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Copping strategies with Climate Variability effects: The case of the village of Zignasso in Mali

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Abstract

Because of concern over the possible impacts of climate variability and change on agricultural productivity, the Sikasso region was selected for the study as this region is the bread basket of Mali. Zignasso, a village near Sikasso, has been subjected to great climate variability and had a long tradition for adapting to such variability through changes in livelihood strategies and land use as well as through migration. There is concern that climate variability may increase over the coming decades, with the possibility of more dry years. This would likely increase food insecurity in Zignasso and neighboring villages. We examined impacts of warmer and drier climate on rural agricultural production and environmental damage, identified adaptation options to minimize impacts of climate change, and evaluated the adequacy of options for current change.

Focus discussions with farmers in Zignasso, representatives of technical services and agricultural experts in Sikasso to prioritize adaptation options based on feasibility, costs, effectiveness and adequacy to current situation. Farmers believe temperatures have increased and precipitation decreased over the past several decades. These factors, they believe, along with deforestation, have decreased yields particularly for rice and maize and declined firewood availability. Farmers recommended adaptations that require outside financial and technical assistance because they need outside assistance to implement them. Adaptations emphasized by both the farmers and representatives of regional technical services are crop diversification and germplasm improvement; soil and water management; equipment (plows, carts, oxen, and improved stoves); credit stockage villageois “warrant age” (CSV); and access to fertilizer. The farmers stated the most important adaptation is to build a water gate to flood adjacent rice fields and allow for furrow irrigation enabling them to farm many crops in a year without water stress. The adaptations identified may present donors with opportunities to enhance and strengthen efforts to promote food security in Mali. Implementation of some adaptations could involve coordination and collaboration with other agencies and organizations that have similar goals.

Key words:

Zignasso, Climate Variability, Adaptation, Resilience

Introduction

Populations in Zignasso like all Mali, are facing great challenges due to climate variability. They cope with this variability by migrating or adapting their land use strategies to improve livelihoods. Some of these strategies are still relevant although their extent and limits are not yet well known. Adapting to climate change is a necessity but at the same time population has limited capacities to do so, because all their production systems are climate-dependent.

They recall from 50 years back not having any socio-economic problem. Today food security in a situation of continuing population growth, access to clean water and health problems are major concerns to be addressed.

To respond these problems, populations expand their cultivated land to meet their food needs first. By doing so and not having accurate means such as drafted or motorized equipment, resources to purchase fertilizers and to apply other improved technologies, they degrade land and destroy the forest.

Fifty years ago the village had plenty of water in the “bas-fond” all year for agricultural activities, animal husbandry, fishing and also a large forest to pick fire wood, hunt wild animals. At that time rainfall occurs during 10 months in a year; the population had enough food for their needs, cultivated areas were not as large, grass was plenty for livestock, temperatures were low and when it rains the moisture remains in the soil at least a week.

Today, water in the “bas-fond” lasts at most only 4 months, some tree species are no longer existing or are in danger, grazing areas are scarce with little capacity of charge, forest land is degraded and fire wood is scarce, some animal species are in danger or disappeared, traditional crop varieties could not reach their maturity cycle, crop yields are dropping, input prices are increasing, temperatures are high and moisture remains in the soil at most only 3 days after a rainfall, etc.

Taking into consideration all the above climate change is a major challenge facing Zignasso and all the country of Mali. Indigenous strategies to mitigate climate change effects are undertaken by the population. Among the different strategies, farmers cited many elements of efficient adaptation towards climate change. Some of which are climate specific and others are non-climate specific.

This study analyzes the different adaptations strategies proposed by farmers and examines them to seek for effectiveness, feasibility before making recommendations for better livelihoods. To achieve the targeted goal, village level meeting was held with farmers for listing all possible adaptation strategies and for each strategy to discuss the cost and the feasibility.

Fourteen adaptation options were chosen through the discussions and proposed to farmers for grading to identifying the best ones.

Objectives

The objectives of the study are:

- To provide information for mitigating impacts of warmer and drier climate while maintaining rural agricultural production and minimizing environmental damage;
- To consider effectiveness of adaptations to minimize impacts climate change, cost and feasibility;
- To propose solution with and without climate change (win-win strategy).

