

# Climate-Smart Livestock Interventions in West Africa: A Review

Working Paper No. 178

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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RESEARCH PROGRAM ON  
**Climate Change,  
Agriculture and  
Food Security**



Working Paper

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## **Abstract**

The livestock sector is one of the major contributors in agriculture, by some estimates contributing up to 18% of the global greenhouse gas (GHG) emissions. Of this, about one third is reported to be due to land use change associated with livestock production, another one third is nitrous oxide from manure and slurry management, and roughly 25% is attributed to methane emissions from ruminant digestion. Recent analysis suggests that developing world regions contribute about two thirds of the global emissions from ruminants, with sub-Saharan Africa a global hotspot for emissions intensities, largely due to low animal productivity, poor animal health and low quality feeds. These numbers suggest, therefore, that there are opportunities for easy gains to be made in terms of mitigation in the livestock sector, as improving feed resource use efficiencies would improve livestock productivity as well as reduce emissions per unit of product. In this context, climate-smart agricultural practices are necessary in the West Africa region and in sub-Saharan Africa in general. Climate-Smart Agriculture (CSA) is an approach that provides a conceptual basis for assessing the effectiveness of agricultural practice change to support food security under climate change. This review focuses on livestock-related CSA options in West Africa looking at herd management, feed, grazing management, animal breeding strategies, manure management, and policy options.

## **Keywords**

Climate-Smart Agriculture; Livestock Productivity; West Africa.

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## Acronyms

ASPS	Agro-Silvo-Pastoral Systems
AU	African Union
CC	Climate Change
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CSA	Climate-Smart Agriculture
CS	Climate Smart
DM	Dry Matter
ECOWAS	Economic Community of West Africa State
FAO	Food and Agriculture Organisation
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change
NPCA	NEPAD Planning and Coordinating Agency
SSA	sub-Saharan Africa
TLU	Tropical Livestock Units

## Introduction

Climate change is one of the greatest challenges to sustainable development in general and food security in particular in recent history. Climate change is a global phenomenon. However, developing countries are more exposed to the hazards of climate change and are less resilient to them (Morton, 2007). Its negative impacts are more severely felt by poor people in developing countries who rely heavily on the natural resource base for their livelihoods. They will have to bear an estimated 75–80% of the costs associated with the impacts of climate change (Smith *et al.*, 2009; The World Bank, 2010). According to IPCC (Intergovernmental Panel on Climate Change) reports, even if we act decisively now, temperatures by 2050 will be at least 2 °C, and perhaps as much as 5 °C, above those of pre-industrial times (IPCC, 2007; The World Bank, 2010), threatening sustainable food production worldwide.

The livestock sector is one of the major contributors in agriculture, by some estimates contributing up to 18% of the global greenhouse gas (GHG) emissions (Thornton and Herrero, 2010). Of this, about one third is reported to be due to land use change associated with livestock production, another one third is nitrous oxide from manure and slurry management, and roughly 25% is attributed to methane emissions from ruminant digestion (Thornton and Herrero, 2010). Dourmad *et al.* (2008) in their report classified the contribution of livestock production system to global climate change directly through three main sources of the GHG emissions: the enteric fermentation of the animals, manure (waste products) and production of feed and forage (field use). However, the contribution of livestock to GHG emissions varies tremendously by type of system, and there is scarce data for Africa. Recent analysis by Herrero *et al.* (2013) suggests that developing world regions contribute about two thirds of the global emissions from ruminants, with sub-Saharan Africa a global hotspot for emissions intensities, largely due to low animal productivity, poor animal health and low quality feeds. These numbers suggest, therefore, that there are opportunities for easy gains to be made in terms of mitigation in the livestock sector, as improving feed resource use efficiencies would improve livestock productivity as well as reduce emissions per unit of product.

At present, very few development strategies promoting sustainable agriculture and livestock-related practices have explicitly included measures to support local communities to adapt to or

mitigate the effects of climate change. Activities aimed at increasing rural communities resilience will be necessary to support their capacity to adapt and to respond to new hazards. Identifying changes in agricultural practices especially in livestock production that result in effectively adapting to site specific effects of climate change and their potential barriers to adoption is essential to addressing interlinked challenges of food security and climate change.

Climate-Smart Agriculture (CSA) is an approach that provides a conceptual basis for assessing the effectiveness of agricultural practice change to support food security under climate change. The aim of CSA is to integrate climate change in agriculture and make agriculture adapt to climate change and to reduce emissions (or mitigation) that causes climate change. Livestock production systems are considered to be “climate-smart” by contributing to increasing food security, adaptation and mitigation in a sustainable way. Any livestock management practice that improves productivity or the efficient use of scarce resources can be considered climate-smart because of the potential benefits with regard to food security, even if no direct measures are taken to counter detrimental climate effects (Ayantunde *et al.*, 2015). CSA is not a single specific agricultural technology or practice that can be universally applied. It is an approach that requires site-specific assessments to identify suitable agricultural production technologies and practices. According to FAO (2010a) CSA aims at:

1. Sustainably increasing agricultural productivity and income
2. Reduce climate change vulnerability (enhance adaptation),
3. Reduce emissions that cause climate change (mitigation), while
4. Protecting the environment against degradation and
5. Enhancing food security and improved livelihood of a given society.

While the concept of CSA is new, it draws on concepts that have been around for a while, such as sustainable agriculture and sustainable intensification.

Environment-friendly development of livestock production systems demands that the increased production be met by increased efficiency of production and not through increased animal number (Leng, 1993). Feeding strategies that increase the efficiency of producing more from fewer animals and less feed will result in reduced greenhouse gas emissions (Blummel *et al.*, 2010). Livestock production systems should be “climate-smart” by

contributing to increasing food security, adaptation and mitigation in a sustainable way. In addressing climate change adaptation for livestock-based livelihoods, Ayantunde *et al.* (2015) listed key questions to consider:

1. Which types of livestock management are suited to climate change and where?
2. Which animal species and breeds should be kept in which areas and what are the trade-offs?
3. Which animal diseases should we focus on?
4. Are there current livestock-based livelihood systems in the region that are best suited to climate change adaptation?
5. How can we add value to the existing livestock-based adaptation strategies?
6. Are there policy and institutional mechanisms to enhance adaptation of livestock production systems to climate change and variability?
7. How could the capacity of rural institutions be strengthened to use appropriate tools and strategies to cope better with consequences of climate change?
8. How could we balance the need for short-term adaptation, which is often reactive, with long-term climate change adaptation planning? At community level, climate change adaptation should be considered in the context of other significant drivers of change (demographic change, economic development, market opportunities).

Although there are many research and analytical efforts to minimize the impact of climate change on agriculture and livelihoods in Africa by various actors, there is however, no coherent documented state of knowledge of livestock-based CSA practices in West Africa. Identifying and documenting successful livestock-based CSA practices has been a challenge. To this end, this study is an attempt to synthesize current knowledge on climate smart (CS) livestock production in West Africa and identify gaps in knowledge. This report presents the state of climate smart livestock production practices in West Africa. Some of the experiences

and lessons learned regarding CSA in relation to livestock production in West Africa have been documented with specific concentration on Burkina Faso and Mali. This work briefly reviewed the literature on climate change impacts on livestock and livestock systems in West Africa, adaptation and mitigation livestock strategies, and climate-smart options in livestock production and identifies some key knowledge gaps. Building on these, the paper provides broad researchable areas associated with smallholders and pastoralists to promote both adaptation and mitigation activities in the development of future projects. This review was conducted as an integral part of the “Building climate smart farming systems through integrated water storage and crop-livestock interventions (IWSLIs)” project in West Africa under the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). This project focuses on water retention techniques for crop production (e.g. Zai, contour ridges) and small-to-medium-scale water storage infrastructure (dugouts, small reservoirs) for multipurpose use, combined with technologies focusing on optimizing crop-livestock production (trees and legumes, fodder production, crop residue management). These are aimed at increasing resilience of farming systems by:

1. Improving water availability for crops, livestock and humans throughout the year;
2. Stabilize cash flow from crops and livestock over time; and
3. Establish a reliable value chain for crops and livestock.

