental impact.

Plate 1 Training of field Enumerators for household survey

The principle of co-generation of knowledge in this CA study was used to the benefit of all by putting in place sieves of expert groups at intervals of the study to preview and make input to preliminary findings by way of comments and suggestions that also shaped the study trajectory. One of such expert consultative session was held on the draft reconnaissance survey findings in a mini-workshop. The household survey instrument in particular, benefitted from this expert group engagement. The decision was taken in this meeting to use Computer Assisted Personal Interview (CAPI) and over 70 enumerators from the Departments of Agriculture in 26 selected districts (Table 2) out of the total of 78 were trained to administer the instrument to a total of 1560 households in the given three agro-ecological zones. The data was collected within 10 days after the training of the enumerators with 100% recovery, cleaned and subjected to various statistical analysis using the SPSS package (computer software).

The participatory rapid CA appraisal was carried out to generate qualitative data to complement that from the household survey. Sources of data included community people's perception of climate change and its variability, mapping their natural resources, indigenous and introduced CA/CSA practices, prioritization of the practices, the adoption profile by gender, climate change and vulnerability assessment and district level CA actor analysis and linkages. Five CA models developed during the reconnaissance survey were downscaled at the district level and two models fitting the farming system of each district selected by stakeholders. Profitability assessment was conducted on the two selected models per District using benefit/cost analysis tool. Similarly the CA coordination structure and PESTELI developed at the regional consultations were also downscaled to the district level thus reflecting district structures and mechanisms. This was aided by data generated earlier on the actor-linkage analysis.

Plate 2 PRA in Kintampo North Municipal and Wa Municipal

District level CA information was elicited within 18 days by three constituted parallel teams in order to save time. Three field teams of three members each were constituted for a one-day rapid participatory appraisal exercise at the district level. Each team covered eight districts across the three agro-ecological zones. At the beginning, all the three teams worked together in two districts Dormaa and Techiman) before splitting to work from 25th October to 10th November, 2019. A single day entry per district was used by each team for the participatory CA appraisal. A checklist (Appendix 5) was developed to guide the field work and various PRA tools employed to engage the multi-stakeholder groups of 30 carefully selected participants representing each district. The participants included male and female crop-livestock farmers, extension staff from extension zones of the Department of Agriculture, Assemblymen and women, traditional rulers, marketers and processors, agriculture input dealers, hunters, traders, and NGO representatives in the district. A total of about 780 people were therefore engaged in the CA appraisal exercise in the selected districts. The medium for effective communication during the sessions included English and the different local dialects of the districts. Interpreters were used where necessary.

Data generated from the participatory CA appraisal sessions were discussed in the various team meetings and subjected to soft systems analysis based on consensus building. Secondary literature sources of information on district profiles were obtained from planning units and the Department of Agriculture of the various Districts and Municipal Assemblies. A two-day write-shop was organized for the field team members to produce draft reports. These outputs backed by the diverse analytical minds of the three-man team of consultants, the information was given tabular and graphical visualization at the household, district and agro-ecological zone level and discussed. Roles were shared to leverage the different expertise of the consultants in order to produce a composite draft report responsive to the given terms of reference. A two-day preview meeting on the draft report by a team of experts within and without GASIP/FAO served as the second sieve to share the information, bring transparency and quality in the co-creation of the product. A one-day national validation workshop was organized for the various CA stakeholders to share and learn about the evidence-based baseline information on CA and thereby confer the buy-in and ownership of the product. Comments and suggestions from these meetings were found useful and incorporated into the final report.

CHAPTER THREE
FINDINGS

This chapter is dedicated to the outputs and outcomes from the household survey and the rapid participatory CA appraisal conducted at the district level. The results have been presented in a form to answer the various terms of reference in the study and effectively respond to the desired deliverables. However, given the scope of work in this study and the concept of CA in literature, it is a first prerequisite to provide our working definition of conservation agriculture to guide prospective readers of this report.

The working definition of CA/CSA adopted in this study is 'resource saving agriculture (crop and livestock) production systems that strive to achieve acceptable profit with high and sustained production levels while concurrently conserving the environment'. In this working definition, CA/CSA practices will include minimum/no till, intercropping, crop rotation, use of manure, permanent soil cover(cover cropping, mulching) and crop-livestock integration.

3.1: Climate change vulnerability Assessment for smallholder farmers

The literature provides a vast variety of definitions for vulnerability, mostly depending on the discipline or sector of focus (Adger, 2006). In this study, definition of the Intergovernmental Panel on Climate Change (IPCC) was adopted. According to the IPCC (2007), ***vulnerability*** in the context of climate change is "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. The IPCC definition specifically highlights three components of vu lnerability in the climate change context namely exposure, sensitivity and adaptive capacity. For example, considering the occurrence of drought in an arid or semi-arid area; the people living in the area may be vulnerable to the drought because the aridity of the area makes them already exposed to the hazard; highly sensitive to the drought if they are mainly growing a crop like maize which requires higher amounts of moisture and have low levels of adaptive capacity and if they lack or have poor access to weather information, lack of money to buy drought tolerant varieties.

The study considered the impact of four (4) common climate hazards (drought, dry spell, floods and bushfires) on households across the (3) agro-ecological zones. The degree to which these hazards affect the various age groups adolescents [boys and girls (below 15 years), young men and women (15-35 years) and the aged (above 60 years)] was assessed.

Of the three (3) climate hazards, drought emerged as the most prominent hazard affecti ng 79.0%, 68.7% and 66.7% of the households in Sudan, Guinea Savannah and Transition as presented in Figure 3. These findings are in consonance with the IPCC report of an emergence of near permanent drought conditions in the semi-arid and arid regions of the continent (IPCC, 2007). This development was attributed to erratic rainfall pattern and rising temperatures being experienced in these areas in recent times. Furthermore, these findings are complemented with results obtained from the PRA and reconnaissance survey conducted at the district and regional levels respectively.

The effects of bushfires were prominent among households in the Transitional zone (50.6%) compared with the Savannahs; 39.7% for households in Guinea and 20.0% in Sudan. This could be linked to the existence of by-laws on bushfire prevention in the Savannah regions. The impact of floods on households in Guinea and Sudan Savannahs are relatively high compared with Transition zone. The seasonal/periodic opening of 'Bagre' dam in Burkina Faso to allow flow of water to the upper part of the country occasionally contributes to flooding in the two Savannahs. Less than 20% of the households in each of the agro-ecological zones indicated that dry spells affect their farming activities.

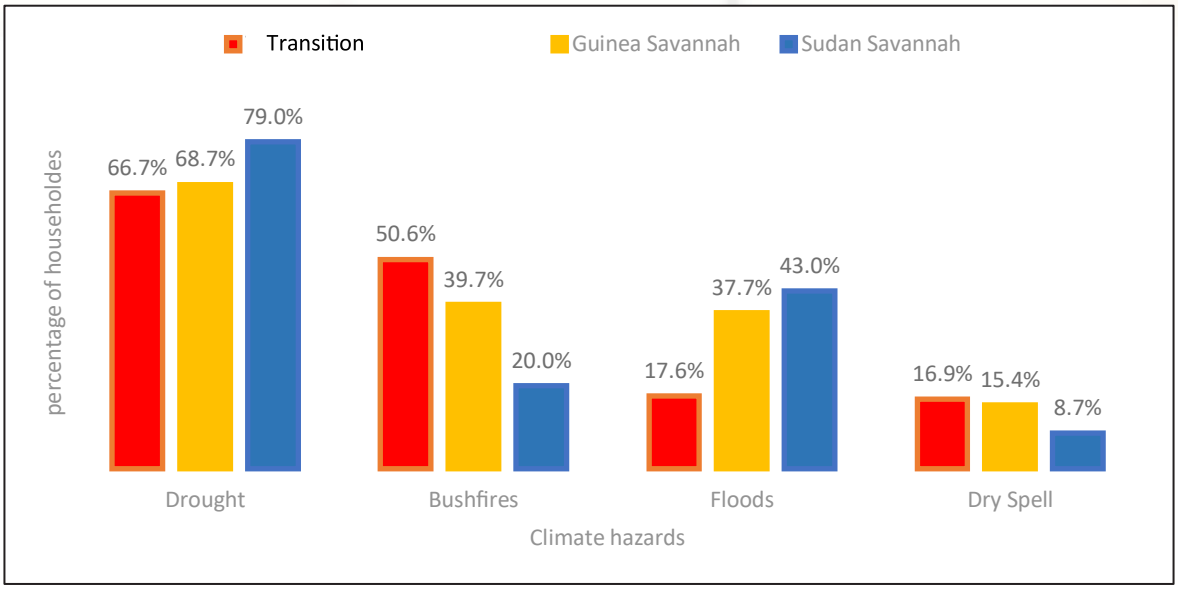

Figure 3: The Impact of Climate change on households across the 3 agro-ecological zones

Source: Field Results (2019)

Drought was ranked as the number one climate hazard that affects all the age groups as shown in figures 4 and 5. In terms of severity it was revealed that drought has mild effect largely on young women (59.5%), boys (60.3%), girls (60.5%) and the elderly (57.7%) across the three zones as presented in figure 4. This is however more prominent in the transition zone.

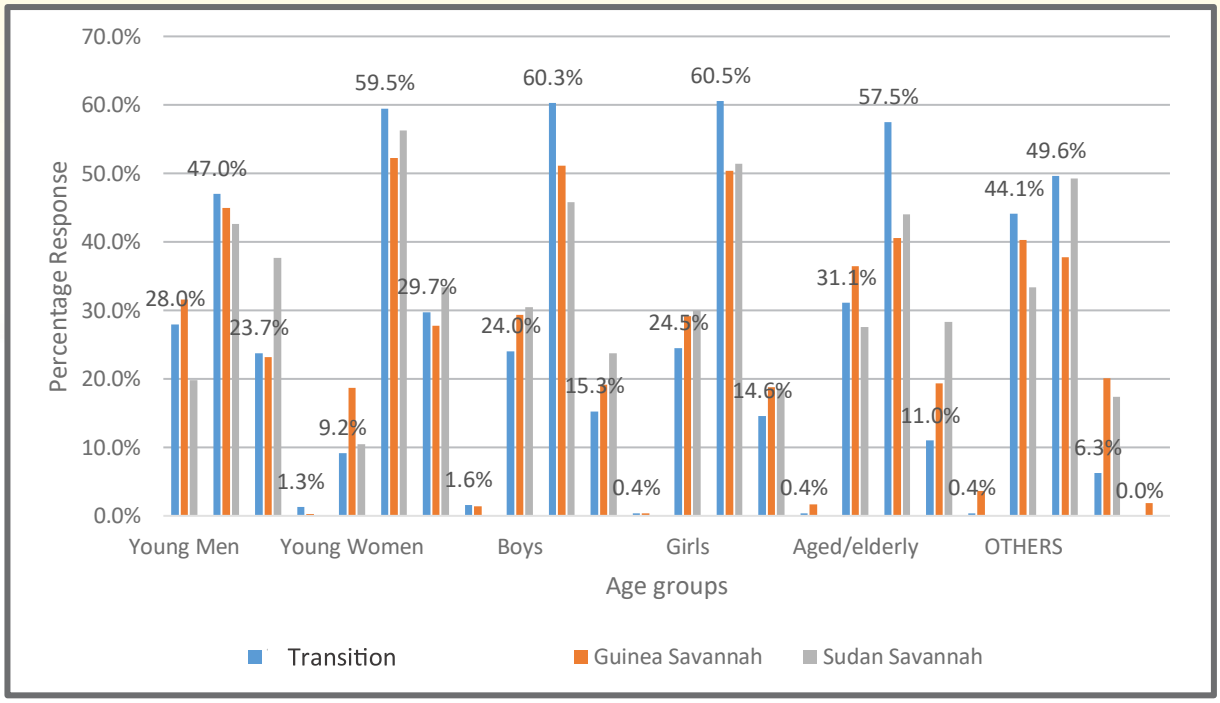

Figure 4: Severity (very severely, severely, mildly, and not at all) of Drought on different age groups by zones

Source: Field Results (2019)

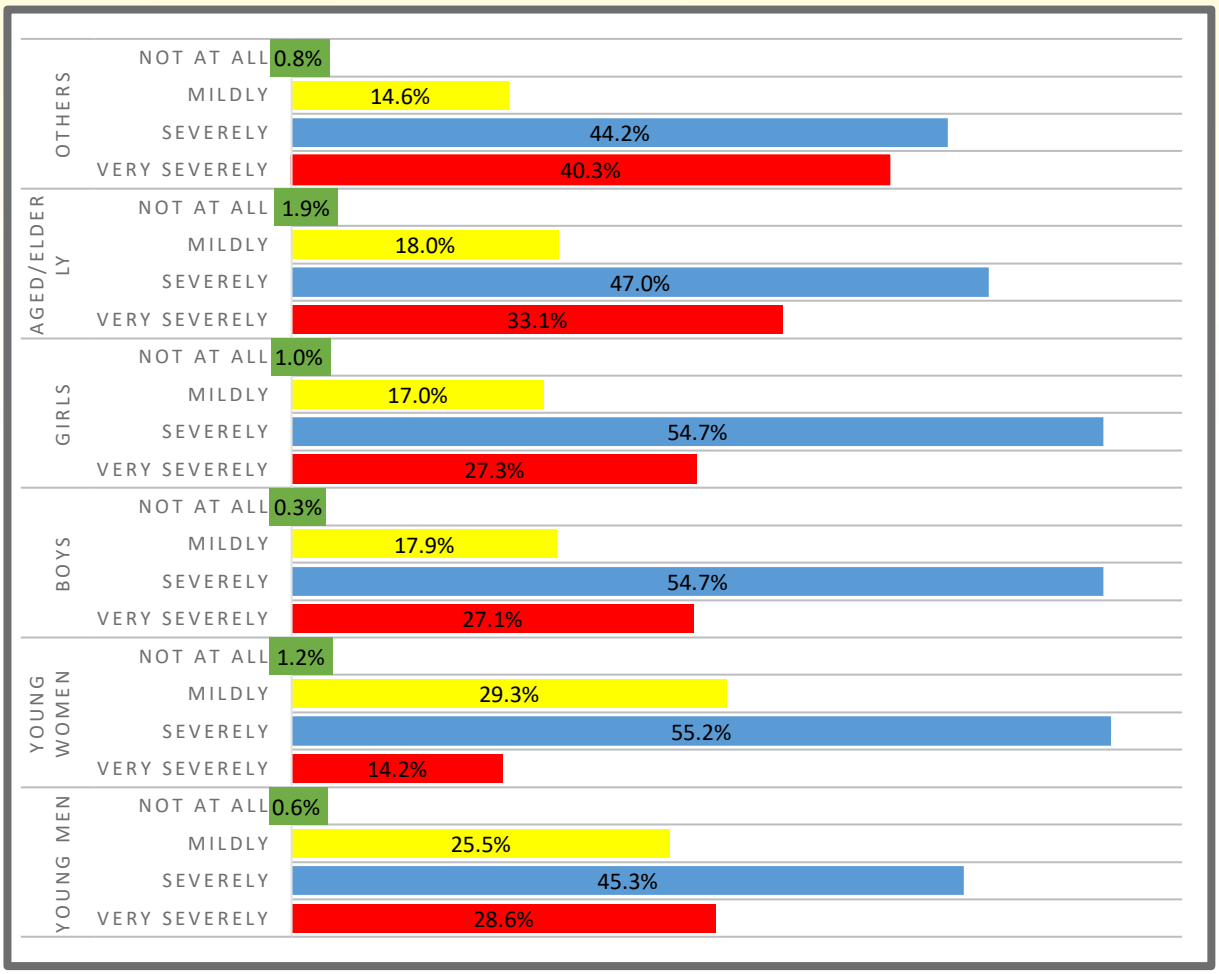

Figure 5: Severity of Drought on different age groups for the pooled data

Source: Field Results (2019)

The study also looked at strategies used by farmers to cope with or adapt to the adverse impact of the climate hazards (see Table 3). Some of the strategies identified include change of planting material/crop variety and planting dates, increase in farm size, crop insurance, food storage, soil and water conservation measures, increase in number of livestock reared (small ruminants and poultry), water harvesting amongst others. Of these adaptation strategies, food storage, non-farm activities, increased number of livestock emerged as the most frequently employed strategies by the farmers. Crop insurance, water harvesting and soil and water conservation were rarely used by farmers across all the agro-ecological zones. Of the three agro-ecological zones, households in the Sudan Savannah were observed to be more prone to frequently employ strategies involving increasing livestock numbers, crop insurance, food storage, water harvesting, change crop variety and planting dates as well as increase land under cultivation as climate change adaptation strategies.

Table 3 : Climate Change Adaptation Practices by Households by agro-ecological zones

Adaptation Strategies	Transition Forest-Savannah	Guinea Savannah	Sudan Savannah
Increase land under cultivation	32.9%	27.3%	23.9%
Change crop variety	66.9%	71.9%	69.5%
Change crop type	52.0%	49.0%	40.3%
Change planting dates	65.7%	80.4%	68.6%
Increase number of livestock	25.1%	24.3%	25.2%
Soil & water conservation practices	41.4%	18.0%	16.8%
Planting trees on the farm	44.1%	31.0%	24.3%
Water harvesting	10.6%	1.8%	1.8%
Food storage	64.6%	39.5%	56.6%
Non-farm income activities	14.7%	13.4%	10.2%
Crop insurance	1.1%	.6%	.4%
Others	1.1%	1.2%	6.2%

Source: Field Results (2019)

3.2 Climate change vulnerability and youth migration

The indicated strategies by households notwithstanding, the participatory district level vulnerability assessment revealed participants behavior during climate change hazards in relation to migration effects. The hazards will influence livelihoods differently within a district and more so across the agro-ecological zones as presented in Table 4. While the hazard influence may generally be strong for districts in the Guinea and Sudan Savannahs, the same cannot be said for the Transition- zone where the influence are minimal. Districts in all the zones however, associated the youth gender with migration as a result of the hazards, particularly in the event of unpredictable rainfall and drought. Productive land, food security and other livelihood forms are also hugely affected. The youth migration to the southern part of the country for socio- economic transformation has implications for further shortage of agricultural labour in the dryer zones.

A system of climate smart practices including the harvesting of rain water for irrigation in the following long dry season could help stem the phenomenon of drift of agricultural labour. Such migration in the past was considered temporary as the youth returned during the rains to farm. The worsening climate situation coupled with limited services, technology and credit ultimately is resulting in permanent migration since the youth no more return to the village to farm.

Table 4 : District level behaviour of participants on a Likert scale towards climate change hazards in relation to migration effects in three agro-ecological zones

Agro-ecological zone		Score on Likert scale (1 – 5)				
		Migration				
Transition	District	Unpredictable rainfall	Drought	Floods	Bushfires	Crop/Animal diseases
	Banda	3 (Y)	2 (Y)	3 (A)	1 (A)	1 (A)
	Jaman	1 (Y)	2 (Y)	1 (Y)	1 (Y)	1 (Y)
	Tain	1 (Y)	1 (Y)	2 (A)	2 (A)	1 (A)
Guinea	Nandom	4 (Y)	5 (Y)	4 (A)	3 (A)	3 (A)
	Wa	5 (Y)	3 (Y)	5 (A)	2 (A)	1 (A)
	North Gonja	1 (A)	3 (Y)	1 (A)	3 (A)	1 (A)
Sudan	Bongo	3 (M)	5 (M)	5 (M)	5 (M)	3 (M)
	Bawku Municipal	5 (M)	5 (M)	5 (M)	5 (M)	5 (M)
	Bawku West	5 (Y)	5 (Y)	5 (Y)	5 (Y)	5 (Y)

Hazards: 1=very minimal influence, 2= minimal influence, 3 = some influence, 4=strong influence, 5=very strong influence; Y=Youth migrate, A=All but no migration

3.3 : Potential for smallholder irrigation

Findings from the household level survey and district level Participatory Rural Appraisal (PRA) confirm that CA is largely practiced across the three agro-ecological zones under rain-fed agriculture (also see Reconnaissance survey report, 2019); however some level of CA practices are happening under smallholder irrigated agriculture. Sources of water for irrigation include hand dug out wells, dams, boreholes, rivers and rain water harvesting. Major irrigation systems identified included manual use of bucket and watering can, pumping of water from wells and surface water systems using canals under gravity. The district specific available water bodies and potential for smallholder irrigation facilities are captured under the PRA reports from the studied districts.