Expected outcomes

- Feasible adaptation options are proposed by farmers;
- Relevant affordable adaptation options are selected among the feasible ones;
- An implementation strategy is developed.

Methodology

To achieve the objectives of the study, step wise information collections were held with farmers in the village of Zignasso; and with farmers and representatives of technical services in Sikasso. Results from these collections were consolidated and presented to the regional decision makers.

The first step was a focus group discussion in Sikasso (February 2017) with an objective of discussing climate change projections and identifying concerns and possible adaptations options. The second step was a workshop to present and discuss the first step results with groups and individual farmers in the village of Zignasso. During the workshop, possible options to mitigate climate change effects have been presented to farmers for collecting their perceptions and appreciate the feasibility of the adaptation options. The third step is a workshop held in Sikasso with villagers and technical services representatives at the regional level and national level. This was to validate outcomes options chosen to mitigate climate change effects and prioritize options based on feasibility and costs.

A valuation of attributes matrix was used to score each adaptation option (see table1). Each attribute is scored from zero to five depending on its importance in the implementation of the strategy (0=none; 1= very low; 2=low; 3=medium; 4=high; 5=very high).

Table1: Valuation of attributes of each option

Value	Assistance required for adoption	Effectiveness for climate change	Cost	Feasibility	Adequacy for current situation
0	none	none	none	Non-feasible	Highly inadequate
1	Very low	Very low	Very low	Very low	inadequate
2	low	low	low	low	Somewhat inadequate
3	medium	medium	medium	medium	indifferent
4	high	high	high	high	adequate

5	Very high	Very high	Very high	Very high	Very adequate

The last step consisted of conducting a discussion with a group of key informants on two possible scenarios:

1. What will the situation be if no changes occurred within 30 years? Which adaptation options would be undertaken?
2. What will the situation be if conditions become dryer and warmer within 30 years? Which adaptation options would be undertaken?

Discussions used projections of an increase of 1°C by the 2030s and an increase of 2-3°C by the 2060s; high uncertainty about whether precipitation will increase or decrease; and highly probable increase in variability, with possibly more dry years and more extreme precipitation events.

Brief Background on Zignasso

The village is at 9 km from Sikasso and is part of the urban commune of Sikasso. It is limited North by the villages of Zangaradougou and N'gorodougou, South by the town of Sikasso, East by the village of Kafuziela and West by the village of Samogossoni. The village is accessible all year long by a non-paved road.

Zignasso has a population of about 3000 people shared between 142 households. Population is mostly young and has high number of women. Total area farmed by population is around 700 ha and most of it is located in the inland valley (bas-fond), nearly 300 ha. The village does not grow cotton; their cash crops are potatoes, vegetables to provide to the town of Sikasso.

Zignasso has many ethnic groups, the main ones are: Senoufo, Fulani, Bambara,Sarakolé, Bozo, Mianka. Farm households are shared among four types depending on equipments:

- Type A farms: they are a number of 15 equipped at least with two pairs of bullocks, a plow, a "multicultor", a seeder, a cart and a number of six heads of cattle;
- Type B farms: they are at a number of 25 equipped with one draft animals and plow and/or a "multicultor";
- Type C farms: they are a number of 40 and possess only part of draft (draft animals or plow);
- Type D farms: they are 62 non-equipped and farm by hand.

The village has 7 farmer organizations or associations, among which there are 2 women's organizations. Major constraints are revenues management, insufficiency of equipment and input and problems related to water management.

Land tenure is not an issue according to the village chief because the land owner allocates a piece of land for each family in the whole community and is not able to get it back unless farmers stop using it. To access land one makes a verbal application to the traditional land owner. After the allocation of a piece of land, one can use it as long as possible with some minor restrictions (should not plant trees, digging a well, or constructing anything which is

sustainable without the approval of the traditional owner). Women have access to fallows belonging to their husbands.
Farmers are also herders; they own crops and animals. Some fighting could occur between participants in the two activities but it is mostly resolved within the village unless there are causalities (very rare cases).