## Existing knowledge on livestock-related climate-smart agricultural practices in West Africa

In West Africa, there is obviously paucity of information on livestock-oriented climate smart practices, although, there are several crop-targeted project based of CS principles. Most information at this stage is either on modelling, scoping of mitigation strategies or on resilience of livestock farmers. However, in other parts of Africa, East Africa for example (CCAP 2013; UNEP 2009) many livestock options for climate smart agriculture had been tested and documented while others are at the scaling up level (Kipkoech *et al.*, 2015). Despite this, a few interventions suggested for sustainable intensified livestock production in West Africa has been identified within the current context, and described below. These interventions are grouped into three major types namely: Feed related interventions, livestock production management, environmental management and Socio-political and financial interventions. Specific interventions are discussed as sub-intervention under these groups. The current state of knowledge of each intervention, limitations and knowledge gaps were discussed in this section.

### Livestock feed related climate smart interventions

#### Fodder cultivation

The possible opportunities for livestock-related mitigation through improved pasture management have been quite widely described (Conant and Paustian, 2002, Peters *et al.*, 2012). In Burkina Faso, many institutions such as l'Institut de l'Environnement et de Recherches Agricoles (INERA) and Ministry of Animal Resources and Fishery have been involved since 1961 in the introduction and testing the adaptability of fodder plants. As a result, technical papers have been elaborated for 22 species that were shown to be promising (Sanon and Kanwe, 2004). Sanfo *et al.*, (2015) also reported that the Ministry of Animal Resources and Fishery encouraged agro-pastoralists who have been settled by the government to plant fodder species.

An assessment of the fodder bank technology developed by ILCA and its national research partners involved about 27,000 smallholder farmers covering an area of about 19,000 ha for the whole of West Africa (Elbasha *et al.*, 1999). The main species that were promoted were *Vigna unguiculata* (cowpea), *Dolichos lablab*, *Macroptilum atropurpureum* (Siratro), *Panicum maximum*, *Cenchrus ciliaris*, *Chloris gayana*, *Cajanus cajan*, *Leucaena leucocephala*,

*Stylosanthes* and *Brachiaria ruziziensis*. However, most of the adoption was concentrated in the sub-humid zone, perhaps due to the adaptability of the species. Cowpea is a species expanding in the Sahelian zone as a multi-purpose crop, the grain being used for human consumption while fodder is used for animal feeding.

According to Kassam *et al.* (2009), an extensive cultivation of the high biomass grass, *Brachiaria ruziziensis*, was introduced to farmers in Burkina Faso under some projects to promote the use of this grass as livestock feed. Furthermore, farmers were encouraged to collect crop residues of several leguminous plants including *Mucuna*, cowpea and soybean for incorporation into livestock feed rations during the dry season. Despite these efforts, the dry season availability of feeds for livestock continues to constrain sustainable livestock production in the region.

### **Fodder conservation**

Some projects in Burkina Faso introduced a silage production technology to farmers and further organized training for women farmer groups in silage production using locally available herbage, such as grasses, cereals and salt (Bayala *et al.*, 2011). For silage making, naturally growing wild grasses, mainly *Andropogon gayanus*, *Brachiaria ruziziensis*, *Digitaria ciliaris*, *Echinochloa* and *Pennisetum pedicellatum*, were harvested at the early flowering stage when the moisture content is about 30 – 40%. Green cereals residues of poorly developing maize, rice, sorghum or millet crops are also harvested for use in silage production. The herbage is then left to ferment and cure for about 3 weeks after which it is ready and collected for feeding to livestock. Through FAO/INERA collaboration, extensive studies in Western Burkina Faso showed that the opportunity cost of silage and salt lick production using this technology is low with a cost-benefit ratio of 527%, and therefore highly profitable and beneficial to small holder livestock farmers. Feeding Azawak cows on silage supplements resulted in a dramatic tenfold increase in milk production, while ewes fed on silage supplement maintained milk yields throughout the year (Bayala *et al.*, 2011). Farmers quickly adopted this silage production technology not only to successfully feed livestock during the dry season but also as an income generating opportunity through the sale of silage and salt-lick blocks. To widely disseminate this technology, group training courses on silage and salt-lick production were organized in several villages not only to build farmer capacities to produce silage and salt licks, but also to facilitate promotion of farmer-to-farmer dissemination of the practice (Bayala *et al.*, 2011). Thus, through the introduction of forage

technology for the production of livestock feeds, farmers successfully increased the levels of animal production and enhanced their farm incomes. Furthermore, feeding livestock with processed *Mucuna* seed rations was reported to be highly successful in Burkina Faso (Kassam *et al.*, 2009). Sheep fed on feed including boiled *Mucuna* seeds increased their weight by at least 35%, and milk production in goats was significantly increased (Kassam *et al.*, 2009). Through adopting this processing technique, farmers were able to significantly increase their farm revenue from the sale of fattened animals as well as the production and distribution of *Mucuna* seeds to neighbouring farmers.

Like many other feed intervention projects in West Africa, the above interventions were not setup with the initial intention of climate change mitigation. It is therefore become difficult to assess the impact of these feed improvement intervention in the context of climate smart practices. Regular availability of forage seed is often the main challenge to projects promoting planting of fodder species.

In general, the cultivation of legumes specifically for forage is minimal in the region. Fodder production in most cases requires relatively secured land tenure to ensure that farmers who invest effort in cultivating the fodder species retain the right to exclude others from harvesting it. As obvious as this may sound, it is a major constraint to forage development in many livestock systems, and one of the most difficult obstacles to overcome due to communal grazing. Many constraints have to be dealt with to overcome the low adoption of planting fodder species such as weak extension services, land tenure, cost of fencing materials, shortage of labour due to overlapping of the farming calendar with the main staple crops, credit and seed availability, uncontrolled bush fire and invasion by grasses and weeds.

### **Forage quality improvement**

Improvements in feed digestibility can be achieved through the processing of locally-available crop residues (e.g. treatment of straw with urea) and by supplementation of diets with better quality green fodder such as multipurpose leguminous fodder trees, where available. Better feed digestibility leads to better animal and herd performance. One way is to manipulate the physical structure of feeds (to increase intake), for example, by making feed blocks or by chopping poor-quality crop residues to increase their intake (Blümmel *et al.*, 2009).

Combining the feeds produced by the household or acquired from neighbours, from common property resources or from formal market channels is necessary to better match the animal's

nutrient requirements thereby increasing the efficiency of conversion of the feeds to live-weight gain or milk. Other method involves urea treatment of crop residues to improve its quality and digestibility and hence reduced enteric methane emission. Many studies have been done on improving their use for ruminant feeding, including physical treatments by chopping and treatment with urea or ammonia (Sanon, 2007).