From the household level interviews, less than 20 percent of respondents across the Transition and Guinea Savannah zones practice any form of irrigation. In the Sudan Savannah zone however, 24 percent of respondents are practicing one form of irrigation or the other (Fig, 6). Majority (75.3%) of respondents across the zones practicing irrigation are producing vegetables (tomato, pepper etc.) with Guinea Savannah and Sudan Savannah posting the higher figures of 85.5% and 72.2% respectively. The next important crop under irrigation is rice with only 9% of respondents as producers, however about 20% of respondents in the Guinea Savannah are rice irrigated producers. The high percentage of vegetable producers could be ascribed to the value of production in addition to irrigated vegetable production as an off-season engagement mostly in the Guinea and Sudan Savannah zones.

In terms of reliability of sources of water for irrigation (see Table 5), rivers were scored as the highest reliable source (53%) followed by Dams/dugouts (47%) and wells (41%). Boreholes and rainwater harvesting are considered as least reliable sources of 22% and 0% respectively. The unreliability of the borehole could be related to either quantity/quality of water and/or power for lifting water from the borehole. In terms of rainwater, the un-reliability could be associated with the increasing unreliability of rainfall within the three zones studied.

In terms of irrigation systems being used, bucket/watering can irrigation is the most popular method (58.9%) followed by gravity method with 25% of respondents across the three zones. The high proportion of users of bucket/watering can is a direct reflection of the extent of informal irrigation practice among smallholder farmers in the zones studied. The very low representation for drip and sprinkler irrigation could be an indication of low level of willingness to invest in technology among smallholder farmers since these systems require some level of investment.

Graphical representation of types of crops cultivated under irrigation are shown in Figure 7 below.

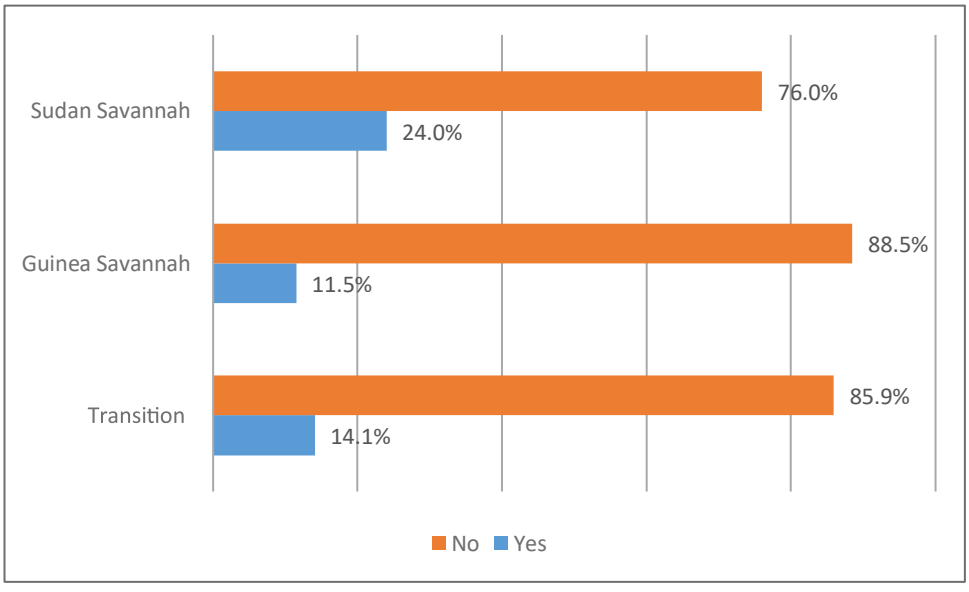

Figure 6: Are you practicing irrigation?

Source: Field Results (2019)

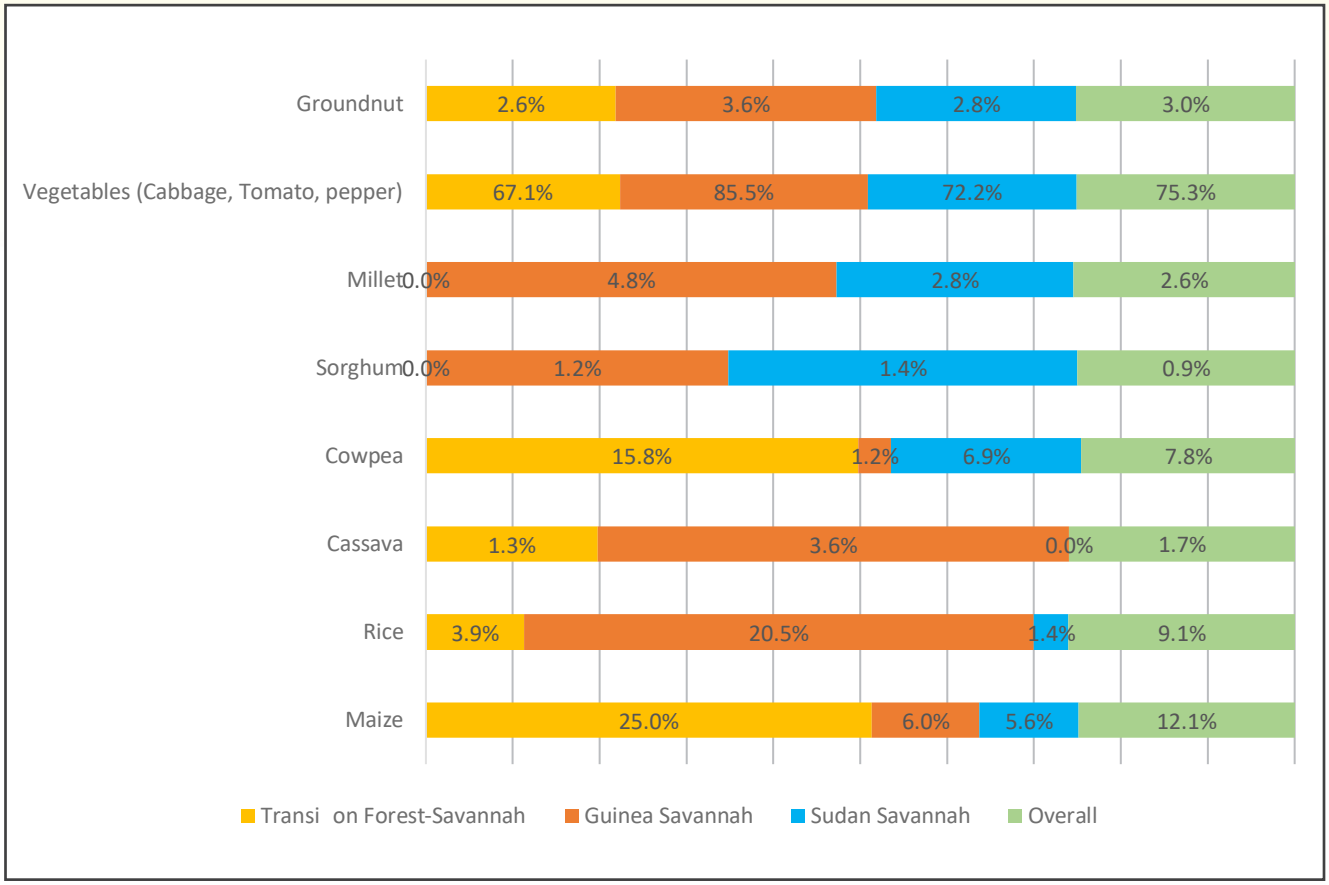

Figure 7: Types of Crops cultivated under irrigation

Source: Field Results (2019)

Table 5: Household sources of water and reliability for irrigation by agro-ecological zones

Type of Irrigation	Level of Reliability	Transition Forest-Savannah	Guinea Savannah	Sudan Savannah	Total
Hand dug	Very unreliable	23.3%	0.0%	16.7%	17.3%
	Unreliable	13.3%	20.0%	66.7%	26.9%
	Average	43.3%	10.0%	16.7%	30.8%
	Reliable	20.0%	50.0%	0.0%	21.2%
	Most reliable	0.0%	20.0%	0.0%	3.8%
Wells	Very unreliable	0.0%	14.3%	0.0%	4.2%
	Unreliable	0.0%	14.3%	100.0%	20.8%
	Average	61.5%	0.0%	0.0%	33.3%
	Reliable	38.5%	14.3%	0.0%	25.0%
	Most reliable	0.0%	57.1%	0.0%	16.7%
Dams	Very unreliable	0.0%	32.6%	33.3%	31.4%
	Unreliable	0.0%	8.7%	2.8%	5.8%
	Average	25.0%	10.9%	16.7%	14.0%
	Reliable	0.0%	15.2%	47.2%	27.9%
	Most reliable	75.0%	32.6%	0.0%	20.9%
Borehole	Very unreliable	75.0%	66.7%	0.0%	55.6%
	Unreliable	0.0%	0.0%	0.0%	0.0%
	Average	0.0%	33.3%	50.0%	22.2%
	Reliable	0.0%	0.0%	50.0%	11.1%
	Most reliable	25.0%	0.0%	0.0%	11.1%
Rivers	Very unreliable	17.6%	27.3%	18.2%	20.5%
	Unreliable	11.8%	4.5%	27.3%	14.1%
	Average	17.6%	4.5%	9.1%	11.5%
	Reliable	52.9%	13.6%	9.1%	29.5%
	Most reliable	0.0%	50.0%	36.4%	24.4%
Rain water harvesting	Very unreliable	0.0%	0.0%	0.0%	0.0%
	Unreliable	58.3%	0.0%	0.0%	53.8%
	Average	41.7%	100.0%	0.0%	46.2%
	Reliable	0.0%	0.0%	0.0%	0.0%
	Most reliable	0.0%	0.0%	0.0%	0.0%

Source: Field Results (2019)

The effectiveness of irrigation systems depends on power for lifting and transporting water from the source to point of utilization. According to the results obtained in this study, almost 70 percent of respondents depend on manual effort to lift water for irrigation. This is consistent with the proportion of farmers/respondents practicing the bucket/water can irrigation. The next major source of power for irrigation as per respondents is diesel/petrol for powering water pumps (27%). This is also consistent with the proportion of farmers/respondents depending on wells for their water for irrigation.

3.4 Profile of CA technologies

Overall, approximately 87 percent of the farmers interviewed were practicing one or more elements of CA. Among the key pillars of CA practices, crop rotation was the most commonly practiced with over 80 percent of the entire sample interviewed practicing. This was followed by inter-cropping which was practiced by 61 percent of the entire sample interviewed. Those responding to practicing zero/minimum tillage at the household level constituted 56 percent. Concentration of farmers practicing zero/minimum tillage CA practice was highest in the transition agro-ecological zone with 86 percent of the farmers interviewed responding yes to this practice at the household level.

Cover cropping was the least commonly practiced element of CA in all the agro-ecological zones. Overall, just about a third of the sampled farmers interviewed practiced cover cropping. This result appears to be at variance with the district level participatory matrix ranking to prioritize the CA practices. The results (responses) obtained from the participatory matrix were derived in an assessed ranking exercise based on a given criteria generated from the discussions, however, the difference in the two levels of information may be due purely to the interpretation and the understanding of the issue by the respondents.

It must be noted that cover crops such as *Mucuna, Stylo, Cajanus cajan* and *Crotolaria* were hardly cultivated. The main crops cultivated under the CA (cover cropping) system were maize and cowpea.

Farmers interviewed had multiple farms. Farmers were asked about the proportion of their total farm land under CA. The average proportion of the total land size under CA practices was estimated at 45 percent.

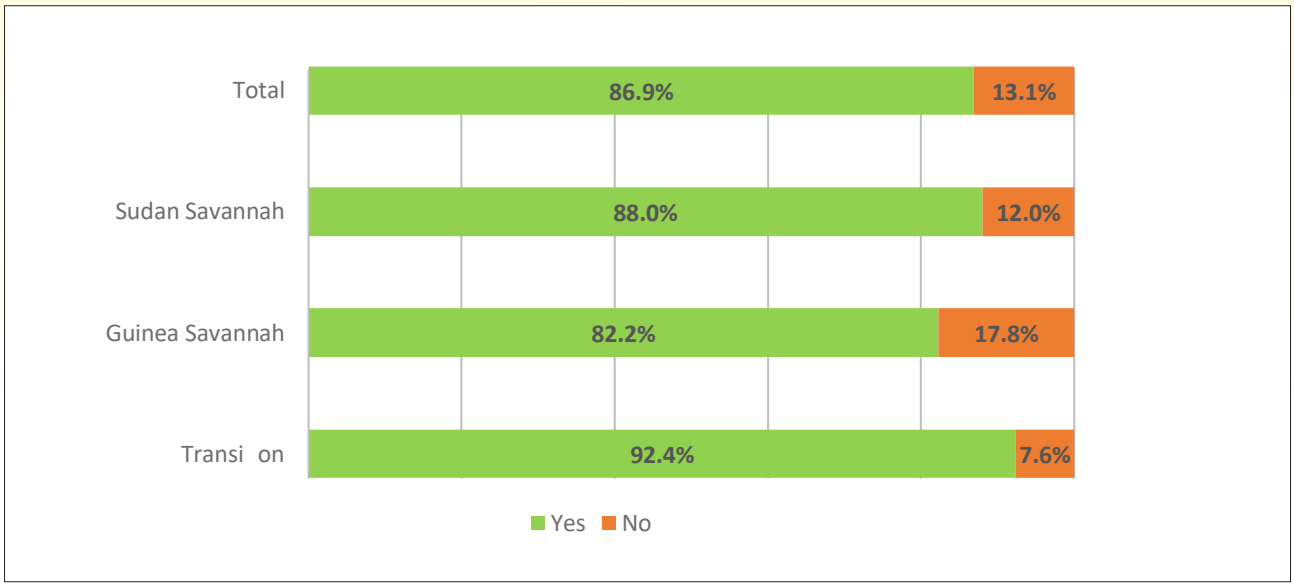

Figure 8: : Activities aimed at conserving farm lands disaggregated by agro-ecological zones

Source: Field Results (2019)

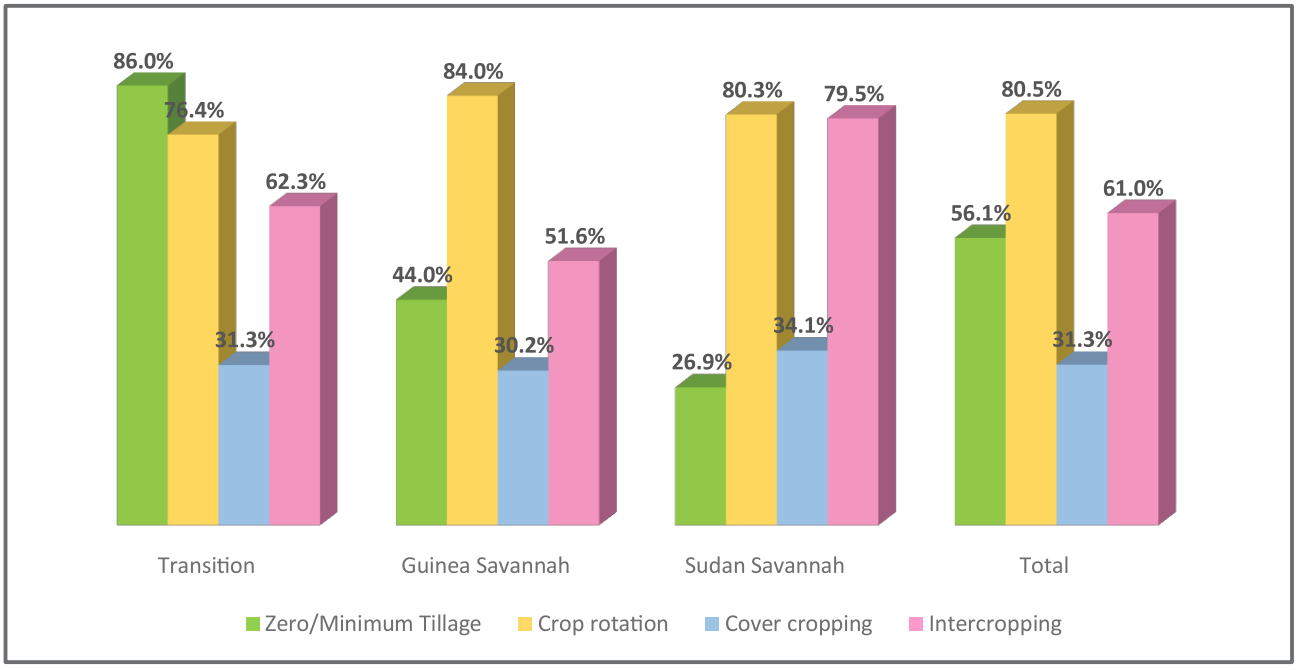

Figure 9: Conservation Agricultural practices disaggregated by agro-ecological zones

Source: Field Results (2019)

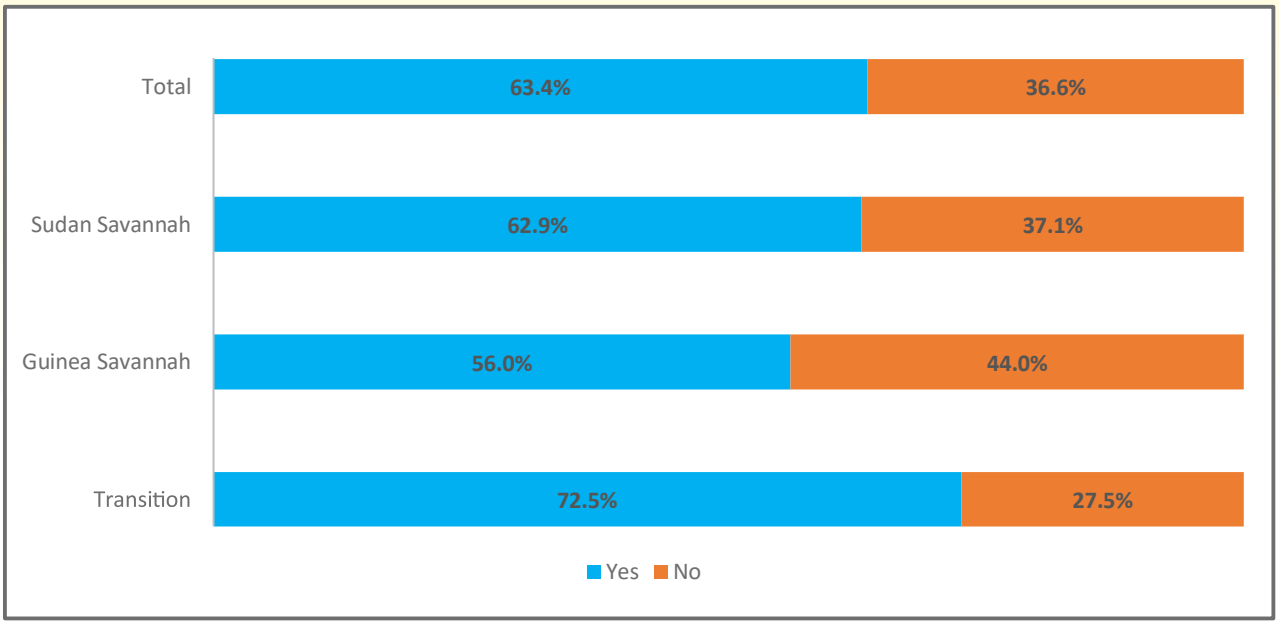

Figure 10: Conservation Agricultural practices training disaggregated by agro-ecological zones

Source: Field Results (2019)

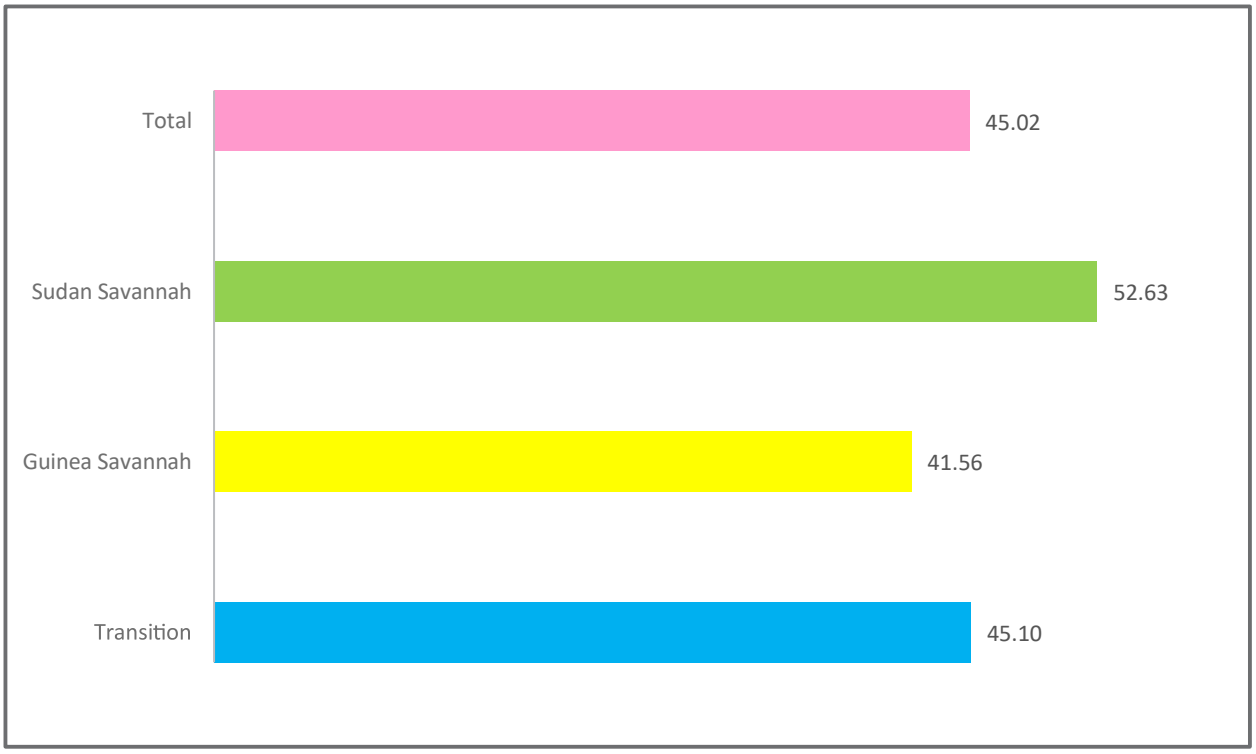

Figure 11 : Percentage of total farm land used for Conservation Agricultural practices disaggregated by agro-ecological zones

Source: Field Results (2019)

About 72.5 percent of the sample interviewed in the transitional agro-ecological zone had ever received training in CA practices (See figure 10). This was followed by 62.9 percent of the sampled farmers interviewed in the Sudan Savannah who had received training in CA practices. Guinea Savannah agro-ecological zone had the lowest representation of farmers trained in CA practices constituting 56 percent of the total sampled farmers interviewed.