Main Results

Farmers' perception of climate change

Through the discussions, farmers stated that they are currently experiencing very heavy rainfall events, this was not happening in the past. For example said a farmer "Last week Zignasso received 180 mm rainfall in less than 24 hours; the annual rainfall is approximately 1000 mm. August is the rainiest month (mild), but it is now hotter and drier". In addition to less precipitation, they observe a decrease in the water table. We have not been able to obtain temperature and precipitation observations to verify the changes.
Farmers attribute decreases in rice and potatoes yields partly to increased temperature, decreased rainfall, and deforestation (which can increase temperatures). Potato yields have been falling for the past six years. "Six years ago, a 25 kg box of seed would yield one metric ton of potatoes, currently it yields less than half a ton". Potato farmers are harvesting between 200-300 kg for a 25 kg box of seed. Rice yields decrease is attributed to less water availability. Farmers also are observing decrease in wild fruit yields (Shea nut, Baobab, Néré, etc.) used for consumption. Women used to harvest firewood that was as large as one's forearm, but now it is no larger than a finger and they have to travel far to get firewood.
Livestock reproductive success has decreased because of decreased water and feed. In the past, a cow could reproduce at two years of age, but now they do not reproduce until they are four years of age.

Adaptation options

The following tables give a general view of the adaptation strategies discussed with farmers during the workshops and the key informants interviews in respect of the attributes.

Table 2. Adaptation option for Climate Change

N0	Adaptation Option	Comment	Assistance Required for Adoption	Assistance	Effectiveness for climate change	Cost	Feasibility	Adequacy for current situation
1	Crop residue incorporation	Competition for use of crop residue as animal fodder, fire wood and home roof	Technical assistance for demonstration is required	Extension agent	Maintain moisture in the soil and improves soil fertility	Slight additional cost	Technically and economically	Adequate with current situation because farmers leave some residues on the field
2	Access to fertilizer	Affordability/local availability of fertilizer, Additional fertilizer application is only effective if there is enough water; water stressed crops do not use fertilizer effectively	Financial assistance is required at least in the first two years	Credit from Micro finance institution or bank	Increase yields of newly introduced varieties, therefore more production for a growing population	Relatively high cost for first and second years of investments	Farmers are used to such operations. The amount of money needed is qut weighted by increase in production	Because fertilizer is not fairly accessible at the village level; they have to travel far to get it. This could save transportation
3	Better understanding of biotic and abiotic stresses in rice, maize and potato (shallow rooting depth, soil fertility/structure, pest, weeds, ect.)	Targeting management improvements to those that can best increase tolerance to climate stress The cost in this strategy is derived from the technical assistance	Community could implement with technical assistance	Close extension agents are needed	Since cropping patterns will change, extension is needed for the adaptations	Most of the cost will be reallocation of human resources by government	Many young trained specialists exist, NGOs also are available	There is no extension agent in the village, so this a good opportunity.
4	Seed priming	Better crop establish, earlier maturation, drought avoidance. In current situation, when there is no drought, the strategy limits production. It has been reported the failure of responding to an “erroneous” weather forecast in Zimbabwe	Community could implement Assistance required to demonstrate value of strategy	Slight assistance is needed	Since climate change conduct to less moisture	Does not require an additional cost	Farmers are used to a similar practice	Will reinforce farmers knowledge on the timing of the technique
5	Use short-duration crop varieties	Wider adoption of NERICA4 for upland rice cultivation	On farm demonstrations and farmer to farmer field visits are needed	Extension agent from NGO or government	Requires less moisture at end	Seed and fertilizer cost	Farmers have experienced it	High yielding variety