### **Integration of forage legumes into arable crops**

Intercropping forage legumes with cereals offers a potential for increasing forage and, consequently, livestock production in sub-Saharan Africa. This intercropping has been shown to improve both the quantity and quality of fodder and crop residues leading to better system efficiency (Ayarza *et al.*, 2007). In such a system, the yield depression of the cereal grain should be minimal, possibly not more than 15%, for it to be acceptable to the farmer (Umunna *et al.*, 1995). The time of sowing of cereal and legume is critical for the yield of each crop. The indication from the few studies on time-of-planting is that sowing a forage legume simultaneously with a fast-growing cereal has no effect on cereal yield (Nandi and Haque, 1986; Amole *et al.*, 2015). Legumes have a potentially significant role to play in enhancing soil carbon sequestration. The role of legumes in supplying nitrogen (N) through fixation is increasingly seen as important as and more beneficial in terms of overall GHG balance than had once been thought. Powers *et al.* (2011) reported increases in soil carbon stock when forest or savanna was converted to pastures (5–12% and 10–22%, respectively). Legumes are likely to have a role to play in reducing GHG emissions from ruminant systems. An approach to reducing methane emissions of current interest and supported by some initial evidence is the use of tannin containing forages and breeding of forage species with enhanced tannin content. In the context of maintaining N fertility, Nichols *et al.* (2007) have called for greater efforts to improve annual tropical legumes to complement species such as lablab (*Lablab purpureus* L.) and cowpea (*Vigna unguiculata* L.).

Despite farmers' recognition of the potential contribution of forage legumes to crop-livestock farming systems in the West Africa, their integration is relatively slow. The use of forage legumes in many parts of the tropics is limited because they do not contribute directly to the human food supply. Growing feeds is a new concept for most farmers as they are used to collect natural forages from roadsides, weeding crops, fallow lands or forests. Some farmers also mention the fear that forages can become weeds. For farmers who are convinced of the

value of improved forages, availability of seeds and planting materials often form a bottleneck.

### **Grazing management**

Grassland management practices have potential to contribute towards food security and agricultural productivity via increased livestock yield and reducing land degradation. Pasture land can be improved by improving vegetation community through planting high productivity, drought tolerant and deeper rooted fodder grasses and/or legumes (Branca *et al.*, 2011) such as Superior Brachiaria bred cultivars (Mulato and Mulato II) and *Canavalia brasiliensis*, (CIAT, 2013). Controlled grazing through stocking rate management, rotational grazing, fallowing grazing to allow rejuvenation of grasses have been reported to improve grazing land, ensure surface cover, and reduced erosion while increasing fodder productivity (Branca, 2011).

One of the main strategies for increasing the efficiency of grazing management is through rotational grazing, which can be adjusted to the frequency and timing of the livestock's grazing needs and better matches these needs with the availability of pasture resources. Rotational grazing allows for the maintenance of forages at a relatively earlier growth stage. This enhances the quality and digestibility of the forage, improves the productivity of the system and reduces CH<sub>4</sub> emissions per unit of LWG (Eagle *et al.*, 2012). Rotational grazing is more suited to manage pasture systems, where investment costs for fencing and watering points, additional labour and more intensive management are more likely to be recouped.

Other grazing management intervention includes adjustment of stocking densities to feed availability. Most of the areas with high livestock densities experience land degradation and deforestation as a result of overgrazing the pasture land which encourages poor fodder production and increased GHG emissions. There is thus need to reduce the incidences of overgrazing and deforestation. This can be achieved by increasing livestock productivity so that fewer animals are raised to produce the required milk and meat leading to a reduction in the amount of GHG emissions. The interventions mainly involve keeping fewer but more productive animals in order to reduce the overall methane, nitrous and carbon dioxide gases produced and emitted from the livestock.

However, there is need to address cultural barriers to grazing management since the local rural communities in West Africa regard livestock numbers as a measure of wealth and a form

of asset to manage risks. Information on stocking capacity of rangelands is needed because of its implications on the sustainability of the resource and the performance of the livestock (Achard and Chanono, 2006). As a consequence of the limited knowledge on the stocking capacity, no appropriate grazing management decision can be made. Despite this general situation, the few available data have revealed that herding or rotational grazing is more efficient than free grazing in reducing resources degradation and improving animal performance as well as reducing conflicts (Ayantunde *et al.*, 2000; Schlecht *et al.*, 2006; Badini *et al.*, 2007). The other major challenge to grazing management is the large scale livestock movements (transhumance) in the region from the dry areas to the wetter zones in search of pasture and water in the dry seasons.

### **Crop-livestock-tree**

Combination of leguminous fodder shrubs and herbaceous legumes can be grown together with food crops with the aim of improving crop productivity and providing fodder for livestock. Trees and shrubs are planted on farms as live fences, boundary markers, windbreaks, soil conservation hedges, fodder banks, and woodlots. Leguminous fodder shrubs have high nutritive value and can help to improve the diets of ruminants while they can also sequester carbon. Forages from the fodder shrubs can effectively replace some of the concentrates and part of the basal diet of dairy livestock leading to increased milk production per cow. Ultimately, this can result in the reduction of the number of cattle on the farm and thus reduce the amount of methane emission from individual farms (Thornton and Herrero, 2010). Wider use of the right fodder trees in substitution for other feed options also provides mitigation opportunities through dietary intensification, tree carbon sequestration and savings through foregone concentrate and annual crop production and use. Trees also provide other functions important for climate adaptation, including shade for animals and, possibly, the provision of ethno-veterinary treatments to counter increased disease threats (such treatments are often relied on in areas with poor state veterinary services, especially in pastoral systems with poor infrastructure (Dharani *et al.*, 2014).

Following a series of experiments both on station and in farmers' fields in the four countries covered by the Sahel agroforestry network (Burkina Faso, Mali, Niger and Senegal), a list of promising tree and herbaceous species susceptible to be used as fodder banks has been elaborated, taking into account soil conditions and rainfall (Bonkougou *et al.*, 2002). Over the last few years, a great amount of research has been particularly devoted to *Pterocarpus*

*erinaceus*, a highly appreciated fodder tree growing naturally in Mali. The lucrative market that exists around this species in the vicinity of Bamako has inspired ICRAF and its partners to launch a special program on this tree. Preliminary results showed that *P. erinaceus* can be densely cultivated and yield enough leaf biomass to solve fodder problems during the dry periods in this part of the Sahel. In his study in northern Burkina Faso, Zampaligre (2012) reported that species, such as *Piliostigma sp.* and *Faidherbia albida*, were preferred and used by all ruminant species across West Africa Sahelian zone, especially the pods. Some of the leguminous fodder shrubs that have been tested and proven to have a high potential for improving soil fertility and that may be used in conservation agriculture include *Gliricidia sepium*, *calliandra*, *Leucaena trichandra*, *Leucaena diversifolia*, *Chamaecytisus palmensis* (tree lucerne), *sesbania* and *Faidherbia albida*. The non-fodder leguminous shrubs include *Tephrosia vogelli*, *Tephrosia candida*, *Crotalaria grahamiana* and *Cajanus cajan* (pigeon pea). Fodder trees have been traditionally used by farmers and pastoralists in extensive systems but fodder shrubs such as *calliandra* and *L. trichandra* are now being used in more intensive systems, increasing production and reducing the need for external feeds (Franzel *et al.*, 2003). The most promising multipurpose species used in these systems are *Gliricidia sepium* and *Leucena leucocephala* as exotic species, *Acacia senegal*, *Faidherbia albida*, *Prosopis africana*, *Pterocarpus erinaceus* and *Azelia africana* as native adapted species (Dowela *et al.*, 1997).

The nutritive value of browse plants has also been widely investigated – while leaves with metabolizable energy (ME) content between 3 and 5 MJ ME kg<sup>-1</sup> DM can ensure the maintenance of sheep but do not allow for production, maintenance and production of goats may be provided by a pure browse diet (Devendra, 1996). A number of other tree and shrubs that can be found in crop fields across the Sahel region of West Africa have been shown to increase crop yields. For example, *Piliostigma reticulatum* and *Guiera senegalensis* have been shown to increase yields of millet and peanut by more than 50 percent (Bayala *et al.*, 2011).