Majority (88.7%) of the farmers had received training on crop rotation. Those who had received training on crop rotation in the transition agro-ecological zone constituted 87.6 percent while those who had been trained in crop rotation in Guinea Savannah and Sudan Savannah constituted 91 percent and 86.7 percent respectively. Overall, 64.5 percent of the sample interviewed had received training on minimum tillage; 84.8 percent in the transition forest Savannah agro-ecological zone, 54.5 percent in Guinea Savannah and 40.4 percent in Sudan Savannah. Training on CA was mostly conducted by MOFA extension agents as shown in Table 6. The trainings were acknowledged to have high implications for increasing the adaptive capacity of the farmers. Though socio-cultural factors may explain why for example, bullock tillage is low in the transitional zone the current findings of less than 50% farmers in general, call for intensification of the training education for increased adoption of the practices for sustainable food systems development in the zones.

Table 6: Type of Training received by farmers, Organization conducting training and crops grown under CA

Characteristics	Variables	Transition	Guinea Savannah	Sudan Savannah	Total
Type of training you received	Improved genetic materials (seeds/breeds)	86.2%	66.3%	78.3%	77.0%
	Zero tillage	63.3%	29.5%	21.1%	42.1%
	Minimum tillage	84.8%	54.5%	40.4%	64.5%
	Bullock tillage	3.3%	13.0%	70.5%	20.0%
	Tractor tillage	25.7%	63.0%	18.1%	38.6%
	Mulching	74.9%	36.1%	38.0%	52.8%
	Cover cropping	47.5%	44.6%	56.0%	48.0%
	Crop rotation	87.6%	91.0%	86.7%	88.7%
	Integrated pest management	51.4%	45.2%	42.8%	47.3%
	Agroforestry/Trees on farms	43.1%	38.9%	18.1%	36.6%
	No burning of residues/biomass on farms	62.4%	67.5%	65.1%	64.9%
	Biogas/Farm waste management	22.4%	29.8%	18.7%	24.5%
	Erosion control structures	53.9%	56.0%	50.6%	54.1%
	Use of chemical fertilizers	80.4%	84.3%	73.5%	80.6%
	Use of manure/composting	46.4%	65.1%	77.7%	59.7%
	Integrated nutrient management	31.8%	23.8%	33.7%	29.1%
	Green manuring	14.4%	15.7%	4.2%	12.9%
	Water conservation	44.2%	21.1%	11.4%	29.0%
	Irrigation	29.8%	25.3%	16.9%	25.6%
	Improved livestock housing	49.4%	51.2%	31.9%	46.7%
	Crop-livestock integration	37.6%	38.9%	42.8%	39.1%
	Supplementary livestock feeding	41.2%	47.6%	33.7%	42.2%
	Livestock diseases prophylactic treatment	41.2%	45.8%	17.5%	38.4%
	Proper Use of pesticides/herbicides	77.6%	53.9%	28.3%	59.0%
Which of the organizations/ actors provided	MoFA Extension Agents	98.9%	97.0%	94.0%	97.2%
	Researchers and Academia	4.4%	13.9%	10.2%	9.2%

Characteristics	Variables	Transition	Guinea Savannah	Sudan Savannah	Total
The major CA training?	Private extension agents	4.1%	9.9%	1.8%	5.9%
	Friends	30.7%	21.1%	13.3%	23.6%
	NGO	31.2%	41.3%	28.9%	34.7%
	Others	3.3%	1.8%	3.0%	2.7%
What crops are you growing in your CA system?	Maize	86.6%	87.5%	93.9%	88.4%
	Rice	5.4%	16.4%	8.0%	10.7%
	Cassava	37.7%	8.9%	0.0%	17.8%
	Cowpea	31.5%	34.1%	45.8%	35.4%
	Sorghum	2.8%	26.3%	24.2%	17.3%
	Millet	3.8%	20.6%	33.3%	16.9%
	Vegetables (Cabbage, Tomato, pepper)	22.0%	9.6%	6.4%	13.6%
	Mucuna	0.4%	0.8%	0.4%	0.6%
	Stylo	0.0%	0.0%	0.0%	0.0%
	Cajanus cajan	0.0%	2.0%	0.0%	0.9%
	Crotolaria	0.0%	0.0%	0.0%	0.0%
	Groundnut	30.1%	59.0%	12.9%	39.4%
	Others	32.3%	18.5%	28.0%	25.4%

Source: Field Results (2019)

3.5 : Practices that promote climate change adaptation and mitigation

This section presents CA/CSA practices with potential to improve adaptive capacity of farmers to climate change and variability and remove/reduce greenhouse gases. The practices as presented in Box 1 were identified by district participants as being indigenous to them for several years. Currently practices not helpful to the environment such as slash-burning, and shifting cultivation are dropping out of the system. The benefits of the practices regarding yield improvement, soil moisture retention, erosion control, chemical fertilizer usage and labour (manual) reduction were used as criteria for responding to both adaptation and mitigation outcomes. A matrix scoring assessment and prioritization of the identified practices was done by the PRA participants across the three ecological zones.

Box 1: Indigenous CA practices across the three ecological zones

Mix cropping, Bullock/donkey plough, zero tillage, dibbling, mounds, crop rotation, slash and burn, manure application, intercropping, cover cropping, trees on farms, long dura. on crop varie es, land fallowing.

The results presented in Table 7, derived from the consensus ranking of CA practices by participants during the PRA suggest that priorities in the use of the practices for adaptation and mitigation will vary from one location to the other. This may therefore serve as guide to the type of practices to be promoted for the various locations across the ecological zones studied.

Table 7 : Prioritized CA/CSA practices promoting climate change adaptation and mitigation in three agro-ecological zones

Practice	Ecological Zone		
	Transitional	Guinea Savannah	Sudan Savannah
Cover cropping	1st	2nd	-
Mulching	2nd	4th	3rd
Minimum tillage	6th	6th	6th
Crop rotation	3rd	5th	5th
Intercropping	5th	3rd	4th
Zero tillage	7th	-	8th
Trees on farms	4th	7th	7th
Bunding	-	1st	1st
Compost/Manure	-	-	2nd

Source: Field Results (2019)

Mulching is important to the farmers both for mitigation and adaptation purposes. It reduces evaporation, conserves soil moisture, reduces soil temperature and improves soil structure.

Cover cropping is not ranked among the first eight practices in the Sudan Savannah but places first and second in the transitional and Guinea Savannah zones, respectively. The practice is important in the control of weed, reducing erosion and increases the fertility of the soil. Bunding (earth or stone) does not appear at all among the list within the transitional zone but is ranked first in the Guinea Savannah and Sudan Savannah. It is important because the bunds prevent soil erosion and conserve the available rainfall water for the crops. In the Sudan Savannah zone stone bunding is more popular as compared to earth bunding.

Intercropping is used in all three zones and places between first and 5th in all three. It is used by farmers as a means of making maximum use of the land available, considering that land is now less available than in the past due to other competing demands. Another reason for its use is because farmers want to assure all year round food security in the household. Participants indicated that culturally the young and unmarried people are not interested and are not expected by the community to practice intercropping since they do not have families to feed. Women are especially interested in intercropping since it ensures crop diversification for supporting domestic nutritional purposes. The youth are noted for not practicing intercropping but rather mono-cropping because their focus is more on incomes than household food security. Intercropping also controls weeds on the farm, and reduces cost of labour.

Manure/composting is ranked second in the Sudan Savannah. In those districts, they either use cow dung or prepare their own compost from both household and farm organic material. The use of compost /manure helps in water retention and improving the soil structure. Although compost preparation is tedious the farmers have been realizing tangible benefits from the practice over the years from same plots.

Minimum tillage was ranked 6th in all three zones while zero or no-tillage placed 7th in the transitional zone and 8th in the Sudan zone. The ranks were obtained based on the following criteria improvement of crop yield, improvement of soil moisture, reduced labour, low use of mineral fertilizer and reduced erosion.

3.6 : CA adoption and practice among smallholder farmers and their perceptions

Ghanaian farmers like others in the sub-Saharan Africa adopt numerous strategies to enhance resilience to and mitigate the incidence of climate change. Among such key strategies is the concept of Conservation Agriculture. Table 9 shows the system of CA/CSA practices undertaken to improve and sustain yields and the farm production resource base among farmers in the transitional, guinea Savannah and Sudan Savannah agro-ecological zones covering parts of the middle belt and whole of northern Ghana. In general farmers in the zones are using not less than 20 practices and deriving various benefits such as the following:

- Drought toleration/maintains moisture
- Less requirement for fertilizer as it does not leach out of the soil
- Higher and stable yield of crops
- Reduced soil erosion/soil conservation/increased soil fertility
- Possibility of early planting/early harvest
- Reduced labour and inputs costs
- Enhanced coping mechanisms for climate shocks/variation
- Improved household food security

It is observed from the results shown in Table 8 that crop rotation is the predominant CA practice as majority of the farmers (80%) are using it to ensure sustainable production but there are agro-ecological zone differences in terms of adoption. Similar results were obtained from the participatory rapid CA appraisal at the district level.

Table 8 : Adoption of CA Practices by Agro-Ecological Zones (percentage distribution)

Practices	Proportion of Farmers			
	Transition	Guinea Savannah	Sudan Savannah	Pooled
Improved genetic materials (seeds/breeds)	64.6	49.2	63.8	57.3
No/zero tillage	44.6	12.5	10.3	23.2
Minimum tillage	80.4	41.7	28.2	52.5
Bullock tillage	0.4	7.8	74.1	18.0
Tractor tillage	17.8	68.9	20.6	41.9
Mulching	63.5	17.5	27.9	35.4
Cover cropping	36.7	30.6	39.5	34.4
Crop rotation	**77.4**	**81.9**	**78.7**	**79.8**
Integrated pest management	44.1	22.6	19.3	29.4
Agroforestry/Trees on farms	28.0	20.0	11.3	21.1
Erosion control structures e.g. bunds	35.7	27.8	45.9	34.0
Use of chemical fertilizers	63.3	79.9	72.1	72.7
Use of manure/composting	30.9	44.0	**73.1**	45.1
Integrated nutrient management	25.0	10.1	27.6	18.6
Green manuring	12.2	5.4	2.3	7.2
Water conservation e.g. planting pits	28.5	7.5	7.6	14.8
Irrigation	14.4	9.9	15.3	12.5
Crop-livestock integration	26.9	20.0	30.2	24.3
Climate Advisory Services	43.0	25.4	8.0	28.1

Source: Field Survey (2019)

The number of years farmers have used these practices ranged from 3 – 22 years and may confer a level of adoption of the practices. The details on the duration of use are presented in Table 9. No/zero tillage and minimum tillage were discovered as age-long practices in the Transition zone. Similarly, minimum tillage and tractor tillage were the age-long practices in the Guinea Savannah zone, whereas crop-livestock integration and minimum tillage (bullock) were the age long practices in the Sudan Savannah agro-ecological zone of Ghana. These observations largely reflect the real cases since the soils in Sudan Savannah are shallow and less fertile and require the manure to improve at the same time the animals survive on the crops residues.

The topography in most parts of the Guinea Savannah are generally flat with deep and less rocky soils, which tend to support tillage of various degrees. For the Transition zone, higher vegetative cover with trees tend to restrict optimum tillage practices. The high vegetative cover basically serves as a source of mulch for the crops. Years of CA /CSA practice index (number of years zonal

practice/years of practice total) more than one (> 1) revealed that respondents in the Transitional zone were seniors only in the use of zero tillage practice compared to the Guinea and Sudan Savannahs. The Guinea and Sudan Savannahs appeared quite advanced in age (practice index >1) in employing most (10-12) of the practices likely to confer a certain level of rich experiences in knowledge and skills application of the practices for innovation.

Table 9 : Duration (years) of respondents using CA/CSA practices by ecological-zones

CA/CSA Practices	Years of practice			
	Transition Forest-Savannah	Guinea Savannah	Sudan Savannah	Pooled
Improved genetic materials (seeds/breeds)	6	8	6	6
No/Zero tillage	12	6	10	10
Minimum tillage	11	14	11	12
Bullock tillage	10	11	18	17
Tractor tillage	7	14	10	12
Mulching	10	13	8	10
Cover cropping	8	11	12	10
Crop rotation	10	13	11	12
Agroforestry	8	8	11	8
Erosion control structures e.g. bunds	5	11	10	9
Use of chemical fertilizers	7	12	10	10
Integrated nutrient management	6	6	12	8
Green manuring	3	12	10	7
Climate advisory services	6	7	8	6
Water conservation e.g. planting pits	4	7	7	5
Irrigation	6	13	12	10
Integrated pest management	6	5	6	6
Crop-livestock integration	9	11	22	13

Source: Field Results (2019)

The study further considered the proportions of farmer adoption, coverage and gender dimensions regarding the CA practices within the agro-ecological zones. From Table 10, use of herbicides (no/zero till), intercropping and crop rotation are the top three commonly adopted CA practices and have the widest coverage in the guinea Savannah agro-ecological zone. The youth adopt more use of herbicides and crop rotation because they often focus on income generation and therefore practice mono-cropping on medium to large scale farms. Fewer women are into crop rotation because they do not generally own lands and with the drive to ensure food security in the household, they concentrate on intercropping.

For the Sudan Savannah zone, intercropping, herbicides use and composting/manure are the top three commonly adopted CA practices and have the widest coverage within the zone. The men are owners of the livestock and therefore have full access to and control over the use of compost/manure in the household, hence their dominance in the practice.

In the transitional zone, use of herbicides, intercropping and mulching are the top three commonly adopted CA practices and tend to have the widest coverage within the zone. The men dominance in mulching may largely be due to the fact that they cultivate more yams, which goes along with mulching as a CA practice.

The youth and the men use more herbicides in the Savannah zones perhaps because they are better resourced financially compared to the women and can thus afford the application services comprising the chemicals, equipment/tools, labour and training. In general, the men and the youth are more income-focused and tend to cultivate large hectares, which require quick and low-cost services. They therefore adopt less intercropping because of their focus on income generation and often practice mono cropping.

Apparently, more women use intercropping than men and youth in all the zones, which may imply that the women are more conscious and have the drive to ensure food security in the household. It is evident that the adoption of herbicide as no/zero till practice and intercropping is common to all the three agro-ecological zones under study. This is an indication that the farming and production systems within the zones are geared towards both income and food security. The use of herbicides could also be attributed to scarce labour (for land preparation and weed control) and limited access to tractor services as discovered during the participatory rapid CA/CSA appraisal sessions in the zones.

Fallow as CA practice is less practiced in the various agro-ecological zones because of limited access to arable lands due largely to increasing human population and degradation via bushfires and indiscriminate felling of trees.

Table 10 : CA/CSA practices and perceived level of adoption by gender in 3 ecological zones

	% Farmer adoption	% Zonal coverage	Male %	Female %	Youth %
1. Guinea Savannah					
No/zero till (herbicides)	**89.0**	**100.0**	**90.0**	**71.0**	**81.0**
Minimum Tillage	42.0	55.0	46.0	38.0	49.0
Intercropping	**80.0**	**89.0**	**87.0**	**90.0**	**74.0**
Crop Rotation	**76.0**	**90.0**	**85.0**	**61.0**	**78.0**
Cover Cropping	37.0	53.0	45.0	44.0	42.0
Trees on Farms	73.0	80.0	73.0	76.0	76.0
Mulching	75.0	80.0	77.0	78.0	69.0
Fallow	**8.0**	**10.0**	**10.0**	**0.0**	**3.0**
Compost/ Manure	24.0	28.0	22.0	29.0	15.0
Contour Planting	9.0	9.0	9.0	6.0	9.0
Bunding	29.0	42.0	30.0	27.0	32.0
Improved Varieties	60.0	70.0	61.0	58.0	56.0

2. Sudan Savannah

CA/CSA Practice	% Farmer adoption	% Zonal coverage	Male %	Female %	Youth %
No/zero till (herbicides)	**85.6**	**96.0**	**89.6**	**82.0**	**100.0**
Bullock Ploughing	52.0	57.0	55.0	49.0	38.0
Minimal soil disturbance	6.0	6.0	6.0	4.0	2.0
Inter Cropping	**88.0**	**100.0**	**82.0**	**90.0**	**58.0**
Crop Rotation	18.0	22.0	15.0	4.0	2.0
Cover cropping	20.0	20.0	20.0	20.0	20.0
Trees on farms	56.0	58.0	59.0	58.0	41.0
Mulching	34.0	68.0	72.0	33.0	56.0
Fallow	**6.0**	**4.0**	**6.0**	**6.0**	**2.0**
Composting/Manure	**81.0**	**68.0**	**59.0**	**31.0**	**12.0**
Rotational Grazing	20.0	20.0	20.0	20.0	20.0
Bunding	30.0	32.0	20.0	24.0	18.0
3. Transitional					
No/zero till (herbicides)	**88.9**	**97.5**	**95.0**	**85.3**	**81.7**
Minimum Tillage	51.8	53.4	64.1	55.4	59.6
Cover Cropping	32.5	39.2	29.2	35.9	30.9
Crop Rotation	55.6	64.0	52.3	57.3	44.0
Fallow	**22.5**	**40.0**	**36.7**	**13.4**	**15.0**
Compost/Manure	26.7	49.2	59.2	48.0	34.2
Intercropping	**93.4**	**97.5**	**84.2**	**90.9**	**75.9**
Mulching	**83.4**	**88.8**	**80.1**	**67.9**	**53.8**
Trees on Farms	37.9	46.3	46.3	47.9	36.3
Agroforestry (mango, cashew, teak)	31.7	33.3	30.0	16.7	11.7
Improved Varieties	88.4	93.4	85.9	80.0	88.4
Improved livestock management	12.9	12.9	12.9	7.9	6.7
Fertilizer use	15.0	15.0	15.0	15.0	15.0
Bee Keeping	0.3	22.5	0.3	0.0	0.3

Source: Field Results (2019)

3.7: Challenges and Possible solutions associated with promotion and adoption of CA Practices

Zero Tillage/Minimum Tillage/Selective herbicides

Primarily, zero tillage/minimum tillage/selective herbicides use have positive impact on soil fertility improvement that translates into enhanced productivity and increased incomes if properly managed. No till CA farming practice has implicit reduction in cost of tillage equipment. However, decisions on no till requires some appreciable level of expertise in soil conditions, timing and initial investment in start-up fertilizer to enhance productivity during the first three years. In terms of soil conditions for example, the use of no till will be less challenging on well-drained soils.

The primary reason for adopting minimum tillage has traditionally been for erosion control, improvement in soil structure and moisture conservation.