N0	Adaptation Option	Comment	Assistance Required for Adoption	Assistance	Effectiveness for climate change	Cost	Feasibility	Adequacy for current situation
6	Crop diversification and crop rotation	Greater use of intercropping where appropriate. Use of crop rotations to break pest cycles. Use successive crops to benefit from remaining moisture in the soil	Technical assistance from NGOs or government agents or projects	Training of farmers and Extension of activities	Moisture should be used effectively	No extra cost is needed for this at farmers side	Farmers are used	Gives more alternative crops, increase production, makes more food available
7	Introduce new crop varieties	Drought and heat tolerant varieties There is an additional cost of using "design" varieties. In some cases new varieties change crop ecology and increase weed and pest infestations	Tests and demonstrations are needed on the field	Research and extension agents	Crop can reach maturity Highly productive crops High valued crops	Seed and input fares	Farmers have experience to accept new technologies	Since traditional crops don't adapt well, new ones will be built on changing conditions to fit.
8	Introduce new crops: possibly other vegetables instead of potato, and moving from rice to more drought tolerant crops such as maize or millet	Need markets for new crops, and technical support. Socioeconomic barriers?	On farm researchand extension required	Research and extension agents	Benefit from residual moisture	Seed and input costs	Research center exists Extension agent available	Farmers are asking for new crops
9	Installing rock lines to catch water runoff	Results need many years to show effects	Training and extension and community mobilization	Small equipments and NGO agents	Moisture conservation	Equipments and man power	Materials exist but time is a constraint	Prevent long term land degradation
10	Agroforestry (including the planting of trees around ponds)	Multi-purpose agroforestry species. Trees that provide nutritional benefits, trees that provide firewood. How much natural regeneration of Accacia or other tree species is occurring in the fields, and can there be better education about protection of naturally regenerated seedlings?	Adapted tree species, training on planting and protecting	NGO to train and mobilize population	Reduce evaporation/ transpiration, increase revenue sources Protect environment	Nursery fares	No extra monetary cost is involved	Women farmers have already planted 5 ha
11	Food Storage (Credit for Food crop Storage)	Evaluate how much food loss is there between harvest and consumption. Improved post-harvest management practices can be introduced	Training and financial assistance	Storage house and NGO agent	Higher prices for commodity gives farmers resources to buy food or	Construction material and cement costs	Area is available and population willingness	The activity is in experimentation in the village

N0	Adaptation Option	Comment	Assistance Required for Adoption	Assistance	Effectiveness for climate change	Cost	Feasibility	Adequacy for current situation
		Storage structures will have to be built This strategy promotes thinking about markets and is effective in avoiding selling at low prices during periods of production			adaptation equipments			
12	Agrometeorology	Farmers could be using RANET and other seasonal climate information to their maximum benefit. Representatives of ACMAD and NOAA could teach farmers.	Communication outreach and training	Special radio station diffusion	Inform and forecast weather and help farmers to chose crops to be planted	Radio stations are available and most farmers have a radio	Not too difficult to put agencies together	Better information make good decisions
13	Dam	Water diversion for rice and potato, or other crops and trees Having water available is an imperative strategy	Financial assistance required	Project, Extension agent	Maintain moisture, lengthen growing season	Construction cost	Feasibility study done, population willingness	Will allow three cropping seasons with high yields
14	Indigenous knowledge/coping strategies	Which current coping strategies should be expanded for adaptation, which are counterproductive? Assistance needed for testing and demonstration	Research and extension	Workshops, extension on techniques, farmer to farmer visits	Knowledge sharing may give opportunities to many farmers to learn about new practices	Workshop fares and travel costs	Funding agencies exists, government's interest	Government's priority is to ensure food security and alleviate poverty

Valuation of adaptation options for zignasso

After presenting the list of adaptation options (tables 2), additional options not included in the list were solicited. Farmers and regional technical advisors identified four additional options: small scale irrigation (such as the pumps that projects are promoting); development of a coherent scheme to address climate change and agricultural issues that takes a livelihood approach (integrate livestock, agriculture, forestry); options to retain and enhance soil moisture, such as dry-soil seeding; storage facilities for potatoes; and enhancement of the organizational capacity of the village.

There were discussions of the importance of maintaining biodiversity; whether planting eucalyptus was appropriate, given the soil type and weather patterns in Zignasso (the women planted five hectares); there were divergent views on whether eucalyptus is beneficial to retaining soil moisture and increasing soil health; land tenure issues (most farmers are land users, not land owners so they can't significantly improve soil health or plant trees); and equipments, farmers believe they need to increase food security (including plow, oxen, cart for transport, and more efficient stoves).
Each farmer has identified options he believes are most important, focusing on the options that require outside financial and technical assistance. Finally, each farmer ranked the three most important options, the overall ranking gave priority to the following adaptation options (in order):

1. Water gate (i.e., small dam that would flood adjacent rice fields and would allow for furrow irrigation)
2. Equipment (plows, carts, oxen, and improved stoves);
3. CSV (a scheme implemented in Zignasso by a USAID project to provide credit for storing potatoes until market prices increase after harvest; the scheme is very popular among women and many of them want to join it);
4. Fertilizer; and
5. Crop diversification and germplasm improvement.