In spite of these success stories, adoption has not been widespread in many parts of West Africa, due to a number of reasons related to the performance of agroforestry practices. In most documented cases of successful agroforestry establishment, tree-based systems are more productive, more sustainable and more attuned to people's cultural or material needs than treeless alternatives. In addressing the challenge of adoption of improved agroforestry

practices, better insights are needed into the productive and environmental performance of agroforestry systems, socio-cultural and political prerequisites for their establishment, and the trade-offs farmers face in choosing between land use practices. These site factors are likely to vary at fine spatial and possibly temporal scales, making the development of robust targeting tools for agroforestry intervention a key priority in livestock-agroforestry research (Cheikh *et al.*, 2014). An active area of research therefore concerns the preconditions that must be met for successful establishment of agroforestry.

Another major limitation to these traditional agroforestry systems is land tenure systems which tends to encourage over grazing beyond their carrying capacity (ICRAF, 2011). Establishing agroforestry systems requires labour to be split between trees and agricultural crops, and managing these two components can be an overwhelming task to many households. But even when labour is available, planting and tendering trees, the benefits of which are not readily seen, may not be that appealing to some farmers who would rather use that extra labour for other activities. In the Fandou Béri area of Niger, the households who enjoyed abundant labour or had better access to land often had the more degraded fields because they tend to expand their cultivation areas or resort to alternative income generating activities rather than investing in soil conservation measures (Warren, 2002). A study on the adoption of live hedges in Burkina Faso also led to a similar conclusion since farming households with a lot of labour can afford to install dead fences, which are much more labour demanding (Ayuk, 1997).

Other obstacles to the adoption of agroforestry strategies are the lack of support for such systems through public policies (Bishaw *et al.*, 2013), which often take little notice of tree-based farming systems. Consequently, agroforestry is often absent from recommendations for ensuring food security under climate change (Beddington *et al.*, 2012) even though many practices have been shown to deliver benefits for rural development, buffer against climate variability, help rural populations adapt to climate change and contribute to climate change mitigation (Noordwijk *et al.*, 2011; Thorlakson *et al.*, 2011).

Not all agroforestry options are viable everywhere, and the current state of knowledge offers very little guidance on what systems work where, for whom and under what circumstances. In most studies, how agroforestry will be of benefit to transhumance pastoralists who move from places to another has not been addressed. An example is the *Fulbe* in Northern Burkina Faso who were reluctant to give up on transhumance mainly due to existential and cultural

reasons, despite the fact that transhumance was associated with difficulties (Nielsen and Reenberg, 2010). In addition, many authors have reported the impact of browse tree in increasing livestock production in terms in meat and milk yield and reducing mortality as ethno-veterinary options. However, most of the studies only assumed reduction on GHG production as a result of improved nutrition. These studies have failed to assess the amount of GHG reduction as to basically identify best-fit species. Sanon (2007) mentioned that the evaluation of browse production is a complex task, especially for indigenous species in natural rangelands, marked by the diversity of species and the great heterogeneity in plant size. The constraints in browse biomass evaluation related to the time cost and tediousness of methods used has led to the development of allometric relations for indirect estimation of the production.

### **Conservation agriculture**

Conservation agriculture has the potential to sequester soil carbon, thereby contributing to climate change mitigation (Corbeels *et al.*, 2006). According to CCAP reports (2103), conservation agriculture was listed as one of the CSA best practices and technologies in sub-Saharan Africa. The practice of CA involves minimal soil disturbance, retention of crop residues as mulch on the soil surface and the use of crop rotations and/or associations (FAO, 2014). The beneficial effects of mulching with crop residues on the soil water balance (through reduced water runoff and soil evaporation) may enhance adaptation to future climate change, when rainfall is projected to decrease and become more unreliable (Scopel *et al.*, 2004; Thierfelder and Wall 2010). According to Corbeels *et al.*,(2014), meta-analysis of CA studies in SSA showed that crop grain yields are significantly higher in no-tillage treatments when mulch was applied and/or rotations were practiced in comparison to only no-tillage/reduced tillage without mulch and/rotation. These results suggest that for farmers to benefit from CA they should be able to keep their crop residues as mulch on the soil surface. Additionally, rotation should be an integral component of their cropping practice.

These two components of CA are, however, for many smallholder farmers in SSA the bottlenecks to adopting CA. Crop residues have several other uses on the farm, in particular as feed for livestock. Crop residues are the major source of livestock feed during the dry season. In many cases, legumes or other non-cereal crops gain limited interest, as ready markets for sale are often not available. In its Research to Action reports (ICARDA Report, 2012), several economic benefits of CA and effective ways to overcome the constraint of its adoption were

discussed, yet the question of trade-offs on crop residues as the main livestock feed on the semi-arid region of West Africa remained largely unanswered.

Derpsch (2008) suggested that one possible solution to the perceived trade-offs between livestock production and the adoption of CA is to plant unpalatable cover crops that livestock will not consume. However, many farmers have little interest in investing in crops that have no human or livestock consumption value, but do have tangible costs in terms of seeds and labour.

### **Agricultural water management**

Livestock feed resources in West African Sahel is largely dependent on exploitation of natural pastures in the wet season and crop residues in the dry season, therefore improved agricultural water management practices will invariably contribute not only to crop production but also livestock production through increased feed resources. Following this rationale, Rockström *et al.* (2002) give various strategies for improved crop water productivity to maximize plant water availability (maximize infiltration of rainfall), minimize unproductive water losses (evaporation), increase soil water holding capacity, maximize plant water uptake capacity (timeliness of operations, crop management, soil fertility management), and bridge crop water deficits during dry-spells through supplemental irrigation. Since agricultural systems are mostly rainfed in the dry areas, rain water harvesting (Vohland and Barry, 2009) techniques in rainfed systems such as in-situ micro-catchment strategies, small reservoirs and small-scale irrigation are essential to improve agricultural productivity.

In-situ micro-catchment strategies aim at enhancing rainfall infiltration in the soil, improve soil water storage and limit top soil losses through wind and water erosion. They can be based on the construction of a physical barrier against run-off and/or on the improvement of soil water holding capacity through improved soil structure and soil fertility. Some of the in-situ micro-catchment strategies of relevance to climate smart livestock interventions include:

- *Zai and half-moon*: Zai is an ancestral practice developed in the Yatenga (Northern Burkina) to regenerate degraded and crusted soils by breaking up the surface crust to improve water infiltration. It consists of dug holes excavated in grids, with a diameter of 15-20 cm and a depth of 10-15 cm that store rainwater for plant growth and concentrate crop nutrients (Maatman *et al.*, 1998). The excavated soil is put on the lower side of the hole, and organic matter (manure or compost) is placed in the holes (Barry *et al.*, 2006).