High cost of labour has been a major push factor influencing farmers' adoption of the use of selective herbicides across all ecological zones. Challenges enumerated by farmers during the Participatory Rapid Assessment (PRA) interactions include health and environmental hazards, high cost of herbicides although still economical low as compared to high cost of labour, extinction of some plants and animal species and emergence of new weed species. The environmental impact of herbicide use will need a more in-depth assessment to determine its CA effectiveness on the balance. Other challenges mentioned by farmers are difficulty in practicing no till or zero tillage on large farm sizes.

Regarding possible solutions to challenges associated with agro-chemical abuse, farmers proposed training on the use of selective herbicides and appropriate use of agrochemicals in general. Some farmers also complained about low yields at the initial stages which could be corrected by the use of start-up fertilizer

Use of Compost/Manure/Mulching

Participants indicated that despite the advantages of using compost and manure the bulky nature of the material makes transportation difficult. The coping mechanisms they used was to package into smaller units. With mulching, the challenges expressed were the threat of fires and termite infestation.

To cope with mulch catching fire farmers create fire belts by clearing around the farms to avoid fire crossing over from adjoining farms.

Crop Rotation

Crop rotation has enormous advantages including potential in increasing soil fertility and soil nutrients content, increasing yields, reducing soil erosion, limiting concentration of pests and diseases, reducing stress of weeds among others.

The primary disadvantage of crop rotation is that it requires increased expertise, equipment, and differing management practices. **Coping strategies** include effective crop management and carefully selected crops for the rotation sequence**.**

Intercropping

Intercropping allows for optimum use of land, complementary use of plant resources (Crops such as cowpeas release nutrients into the soil for the benefit of others), checks soil erosion, conserves soil moisture content, diversification of farm income, weed suppression and reduction in susceptibility to pests and diseases. Despite the advantages, inter-cropping comes with challenges including poor yield if the crop combinations are not carefully chosen to ensure compatibility. Other challenges mentioned by farmers are that inter-cropping could be labour intensive at harvesting as compared to a mono-cropping system. **Coping strategies** include effective crop management and carefully selected crop combinations**.**

Crop & Livestock/Poultry Integration

Crop-livestock integration farming system allows for efficient use of crop residue and fodder for feeding livestock while using livestock manure for plant growth in a system of nutrient recycling (circular economy). The benefit of this system is dependent on the type of manure. For example, Poultry manure, which was commonly used in some districts in the transitional agro-ecological zone, contain high quantities of nitrogen while manure from ruminants contain high quantities of carbon. Challenges associated with the crop-livestock integration include destruction of crops by animals, communal conflicts, poor livestock management practices, poor housing infrastructure for the animals, diseases and lack of veterinary services.

Cross-cutting constraints and coping strategies

- Erratic rainfall pattern – Coping strategies include reforestation; avoid bush burning, irrigation, phasing out planting times; plant early maturing varieties; increase tree planting;
- Loss of soil fertility - improved land management: land and crop rotation; education on excessive use of chemical fertilizer, weedicide etc.
- Lack of Access to Funding - Strengthen FBO to enable them source credit and input. For example, Village Savings and Loans Associations (VSLA)
- Inadequate land for agriculture and land tenure challenges - Use of technologies such as intercropping, maximum use of available land through row planting and optimum planting use of marginal lands
- Difficulty of adoption of introduced technologies by farmers - Continuous dissemination of information and skills development
- Inadequate machinery e.g. tractors - Use of power tillers, hoes and use of zero tillage, organize farmers into functional groups to seek support for machinery. For example in Tolon, unreliable and inadequate tractor services were coped with alternative land preparation methods e.g. construction of ridges with hoes
- Post-harvest Losses - Meeting standards (high cost of aflaxsafe to reduce aflatoxins), lack of storage facilities

  High Cost of Labour - Inadequate labour to support harvesting of large acreage farms. Farmers are coping with the use of herbicides
- Challenges with Marketing: Buyers determine prices especially aggregators; Strengthen existing FBOs, Use of standards e.g. scales. Poor road network affects transport of produce
- Unavailability of ready market for food commodities resulting in low pricing - Formation of farmer groupings or association for advocacy
- Fewer extension staff and inadequate access extension service - Farmers continue to use their old methods
- Inadequate irrigation facilities
- Land tenure issues and indiscriminate encroachment of agricultural farm lands
- Poor road networks affecting transport produce to market centers
- No voice for FBOs
- Low attention to livestock sector. Improved livestock/poultry management would improve yields of crops in an integrated

From Table 11, the primary opportunities or advantages from CA practices identified from the household level interviews are the maintenance of soil moisture and improvement in yields overtime as reported by 61 percent and 63 percent of the total sample interviewed respectively. Fifty eight percent (58%) of the total sample interviewed indicated that CA practices offers the opportunity to improve on household food security. Again, more than half (54%) of the farmers interviewed at the household level expressed advantages of CA including reduced soil erosion and increased soil fertility

As shown in the Table 11 below, challenges facing farmers are in relation to CA practices include bushfires destroying crop residues/biomass expressed by 58% of the sample interviewed, lack of money to buy herbicides (45% of sample interviewed responding), limited labour to apply CA on a large area due to unavailability of CA equipment (42%) of the sample interviewed responding.

About eighteen percent (18%) of the sample interviewed expressed concerns about the time lag before enjoying benefits of CA. Other challenges mentioned at the household level include limited or absence of extension information flow on CA equipment (23% of the sample interviewed responding), lack of commodity market for some crops such as soybeans and other legumes and socio-cultural issues such as land tenure challenges and in some cases taboos associated with mixing certain crops on farm (8% of the sample interviewed responding).

Table 11 : Advantages and Challenges of CA Practices at the household levels across agro-ecological zones

What do you see as the main advantages of CA for your Household?	Transition Forest-Savannah	Guinea Savannah	Sudan Savannah	Total
Soil Moisture Retention	71%	58%	50%	61%
Less requirement for fertilizer as it doesnot leach out of the soil	51%	45%	44%	47%
Higher and stable yield of crops	66%	63%	56%	63%
Reduced soil erosion/increased soil fertility	59%	51%	50%	54%
Possibility of early planting/early harvest	42%	37%	31%	37%
Reduced labour and inputs costs	23%	33%	24%	28%
Enhanced coping mechanisms for climate shocks/variation	32%	15%	16%	21%
Improved household food security	59%	52%	67%	58%
Reduced pest and diseases	30%	22%	18%	24%

What do you see as the main challenges of CA for your Household?	Transition Forest-Savannah	Guinea Savannah	Sudan Savannah	Total
Lack of tools, animals or tractors for ripping, planters, etc.	40%	42%	42%	42%
Bushfires destroying crop residues/biomass	71%	55%	44%	58%
Lack of money to buy herbicides	46%	49%	32%	45%
Difficulty in obtaining legume seeds	8%	16%	23%	14%
Limited labour to make CA for a large area	32%	26%	34%	29%
The difficulty of digging basins in dry, hard soil	17%	9%	15%	13%
Lack of commodity market for soybeans and other legumes	13%	20%	27%	19%
More weed pressure when ploughing is not utilized	15%	21%	17%	18%
Weeding is hard work	51%	27%	16%	33%
Time lag before enjoying benefits of CA	23%	10%	26%	18%
Limited or absence of extension information flow on CA	18%	25%	28%	23%
Taboo for household to mix certain crops on farm	13%	6%	4%	8%

Source: Field Survey Results (2019)

District Specific challenges and possible solutions disaggregated by the various ecological zones are presented in Appendices 2-5.

3.8: PESTEL I Analysis for CA promotion and practice in Ghana

Political, Economic, Social, Technological, Environmental, Legal / Institutional (PESTELI) Analysis done at the national level was downscaled at the district and municipal levels. Participatory Rapid CA Appraisal (PRA) and summarized in Table 12.

POLITICAL

It is evident from the analysis of the Political space for CA promotion and practice in all the Agro-ecological Zones of Ghana through the studies conducted in the selected districts that several initiatives, plans and policies put in place by the Government support CA practice.

These include but not limited to subsidies on farm inputs including FASDEP II / GHAIP, Planting for Food and Jobs (PFJ) /RFJ/P, Fertilizer subsidy, Planting of Export and Rural Development (PERD), Ghana Agricultural Engineering Policy (GAEPS) (possibility of CA having its own type of mechanization equipment), Tree Crops Policy, Decentralization Policy, Ghana irrigation policy, Agricultural extension policy, National Climate Change policy, CSA Action plan, FBO Strategy, Gender in Agriculture development strategy.

All the Districts and Municipalities visited were seen to have put in place plans aligned with some of the national policies that has the potential to enhance the promotion and practice of CA within their jurisdiction. The Medium-Term Development Plans for all the Districts sampled were linked to the Agenda for Jobs: "Creating Prosperity and Equal Opportunity for All" policy objectives with key focus areas including Private Sector Development, Growth and Development of MSMEs, Agriculture Productivity. Other projects and interventions include Green Innovation Centre (GIC) by GIZ, Post-Harvest handling of Cocoa by Amplify Ghana, Dedicated Grant Management (DGM), Business Resource Centers (BACs) under Rural Enterprise Project (REP).

ECONOMIC

It was observed that available labour was inadequate and costly across all the agro-ecological zones. Access to credit (capital) is limited if at all available to men, women and the youth yet more favorable towards women in most areas due to their ability to service their debts better than their male counterparts and the youth. The ability of women to service their debts better was attributed in some cases to their engagement in petty trading to earn extra income than their male counterparts.

Village Savings and Loans Associations (VSLA) exist in some areas and are only helpful to members of the association. Contract farming, locally known as "advance" which is the pre financing (but limited informally from individuals) exists in some areas and when the produce are ready, the farmers pay back either in kind or cash in accordance with earlier agreements or the prevailing rates. Access to land resource which is critical for economic growth is limited for women in areas where the customary laws do not allow women to own lands.

The youth like the women in most areas were economically trapped due to limited access to credit yet vibrantly engaged in agriculture due to the perceived economic potential. It was also notable that farmers wished to have premium prices for niche market cash crop like Cashew similar to that of the Ghana Cocoa Board. Prices in most cases were determined by aggregators including officially established institutions e.g. Produce Buying Company of Cocoa Board

Marketing of farm produce seem to be the greatest challenge of farmers across all the agro-ecological zones. High rates of post-harvest losses were observed across all the agro-ecological zones because of inadequate numbers of storage facilities, silos and warehouses. Stakeholders were of the view that (i) Government should assist farmers with farm machinery and implements (ii) the district assembly must build warehouses for crop produce in other to avoid post-harvest losses (iii) farmers should be linked to market outlets to sell crop produce, and (iv) most interventions in CA should cover the entire commodity value chains.

SOCIAL

The land tenure system varies across the agro-ecological zones with some areas permitting the outright purchase of land with title papers (accessibility, ownership and control) and others not. Social practices like *Abunu* (50:50), *Do di di* (staples belong to the farmer with the main cash crop for the owner of the land) and *Ahayin* (renting/hiring for cash) was consistent in the areas as permitted by their customary laws with the participation of women. Social norms and taboos like "*Nkyida* - days forbidden to go farming" which fall on different days in the different agro-ecological zones, raring of some animals like goats and pigs was a taboo in some areas.

Women were not previously allowed in some areas to cultivate some crops but now women could cultivate any crop depending on the level of financial standing. Men have more access to mechanization because they are predominantly into cash crops and have bigger farm sizes than women who are into food security crops with smaller farm sizes. The youth are particularly into short duration maturity crops.

Tree tenure issues also exist in certain areas with women not allowed to plant and or own trees in some districts (for example Talensi). Women in some areas are not fortunate to get productive lands and only have access to marginal lands for farming if at all. However, it was observed that women were allowed to inherit productive lands from their deceased spouse as noted in Talensi.

In the reconnaissance survey, gender and socio-cultural issues with access and control of productive resources particularly land came up strongly in the Sudan Savanna and Guinea Savannah Agro-ecological zones. The study recommended the critical role of traditional authorities in solving land tenure issues in the Conservation Agricultural system in Ghana.

Some specific festivals that promote CA practices were mentioned by the PRA participants. For example, the festival of the people of Lawra has now become a platform for educating farmers on anti-CA practices e.g. bush burning. Other festivals are farming related e.g. yam festivals, which is used for celebrating good farming practices for good harvests.

Other socio-cultural issues have been detailed in the reconnaissance survey report including strategies for Breaking down gender stereotypes by encouraging women to take-up male dominated tasks, Use of gender champions and Advocacy groups, Promoting CA through women crops and livestock and Mainstreaming gender in CA related projects.

TECHNOLOGICAL

Access to mobile phones is universal but men and the youth have more access than women. With the phones farmers are able to access agricultural information. Most farmers seem to have received some kind of training in principal technologies for CA including: minimum till, cover cropping, crop rotation, trees on crop land, mulching and succession cropping

Men, women and the youth all have access to appreciable technical know-how with the youth having extended know-how in modern technology (ICT). Youth (20 years to 45years) have undergone one form of training or the other on the use of agro-chemicals, ICT, standard until measurement, storage / warehousing, agro processing value addition e.g. Cassava – Gari processing machines / packaging – visibility.
CA mechanization operators have been trained in some areas.

ENVIRONMENTAL

Inappropriate use of machines and chemicals caused complications on the CA environment. The environmental factors discussed in relation to water resources includes; some water perennial water bodies becoming seasonal, reduction in volume of water bodies during the dry season and pollution of water bodies by animals e.g. Cattle, and Pigs.

The environmental factors discussed in relation to forest reserves includes; depletion of the natural forest due to excessive logging but there are some plantations by individuals and the state, charcoal production activities, Bush fires which is on the increase and scarce resources of forest timber species such as Mahogany, Paaph, Sheanut trees, Wabre and Odum. Group hunting and burning of the bush is a huge challenge in some of the areas visited.

LEGAL / INSTITUTIONS

It was interestingly observed that a huge knowledge gap exists about the laws between the National level and the District Level across all the agro-ecological zones of Ghana.

There were no by-law on bush burning in most areas and little or no enforcement of such by-laws where they existed. In any case it was difficult monitoring the farming areas to arrest culprits. Even when arrests were made, the bonds of family relationships inferred with imposing sanctions. According to participants, by-laws on bush fires/burning are no longer effective but this is critical for CA promotion.

Farming along river banks was largely banned. Though taboos were observed in some communities, the enforcement of the taboos has lessened in some other communities , thus , the ban is being violated in some communities with the excuse that these were the most fertile lands or that with the scarcity of lands, such lands close to the river banks could be farmed.

Traditional authorities and rulers play a key role in the provision of land, settling disputes and conflicts among actors. Fishing in sacred rivers is prohibited by sacred customary laws. In many communities, without the traditional authorities, there would have been total breakdown of law and order in the respective societies.

Environmental legislations by Forestry Commission (Forestry Commission Act), Environmental Protection Agency (Environmental Policy), Chemical Registration Act, Seed Law, land related laws were discussed.

Some identified key institutions that could play critical roles in promoting CA in all the agro-ecological zones include:

- Traditional Authorities for land access and conflict resolution to allow for investment in soil improvement
- Development partners and – funding and technical support
- Municipal Assembly – policies and on the ground action
- Processors, Traders and Marketers – Catalyze of the CA implementation
- Input supplies and mechanization
- Academia and research institutions – research purpose
- NGOs and CSOs - mobilization and technical support
- MDA and MMDA – policies and on the ground action
- Private sector – Catalyze of the CA implementation

Farmers have strong relationship with institutions such as Department of Agriculture, Fire services, Input dealers, Transporters, Tractor operators and the Forestry Department.

Other institutions existing in the agro-ecological zones include:

Various work related Women Associations including petty trading, farming, rearing of livestock, Food banking (that is buy food products and sell during the lean season).

Participants at the PRA expressed the need to build capacities of Farmer-based Organisations (FBOs) and Community-based Organisations (CBOs). Expansion of the use of mass extension methods e.g. farmer field schools, nucleus-farmer out-growers schemes, extension fields in the districts through mass education via radio, TV, Junior Farm Field and Life School (JFFLS), communication vans, for knowledge dissemination to the CBOs and FBOs need to be encouraged and enhanced.

Table 12 : Political, Economic, Social, Technological, Environmental, Legal / Institutional (PESTELI) Analysis

POLITICAL	Political (Policy documents and initiatives): ► Government subsidies on farm inputs ► FASDEP II / GHAIP ► PFJ/RFJ/P ► Fertilizer subsidy ► PERD ► Ghana Agricultural Engineering Policy (GAEPS) – CA has its own type of mechanization ► Tree Crops Policy ► Decentralization Policy ► Ghana irrigation policy ► Agricultural extension policy ► National Climate change policy ► CSA Action plan ► FBO Strategy ► Gender in Agriculture development strategy (also see CA/CSA policy and programmes review, 2019) document deliverable. ► Global commitments (NDCs, Paris Agreements, CAADP, AUDA-NEPAD on CSA and SDGs)
ECONOMIC	Labour (inadequate and costly) Capital (access to credit) – Limited Premium price niche market – Cashew Machinery for planting – Sticks and Cutlasses Available human resource/ existing knowledge CREDIT Favourable to women because they then to service their debts better than men do in their area. Men Access to credit is Limited Women Labour (drudgery) Access to land, credit. YES Women pay and have easier than men Youth Access to resources (land, credit)
SOCIAL	Land tenure system – One can buy land outright with title papers (accessibility, ownership and control) ► Abunu (50:50) ► Hiring (Renting; Ahayin) pay cash) also applies to the women. ► Outright buy land- cash/ title ► Do di di staples belong to the farmer with the main cash crop for the owner Social Norms & Taboos: example “Nkyida - days forbidden to go farming” which falls on different day. Goat raring is not allowed in some areas and parts of the Jaman South Municipality

TECHNOLOGICAL	Technological Analysis (Principal technologies for CA) they have received training on includes: ► Minimum Till ► Cover cropping ► Crop rotation ► Trees on crop land ► Succession cropping ► Men have access to technical know-how. ► Women equally have access to technical know-how. ► The Youth also have access to technical know-how and modern technology (ICT)
ENVIRONMENTAL	Analysing from the climate change perspective, the following impact area on Ghana's agriculture were listed. ► Unreliable ► Rainfall pattern ► Early cessation ► Erratic rainfall ► Invasive pest - FALL ARMY WORM (FAW) Analysing from the climate change perspective, the following impact area on Ghana's agriculture were listed. ► Drought ► Poor soils Inappropriate use of machines and chemicals caused infractions on the CA environment.
LEGAL / INSTITUTIONS	Laws at National not seen at District Level (Lack knowledge on most legal issues). ► By-laws on bush burning. ► Farming along river banks is banned. Penalty: Chief's Palace, fined, pacify the gods. ► Fishing in sacred rivers is prohibited. Penalty: gods will deal with person ► By-law on the confinement of animals (housing of small ruminants (SR), intensive livestock farming) exists for the owners to pay the compensation All environmental legislation – Environmental Action plan (EIA), Forestry Commission Act, Plant and Fertilizer Act, Chemical Registration Act, Seed Law, land related laws were mentioned. Some key institutions (though generic) that play lead roles in promoting CA in Ghana were listed as: ► The academia and research institutions – research purpose ► Development partners ► Ministries Departments and Agencies – Policies, programmes and plans ► Metropolitan, Municipal, District Assemblies – On the ground implementation ► Private section – Catalyse of the CA implementation ► Input supplies and mechanization ► NGOs and CSOs Lack of knowledge on these legal documents – "SO THAT WHEN YOU SEE SOMETHING YOU CAN SAY SOMETHING" (Stephen Asante, a participant).

Source: Field Results (2019)

3.9: Market arrangement in support of sustainable CA adoption and practice

The study discovered that the adoption of the CA practices is associated with increased productivity of the smallholder farmers. This is evident in the fact that majority of the respondents (98.2%) indicated agreement to the assertion. However, marketing of the commodities produced from farmer adoption of CA practices was a critical challenge. The results in the Table 13 below show that over 95% of the farmers within three selected agro-ecological zones agreed to the statement that marketing and unfair pricing remains a huge challenge in the adoption and use of CA Practices. Additionally, a range of 13% – 27% of the farmers within the entire zones indicated the lack of commodity market for soybeans and other legumes during the farming season.