Items 1, 2, and 3 received far more votes than the last two.

When asked if they would change their ranking if they knew it was going to get drier, the farmers responded that they took possibly drier conditions into account when ranking the options and that these are the key priorities.
The priorities for the regional technical advisors were:

1. Crop diversification and germplasm improvement
2. Soil management
3. Fertilizer

Some of the technical advisors noted concern about the water gate option because of land tenure and administration issues. We learned in a trip to the village following the workshop that villages upstream and downstream of Zignasso have water gate.
The valuation matrix has been applied using the adaptation options prioritized by the different participants to minimize impacts of a warmer and drier climate while maintaining rural agricultural production and minimizing environmental damage. The following tables show scores given to different options in respect of the valuation matrix.

Table 3. Assessment of Adaptation Options

Adaptation option	Comment	Assistance Required?	Assis-tance	Effecti-veness	Cost	Feasibi-lity	Adequacy for current situation
Soil management							
Install rock lines through community actions to reduce soil erosion	Training may be needed.	Community could implement with technical assistance and equipment for transporting rocks	5	3	5	3	3
Ridge-tillage (ACN)	Capture and efficient use of rainfall for increased yield, access to drinking water, environmental rehabilitation (soil and vegetation), etc	Technical assistance strongly needed	5	5	2	4	5
Crop residue incorporation (left on the soil surface and not necessarily incorporated with soil cultivation)	Use the approximately 20% that is currently burned.	Technical assistance required	1	5	1	4	3
Better understanding of biotic and abiotic stresses in rice, maize, and potato (shallow rooting depth, soil fertility/structure, pests, weeds, etc.)	Targeting management improvements to those that can best increase tolerance to climate stress (cost due to technical assistance).	Community could implement with technical assistance	4	4	4	4	4
Crop diversification and germplasm improvement							
Use of short-duration rice and maize (such as Kababléni).	Projects have worked to promote wider adoption of NERICA	Community could implement with financial assistance.	4	3	2	3	3
Introduce new crop varieties on a pay-at-harvest basis	Drought and heat tolerant varieties will be needed.	Community could implement with technical and financial assistance	4	3	5	3	3
Introduce new crops (such as sesame) instead of potatoes and possibly other vegetables	Need markets for new crops and technical support.	Research is required	2	4	4	2	4

Adaptation option	Comment	Assistance Required?	Assis-tance	Effecti-veness	Cost	Feasibi-lity	Adequacy for current situation
Crop diversification and crop rotation in the following order: rice (women) – potatoes (men) – gardening for groundnuts, sweet potatoes, eggplant, and okra (men & women).	Greater use of intercropping where appropriate. More use of crop rotations to break pest cycles.	Community could implement with technical assistance	2	5	1	4	3
Seed priming for rice or maize for one night and day if soil is moist enough, or during the night if it rained the preceding afternoon	Better crop establishment, earlier maturation, drought avoidance						
Agroforestry, including: • planting of trees around ponds (Moringa) • Live fencing (citrus, jatropha, Zizuphus, Acacia) • Interplanting species in fallow or grazing lands (for fire wood) • Fodder bank with selected species such as Stylosanthes	Multi-purpose agroforestry species, including trees that provide nutritional benefits and trees that provide firewood. How much natural regeneration of Acacia or other tree species is occurring in the fields, and can there be better education about protection of naturally regenerated seedlings?	Community could implement, but assistance required to demonstrate value of strategy	1	4	1	4	4
		Community could implement with financial and technical assistance	3	3	3	3	3
Agrometeorology for more accurate weather forecasts, particularly for the onset of the rainy season; and predicting rainfall events.	Farmers need access to seasonal climate information.	Community could implement with technical assistance	5	5	5	5	5
Access to capital/finance Water gate considered by farmers as 'THE LIFE-SAVER.'	Water diversion for rice, potato, other crops, and trees. Having water available is an imperative	Financial assistance required	5	5	5	5	5