- The technique combines water harvesting as well as nutrient management practices. It helps to minimize the diversion of water to where it is unproductive, and ensures that its utilization by the crop is as efficient as possible (Fatondji et al., 2005). Decomposition of the organic material releases nutrients required for crop growth. Biological activity, and especially the action of termites favors the development of soil macroporosity that improves water infiltration (Fatondji et al., 2005). Besides the supply of valuable nutrients for crop growth, the Zaï pits promote better infiltration of water locally. Since this water infiltrates deeper than usual, Zaï ensures that a sizable fraction of the water percolates to depths where evaporation losses are reduced. Studies on Zaï have been conducted in Burkina Faso, Mali and Niger. Hassan (1996) reported millet yields of 400 kg ha<sup>-1</sup> with Zaï in low rainfall years, compared to zero yields without Zaï treatment. Production increase can go up to 428% in some cases, as reported by Reij et al. (2009). In Mali, it performed very well and average yield for eight farmers was 969 kg ha<sup>-1</sup> in the control (farmers' treatment) against 1740 kg ha<sup>-1</sup> in the Zaï treatment, which represents a production increase of 80%. Besides the increase in grain yield, there is also increase in crop residues which serve as animal feed.
- Half-moons are half-circle shape water harvesting structures dug perpendicular to the slope and surrounded by downstream of so-called earth glasses prolonged by wings in stone or earth. Half-moons are used to collect surface water, stabilize soils on steep slopes and recover degraded soils. Half-moons allow for improvement of ground water reserves as well as increase in soil moisture from 20-40 cm depth. They improve agricultural production through addition of mineral or organic matter. In Burkina Faso, the technique is widespread in the Sahel region. Production increase varies from 49% to 112% (Belemviré et al., 2008). However, most of these studies have failed to quantify the increase in biomass production using these water management practices in absolute terms as against the normal cultivation practices.
- *Earthen contour bunds*: Earthen contour bunds were one of the first forms of field management, where small soil bunds are placed along the contour lines. It has been almost completely replaced by rock bunds or grass strips (Barry et al., 2006).
- *Rock bunds/stone rows*: Constructing rock bunds/stone rows is the most widely practiced technique to combat run-off and erosion by farmers (Barry et al., 2006). The challenge was always to follow the contour lines, especially where the landscape is flat. Sometimes,

forage species such as *Andropogon gayanus* is planted along the stone rows to provide feed for livestock.

- *Small reservoirs*: This water harvesting technique refers to concentration, collection, and storage of surface runoff in ponds or cisterns for supplementary irrigation during dry spells (Douxchamps *et al.*, 2012). It provides access to water during dry season for irrigation farming (vegetable production) and serves as source water for livestock in the dry season. However, there is potential for conflict in using the water for livestock and for crop production
- Indeed, technologies such as Zai, half-moons and stone bunds, combined with an application of organic/inorganic sources of nutrients, are promising climate-smart agricultural practices that could be widely used by smallholder farmers to maintain food production and secure farmers' livelihoods, while contributing to ecosystem services. Irrigated fodder for livestock feed is a relatively rare in the region, but has potential in terms of production of dry season feed for livestock.
- As can be inferred from the agricultural water management practices described above, building climate smart water-crop-livestock farming systems requires integrated approach, as the interaction between livestock production and the other components sometimes create win-win situations but also it creates trade-offs and potential conflict. Climate smartness adds another complexity to the table as not all proposed interventions are necessarily climate smart. The following chapter describes climate smart livestock interventions.

## **Livestock production management related climate smart interventions**

- According to FAO (2013), there are a number of animal and herd management options for pastoralist and agro-pastoralist systems that can enhance animal productivity, improve feed conversion efficiency and thereby reduce enteric emission intensities. The plausible mitigation potential of these options could contribute approximately 4% of global agricultural GHG mitigation. These management options include:

## **Herd management**

- Blench (1999) describe how Fulbe herders in Nigeria, faced with a shortage of grass in the semi-arid zone, switched to keeping the Sokoto Gudali cattle breed, which copes well with a diet of browse, instead of the Bunaji breed. In a related study carried out in Burkina Faso, Sanfo et al (2015) reported that the main adaptation strategies among the people remained diversification of their livestock species and transhumance practice. Although, cattle remains their most important species, the small ruminants are becoming more and more important because they are less vulnerable to warming (requiring less water and food). For them, this is a risk-free strategy: the use of the scarce natural resources by reducing the risk of livestock losses during extreme climate events. The small ruminants play an important role in their livestock system by allowing them to meet their immediate social and economic needs (Malonine, 2006).
- Various species also have different production attributes and uses, with camels providing transport in addition to milk and meat, goats providing rapid rates of post-drought herd recovery, sheep providing seasonal income opportunities related to Islamic festivals, and camels and cattle providing prestige and social status in some communities (Sanfo et al., 2015).
- Among the Fulani, the principal pastoral ethnic group in West Africa, a shift from cattle to small ruminants will require overcoming a significant cultural barrier since cattle represent such a central part of the group's identity. Agro-pastoralism could be an alternative to shifting from cattle to small ruminants, a shift that represents a significant loss in material and financial wealth. However agro-pastoralism does allow pastoralists to produce their own grain, feed supplements, and/or cash crops, it also allows them to access the benefits of indigenous population such as schools, markets, health clinics, and political resources (Fratkin, 2012).

## **Breeding strategies**

- Identifying and strengthening local breeds that have adapted to local climatic stress and feed sources is a breeding strategy that is climate smart option. Improving local genetics through cross-breeding with heat and disease-tolerant breeds has been viewed as one of the climate smart option for livestock production in West Africa. Within species, there are also differences in the capacity of different breeds to utilize particular kinds of feed. For

example, Blench (1999) reports that the Sokoto Gudali cattle of West Africa specialize in eating browse and will feed on woody material that other breeds find very unpalatable. Among cattle in general, zebu (*Bos indicus*) breeds tend to deal better with low-quality forage than do taurine (*Bos taurus*) breeds, while the latter have better feed conversion ratios when fed on high-quality feed (Albuquerque *et al.*, 2006).

- A number of breeds have been shown to possess superior resistance or tolerance to specific diseases or parasites. In many cases, such adaptations enable these breeds to graze in areas that are unsuitable for other animals. For example, several studies have shown that the ability of Kuri cattle to tolerate insect bites enables them to remain close to Lake Chad during the rainy season when other cattle have to leave the area (Blench, 1999).
- On a more local scale, species and breed substitution has already occurred in some production systems that have been badly affected by droughts in recent decades (Blench, 1999). Goats also have the advantages of being able to rear-up on their hind legs, climbing well and having mobile upper lips and prehensile tongues that enable them to pluck leaves from thorny shrubs and select the most nutritious parts of the plant (Barroso *et al.*, 1995). Keeping browsing animals has certain advantages when feed is in short supply as they make use of forage that cannot easily be used by other species – i.e. there is a degree of complementarity if grazing and browsing animals are kept together – and because shrubs tend to provide a source of green forage during the dry season.
- Although many existing technologies in animal genetic resource characterization, conservation and breeding will be crucial for climate change adaptation and mitigation, research gaps exist, especially with regard to the physiology and genetics of adaptation. Breeding intervention as an option within climate smart livestock production has to be disaggregated. A number of studies has focused on breeding for tolerance of climatic extremes (Burns *et al.*, 1997; Prayaga *et al.*, 2006) while other have focused on resistance and tolerance to diseases and parasites (Axford *et al.*, 2000; FAO, 2002; FAO, 2007). There have been some reports on breeding for feeding and nutritional adaptations to reduce emissions from the animals by improving feed conversion efficiency (less emission per unit of meat, milk, etc. produced) and reducing the amount of methane produced during digestion (FAO, 2010b). Overall, the nature of production system could influence the result of breeding intervention (Pilling and Hoffman, 2011). However, all

the interventions are affected by the type of animal kept and the nature of the livestock production systems. Care is needed to ensure that production environments and animals remain well-matched to each other.

- Identifying the factors that make livestock breeds vulnerable to the effects of climate change (or other threats) may be a valuable means of identifying preventive steps that can be taken to reduce the risk of extinction. However, the factors involved would probably differ considerably from those in wildlife and might be location specific. As discussed above, breeds' capacity to survive the effects of climate change in their home zones is not simply a matter of their biological capacity to adapt, but also of how their management can be adapted. Capacity to adapt livestock management practices in response to climate change is, in turn, influenced both by access to inputs (external inputs and local natural resources) and by knowledge (traditional or newly acquired) of the local production environment.