Table 13: Level of agreement by respondents on statements likely to affect CA/CSA Adoption

Level of Agreement	Transition		Guinea Savannah		Sudan Savannah		Total	
	Count	N %	Count	N %	Count	N %	Count	N %
CA Practices are associated with increased productivity of the smallholder farmer								
Completely agree	432	80.0%	534	74.1%	239	79.7%	1205	77.2%
Partly agree	107	19.8%	165	22.9%	56	18.7%	328	21.0%
Do not agree	1	0.2%	22	3.1%	5	1.7%	28	1.8%
Marketing and unfair pricing remains a huge challenge in CA Practices								
Completely agree	373	69.1%	462	64.1%	211	70.3%	1046	67.0%
Partly agree	135	25.0%	226	31.3%	83	27.7%	444	28.4%
Do not agree	32	5.9%	33	4.6%	6	2.0%	71	4.5%

Source: Field Results (2019)

In line with the marketing challenges, there is a high level of perception that a successful CA promotion should be market-led. It is evident therefore that CA adoption and practice will increase if farmers are able to market the produce resulting from the increased productivity associated with CA. However, some school of thought argue that quality and standards of the produce currently being delivered by farmers to the market needs to be improved alongside cutting down production cost inefficiencies. Programmed cropping of certain commodities is also believed to likely beat glut periods in order to benefit from demand and supply high pricing.

Major crop and livestock commodities produced for sale include the following presented in Box 2. These commodities appear to cut across all the three studied agro-ecological zones.

Box 2: Main crops and livestock produced under CA across the zones

Crop commodities
Maize, Vegetables, Yam, Plantain, Cocoyam, Soya, Sorghum, Millet, Rice, Groundnut, Cowpea
Other Crops (cashew, mango)

Livestock commodities
Cattle
Goats, Sheep
Pigs, Poultry

Farmers within the various zones market their produce from CA systems within the locality, outside the locality or through both marketing outlets. The details of the commodities and the marketing places are presented in the Table 14 below. It is observed that majority of the farmers sell their produce within their localities though there are zonal disparities. In general, these findings show that smallholder farmers are market-oriented while addressing their domestic staple food needs.

Table 14 : Place for marketing produce by Agro-Ecological Zone

Commodity	Marketing	Transition	Guinea Savannah	Sudan Savannah	Total
Maize	Within the locality	51.8%	45.5%	56.9%	49.8%
	Outside the locality	20.4%	12.9%	23.1%	17.3%
	Both within and outside the locality	27.8%	41.6%	19.9%	32.9%
Soya	Within the locality	68.8%	36.3%	56.5%	44.0%
	Outside the locality	12.5%	15.8%	15.9%	15.7%
	Both within and outside the locality	18.8%	47.8%	27.5%	40.3%
Sorghum	Within the locality	25.0%	54.0%	69.2%	58.3%
	Outside the locality	43.8%	18.8%	16.5%	19.1%
	Both within and outside the locality	31.3%	27.2%	14.3%	22.7%
Millet	Within the locality	44.8%	51.7%	56.9%	53.3%
	Outside the locality	41.4%	10.0%	22.8%	17.5%
	Both within and outside the locality	13.8%	38.3%	20.4%	29.1%
Groundnut	Within the locality	52.0%	49.2%	65.0%	52.6%
	Outside the locality	18.7%	14.7%	8.1%	14.4%
	Both within and outside the locality	29.3%	36.1%	26.8%	33.0%
Cowpea	Within the locality	48.5%	36.6%	55.1%	45.2%
	Outside the locality	29.2%	20.0%	14.7%	21.0%
	Both within and outside the locality	22.3%	43.4%	30.1%	33.8%
Rice	Within the locality	52.7%	33.2%	59.5%	43.0%
	Outside the locality	30.9%	21.3%	20.6%	22.2%
	Both within and outside the locality	16.4%	45.5%	19.8%	34.8%
Vegetables	Within the locality	51.0%	34.5%	57.1%	45.9%
	Outside the locality	16.1%	16.8%	18.4%	16.7%
	Both within and outside the locality	32.9%	48.7%	24.5%	37.4%
Yam	Within the locality	39.0%	37.6%	0.0%	38.4%
	Outside the locality	27.0%	12.9%	0.0%	22.2%
	Both within and outside the locality	34.1%	49.5%	100.0%	39.4%
Plantain	Within the locality	49.0%	0.0%	0.0%	49.0%
	Outside the locality	15.6%	0.0%	0.0%	15.6%
	Both within and outside the locality	35.4%	0.0%	0.0%	35.4%
Cocoyam	Within the locality	55.6%	50.0%	0.0%	55.4%
	Outside the locality	1.9%	0.0%	0.0%	1.8%
	Both within and outside the locality	42.6%	50.0%	0.0%	42.9%
Other crops	Within the locality	54.5%	44.2%	43.3%	50.4%
	Outside the locality	20.0%	5.8%	16.7%	15.3%
	Both within and outside the locality	25.5%	50.0%	40.0%	34.3%

Source: Field Results (2019)

Generally, there are zonal disparities regarding the marketing strategies used by the farmers. Market aggregation (84%) constitutes the highest proportion of the marketing strategies in use across all the zones as detailed in the Table 15. This evidence suggests the need for conscious effort to be focused on the development of ICT-led marketing strategies to support CA market development.

Table 15 : Marketing strategies by Agro-ecological Zones

Marketing strategies		Transition		Guinea Savannah		Sudan Savannah		Total	
		Count	N %	Count	N %	Count	N %	Count	N %
SMS (text messages)	No	528	97.8%	710	98.5%	299	99.7%	1537	98.5%
	Yes	12	2.2%	11	1.5%	1	0.3%	24	1.5%
Market Aggregators	No	153	28.3%	74	10.3%	25	8.3%	252	16.1%
	Yes	387	71.7%	647	89.7%	275	91.7%	1309	83.9%
Online Marketing	No	536	99.3%	713	98.9%	298	99.3%	1547	99.1%
	Yes	4	0.7%	8	1.1%	2	0.7%	14	0.9%
Others (Specify)	No	366	67.8%	616	85.4%	277	92.3%	1259	80.7%
	Yes	174	32.2%	105	14.6%	23	7.7%	302	19.3%

Source: Field Results (2019)

The findings in Table 16 below captures some of the market-related CA/CSA actors in the Transitional and Sudan Savannah Agro-ecological zones surveyed.

Table 16 : Market Related Actors identified within Conservation Agriculture Space

Agro-ecological Zone	Actors, Projects & programmes	Actor Category	Roles and Responsibilities/CA practices
Transitional Agro-ecological Zone	Input dealers	Private Sector Player	Input supply and servicing
	Alliance for Green Revolution in Ghana (AGRA)	Development Partner	Support Small Holder Farmers in selected commodity value-chains including maize Input and output aggregation; training in improved production including CA and post-harvest management practices
	Blue skies, Yedents	Industry off-takers	Marketing,
	Modernizing Agriculture in Ghana (MAG)	Development Partner	Budget Support for MoFA, RELCs & R&D Institutional Support
	Essoko	Private Sector Player	Market Information (Prices and buyers), Climate advisory services
	CSIR-College of Science and Technology	Public Institution	Human Resource Development, Research
	KNUST- Department of Agric Engineering	Public Institution	Information on CA Equipment, Training
KNUST- Department of Agric Sudan Savannah Agro-ecological Zone	MOAP-GIZ Project	GIZ Project	Input and Output Market linkages
	MoFA WIAD	MoFA/Public	Gender & Extension
	Training and Extension for Conservation Agric in the Savannahs (TECAS)	Private Sector Player with start-up funding from GIZ,	Mechanization Services, CE equipment lease and own – Piloted in 2018, Currently registered as Social Business in Wa Municipal, Wa East, Nadowli-Kaleo, Jirapa, Dafiama-Busie
	International Development and Sustainable Enterprises (IDE)	NGO	Access to credit, soil Improvement, Production Level Demonstrations
	CCAFS/CSIR	Project	Engaging value chain CA/CSA actors at various levels towards adoption

Important for the enhancement of CA adoption in the zones is the role of farm machinery to reduce drudgery. Table 17 provides machinery and equipment identified, the mode and sources of acquisition by farmers for their operations. The results in this study appear quite revealing as more has to be done to boost the mechanization of CA in the three agro-ecological zones. To aid any deliberate policy process in mechanizing CA in the three zones a comprehensive list of CA/CSA machinery and equipment with value chain perspective suitable for the zones have been proposed in Appendix 6.

Table 17 : Farm Machinery identified within Conservation Agriculture Space in the three zones

Farm Machinery			Transition		Guinea Savannah		Sudan Savannah	
			Count	N %	Count	N %	Count	N %
Bullock plough	Outright	Open market	0	0.0%	14	87.5%	139	98.6%
		Government	1	100.0%	0	0.0%	0	0.0%
		Private Company	0	0.0%	2	12.5%	2	1.4%
Trained bullocks	Hire	Open market	0	0.0%	1	33.3%	10	45.5%
		Government	0	0.0%	0	0.0%	1	4.5%
		Private Company	0	0.0%	2	66.7%	11	50.0%
	Outright	Open market	0	0.0%	5	100.0%	76	98.7%
		Government	1	100.0%	0	0.0%	0	0.0%
		Private Company	0	0.0%	0	0.0%	1	1.3%
	Hire	Open market	0	0.0%	0	0.0%	1	11.1%
		Private Company	0	0.0%	1	100.0%	8	88.9%
Harrow	Outright	Open market	0	0.0%	5	71.4%	0	0.0%
		Government	0	0.0%	1	14.3%	0	0.0%
		NGO	1	100.0%	0	0.0%	0	0.0%
		Private Company	0	0.0%	1	14.3%	1	100.0%
		Private Company	1	100.0%	3	100.0%	0	0.0%
Disc plough	Outright	Open market	2	50.0%	13	72.2%	0	0.0%
		Government	0	0.0%	2	11.1%	0	0.0%
		NGO	1	25.0%	1	5.6%	0	0.0%
		Private Company	1	25.0%	2	11.1%	1	100.0%
	Hire	Open market	0	0.0%	28	73.7%	0	0.0%
		Private Company	2	100.0%	10	26.3%	0	0.0%
Tractor	Outright	Open market	4	66.7%	31	77.5%	11	91.7%
		Government	0	0.0%	1	2.5%	0	0.0%
		NGO	1	16.7%	1	2.5%	0	0.0%
		Private Company	1	16.7%	7	17.5%	1	8.3%
	Hire	Open market	0	0.0%	54	47.0%	1	5.6%
		Government	0	0.0%	2	1.7%	2	11.1%
		NGO	0	0.0%	0	0.0%	1	5.6%
		Private Company	15	100.0%	59	51.3%	14	77.8%
Trailer	Outright	Open market	2	66.7%	8	80.0%	0	0.0%
		Government	0	0.0%	1	10.0%	0	0.0%
		NGO	1	33.3%	0	0.0%	0	0.0%
		Private Company	0	0.0%	1	10.0%	1	100.0%
	Hire	Open market	0	0.0%	13	52.0%	0	0.0%
		Private Company	1	100.0%	12	48.0%	0	0.0%
Mould - board plough	Outright	Open market	0	0.0%	3	100.0%	2	100.0%
		Government	1	100.0%	0	0.0%	0	0.0%
	Hire	Open market	0	0.0%	1	100.0%	0	0.0%
Ridger	Outright	Open market	0	0.0%	0	0.0%	3	75.0%
		Private Company	0	0.0%	0	0.0%	1	25.0%
Ripper	Outright	Open market	0	0.0%	1	100.0%	0	0.0%
Hoe	Outright	Open market	517	99.4%	690	99.9%	292	99.7%
		Private Company	3	0.6%	1	0.1%	1	0.3%
	Hire	Open market	0	0.0%	3	75.0%	0	0.0%
		Private Company	0	0.0%	1	25.0%	0	0.0%
Cutlass	Outright	Open market	528	99.4%	678	99.3%	279	99.3%
		Government	0	0.0%	2	0.3%	0	0.0%

Farm Machinery			Transition		Guinea Savannah		Sudan Savannah	
			Count	N %	Count	N %	Count	N %
		NGO	0	0.0%	0	0.0%	0	0.0%
		Private Company	3	0.6%	3	0.4%	2	0.7%
	Hire	Open market	2	100.0%	3	75.0%	0	0.0%
		NGO	0	0.0%	1	25.0%	0	0.0%
Power tiller	Outright	Open market	0	0.0%	0	0.0%	0	0.0%
		Private Company	0	0.0%	0	0.0%	1	100.0%
Jab planter	Outright	Open market	0	0.0%	0	0.0%	0	0.0%
		Private Company	0	0.0%	0	0.0%	1	100.0%
		NGO	1	100.0%	0	0.0%	0	0.0%
Motor King	Outright	Open market	38	95.0%	53	72.6%	13	86.7%
		Government	1	2.5%	1	1.4%	0	0.0%
		NGO	0	0.0%	0	0.0%	2	13.3%
		Private Company	1	2.5%	19	26.0%	0	0.0%
	Hire	Open market	4	13.8%	46	79.3%	1	8.3%
		Government	0	0.0%	1	1.7%	0	0.0%
		NGO	0	0.0%	0	0.0%	3	25.0%
		Private Company	25	86.2%	11	19.0%	8	66.7%
Donkey	Outright	Open market	1	100.0%	20	95.2%	56	96.6%
		Government	0	0.0%	0	0.0%	1	1.7%
		NGO	0	0.0%	1	4.8%	0	0.0%
		Private Company	0	0.0%	0	0.0%	1	1.7%
	Hire	Open market	0	0.0%	3	100.0%	3	37.5%
		NGO	0	0.0%	0	0.0%	1	12.5%
		Private Company	0	0.0%	0	0.0%	4	50.0%
Donkey	Outright	Open market	1	100.0%	20	95.2%	56	96.6%
		Government	0	0.0%	0	0.0%	1	1.7%
		NGO	0	0.0%	1	4.8%	0	0.0%
		Private Company	0	0.0%	0	0.0%	1	1.7%
	Hire	Open market	0	0.0%	3	100.0%	3	37.5%
		NGO	0	0.0%	0	0.0%	1	12.5%
		Private Company	0	0.0%	0	0.0%	4	50.0%
Cart	Outright	Open market	0	0.0%	11	73.3%	70	98.6%
		Government	1	100.0%	1	6.7%	1	1.4%
		NGO	0	0.0%	1	6.7%	0	0.0%
		Private Company	0	0.0%	2	13.3%	0	0.0%
	Hire	Open market	0	0.0%	1	25.0%	5	45.5%
		Government	0	0.0%	0	0.0%	0	0.0%
		NGO	0	0.0%	0	0.0%	1	9.1%
		Private Company	0	0.0%	3	75.0%	5	45.5%
Axe	Outright	Open market	113	100.0%	269	99.6%	58	98.3%
		Government	0	0.0%	1	0.4%	1	1.7%
	Hire	Open market	1	100.0%	1	100.0%	0	0.0%
Manual thresher	Outright	Open market	19	100.0%	51	96.2%	33	94.3%
		Government	0	0.0%	0	0.0%	0	0.0%
		NGO	0	0.0%	1	1.9%	2	5.7%
		Private Company	0	0.0%	1	1.9%	0	0.0%
	Hire	Open market	3	75.0%	13	92.9%	0	0.0%
		Government	0	0.0%	0	0.0%	0	0.0%
		NGO	0	0.0%	0	0.0%	0	0.0%
		Private Company	1	25.0%	1	7.1%	1	100.0%

Source: Field survey, 2019

Marketing models such as prosecuted by ADVANCE Ghana (an NGO) is a cashless system involving the private sector and banks for input supply to mobilized farmer groups exist in the zones could be adapted to support promotion of CA. There are evidence of various contract agreements where farmers acquire credit facilities during the farming season from identified private sources mostly individuals (market aggregators), MoU signed in some cases that enables the produce to be given out to the sponsor to buy after harvest. This local arrangement is however, being negated in some cases by mistrust between partners. TECAS (under REACH project) promotes a 'hire pay to own' model in the CA equipment supply space. The equipment such as tractor mounted rippers are given out to identified nucleus farmers on hire purchase to work on their farms and additionally offer services to other farmers for a fee. Full ownership is conferred upon full payment for the equipment.

3.10: Appropriate CA models by agro-ecological zones and Profitability Analysis

3.10.1 Appropriate CA models by agro-ecological zones

Five key CA models were developed during the reconnaissance field study based on the production systems and responsiveness to the production, socio-economic and sustainability objectives of the CA actors. The proposed CA models are as follows.

1. Medium /Large Tractor Operated
2. Small Holder Manual Operated
3. Crop-Livestock Integration
4. Integrated Tree-Crop-Livestock
5. Irrigated Rice-Maize-Vegetable-Livestock

These CA models were presented to participants for further consultations and validation for possible promotion within the respective districts and agro ecological zones in Ghana. Almost all the CA models were chosen in each agro-ecological zone for several reasons. The major reasons for the selection of the models are summarized below:

A. Reasons for the choice of CA model 1 - Medium/large tractor operated

1. Use of tractor will make farming very efficient, especially for large farm size
2. Portions of land will require ploughing
3. Crop residue will be used to prepare livestock feed
4. Inclusion of legumes (cowpea) will improve soil fertility
5. Tractor use is faster for ploughing and enables coverage for large farm sizes
6. Tractor use reduces cost of hired manual labour
7. Tractor use enables farming on large scale that increases income
8. Introduction of CA tractors and equipment will reduce soil spoilage
9. The model will increase productivity
10. Will reduce reliance on importation of food crops e.g. rice etc
11. It will encourage more people to enter into agriculture particularly the youth and women

B. Reasons for the choice CA model 2 - Smallholder manual operated

1. Already being implemented by majority of the farmers
2. Farm lands can support variable crops
3. Inclusion of livestock rearing serves as food security to support family.
4. Less expensive, require less capital and no ploughing cost
5. A lot of farmers have the know-how or experience
6. Availability of required resources such as hoes, cutlasses etc. as well as seeds for planting
7. Inclusion of small ruminant in the model will enable them get extra income to support crop cultivation
8. Droppings of livestock will serve as manure
9. Can easily be done because it is not different from their current farming practices
10. Inclusion of legumes (e. g. cowpea) for cover copping will improve soil fertility

C. Reason for the choice of CA Model 3 - Crop-livestock Integration

1. Improve food security and farm income from multiple sources (food crops, cashew and goats/sheep)
2. Already practicing crop and livestock farming
3. Manure from the animals will help fertilize the crop field
4. Residues from the farm is used to feed animals
5. Sale of animals to buy farm inputs, and after the season the crops can be used to buy more animals
6. Availability of animals for domestic consumption and ceremonies
7. Will serve as insurance for the farmers i.e. if one fails the other will support the family
8. Use animal for traditional purposes
9. Ease of management of the model

D. Reasons for the choice of CA model 4 - Tree Crop-livestock integrated

1. Abundant land that supports cashew production
2. Land and climatic conditions support cashew production
3. Livestock rearing is common practices, have the experience and know-how to rear them
4. Cashew apple can be used as feed for livestock
5. Cashew residue can be dried to prepared feed for livestock
6. Inclusion of Leucaena in farmland to serve as feed
7. Almost every household has one livestock or the other and their faecal matter could be used as fertilizer on farm to reduced number and cost of mineral fertilizer
8. It can be practiced on the same piece of land for a longer time period (50 years and above for cashew)
9. Ginger can be grown throughout the growing period with cashew
10. Droppings from ruminants will serve as manure
11. Efficient utilization of agricultural land (crops and animals cultivated/reared on the same piece of land

12. Income is diversified and generated all year round with this model.
13. Aside food production obtained from this model, fuel (firewood) can also also be obtained
14. This model improves microclimatic conditions
15. The trees will moderate the high temperatures

E. Reasons for the choice of Model 5 - Irrigated Cereal-Vegetable-Livestock

1. There is one rainy season in the area, with the irrigation system farmers can do all year-round farming
2. Some of the communities are located at low lying areas, considered an idle place for rice and vegetable production
3. Inclusion of small ruminants in the model makes it very appropriate for wider farmer participation as goats and sheep are found in every
4. Household animal droppings can be used as manure/fertilizer to improve soil fertility
5. There is high demand for rice, vegetables and livestock. Maize is one of the major staples in the municipality. Growing these crops will contribute to improvement in food security, incomes and livelihoods of farmers

3.10.2 Description of the CA Models and Profitability

In the description of the CA models participants were taken through the five CA models developed and were tasked to select two that best suit the existing district farming systems and the current and future production objectives. The Table 18 below provides the CA models selected by districts within the transitional agro-ecological zone with their respective profitability indicators associated with their major farming systems. The choice of CA model 4 (Integrated Tree Crop – livestock) was relatively high in the transitional zone, followed by CA model 2 (Smallholder manual operated) and CA model 1 (medium/large tractor operated).

Assumptions of CA Model and Profitability

1. Crops are accessed on the basis of per acre.
2. Major season of crops production are used as reference point.
3. Farm gate crop prices are used as a reference point.
4. The maximum yield at the time of fruiting is use for tree crops (the canopy of the trees must not be closed entirely).
5. Average number of small ruminants disposed by household per annum.

CA model 3 (Integrated Crop-livestock) was less chosen which is attributed to the fact that most of the farmers have tree crops as major “cash crop” and only require the integration of small ruminants as a means of diversifying income. All the chosen models within the agro-ecological zone are economically and financially viable with the highest net profit (GhȻ 39,610.00 or 7149.82 USD equivalent) attributed to a Cashew-Yam-Plantain-Small Ruminant field setup associated with the tree-crop-livestock integration (model 4). With this CA model and farming system, every pesewa invested yields 0.8 cedis making it a viable CA based farming system.

All the farming systems associated with the tree-crop-livestock integration model had net profits above Gh₵ 10,000.00 with relatively high benefit-cost ratios ranging between 1.9- 5.9. Maize-Tuber-Small Ruminants farming system associated with Smallholder manual operated CA model, had the next highest net profit of GH₵15,166.00 with benefit-cost ratio of 3.2 as reflected in Table 18 below. None of the districts within the transitional agro-ecological zone selected irrigated livestock system (CA model 5). This was attributed to the lack of and or inadequate irrigation facilities, dry season farming was seen to be very expensive and that rice, maize and vegetable can also be cultivated under the smallholder manual operated CA model under rain-fed conditions (see Table 18).

Table 18 : District selected CA models, farming system and estimated profitability in the Transitional Agro-ecological Zone

Selected Districts/Municipalities within the zones	CA Models Selected	Major farming system	Gross Profit	Profit Margin	Benefit-Cost Ratio	Net Profit/ Operating Profit
Banda District	Medium/Large Tractor Operated	Maize-'Agushi'-Small Ruminant	4,844.0	0.6	2.4	4,587.0
	Integrated Tree-Crop-Livestock	Cashew-Yam-"Agushi"-Pepper-Small Ruminant	14,358.5	0.7	2.9	13,917.0
Dormaa Central Municipal	Small-scale manual operated CA model	Maize-Tuber-Small Ruminants	15,624.0	0.7	3.2	15,166.0
	Crop-livestock integrated CA Models	Cashew-Cowpea-Small Ruminant	16,719.0	0.8	6.1	16,569.0
Jaman South Municipal	Medium/Large Tractor Operated	Maize-Cowpea-Small Ruminant	1,367.0	0.3	1.3	1,143.0
	Integrated Tree-Crop-Livestock	Cashew-Yam-Pepper-Small Ruminant	23,368.0	0.7	3.3	22,768.0
Tain District	Smallholder Manual Operated	Maize-Cassava-Pepper-Small Ruminant	3,325.0	0.4	1.6	2,790.0
	Integrated Tree-Crop-Livestock	Cashew-Yam-Plantain-Small Ruminant	40,610.0	0.8	5.9	39,610.0
Kintampo North Municipal	Medium/Large Tractor Operated	Maize-Groundnut-Cashew-Small Ruminants	3,795.0	0.3	1.5	3,145.0
	Medium/Large Integrated Tree-Crop-Livestock	Maize-Yam-Cashew-Small Ruminants	10,935.0	0.5	1.9	10,285.0
Nkoranza South Municipal	Smallholder Manual Operated CA Model	Yam-Cassava-Small Ruminants	7,690.7	0.7	3.0	7,540.7
	Integrated Tree-Crop-Livestock	Maize-Plantain-Cashew-Small Ruminants	10,880.7	0.8	4.2	10,620.7
Techiman Municipal	Smallholder Manual Operated CA Model	Maize-Cassava-Yam	13,067.0	0.6	2.2	12,627.0
	Integrated Tree crop - livestock integration	Yam-Cashew-Small Ruminant	14,877.0	0.5	2.2	14,627.0
Krachi-East	Smallholder manual operated CA Model	Maize-Yam-Cassava	4,830.0	0.5	2.0	4,330.0
	Tree crop-livestock integration CA Model	Maize-Yam-Cassava-Small Ruminants	5,340.0	0.5	2.0	4,840.0
	Smallholder manual operated	Sorghum-Yam-Small Ruminant	8,233.0	0.8	3.9	8,023.0
	Crop-livestock integration	Maize-Yam-Small Ruminants	7,795.0	0.7	3.7	7,750.0

Source: Field Results (2019)

In the Guinea Savannah zone, Crop-livestock integration CA Model was most preferred and irrigated crop-livestock CA model was the least preferred within the zone. Almost all the selected CA models were economically profitable justifying viability of most of the models within the zone. Though medium/large tractor operated model appeared profitable, same model was not financially viable with maize-groundnut-small ruminant in North Gonja district. This is partly attributed to unavailability of tractor services, associated high cost of production and productivity. Also net profit from Maize-cowpea-small ruminants farming system associated with smallholder manual operated model was not profitable (Gh₵-730.00) in the Wa municipal partly attributed to the facts that much investment went into the provision of improved housing infrastructure for small ruminants as well as high cost of production and selling price of livestock were low at the farm gates. However, financial analysis of the Integrated-Tree-crop livestock system within the district revealed the highest net profit of GH₵16,000.00 with a benefit-cost ratio of 3.6. These estimates are associated with the adoption of Cashew-Yam-Cowpea-Small ruminants farming system under the integrated tree-crop livestock CA model. The crop-livestock integration model which is the most preferred in the zone was observed to be negative (GH₵-1,951.00). This is attributed to lower yields of maize and groundnut and limited sales of small ruminants by farm families. With the inclusion of Bambara beans in this farming system associated with smallholder manual operated CA model was financially viable due to higher yields and price for Bambara beans within the district with a positive net profit of GH₵1,260.00 and improve benefit-cost ratio of 1.2 as reflected in table 19.

Table 19 : Districts selected CA models, farming system and estimated profitability in the Guinea Savannah Agro-ecological Zone

Selected Districts/Municipalities within the zones	CA Models Selected	Major farming system	Gross Profit	Profit Margin	Benefit-Cost Ratio	Net Profit/ Operating Profit
Gushegu Municipal	Medium-Large Tractor Operations	*Groundnut-Maize Small Ruminants*	*1,510.0*	*0.5*	*2.2*	*1,340.0*
	Crop-livestock integration CA Model	*Groundnut-Maize Small Ruminants*	*1,630.0*	*0.6*	*2.4*	*1,460.0*
Nanumba South District	Crop-Livestock Integration CA Model	*Sorghum-Yam-Small Ruminants*	*8,233.0*	*0.8*	*3.9*	*8,133.0*
	Tree Crop-Livestock Integration Model	*Maize-Yam-Cashew-Small Ruminants*	*10,100.0*	*0.9*	*6.8*	*10,055.0*
Sagnarigu Municipal	Small Holder Manual Operated CA Model	*Maize- Soybean*	*3,005.3*	*0.7*	*3.3*	*2,802.6*
	Crop-Livestock Integration CA Model	*Soybean-Maize-Small Ruminants*	*3,935.3*	*0.7*	*3.3*	*3,732.6*
Savelugu Municipal	Crop-Livestock Integration CA Model	*Sorghum-Cowpea-Small Ruminant*	*9,955.3*	*0.9*	*6.7*	*9,705.3*
	Irrigated Crop-Livestock CA Model	*Rice-Cowpea-Groundnut-Small ruminants*	*8,113.0*	*0.8*	*4.2*	*7,743.0*
Tolon District	Smallholder manual Operated CA Model	*Millet- Groundnut*	*2,253.8*	*0.5*	*2.0*	*1,943.8*
	Tree Crop- livestock integration Model	*Sorghum Cowpea-Small Ruminants*	*2,187.5*	*0.6*	*2.2*	*1,937.5*
East Mamprusi Municipal	Medium/Large Tractor Operated	*Maize-Water Melon-Small Ruminants*	*521.3*	*0.2*	*1.2*	*401.3*
	Crop-Livestock Integration	*Maize-Water Melon-Small Ruminants*	*591.3*	*0.2*	*1.3*	*471.3*
West Mamprusi Municipal	Smallholder Manual Operated	*Millet-Groundnut-Small Ruminant*	*812.0*	*0.2*	*1.3*	*562.0*
	Crop-Livestock Integration	*Millet-Water Melon-Small Ruminant*	*1,962.0*	*0.4*	*1.7*	*1,712.0*
North Gonja District	Medium/Large Tractor Operated	*Maize-Groundnut-Small Ruminant*	*-1,461.0*	*-0.5*	*0.7*	*-1,621.0*
	Irrigated Crop-Livestock Integration	*Rice-Okro-Pepper-Small Ruminant*	*2,456.0*	*0.2*	*1.3*	*2,166.0*
Sawla-Tuna-Kalba District	Medium/Large tractor operated	*Guinea Corn-Groundnut-cowpea-Small Ruminant*	*2,855.0*	*0.4*	*1.7*	*2,551.0*
	Integrated Tree-Crop-Livestock	*Cashew-Maize-Groundnut -Small Ruminant*	*12,811.0*	*0.7*	*3.6*	*12,452.0*
Lawra Municipal	Smallholder Manual Operated	*Maize-Okro-Tomatoes-Small Ruminant*	*224.0*	*0.0*	*1.0*	*-151.0*
	Irrigated-Rice-Maize-Vegetable-Livestock	*Rice-Okro-Tomatoes-Cabbage-Small Ruminant*	*8,424.0*	*0.4*	*1.7*	*7,999.0*
Wa Municipal	Smallholder Manual Operated	*Maize-Cowpea-Small Ruminant*	*-460.0*	*0.1*	*0.9*	*-730.0*
	Integrated-Tree-Crop Livestock	*Cashew-Yam-Cowpea-Small Ruminant*	*17,550.0*	*0.7*	*3.6*	*16,790.0*
Nandom District	Smallholder Manual Operated	*Maize-Groundnut-Bambara Beans-Small Ruminant*	*1,505.0*	*0.2*	*1.2*	*1,260.0*
	Crop-Livestock-Integration	*Maize-Groundnut-Small Ruminant*	*-1,816.0*	*-0.4*	*0.7*	*-1,951.0*

In the Sudan Savannah agro-ecological zone, crop-livestock integration emerged as the most preferred CA model selected by every district within the zone. The CA model's highest net profit of GH₵7,384.00 was observed to be associated with groundnut-Bambara beans and small ruminants. Its benefit-cost ratio (4.1) was also good. A pesewa invested yields 0.8 cedis making it more viable for promotion and investment within the zone. The least net profit under this CA model was GH₵1,387.00 and it is associated with maize-soybean and small ruminants. All other CA models selected and presented in Table 20 were all profitable irrespective of the type of farming systems.

Table 20 : District selected CA models, farming system and estimated profitability in the Sudan Savannah Agro-ecological Zone

Selected districts/Municipalities within the zones	CA Models Selected	Major farming system	Gross Profit	Profit Margin	Benefit-Cost Ratio	Net Profit/ Operating Profit
Bawku West District	Crop-Livestock Integration	Groundnut-Bambara Beans-Small Ruminants	7,399.0	0.8	4.1	7,384.0
	Medium/Large Tractor Operated	Maize-Soya Bean-Small Ruminants	2,964.0	0.6	2.2	2,949.0
Bongo District	Crop-Livestock Integration	Groundnut-Bambara Beans-Small Ruminants	1,872.0	0.4	1.7	1,710.0
	Small Holder Manual Operated	Millet-Cowpea-Small Ruminants	1,235.0	0.4	1.6	1,121.0
Bawku Municipal	Crop-Livestock Integration	Maize-Soya Bean-Small Ruminants	1,712.0	0.4	1.6	1,387.0
	Medium/ Large Tractor Operated	Maize-Cowpea-Small Ruminants	1,546.0	0.3	1.5	1,221.0
Garu District	Crop-Livestock Integration	Millet-Cowpea-Small Ruminants	3,000.5	0.7	2.9	2,960.5
	Integrated Tree Crop-Livestock	Maize-Cowpea-Cashew-Small Ruminants	2,768.0	0.6	2.2	2,608.0
Talensi District	Medium/Large Tractor Operated	Millet-Sorghum-Cowpea-Small Ruminants	3,429.3	0.6	2.5	3,199.3
	Crop-Livestock Integration	Millet-Cowpea-Small Ruminants	2,725.3	0.6	2.4	2,565.3

Source: Field Results (2019)

3.11: CA coordination structure and Mechanisms

The actors in the various districts involved in conservation agriculture were identified and their roles described. These actors were categorized either as internal or external actors depending on whether they were stationed in the district or stationed outside and yet were involved in CA activities in the district. The identified actors in the districts/municipalities included the traditional authorities, Farmer Based Organisations (FBOs) and Community Based Organisations (CSO), the District or Municipal Assembly which includes government organisations such as Department of Cooperatives, Ghana Fire Service, Ghana Police Service, Ghana Health Service, Ghana Immigration and Forestry Commission, Department of Agriculture; Also there were financial institutions (commercial, rural banks and village savings and Loans associations (VSLA)), NGOs, input suppliers, aggregators/traders/ marketers and processors.

External actors identified as operating in the districts or municipalities include government, non-governmental organisations and private institutions. For instance, in the Guinea Savannah zone, the NGO SEND is an external actor in Nanumba South stationed in East Gonja District. CARE International, WFP, KOEKA from South Korea are external actors in Nandom district. Both internal and external actors were reported by participants to have different levels of collaboration with each other, with the farmers and with the Department of Agriculture in the District. The Department of Agriculture, through its AEAs provide extension services to farmers. It serves as the link between the other organizations who wish to work with farmers. Most of the organizations collaborate with the Department of Agriculture to serve as their extension wing in their efforts to provide CA related services to farmers.

In a bid to find out from participants about how best CA activities could be coordinated at the local (district/ municipal) level, a national coordination structure (Figure 12) put together from the reconnaissance survey was presented to the participants for validation and downscaling to the district level. The structure is presented in figure 12 below.

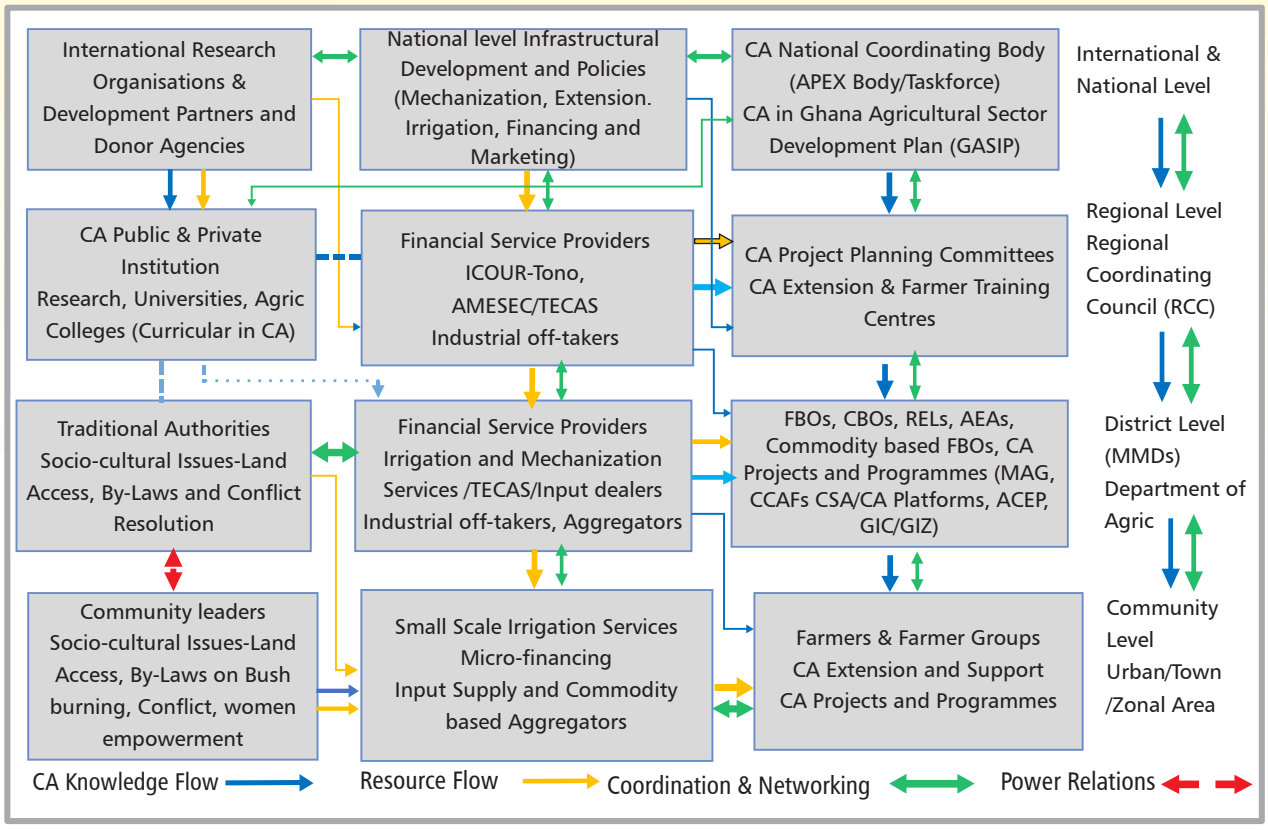

Figure 12: CA coordination structure and Mechanisms

Functional coordination mechanisms

Proposed mechanisms/strategies to engineer a functional coordination of CA based on existing structures at all levels may include the following:

- Joint zonal planning sessions
- District planning sessions
- Quarterly CA review meetings
- Bi-annual sector reviews at the regional level
- National joint sector reviews
- Annual conference on CA/CSA

Participants in the district level participatory engagement were in agreement with the general coordination structure and made suggestions for a structure to enable effective promotion of CA at the district / municipal levels and aggregated across the zones (Table 21). Farmers gave suggestions on how the various actors could contribute in this regard. Similar suggestions were given across the zones.

Table 21 : Areas of CA coordination and suggested district level mechanisms for effective CA implementation by ecological zones

Area	Sudan Savannah	Transitional	Guinea Savannah
Technology Development/ Dissemination	-Conservation agriculture technologies to be developed for production by scientists in collaboration with the department of agriculture for dissemination (CSIR) -Need for Conservation agriculture technologies for processing targeted at women farmers (SARI, Dept. of Agriculture and the NGOs) - Farmers to be supplied with tree seedlings and technical support (EPA and Forestry Commission collaboration) - Conservation Agriculture should also give attention to livestock production, not focus only on crops production.	Department of Agriculture should collaborate with research institutions to establish demonstration and farmer training sites within the districts. Faculties/schools of agriculture of tertiary institutions within the zone should collaborate with farmers and extension to develop and try out new technologies	
Input dealers/ Supplies	--Need for more farm equipment for conservation agriculture. - Harvest machines should be provided to facilitate harvesting of crop produce to prevent crop losses on the field.	Need for and access to CA equipment to be supplied	-Input suppliers to recommend agro-chemicals to farmers - Agro-input dealers to ensure that farmers are provided with good quality planting materials (especially grafted cashew seedlings
Information dissemination/ Technical Assistance/ Training	-Input dealers to educate farmers on correct use of chemicals; -Farmers to be supplied with tree seedlings and technical support in conservation agriculture concept. - Regular training of farmers on farm record keeping. -Ghana Meteorological Agency to collaborate with Dept of Agriculture to provide daily meteorological information - More information dissemination through demonstration and field days by agricultural Extension Agents (AEAs)	-Use of existing structures for farmer business schools - More information dissemination through demonstration on GAPs and CSA by Department of Agriculture /extension services provision and technical advice. - NGO s to provide capacity building in GAP/CSA and Alternative Livelihoods including Bee Keeping; - Agro-input dealers to train farmers on appropriate use of agro-chemicals and supply recommended agro-chemicals to farmers	-Department of Agriculture to provide extension services, technical advice, training and demonstration on GAPs and CSA, District - Agro-input dealers to train farmers on the appropriate use of agro-chemicals.
Marketing	-Need to provide better market outlets -Effective collaboration between MoFA and stakeholders for better marketing optons	-Commodity value chain structure to factor in issues of pricing (attractive prices for CA products) and better marketing, -Aggregators facilitate markets for farm produce, and ensure good pricing of produce -Need for market linkages for the sale of produce	FBOs and Cooperatives to facilitate market access for farmers and pricing of produce
Financial Assistance	-Farmers and input dealers need assistance to acquire credit facilities aided by Department of Agriculture	-Need access to financing and business advisory services -Banks – provision of loans and credit to farmers (NAFANA Rural Bank-Banda); Rural banks in Jaman (Suma, Kaseman, Drobo Community, Wamfie, Dormaa Teachers Credit, Nkoraman Rural Bank, and VSLA. They support farmers with loans and credit.	Banks i.e. rural banks need to provide loans and credit to farmers. VSLA supports farmers with loans

Area	Sudan Savannah	Transitional	Guinea Savannah
Farmer Based Organisation (FBO)	-Form Farmer Based organizations -Strengthen old Farmer Based organizations and build rapport among farmers for better exchange of ideas/ peer training.	-FBOs and Cooperatives to facilitate market access and pricing of produce.	Farmer-based organizations to be strengthened for advocacy
Collaboration	-Effective collaboration needed between Dept. of Agriculture, other government organizations (CSIR), RELCs, NGOs and other stakeholders.	Strong Research/Farmer - Extension - Linkages Committees (RELC); -Use of strong advocacy groups (CSOs and NGOs) to push for enforcement of by-laws against bush fires and indiscriminate felling of trees -NGOs, FBOs and Dept. of Agriculture to collaborate to organise farmer business schools -Need for strong collaboration between relevant stakeholders including traditional authorities, RCC, registered functioning FBOs, input dealers, marketing actors	-The Department of Agriculture is expected to lead the coordination of CA activities with strong collaboration with NGOs. Need to establish zonal councils with unit head coordinating and reporting to the district assembly. -Need to use existing: institutions including Department of Agriculture, NGOs to collaborate with other relevant stakeholders to work with FBOs. - RELC to facilitate technology dissemination Department of Agric. to collaborate with input (cashew seed) suppliers
Programme mplementation	Need to detach politics from implementing programmes.		
Enforcement of By-Laws/Conflict resolution		-Use of strong advocacy groups (CSOs and NGOs), traditional authorities, Community Fire Volunteers to push for enforcement of by-laws against bush fires and indiscriminate felling of trees. -National Fire Service and Community Volunteers / NADMO to educate farmers on	-District Assembly to enact and enforce by-laws on bushfires and illegal logging)
		bushfire prevention, and monitoring of fire outbreaks and other disasters -Traditional Authorities and judicial services to engage in conflict resolution.	
Transport/Roads		GPRTUs to facilitate transportation of produce from farm gates to market	District Assembly to ensure that farm tracks and roads are in good shape (motorable/accessible
Land issues	Traditional leaders to facilitate accessibility of farm lands especially for land tenants	-Traditional leaders and family heads to facilitate accessibility of farm lands especially for land tenants	

Source: Field Results (2019)

CHAPTER FOUR
CONCLUSIONS AND RECOMMENDATIONS

The CA profiling study required a complex multi-level framework of the farming systems including households and districts within the selected agro-ecological zones. This called for the provision of a working definition of CA to include livestock and a diversity of climate smart agriculture practices. The definition is consistent with that of FAO (2007). This working definition informed information gathering during regional reconnaissance survey and data collection exercises undertaken at both district and household levels.