## **Livestock and environment related climate smart interventions**

### **Manure management**

- Animal manure management is defined as a decision making process aiming to combine profitable agricultural production with minimum nutrient losses from manure, for the present and in the future. Good manure management will minimize the negative and stimulate the positive effects on the environment. Gas emission and leaching of nutrients, organic matter and odour have undesirable effects on the environment. Efficient treatment of manure can reduce the emission of GHGs and raise agricultural productivity (Wambugu et al., 2014).
- In Niger, to exploit the benefits of urine and to minimize nutrient losses, corralling livestock on fields is preferable to the application of farmyard manure (Schlecht and Buerkert, 2004). About 13% of fields are reportedly corralled (Schlecht and Buerkert, 2004) in Southwestern Niger. The average annual rate of manure deposition on field-based corrals was 12.7 t DM ha<sup>-1</sup> for cattle and 6.8 t DM ha<sup>-1</sup> for small ruminants (Hiernaux and Turner, 2002). Because of these high rates, the aggregated corral area is about only 0.5-1.2% of the village cropped land in Fakara, Niger. However, the effects of such high rates are expected to last 4-5 years.

- In Mali, litter and household wastes, left-over from animal feed, groundnut shells and sometimes, animal dung are mixed as compost from June to March and are transported to the field in March-April (Harouna, 2002). In Burkina, manure is either collected from households and applied in the fields or applied through direct corralling of the livestock. There was a Presidential Programme for production of compost, and each year a national target is agreed upon during the Farmers' Day (an annual event during which the President meets with farmers to discuss the problems related to their activities) (Bayala *et al.*, 2011).
- In his review, Harris (2002) reported factors that affect the quality of the manure used in semi-arid areas of West Africa which include methods for keeping livestock and storing manure. The paper reviews the strategies, such as night corralling and crop-livestock integration, which farmers employ to ensure that manure reaches their fields. The paper concluded that within the constraints in which smallholder farmers operate in semi-arid West Africa, manure will remain an important component of soil fertility management strategies for the foreseeable future. Appropriate interventions need to focus on improving manure management to ensure that the material which farmers so laboriously prepare and transport is of the best possible quality.
- The main constraints to corralling are the low number of animals with an average of 2.5 to 3.4 TLU (1TLU represents 250 kg live weight, equivalent to 1 camel, 1.43 cattle or 10 small ruminants) per farm and the lack of means of transport (Balaya *et al.*, 2011). Yields obtained on manured crop field are always much higher than fields that are not manured. However the areas manured are very small (1% to 12.5 % of the total areas by holding) and this is also why farmers combine this practice with mulching and organic fertilizer. Other constraints to manure management are the inadequacy of forage, stealing of corralled animals and animal diseases. A proposed improvement is to collect and store forage at harvesting period to increase the duration of the stay of the animals on the plots (Harouna, 2002; Hassane, 2002; Kanta, 2002; CRESA, 2006). Trampling by livestock can also increase soil bulk density and decrease water infiltration rates and therefore enhance water run-off and soil erosion. In Madagascar, converting manure to biogas is considered as a better option for manure management as it provides the added benefits of an alternative energy source with fewer negative health impacts from cooking, heating, and lighting (Scherr *et al.*, 2012). This option has not been well documented and practiced in

West Africa unlike the other parts of Africa (Kipkoech *et al.*, 2015). More widespread corralling of animals on cropland that returns urine could greatly reduce nutrient losses from mixed farming systems. This may require the provision of feed and water closer to cultivated areas and during longer periods of the year. Setting up mobile corrals and stall-feeding animals on cropland involves, however, considerable labour in harvesting and transporting feeds and water. If the trend in animal management is towards increased stall-feeding, then composting will have to play a greater role in minimizing nutrient losses. Compost pits that capture feed refusals, and manure and urine need to be designed to minimize nutrient losses. Low-cost appropriate implements to spread compost over the typically large cultivated areas of the Sahel are also needed.

- Another problem is the seasonal differences in the diet of grazing animals which also greatly influence manure output and its nutrient content. Manure output by grazing cattle during the rainy season (2.2 kg/animal/day) is twice as high as manure output during the dry season (Siebert *et al.*, 1978). Likewise, the N and P concentration in cattle manure varies considerably by season (Powell, 1986). Wet season manure is more abundant and of higher quality. But it is largely unavailable to cropping, as animals are largely outside the cultivation zone in the wet season.

## **Socio-political and financial related interventions**

- An enabling socio-political and technical environment is needed so that livestock keepers can adapt to climate change and enhance their livelihoods and food security. Efforts to promote CSA in Africa are advancing at the policy level. At the 23rd ordinary session of the African Union (AU) held in June 2014 in Malabo, Equatorial Guinea, African leaders endorsed the inclusion of CSA in the NEPAD programme on agriculture and climate change. The session also led to the development of the African Climate Smart Agriculture Alliance which is expected to enable the NEPAD Planning and Coordinating Agency (NPCA) to collaborate with Regional Economic Communities (RECs) and Non-Governmental Organisations (NGOs) in targeting 25 million farm households by 2025. As a follow up action at the sub-continental level, ECOWAS, for instance, also put in place the West Africa CSA Alliance to support the mainstreaming of CSA into the ECOWAP/CAADP programmes (ECOWAS, 2015; Zougmore *et al.*, 2015). The NEPAD Heads of State and Government Orientation Committee at its 31st session also welcomed the innovative partnership between NPCA and major global NGOs to strengthen grass-

root adaptive capacity to climate change and boost agricultural productivity. The meeting requested NPCA in collaboration with FAO to provide urgent technical assistance to AU Member States to implement the CSA programme and that the African Development Bank (AfDB) and partners should provide support to African countries on investments in the CSA field (African Union, 2014). Several countries in Africa already screened their National Agriculture Investment Plans using a framework developed by FAO in consultation with NPCA and identified specific additional investment needs for CSA implementation and upscaling (FAO, 2012). Although there has been a rapid uptake of CSA by national organizations and the international community, implementation of the approach is still in its infancy and equally challenging partly due to lack of tools, capacity and experience.

- In many countries there are not yet in place financing plans to promote the uptake of CSA, yet the transition to climate-smart agricultural development pathways requires new investments. “As farmers in Africa face major risks arising from the effects of climatic hazards, they also face the challenge of managing risks associated with the high costs (at least initial costs) of adopting new technologies (e.g. conservation agriculture and agroforestry) whose benefits often only come after several years/seasons) of production. Most of the farmers have little or no access to credit, micro-financing and/or insurance.” (Mapfumo *et al.*, 2015). This is because there still exists difficulty in managing trade-offs from the farmers’ and policymakers’ perspectives. There is often a disconnection between farmers and policy makers in the agricultural sector with respect to priorities for resource management. One of the underlying causes of this problem is the difference in objectives between the two groups. Prioritization of the three objectives of CSA (increased productivity, adaptation and reduction of greenhouse gaseous emissions where possible) is likely to differ among key stakeholders including farmers, government officers and policy makers. This has implications on how CSA practices are ultimately evaluated, and whether or not policy makers and practitioners at various levels will be attracted to the advocated CSA options for financial considerations.