1. Data collected and analyzed across the three agro-ecological zones show that people's livelihoods appear to be intrinsically tied to CA practices because of their impact on a number of criteria including yields improvement. This linkage is however strongly influenced by markets for products from CA systems. Farmers/respondents see absence of reliable markets and low prices as major challenges to their engagements.

2. Consistent with the adopted working definition of CA for the study, a number of practices have been identified which respond to one or more pillars of CA. Practices were found to be both indigenous and introduced into the farming system. The commonality of some practices e.g. intercropping, mulching, no-till (use of herbicides or slash and plant) is an indication of the importance and ease of use of the technologies. Assessment of these technologies against selected criteria including; yield improvement, soil moisture conservation, reduction in use of chemical fertilizers shows high scores of 4 and 5 on the Likert scale across the three zones. The use of these technologies in association with other technologies like improved genetic materials and application of soil and water conservation practices holds a great potential for enhancement of land productivity on sustainable basis. The technologies/practices individually and in combination were found to have the potential of reducing the impact of climate change related hazards on livelihoods of people in the selected zones.

3. No-till using herbicides is one of the CA technologies found to be popular among farmers across the three ecological zones. There is however a challenge with the handling and use of the chemicals among the farmers. A major result of the increasing and indiscriminate use of herbicides is the decreasing biodiversity within farming systems. Additionally, some farmers believe the continuous use of chemicals is paving the way for emergence of new weeds and increasing weed incidence. The increasing use and poor handling of agro-chemicals is having implications for human health in all agro-ecological zones. There is the need therefore to take a critical look at the use of herbicides within a CA system to ensure it does not result in the breakdown of the system.

4. Irrigated agriculture is an important component of the farming systems of the three zones studied. Its importance is increasing with the ever-increasing water stress associated with climate change. Irrigation is practiced as a full-production system or as supplementary in the absence of adequate rainfall. Although there are formal irrigation schemes providing resources to support farmers' production most smallholder farmers are engaged in low technology irrigation practices such as use of buckets and watering cans to lift water requiring high inputs of labour. An input of machinery towards mechanizing the smallholder irrigation would greatly enhance productivity of the systems thus leading to improving livelihoods. Systems of practices include one or combination of technologies; including no-till and crop rotation that are consistent with CA principles providing a great avenue for up scaling of CA beyond the rain-fed system.

5. Conservation Agriculture has a focus of building up nutrient capital that would in the long term enhance productivity on a sustainable base. Information from the study indicates that adoption of CA practices could initially lead to actual reduction in yields or lowering of net profits. This may hugely limit motivation for smallholders to spend time and resources in adopting CA as a production system. Considering that an enhanced natural resource base holds benefits for all in terms of provisioning of environmental services, the institution of an incentive system for potential practitioners must be given strong consideration. Such incentive system must consider inputs and markets for products.

6. Most farmers are small-scale farmers using rudimentary technologies with little use of machinery. Their operations are therefore heavily weighed down by drudgery. Experience from elsewhere shows the benefits of appropriate machinery for the adoption and use of CA practices. There appear to be a huge gap for CA equipment in the selected zones. Available machinery is heavily skewed towards large scale operators which, in all cases is not enough. Up scaling of adoption and use of CA within all proposed models would benefit greatly from increased availability of appropriate machinery/equipment.

7. The proposed models are based on existing farming systems within the three agro-ecological zones studied. Each model is based on no tillage and/or minimum tillage in combination with other CA/CSA practices including crop rotation, and intercropping thus creating a system of practices. The models provide for the production of a combination of a number of crops together with livestock and poultry. The systems/models were found to be profitable across the selected agro-ecologies to varying degrees. The tree crop-based and crop-livestock integrated systems are more profitable into the medium to long term as compared to the food crop-based system. The profitability of the systems is however linked to availability of a marketing system that provides for payment of fair prices to farmers.

8. In addition to increasing yield and building resilience of the production systems, combination of technologies would contribute to mitigating climate change effects especially carbon sequestration (mulching), above ground reduction in atmospheric carbon through absorption by vegetative cover e.g. cashew-based cropping systems. Bushfires and un-favorable land tenure systems have been identified in all zones as major threats to these systems most importantly the tree crop-based systems.

9. The need for a coordination structure for CA/CSA at all levels is a basic necessity in support of efforts to upscale adoption and use of CA/CSA within farming systems in Ghana. The proposed CA/CSA coordination structure has been assessed as adequate for effective up scaling of CA/CSA in the three zones studied. For effectiveness, the need for identification and involvement of all relevant stakeholders (public, private, traditional and NGOs) is emphasized. Grounds must be created for effective collaboration among stakeholders with clearly defined roles at all levels. Whiles achieving the later a lead institution must be identified and given the role of ensuring the establishment and functioning of these coordination structures at all levels.

10. In general, the study proved to be interesting and successful as it offered opportunities for training of over seventy-eight AEAs of 26 District/Municipal/Departments of Agriculture. Joint learning and sharing of both indigenous farmer knowledge and the introduced improved practices in CA/CSA was achieved and likely to contribute immensely to the awareness creation on these methods and approaches to farming in order to stem climate change and its variability and thereby secure increased productivity, incomes, the adaptive capacity of actors, reduced emissions and a sustainably healthy environmental outcomes now and into the future.

Recommendations

	Problem/Issues	Policy/institutional	Extension education	Research and Development
1	Indiscriminate use of herbicides by farmers in all agro-ecological zones with reported pollution and degradation of the environment	Policy regulation on the import and marketing of herbicides must be enforced	Enhanced awareness and education on handling, use and disposal of herbicide materials	
2	Labour and drudgery have been observed to be associated with small holder CA systems. The need for simple equipment to mechanize CA operations was too visible to be ignored in most of the districts visited particularly those favoring women	Deliberate policy on importation of CA supportive equipment/local prototype fabrication.	Training on use and maintenance of available equipment	Development and testing of prototypes of essential CA equipment
3	Marketing challenges with most of the value chain commodities was encountered. There appear to be mistrust and non-transparency among the different value chain actor; though a level of contract farming and marketing arrangement exist.	Policy and marketing information	Organize and strengthening of FBOs and Cooperatives for a bigger voice and advocacy Train, educate and promote ICT in marketing in collaboration with TELECOs	
4	Food -feed crops have found space and favour with many CA farmers. The same cannot be said for certain forage crops such as mucuna, stylo, serata, etc. which can provide good soil cover and have high value livestock feed and soil amendment properties		Set-up CA demonstration and social learning sites incorporating the forage crops.	Research and development of new varieties of forage crops
5	Indiscriminate bush burning threatens CA adoption in the communities	Enhancement of existing regulations against bush burning. MMDAs in collaboration with Traditional authorities should develop and pass by-laws for gazetting.	Establish and strengthen existing CSA platforms at sub-national level Identify and promote technologies that add to and or enhance value of farmlands during dry periods	
6	There is absolute void of intervention on climate change and natural resource management that favour CA at the sub-national level. This is negating smooth implementation and adoption of CA/CSA relevant technologies		Policy dissemination and education at MMDA and community levels Prioritize CA/CSA in extension service delivery planning and implementation	
7	The various CA practices in the districts and agro-ecological zones are at different levels of adoption and farmer perceptions on their use appear to limit the harnessing of the benefits of CA potentials		Education and training technologies such as no/minimum tillage, crop rotation etc. at established demonstration and social learning sites. Scaling-up of CA within the 26 studied districts	
8	Communities in the study area appear to be well aware of climate change and the related effects on temperature, rainfall patterns etc. Drought and unpredictable rainfall in the zones negatively affect the rainfed agriculture currently being practiced under CA with varying influence and food security and livelihoods	Develop smallholder irrigation infrastructure for the zones	Disseminate available improved irrigation technologies that favour smallholder operators	Research should explore CA/CSA practices under irrigation agriculture
9	Most of the districts downscaled the proposed CA models to suit farming system within their districts. Common was the integrated model with small ruminants for increased profitability. However, the perception of conflict in the management of these resources is also wide spread due to limited knowledge in the intensive management of the systems	MMDAs in collaboration with Traditional Authorities to revive indigenous knowledge systems and pass by-laws for gazetting and enforcement	Educate and train farmers and extension agents on intensive feed production, storage and management to promote crop livestock integration.	
10	CA/CSA knowledge and information data management is virtually absent making action planning and capacity strengthening a challenge	Set-up database management system at all levels. Track CA/CSA changes in the districts for national and sub-regional (ECOWAS) reporting	Integrate CA/CSA data collection and management into the District Commerce, Agriculture and Technology systems	Research to profile and demonstrate profitability of CA systems of practice
11	The proposed coordination structure was successfully downscaled at the district level. However, the setting up of this structure is critical the absence of which, could result in disjointed and inefficient planning and implementation of CA/CSA in the country	Establish a taskforce to set up coordination with clearly stated terms of reference at all levels. Taskforce (MoFA and GASIP) and MMDAs create awareness among stakeholders on the roles and responsibilities of the coordination unit.		

Action Research Areas for CA Promotion

Suggested potential areas for action research and development for evidence likely to aid CA promotion and adoption in the agro-ecological zones include the following:

- Use of Agro -Chemicals and their Effects on Farmers and Consumers
- The cost effectiveness of the practice of CA on the various Models
- Assessing and evaluation of various CA machinery/equipment/ tools in the Ghanaian context
- Experiential comparative study of smallholder CA Adopters, Innovators, Deserters, and Non Users
- Identifying the types and suitability of varied cover crops in the ecological zones.
- Role of irrigation and water harvesting in Conservation Agriculture in the various Agro Ecological zones.

However, low hanging fruits intervention areas for consideration across all the 26 studied districts for accelerated promotion and adoption of CA in the zones may include the following:

1. Pilot the district selected CA models.
2. Establish and strengthen existing District CA/CSA platforms.
3. Establish and scale up CA/CSA Demonstration farms and villages.
4. District warehousing systems and marketing linkage development.
5. ICT in Inputs and climate advisory services
6. CA Equipment and mechanization.
7. Train farmers and AEAs on CA/CSA systems of practice.
8. Irrigated CA Agriculture
9. Gender in CA/CSA Agriculture

Future Scenario Visioning

Moving forward participants at the participatory CA appraisal sessions in the 26 districts expressed their future aspirations about agriculture at the district level. Samples of future developments desired in agriculture as expressed by the multi-stakeholder groups in some of the districts surveyed are shown in the text Box 3 below:

Box 3: VISIONING (MENTAL PICTURE of AGRICULTURE) 10 - 15 YEARS

More Extension officers, Establish AMSEC centres, Agricultural inputs must be cerfi ed, Irriga on facili es established, transporta on services must be improved for agricultural marke ng, Private tractor service opera ons must be controlled and regulated, warehouses and processing facili es ***in EAST MAMPRUSI MUNICIPALITY***

Sustainable livelihood, stable Cashew prices like Cocoa, Processing Plants for Cashew nuts, stable markets for all food crops, Warehouse for storage of Maize and Cashew, Dams for irriga on farming, and Climate Smart Agriculture (CSA) in ***JAMAN SOUTH MUNICIPAL***

Modernized agriculture, a major source of employment, irriga on for all year farming, availability of inputs, improved road networks in farming communi es, establishment of mechaniza on centres, upgrade human resources and improved marke ng systems. Guaranteed prices of agricultural produce and availability of agricultural financing facili es ***in TALENSI DISTRICT***

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Appendix 1 : Terms of Reference (TOR)

	ToR A (Karbo)	ToR B (Delali)	ToR C (Wilhemina)
1	Coordinate and provide direction for a team of experts and field officers to undertake the profiling and baseline survey of CA practices in Ghana	Collaborate with the Lead Consultant to prepare an inception report detailing the overall approach (es) to be adopted for the assignment including outline of methods/methodology and draft data collection instrument(s).	Collaborate with Lead Consultant to prepare an inception report detailing the overall approach (es) to be adopted for the assignment including outline of methods/methodology and draft data collection instrument(s).
2	In coordination with team of experts, prepare an inception report detailing the overall approach (es) to be adopted for the assignment including outline of methods/methodology and draft data collection instrument(s).	Review relevant policy and strategic documents and project reports	Identify key actors and stakeholders in the promotion of CA among small holder farmers in the target ecological zones, assess their respective roles, approaches, the kinds of CA technologies and practices they promote, challenges they face, strategies adopted to address the challenges, and their achievements/contributions to CA adoption and practice.
3	In league with other experts and consultants, document the different CA technologies and practices in the three Northern regions and selected districts in Brong-Ahafo	In the context of climate change adaptation and mitigation along the priority value chains, identify, assess and document the different CA technologies and practices that farmers have adopted (over time and circumstances)	Establish the number and profile of CA smallholder farmers
4	Ascertain vulnerabilities of CA-CSA small-holder farmers in achieving food security, resilience and emission reduction from agricultural activities	Conduct climate change vulnerability assessment on small-holder farmers practicing CA and climate smart agriculture that contribute to agriculture resilience	Assess the effects (gains and draw backs) of CA technologies and practices adopted by farmers on their livelihood, the natural resource base (soils, water, etc) and productivity in the selected regions
5	Characterize the (existing/new) institutional structure/ arrangement for promotion of CA adoption and practice and design a framework for coordination and collaboration among various CA promoters necessary for effective promotion of CA adoption and practice for priority value chains.	Assess the potential irrigation options for CA taking into consideration, climate change mitigation and adaptation needs	Assess and recommend the kinds and levels of CA equipment, tools and mechanisation appropriate for the 3 agro-ecological zones taking into account gender and ecological diversity
6	Develop appropriate CA model (s) that meet the needs of smallholder actor for adoption and practice taking into account gender and ecological diversity.	Propose climate change sensitization strategies, methods and messages appropriate for farmers, CA actors and promoters towards effective large-scale advocacy, adoption and practice of CA	Ascertain potential market linkage opportunities and propose marketing arrangements/business model for CA inputs and tools/equipment, their manufacture and maintenance services, as well as local fabrication necessary to sustain wide adoption and practice of CA
7		Support Lead Consultant to develop appropriate CA model (s) that meet the needs of smallholder actors for adoption and practice taking into account gender and ecological diversity.	Conduct a Political Economic Socio-cultural Technological and Institutional (PESTLI) Analysis to assess strengths and weaknesses in promoting the adoption and practice of CA among smallholder (including youth and women) farmers.
8			Make recommendations for increasing adoption and uptake of CA among smallholder actors especially youth and women

Appendix 2: Composition of the Multi-Disciplinary Team of Researchers

No	Name of Expert	Expertise	Status
1	Dr. Naaminong Karbo	Crop-Livestock Integration Farming Systems Research and Development, AR4D, CA profiling and Organizational Change Management Facilitation	Lead Consultant
2	Mr. Delali Kofi Nutsukpo		Consultant
3	Dr. Wilhelmina Quaye		Consultant
4	Dr. George Owusu Essegbey		Member
5	Mr. Vincent A. Botchway		Member
6	Mr. Kingsley Odum Sam		Assistant

Appendix 3: Bio data of Respondent for Household Questionnaire

Characteristics	Variables	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Age of Respondent	below 18yrs	0	0.0%	2	0.3%	1	0.3%	3	0.2%
	18-35yrs	89	16.5%	138	19.2%	73	24.3%	300	19.2%
	35-60yrs	388	71.9%	489	67.9%	188	62.5%	1065	68.2%
	above 60yrs	63	11.7%	91	12.6%	39	13.0%	193	12.4%
Sex of Respondent	Sex of Respondent	400	74.1%	572	79.4%	217	72.1%	1189	76.2%
	Female	140	25.9%	148	20.6%	84	27.9%	372	23.8%
Educational Level of Respondent	None	175	32.4%	474	65.8%	181	60.1%	830	53.2%
	Basic (Primary/JHS)	207	38.3%	129	17.9%	72	23.9%	408	26.1%
	Secondary (SHS, Tech/ Vocational)	86	15.9%	81	11.3%	28	9.3%	195	12.5%
	Tertiary	34	6.3%	27	3.8%	18	6.0%	79	5.1%
	Others (Specify)	38	7.0%	9	1.3%	2	0.7%	49	3.1%
Marital Status of Respondent	Married	464	85.9%	648	90.0%	259	86.0%	1371	87.8%
	Single	26	4.8%	20	2.8%	12	4.0%	58	3.7%
	Divorced	25	4.6%	8	1.1%	2	0.7%	35	2.2%
	Widowed	25	4.6%	44	6.1%	28	9.3%	97	6.2%
Position of Respondent in the household	Head	439	81.3%	573	79.6%	240	79.7%	1252	80.2%
	Spouse	76	14.1%	87	12.1%	39	13.0%	202	12.9%
	Son	11	2.0%	42	5.8%	13	4.3%	66	4.2%
	Daughter	9	1.7%	4	0.6%	3	1.0%	16	1.0%
	Other Relative	5	0.9%	14	1.9%	6	2.0%	25	1.6%
Gender of the Household Head	Male	383	87.2%	516	90.2%	202	84.2%	1101	88.0%
	Female	56	12.8%	56	9.8%	38	15.8%	150	12.0%
	Both	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Who are the major decision makers in the household?	Head of household only	195	36.1%	335	46.5%	75	24.9%	605	38.8%
	Head and spouse	284	52.6%	235	32.6%	148	49.2%	667	42.7%
	Entire household	61	11.3%	150	20.8%	78	25.9%	289	18.5%
How many people are in your household?	Average	8		12		10		10	
Occupation of Respondent	Government employment	19	3.5%	21	2.9%	10	3.3%	50	3.2%
	Private sector employment	13	2.4%	5	0.7%	3	1.0%	21	1.3%
	Agriculture (crops, livestock, aquaculture)	539	99.8%	715	99.3%	299	99.3%	1553	99.5%
	Agro-processing	29	5.4%	50	6.9%	4	1.3%	83	5.3%
	Petty trading/marketing	48	8.9%	100	13.9%	48	15.9%	196	12.6%
	Artisan(specify)	24	4.4%	39	5.4%	14	4.7%	77	4.9%
	Others (specify e.g. driving)	42	7.8%	28	3.9%	4	1.3%	74	4.7%
How many years have you been practicing Agriculture?	Average	23		24		25		24	