## Recent and ongoing projects on livestock-related climate smart practices in West Africa

### Box 1

#### ***Additive impacts of climate-smart agriculture practices in mixed crop-livestock systems in Burkina Faso***

*Smallholder farmers of Northern Burkina Faso have important development opportunities, but they will have to cope with the effects of climate variability and change. In four farms representative of the area, crop and animal production, income and food security indicators have been simulated, with all combinations of four interventions:*

- i) Optimized crop residue collection;*
- ii) Improved allocation of existing feeds,*
- iii) Crop fertilization;*
- iv) Animal supplementation.*

*The modeling framework used was based on three existing dynamic livestock (Livsim), crop (Apsim) and household (IAT) models. A 99 years current climate series was generated with the climate generator Marksims to assess the impacts of climate variability.*

#### *Results:*

*The simulations showed that collecting crop residues improves significantly the food security indicator in one farm because it enables the development of cattle production, whereas the effects were moderate in the three other farms. Low amounts of fertilizer have a significant effect, but the simulations showed decreasing yield returns and the higher downside risk in the bad years. Improved feed allocation strategies with available resources have a positive effect, which is as important as supplementation with additional feeds. The impacts of the tested interventions are additive and synergistic, because increased crop residues production with fertilization creates opportunities for optimized feeding. As a consequence, in the four farms, the highest income and kilocalorie production (up to 53% compared to current farmer practices) were obtained with a combination of interventions enhancing synergies between the crop and the livestock systems. The household yearly probabilities to be food secure also increases by up to +26%, suggesting an increased resiliency toward climate variability. The study concluded that the best options for adapting mixed crop-livestock systems might be found in the synergies between their components, rather than in single interventions.*

## **Box 2**

### ***Modeling livestock production under climate constraint in the African drylands to identify interventions for adaptation***

*A modelling framework for livestock productivity under climate constraints was conducted as a result of collaboration between FAO, CIRAD, IFPRI and Action contre la Faim (ACF), for a contribution to the World Bank study on the economics of resilience in the African drylands. The methodology relied on the integration of four models and a participative interaction with local livestock experts: biomass availability under various climate scenarios (baseline, mild drought, severe drought) for the period 2012-2030 was computed by Biogenerator (ACF); livestock population dynamics and feed requirements for different interventions (baseline, animal health improvements, male cattle early offtake) were extracted from MMAGE (CIRAD); feed rations and balances were calculated by GLEAM (FAO) and levels of demand, supply and prices were analysed with IMPACT (IFPRI).*

#### ***Results:***

*Results showed that interventions can significantly increase the output of livestock products (5% to 20% in meat production) if accessibility to feed is improved. This can be achieved through enhancing livestock mobility, developing feed processing and transport and supporting market integration. Livestock systems have the potential to buffer climatic variability through consecutive filters and management decisions: mobility, animal physiology, feeding practices, herd management and eventually milk production and offtake rates. Livestock proves to be a significant asset for adaptation to climate change and interventions should be designed to fully take advantage of this potential.*

*Mottet et al., 2015*

**Table 1. Summary of livestock production interventions in West Africa and ways of improving their climate-smartness**

*Aggregate assessment						
	Management objectives	Practices/ Technologies	Food security	Adaptive capacity	Mitigation of GHGs	Suggested improvement
Feed related interventions	Fodder cultivation	Dual purpose legumes; Forage grass and legume cultivation; Fodder bank	+++	++	++	The use of improved seed and adapted species. Grass-legume mixture will reduce the use of inorganic fertilize, increase sequestration and feed quality
	Forage conservation	Harvesting and conservation of natural and cultivated pasture in form of silage and hay	+++	+++	++	The condition for its realization requires careful selection of species, harvesting at vegetative stages, heights and at proper weather condition. Technical training on conservation technique.
	Forage quality improvement	Supplementary feeding using concentrate and by-products; Urea treatment of crop residues	+	++	+++	Improving the feed value chain to facilitate delivery of agricultural by-products from producer to farmers. Improvement of storage facilities for the by-products.
	Forage integration	Forage legume incorporation into arable cropping	+++	+	++	Its contribution to adaptation to climate change can be improved by involving ploughing partitioned and improved seeds
	Grazing management	Rotational grazing; Controlled grazing; Adjust stocking densities to feed availability	++	+++	+++	Requires a planned and well controlled movement. Awareness and training of pastoralist on their rights and duties, and laws regulating mobility and transhumance. Improve market linkages
	Crop-livestock-tree	Shade trees have impacts on reducing heat stress on animals and contribute to improve productivity, improved forage value	+++	+++	+++	Development of early maturing tree species with high biomass yield. Institutional and policy support for the production of tree seedlings adapted to different agro-ecological zones.
	Conservation agriculture	Improve soil condition and promote high yield and consequently crop residues	++	+	+	The use of cover crops with no forage value while crop residues are harvested for livestock feed
	Agricultural Water Management solutions	Water storage options (Zaï, demi lune, rainwater harvesting, small reservoirs)	+++	+++	++	Increasing fodder production during wet season and provide dual cropping season to improve feed access and water availability during the dry season

	Breeding strategies	Alteration of animal species and breeds	+++	++	++	Institutional and policy support for animal breeding projects.
			*Aggregate assessment			
	Management objectives	Practices/ Technologies	Food security	Adaptive capacity	Mitigation of GHGs	Suggested improvement to
Feed related interventions related	Herd management	Species diversification	+++	+++	++	Institutional and policy support for incentive for farmers
	Breeding strategies	Alteration of animal species and breeds	+++	++	++	Institutional and policy support for animal breeding projects.
Environmental management	Manure management	Anaerobic digesters for biogas and fertilizer.	+++	+++	+++	Reduce methane emission and pressure on crop residue as energy source
		Composting, improved manure handling and storage, (e.g. covering manure heaps) application techniques (e.g. rapid incorporation)	+	++	++	Its contribution to climate change adaptation can be improved associating the practice of Zai, micro-irrigation, stone bunds and filter bunds

## **Existing knowledge on livestock-related climate-smart agricultural practices in West Africa**

In view of above development challenges and opportunities for transforming livestock agriculture to underpin climate resilient livelihood systems and foster food and nutrition security as well as sustainable natural resources utilization, agricultural transformation in relation to livestock through CSA will require the following necessary actions:

### **Forage improvement**

In order to make fodder cultivation more productive and adaptive while increasing the mitigation capacity, emphasis should probably be placed on the development and spread of improved dryland forage species. The efforts of new approaches such as marker assisted selection on forages could be exploited to produce grasses and legumes varieties which can sustainably support livestock production in the predicted uncertainties of climatic variability. Forage varieties with multiple attributes to overcome a range of biotic and abiotic constraints induced by climate change are needed. Promoting adapted pasture species will play a major role in reducing vulnerability of feed resources to climate change. This improves preparedness for harsh climate induced conditions on livestock production itself and thus substantially raising survival rates and livestock performance due to availability of feed resources (Assan, 2014).

Livestock keepers need to have better access to information regarding the variety of plants that are available to them, and availability of seed needs to be increased through market development or through extension projects. Livestock keepers can also benefit from learning different techniques for forage conservation and identifying solutions that fit with the production system, although the most mobile herders who could benefit most from forage conservation may find the technique the least convenient.

### **Improved rangeland and grazing management**

The starting point to improved rangeland management can be allocation of land to pastoralists for grazing. Allocation of land to pastoralist will encourage them to manage it and practice control grazing (Tumbo *et al.*, 2011). Improving pasture will indirectly help to improve agricultural land by reducing the demand for crop residue removal to feed livestock. In

presence of managed pasture and grazing land, the crop residues removal from farms will be reduced and the soil will be protected by soil cover and build soil organic matter (SOM) in the long run (CCAP, 2013).