Appendix 4: Challenges associated with CA practices by districts in Transitional Zone

District/Municipal	Challenges Associated with CA Practices					Possible Solutions
	Zero/Minimum Tillage	Crop rotation	Cover cropping & Mulching/Compost	Intercropping	Crop & Livestock/Poultry Integration	
Banda District	High cost of labour hence resort to herbicides but has health and environmental effects if not properly managed	Have low education / loss of knowledge with time	Bushfires Change in rainfall pattern Marketing	Labour intensive for multiple harvest		Minimum tillage is quite indigenous practice among farmers but now needs more education on proper applications
Dormaa Central Municipal	Resort to use of herbicides due to high cost of labour	Lack of CA equipment for crop rotation	Most of the farmers cultivate yam and need to apply mulch but there are challenges with bushfires	The intercropping increases crop yield per unit area as well as reduces soil erosion but challenged by nadequate labour	There are challenges with bulky nature of manure	Improved livestock/poultry management would improve yields of crops in an integrated manner as well decrease soil erosion.
Jaman South Municipal	Lack of CA Machinery Difficulty with marketing of produce		Unreliable rainfall pattern Drying up of water bodies		There are challenges with bulky nature of manure	Initiate small scale irrigation schemes to address the drying up of water bodies.
Tain District	Health and environmental implications with herbicide use High cost of agro chemicals Extinction of certain plant and animal species Emergence of new weed varieties	High cost of labour Requires enhanced expertise, CA equipment and diversification of crop management practices	High cost of labour			Use of botanicals as herbicides Compost / manure use Training of farmers in appropriate use of agro chemicals
Kintampo North Municipal	Long use of herbicide makes the land bare and creates more erosion Lack of CA equipment Invasive pest	Inadequate labour Unreliable rainfall pattern	Inadequate labour Bushfires	Dry spells Poor soils	Destruction by animals, conflicts, diseases	Appropriate use of herbicieds
Nkoranza South Municipal	Low initial yield. This could be resolved with Start-up fertilizer use of early maturing varieties		Bushfire threats Termites infestation Bulky and difficult in transporting compost		There are challenges with bulky nature of manure	Fire belt for bushfire contro.l Use of pesticides Packaging of compost in smaller units
Techiman Municipal	Low yield initially this could be corrected by Use of start-up fertilizer		Bushfire threats Bulky and difficult in transporting compost Termites infestation		There are challenges with bulky nature of manure	Fire belts to control bushfires. Packaging of compost in smaller units Early Mulching destruction of termites' colonies using pesticides.
Krachi-East	With minimum tillage, soil surface is protected so water is retained. Initial yields could be low if not properly managed		Mulching is common and associated with Weed population control. Main challenge is inadequate labour	Moisture is conserved by the population of the crop	Land use conflict (crops and livestock farmers) Plough the land before raising the mounds due to soil compaction by hoofs of livestock.	Use of weedicide Use of improved practices such as line planting to increase yield
Nkwanta North	Inadequate access extension service					

Appendix 5: Challenges associated with CA practices by districts in Sudan Savannah

District/Municipal	Challenges Associated with CA Practices					Possible Solutions
	Zero/Minimum Tillage	Crop rotation	Cover cropping & Mulching/Compost	Intercropping	Crop & Livestock/ Poultry Integration	
Bawku Municipal	Inadequate bullocks. Difficulty in feeding bullocks. Theft of bullocks. Attack by diseases. High cost of bullocks. Health effects on humans and environment associated with improper herbicide use. High cost. Lack of technical-know-how. Indiscriminate disposal of herbicide waste.	None availability of land	Insufficient organic materials for composting. Labour intensive. High cost of transporting compost to farms. Wet compost promotes pests and diseases.	Scarcity of land. Crops compete for nutrients. Lack of knowledge on appropriate inter cropping practices. Fast depletion of soil fertility.	Destruction of crops by animals, conflicts, poor livestock management practices, poor housing infrastructure for the animals diseases and lack of veterinary services.	Government should establish mechanization centres. Efficient veterinary services. Establish breeding centres. Promote waste separation. Establish compost fields on farms.
Bawku West	High cost of herbicides. Health effect. Lack of knowledge on appropriate use. Lack of accessibility. Infiltration of fake herbicides. Inappropriate labelling. Low accessibility of Bullock and theft cases	Scarcity of lands. Farmer preference for specific crops. High cost of production of specific crops for rotation. Inadequate technical knowledge on crop rotation.	Practice is Laborious. Limited knowledge in compost making. Limited to small farm sizes. Unavailability of raw materials. Limited to only dry season farming. Labour intensive. Inadequate technical-know-how. Bushfires	Crop competition for soil nutrients. Limited to only smallholder farming. Labour intensive.	Destruction of crops by animals, conflicts, poor livestock management practices, poor housing infrastructure for the animals diseases and lack of veterinary services.	Build capacity of farmers and support with credit facilities. Use of improved varieties. Avoid burning of crop residue. Add bullocks to Raring for Food and Jobs Programme. Educate farmers on improved housing keeping for bullocks
Bongo	With herbicides use, lack of technical-know-how. Requires high capital to buy chemicals and full operational kits. Harmful effects to humans. Bullock Ploughing causes erosion when done wrongly. Initial cost of bullocks is high. Theft of bullocks. Lack of CA equipment	Inadequate knowledge and skills. Limited farm lands	Compost/Manure application is tedious. Raw materials not readily available. Limited to small size farms. Lack of access to water. Bushfires	Difficulty in weeding. Improper combination attracts pests. Time consuming.	Destruction of crops by animals, conflicts, poor livestock management practices, poor housing infrastructure for the animals diseases and lack of veterinary services.	Education of farmers on appropriate usage. Sensitization of effects of chemicals on humans. Encourage use of protective outfits. Education on appropriate crop combination for crop rotation. Prevention of burning of crop residue. Training on proper ploughing techniques Support and train farmers on CA equipment.

District/Municipal	Challenges Associated with CA Practices					Possible Solutions
	Zero/Minimum Tillage	Crop rotation	Cover cropping & Mulching/Compost	Intercropping	Crop & Livestock/ Poultry Integration	
Garu	Use of herbicide results in land degradation. The Practice kills micro-organisms resulting in loss of soil nutrients. Harmful effect of practice to human and livestock. High cost of practice. Theft of bullocks. High cost of bullocks. Limited to small acreages. Difficult to plough lands with stumps.		Difficulty in building compost. Practice is time consuming for large farm sizes. Lack of technical-know-how. Results of compost is seen to delay as compared to fertilizer application. With mulching, Burning of crop residue. Practice is time consuming. Practice is labour intensive.	Competition among crops for sunlight. Difficulty in harvesting. Reduces sizes of grains.	Destruction of crops by animals, conflicts, poor livestock management practices, poor housing infrastructure for the animals diseases and lack of veterinary services.	Shift from herbicides use to composting/manure application. Use protective clothing. Train input dealers and farmers on appropriate herbicide use. Government should further subsidy herbicides. Educate farmers against bush burning. Training on efficient mulching making
Telensi	Lack of CA equipment		Bushfires		Destruction of crops by animals, conflicts, poor livestock management practices, poor housing infrastructure for the animals diseases and lack of veterinary services.	Government should establish mechanization centres. By-laws in the district on bush fires/burning

Appendix 6: Challenges associated with CA practices by districts in Guinea Savannah

District/ Municipal	Challenges Associated with CA Practices					Possible Solutions
	Zero/Minimum Tillage	Crop rotation	Cover cropping & Mulching/Comp	Intercropping	Crop & Livestock/Poultry	
Gushegu Municipal	When Glyphosate is used for legumes there is no fruit		Mulching is common especially for yam cultivation but challenged with termites and bushfires			
Nanumba South District	Weedicides used. Plots that are sprayed with weedicide appear greener than the others, depicting healthier soils.			Crops such as cowpeas release nutrients into the soil for the benefit of others.		
Sagnarigu Municipal	Grass left on land conserves moisture. Less weeding so less labour Compacted soil reduces erosion					
East Mamprusi Municipal	Difficult to practice no till or zero tillage on large farm sizes. The use of herbicides is a constraint because of Lack of protective gears. It also affects livestock consumption of weeds leading to death due to inadequate knowledge of proper use of herbicide Difficult to use the dibbler in minimum tillage hence poor germination	Lack of legume seeds				Therefore agro-input dealers should sell protection gears. Also farmers must avoid spraying grazing lands whilst capacity building for farmers must be done. Input dealers should have more legume seeds for crop rotation. Whilst subsidy must be added to the cost of legume seeds.
West Mamprusi Municipal	Challenges with soil management with zero tillage, Weeding and fertilizer application must be accompanied quickly after two weeks of seed germination if not crops may die off Theft of bullocks for ploughing under minimum tillage					
North Gonja District	With the use of herbicides, inadequate input dealers for the districts (only 3 in the district). soil becomes exposed to rains and erosion prone		Labour for weeding reduces but for harvesting increases		No by-laws for bushfires and livestock grazing	Proposed Enactment of by-laws on bushfires and overgrazing of farmlands by animals More consultation between chiefs and farms Education on bush fire prevention Establish mechanization centres Farming communities to be linked to markets

District/ Municipal	Challenges Associated with CA Practices					Possible Solutions
	Zero/Minimum Tillage	Crop rotation	Cover cropping & Mulching/Comp	Intercropping	Crop & Livestock/Poultry	
Lawra Municipal			Mulching is common especially for yam cultivation but challenged with termites and bushfires		Bushfires High cost of labour	Marketing – to get local processing equipment to add value to produce. Changes in rainfall pattern – stop cutting down of trees and bushfires. Assembly and Traditional Authorities. Enforcement of existing by-laws. Establishment of more irrigation facilities / infrastructure. Build storage facilities – warehouses and Financial institutions – should bring their interest rates Train Extension Volunteers – build capacity of some of the community people to support.
Wa Municipal	Farmer challenges in the selection of appropriate herbicides, cost element and availability. Fulani herds – destruction of crops		Bushfires High cost of labour. Don't get weather information for planning Low knowledge of agro-input use Post-harvest losses and unavailability of market			Issues with land tenure system Assembly has a role to play – establish a agro-processing factory and storage facilities (warehouse). Written tenancy agreements By-law enforcement to deal with the Fulani herdsmen Intensify education and awareness creation
Nandom District	Pest and disease on crops – example FAW High cost of labour Insufficient funds for production Ignorance of wearing protective clothing (spraying chemicals etc)		Unavailability of some varieties (hybrid maize seeds, groundnuts) Bushfires Inadequate irrigation facilities Inadequate extension services (AEAs ratio to farmer) High cost of inputs		High mortality rate of livestock Use of chemicals is reducing the livestock production	

Appendix 7: Field Work Checklist for District Level Participatory CA Profiling

Introduction and general information

1. Travel to district/community, welcome, introductions and purpose and objective of the meeting.
2. Collect district level general information (Location, population, education, agriculture general, crops, livestock, production and yield gaps, temperature, rainfall, vegetation, tourism, markets, etc.) from secondary sources

Understanding the farming system

3. Discuss Climate change and agriculture in the district. Perceptions on temperature, rainfall change. Identify and list practices in participatory discussion/brainstorming:
   a. Indigenous knowledge Farming methods and practices.
   b. Introduced Farming methods and practices in past 30 years.
   c. What change has taken place with the indigenous practices?
4. Estimate the % farmer adoption, % district coverage of practices (CA/CSA) and by gender of the introduced methods and practices. Employ scoring/proportional piling tool with Tabular illustration as suggested in Table 1 below.

Table 1: Introduced CA practices and perceived district level adoption by gender

Introduced CA/CSA Practice	% Farmer adoption	% District coverage	% Proportion of Gender in practice			Reasons
			Male	Female	Youth	
Minimal soil disturbance						
Fallow						
Intercropping						
Crop rotation						
Rotational grazing						
Compost						
Mulching						
Cover cropping						
Trees on farms						
Early varieties						
Stone bunding						
Tied-ridges, etc						

5. Conduct district resources/agriculture inventory using Resource mapping Tool **(see Appendix 1)**

List district resources/infrastructure of importance (e.g. markets, dams, rivers, forests, farm lands grazing lands, storage facilities, mechanization/service centers, human, etc.) to their agriculture. Explore visualization on map using flip chart/floor. A mixed gender group may be used. Discuss state of the resources. What has changed? Probe for causes/hazards (climate change, floods, drought, bushfires, disease, etc.) and the vulnerability of farmers in the district.

6. Initiate discussion on good agriculture farm practices and list the types of practices (CA/CSA). Prioritize important/dominant practices employing Matrix ranking tool. For example 25 counters may be used to score for the practices (rows) along the given criteria (column) generated from discussions or predetermined from existing knowledge with participants. Prior weighting may be given to the various criteria which should allow for the matrix comparison and ranking using the total scores in the rows (Table 2)

Table 2: Matrix ranking for priority CA/CSA practices

CA/CSA Practice	Criteria					Total score	Rank
	Improve yield	Improve soil moisture	Reduced Labour	Low use of mineral fert.	Reduce erosion	(Row sum)	
No/minimum till							
Trees on farms							
Crop rotation							
Intercropping							
Cover cropping							
Others, etc.							

Discuss the resulting scores and rankings with participants to reveal reasons behind the figures. Identify which practices go together as a system.

7. List by mapping constraints and solutions in the identified systems of practices
8. District CA/actor identification and Mapping by gender. Identify CA promoters and their linkage strengths using Venn diagramming **(see Appendix 2)**
9. **Vulnerability Assessment employing matrix scoring on Lickert scale**

Vulnerability Assessment matrix table

Criteria	Hazards influence, 1=minimal influence, 3=has some influence, 5=hazard has very strong influence											
	Drought		**Floods**		**Wildfires**		**Unpredictable rainfall pattern**		**Livestock/Crop diseases**		**Total Score**	**Average**
	Score	Who affected most	Score	Who affected most	Score	Who affected most	Score	Who affected most	Score	Who affected most		
Productive land												
Food security												
Water Resources												
Livestock												
Fertilizer use (organic & inorganic)												
Pesticide & Herbicide use												
Human Health												
Migration												

Downscaling CA models, Coordination Structures/bodies and PESTELI/SWOTs to District/community level

Facilitation Process: Group work will be encouraged at this stage. There will be a group made up of technocrats including researchers/NGOs from the District/Municipal Assembly. The Community group will consist of farmers, traditional authority and other CA actors within the community.

Reflecting on the various challenges/constraints facilitate groups define model objective(s). Identify elements of the model using regional level models as guide. Identify existing actors/institutions in the district/community performing roles (marketing, production inputs, etc.) using sub-models beneficial in the promotion of CA at that level in the given zone for inclusion.

Similarly, employ proposed Coordination structure and PESTELI from Regional/National level as guides for downscaling to the district/community levels.

Make copies of CA models, PESTELI and coordination structures available to group participants to be used for discussion with district perspective, review and validation.

Probing questions from facilitation may include:

- ✓ Do models and governance structures reflect your district situation for promotion of CA?
- ✓ What ought to be removed or added? Give reasons.
- ✓ Selection of any two of the models best suited for the district with explanations

District Level Participatory Scenarios Visioning of Agriculture

Discuss the old/new methods (e.g. CA) of farming and the future of Agriculture in the district (Scenarios visioning). Participants to mention things they will like to see in the new world and what needs done moving district agriculture forward and on sustainable footing (A New World of Agriculture!!?). Increased productivity from inputs service providers, promoting CA machinery equipment, value addition, one village one factory, jobs, exports, increased incomes, food security, etc.!!!!

CA Profitability measurements

1. Estimating the profitability for identified CA models for a Cereal-legume-tuber-tree crop farm systems

i. Participants should mention at least four (4) major crop commodities produced in the district. The crops selected should be those that can be practiced under minimum or no till, crop rotation, intercropping, cover cropping and trees on farms.

ii. Introduce participants to the CA models developed and let them identify and select the Models that can work in the district.

iii. Let participants give estimates on *tractor use services per acre or any equipment hired for use* with respect to selected CA implementation models. This estimate is different from other *land preparation cost.* Ensure the two costs are obtained differently so as to estimate operating profit at farm level.

iv. Participants should also list main activities and provide estimates (annual average cost per acre) on these activities (variable costs) in connection with CA model implementation with respect to farming systems mentioned in i. above.

v. Generate average quantities of crop output produced (number of bags etc. per acre) for both major and minor seasons where possible and price sold.

Appendix 8: List of CA Equipment/Machinery with Value Chain Perspective for livestock and crop commodities are provide in Table below.

	BIRDS	RUMINANTS
Breeding	Incubators, hatcheries Heaters	Artificial Inseminators,
Husbandry	Feed Mixers, watering Trough Bailers	Feed Mixers, Milling Machines (Hammer Mills), Silage and Hay harvesters, Watering Trough, Appropriate Housing ,Silage and Hay harvesters
Processing	Pelleting machine	

OPERATIONS		COMMODITY			
		Cereals	Legume	Root Crops	Tree Crops
LAND PREPARATION	Small Scale	Hand Tools: Cutlasses, hoes, Power Tiller Rotavator, Animal Aggregated Tillage Implement, Knapsack Sprayer, Brass Cutter,	Hand Tools: Cutlasses, hoes, Power Tiller Rotavator, Animal Aggregated Tillage Implement, Knapsack Sprayer, Brass Cutter,	Hand Tools: Cutlasses, hoes, Power Tiller Rotavator, Animal Aggregated Tillage Implement, Knapsack Sprayer, Brass Cutter,	Hand Tools: Cutlasses, hoes, Power Tiller Rotavator, Pick Axe, Knapsack Sprayer, Brass Cutter, Motorized Auger
	Large Scale	Tractor –Mould board, Harrow, Ripper, Chisel Plough, Roller Crimper , Slasher, Boom Sprayer, aggregate, Ridger	Tractor –Mould board, Harrow, Ripper, Chisel Plough, Roller Crimper , Slasher, Boom Sprayer, aggregate, Ridger	Tractor –Mould board, Harrow, Ripper, Chisel Plough, Roller Crimper, Slasher, Boom Sprayer, aggregate, Ridger	Tractor –Mould board, Harrow, Ripper, Chisel Plough, Roller Crimper, Slasher, Boom Sprayer, aggregate, Ridger
PLANTING	Small Scale	Jab Planter, Dibbler, Animal Aggregated Planter	Jab Planter, Dibbler, Animal Aggregated Planter	Jab Planter, Dibbler, Animal Aggregated Planter	Dibbler, Motorized Auger, Spade, Axe,
	Large Scale	Tractor aggregated CA Mechanical/ Pneumatic Planters, Power Tiller Mounted Transplanters	Tractor aggregated CA Mechanical/Pneumatic Planters Power Tiller Mounted Transplanters	Tractor aggregated CA Mechanical/ Pneumatic Planters Power Tiller Mounted Transplanters	Motorized Auger, Earth Chisel
HUSBANDARY	Small Scale	Knapsack Sprayer, Animal Agregated Cultivator, cutlass, hoes	Knapsack Sprayer, Animal Agregated Cultivator, cutlass, hoes	Knapsack Sprayer, Animal Agregated Cultivator, cutlass, hoes	Knapsack sprayers, Hand Pruning shears, cutlass, Axe, Insect Traps
	Large Scale	Tractor mounted cultivators, Boom Sprayers, Fertilizer Spreader	Tractor mounted cultivators, Boom Sprayers, Fertilizer Spreader	Tractor mounted cultivators, Boom Sprayers, Fertilizer Spreader	Tractor mounted cultivators, Boom Sprayers, Fertilizer Spreader
HARVESTING	Small Scale	Sickle, Cutlass, knife	Power Tiller mounted Reaper,	Hoe, Cutlass	Hand Rollers for shear nuts, Pickers
	Large Scale	Power Tiller mounted Reaper, Tractor Mounted Harvester, Combine Harvesters, Self-Propelled Pickers	Power Tiller mounted Reaper, Combine Harvesters, Tractor Mounted Harvester,	Power Tiller mounted Reaper, Root crop Harvesters	Mango Harvester, Limb Shaker, Mechanical harvesters
PRIMARY PROCESSING	Small Scale	Threshers, Hand Shellers, Banbam box, Drying Patios, Grinding Mills	Threshers, Decorticators,	Dryers (Solar, Vacuum, Mechanical etc),	Dryers (Solar, Vacuum, Mechanical etc),
	Large Scale	Threshers, Shellers, Processing Mills, Drying Patios	Threshers, Decorticators,	Dryers (Solar, Vacuum, Mechanical etc),	Dryers (Solar, Vacuum, Mechanical etc), Fruit Juicing machines

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