Long term adaptation strategies for livestock keepers include destocking or animal harvesting followed by migration and diversification (Tumbo *et al.*, 2011). In other semi-arid areas, sale of animals (or destocking) is done due to drought. Other adaptation actions include conservation and storage of forage, and keeping more animals of resilient species (Tumbo *et al.*, 2011). Therefore, animal culling, improved pasture, improved breeds and ownership of land for grazing and pasture can be promoted to wider livestock keepers and contribute to achieve CSA. Grazing lands can also be rehabilitated by planting improved grass and fodder trees but few studies in SSA are available on this aspect. These management practices are likely to result in increased carbon sequestration through the restoration of degraded rangelands and changes in land uses. The impacts from a combination of various interventions can greatly reduce the total amount of GHG produced by livestock.

### **Agro-silvo-pastoral practices**

It is generally believed that farmers will be more inclined to adopt agroforestry technologies if these can produce immediate benefits. Therefore, even the agroforestry techniques designed to serve long-term environmental purposes may need to include short-term benefits to stand a chance of being adopted at a large scale. Furthermore, understanding the specificity of the Sahelian socio-economics is crucial in using agroforestry technologies.

In addition, tree breeding may offer a unique set of opportunity for adopting tree-crop-livestock practices. Breeding, selection and introduction of early maturing, drought-tolerant and high biomass yielding tree varieties may attract adoption. Breeding priorities for future trees need to be identified through close interaction between breeders, farmers and climate and global change scientists, and then the breeding strategies need implementation through appropriate investment.

In the report of CORAF/WECARD (2012) deliberate association of ruminants with trees in pre-existing agricultural production known as Agro-silvo-pastoral systems (ASPS) was suggested as a key to strengthening and sustaining land use systems in West Africa. Trees, pasture and livestock in well-managed ASPS yield several products in a sustainable manner,

including efficient nutrient management. Improved integration of trees with crop-livestock systems do not only increase productivity of the farming system but also provide complementary crop residues to feed livestock, especially in rural communities where forage crops are rarely grown specifically for livestock.

### **Breeding adaptive animal**

For the optimal utilization of the adaptation traits harboured in all breeds, research in genetic characterization and understanding adaptation in stressful environments needs to be strengthened. Developing methods for characterizing adaptive traits relevant to climate-change adaptation (heat tolerance, disease resistance, adaptation to poor diet, etc.) and for comprehensive evaluation of performance and use of animals in specific production environments will be an attractive option.

### **Improved manure management**

Low-cost implements suitable for manure collection and spreading, and appropriate institutional arrangements to strengthen complementary interactions between farmers and herders, will improve manure utilization, consequently mitigate methane emission, improve soil fertility and increase food security.

### **Provision of support to overcome institutional, socio-political and financial barriers to livestock - related climate-smart practices**

- *Appropriate institutional support:* Without appropriate institutional structures in place, livestock-related CS innovations may overwhelm smallholder farmers. Strong institutional support is required to: promote inclusivity in decision making; improve the dissemination of information; provide financial support and access to markets; provide insurance to cope with risks associated with climate shocks and the adoption of new practices; and support farmers' collaborative actions. Many institutions and stakeholders, including farmers (and farmer organizations), private sector entities, public sector organizations, research institutes, educational institutions, and Civil Society Organizations can play important roles in supporting the adoption of climate-smart agriculture (AGRA, 2014) Institutional support is needed to develop and promote fodder production and conservation through the extension services, recognizing that in many cases these are tried and tested technologies that have historically been practiced by many

livestock keepers, and focusing on addressing the structural/institutional barriers that have led to the loss of such practices.

*Promote a more conducive and inclusive policy:* Governments and policy makers should craft country specific CSA policies that can help farmers especially livestock keepers, cope with the adverse effects of CC. Farmers need policies that remove obstacles to implementing CS practices and create synergies with alternative technologies and practices. Such policies should promote innovative approaches to local breed development that are driven by the environmental exigencies of livestock keeping groups, focusing on development of local breeds as well as promotion of ‘exotic’ breeds from comparable environments that display more locally-appropriate attributes such as drought survival and disease resistance. Policy makers should harmonize and bring together the various scattered CS practices. A related policies, projects and programmes into one which is comprehensive and accessible by all stakeholders. One of the keys to generating policy results and impacts would seem to be policy implementation; this argues for action plans that accompany all policies. Similarly, a regional monitoring and review process for policy implementation is needed. A thematic, multi-disciplinary task force dedicated to CSA could provide the impetus for improved policy implementation and monitoring and review of this implementation. Policy makers should promote financial incentives that encourage livestock – related CSA. Considerable policy support and capacity enhancement is needed for climate risk management including insurance and safety nets as well as improved access to weather information adapted to farmers’ needs. Identify incentives and institutional arrangements that enable and empower farmers, in particular women, to adopt livestock climate-smart practices. Building the institutions and incentives for climate-smart agriculture and pro-poor mitigation (e.g., the role of farmer organizations, reducing transaction costs, policy instruments that work for farmers and that help balance trade-offs amongst food security, adaptation, mitigation, energy needs etc.).

- Increase research into the specific roles of women in the livestock sector, including their role in processing and value addition (e.g. dairy processing) and product marketing, and target specific participatory research at boosting their capacities and security. The roles and the rights of women livestock keepers are often overlooked and development is frequently skewed towards the interest of men, yet women are

responsible for most sedentary care of livestock and play an active role in on-farm livestock duties and in the marketing of products (milk). The same constraints that confront livestock keepers in general—such as low education, low access to financial services and weak resource rights—burden women livestock keepers to a greater extent. Efforts to build resilience in livestock keeping communities therefore requires particular emphasis on building the resilience of women and enabling them to adapt to climate change.

## Conclusion/recommendations

Livestock remain a key component in the rural agricultural setting in West Africa. It provides the much-needed inputs into crop production, provides key source of income and to rural livelihood as well as augmenting their nutrition. Sustainable increase in agricultural productivity which support equitable increases in farm incomes, food security and development while adapting and building resilience of agricultural and food security systems to climate change at multiple levels; and reducing greenhouse gas emissions from livestock, is the only way to put West Africa ahead in meeting the increasingly growing needs for livestock products. Mainstreaming livestock practices that are climate smart should be the goal of any research for development in West Africa. We therefore recommend that:

Livestock Climate smart practices are highly context specific, and at times involves trade-offs between productivity, adaptation and mitigation. As such, stakeholder consultation is important when deciding which climate smart practice to implement, as factors such as labor availability and agro-ecological conditions may constrain outcomes. Given this context specificity, livestock CS investment portfolios must be nationally and locally determined.

Successful CSA strategies will require investment in infrastructure that support smallholder farmers in understanding climate change, developing and refining strategies and evaluating CSA options. The priority for small-scale farmers in Africa is to minimize the impacts of climate change and increase their production. Mitigation is often a positive non-intended outcome unless farmers are provided incentives; some researchers have recommended the establishment of transition funds to be used to compensate farmers during the periods between the establishment of CSA structures and benefits.

Strengthen farmers' access to and understanding of information, through improved communication approaches and stronger extension services, including improved extension methodologies and practices based on farmer participation expanded farmer field schools (and "pastoralist field schools") will be crucial for the actualization of climate smart livestock production.

Policy and institutional support is crucial to produce an enabling environment for both research and farmers to implement livestock-related climate smart agriculture.

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RESEARCH PROGRAM ON  
**Climate Change,  
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Food Security**



The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is a strategic initiative of CGIAR and Future Earth, led by the International Center for Tropical Agriculture (CIAT). CCAFS is the world's most comprehensive global research program to examine and address the critical interactions between climate change, agriculture and food security.

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