Adaptation option	Comment	Assistance Required?	Assis-tance	Effecti-veness	Cost	Feasibi-lity	Adequacy for current situation
	strategy that would increase efficiency by 2-5 folds and bring immigrants to Zignasso.						
Food storage specially 'credit stockage villageois' (CSV). rice for women and CSV maize for men	Evaluate how much food loss there is between harvest and consumption. Improved post-harvest management practices can be introduced. This strategy promotes thinking about markers and is effective for avoiding periods of malnutrition.	Community could implement. Storage structures will have to be built.	5	5	3	5	5
Access to fertilizer through credit stockage villageois (CSV) to install fertilizer dealers or stockists, or arrange 'pay-at-harvest'	Affordability/local availability of fertilizer. Promote soil organic matter management for better efficiency of fertilizers	Community could implement with financial assistance	5	5	5	3	5

Farmers recommended adaptations that require outside financial and technical assistance because the ones which don't are easily applicable by them. Adaptations emphasized by both the farmers and representatives of regional technical services are crop diversification and germplasm improvement; soil and water management; equipment (plows, carts, oxen, and improved stoves); credit stockage village is "warrant age" (CSV); and fertilizer.
Farmers said they believe the most important adaptation is to build a dam on the stream which floods the inland valley "bas-fond"enabling them to farm many crops in a year without strong water stress. Some concerns were raised about the construction of the dam for land tenure issues; but the villagers ensured that the land does not have any kind of problem with other villages upstream and downstream of Zignasso.
The priority adaptation options that fit with regional priorities are particularly:

- Crop diversification and germplasm improvement;
- Improve soil management through integrated natural resource management;
- Facilitate access to credit for fertilizer, equipment, and storage; and
- Communications outreach.

Discussion of priority options

Building the dam
The principal goal of building the dam is to recharge the water table through canal system or by infiltration. The effect is more relevant during the off-season for potato and vegetables production. The impact will be seen on rice on September. The objectives are:

- To increase moisture availability in the soil by reducing run-off;
- Secure off-seasonal cropping (potatoes);
- Enhance rice production;
- Promote tree cropping
- Increase water accessibility to animals (livestock)

The management of the dam is done by beneficiary population through a management comity in each partner village. At this time there is no consultation among users of water gates on the stream, which could end in conflicts among different villages.
The dam will be one with a water gate built to constitute a reservoir during the rainy season. A few of the type are built in other villages using the benefice of the same river.
The estimated cost of the dam is 13 412 484 FCFA, almost 25 547$ if enterprise work; the cost will be about 9 000 000 FCFA (17 142$) with villagers participation.
The dam could:

- Facilitate new activities in the bas-fond
- Increase crops intensification
- Improve cropping seasons
- Increase farmed area to 250 ha
- Increase farm income.

Internal rate of return of total investment considering two crops a year is estimated at 25% wile with three crops a year is 65%. Farm net incomes could rise on average from 740 650 FCFA to 1 356 750 FCFA.

Crédit Stockage Vivrier (CSV)

This is a system where farmers can stock their production during a time period until market prices reach an acceptable level. The process is as follow, farmers put their stock together and seek credit from a bank (or mostly "Grammy bank"). The value of the stock is estimated at the current market price, 70% of this value is given to farmers and 30% kept as guarantee of the credit. When market prices of the commodity are higher the stock is sold and the amount of credit is deducted, and the benefit is returned to farmers.

This system prevents farmers to sell their crops at very low price. The population has experienced it for rice. The benefit they got from it allowed them to get fertilizer loans from the bank. Population wants the system not only for rice but for other crops especially for potatoes.

The problem with this system is farmers' organization and management capacity.

Access to fertilizer

Fertilizer is a key issue in farmers' production system. Soil fertility is low because of non-sustainable cropping practices (slash and burn, sole cropping, no fallow in the cropping system, etc.); population increases at high rate; income is low at farm level; prices of inputs are higher and higher on the market.

Farmers always face difficulties to access credit for fertilizer if they don't belong to the cotton (CMDT) or rice (Office du Niger) organization systems.

A "boutique d'intrant" or input shop is a way which allows farmers to buy the amount they afford. This is feasible if farmers have access to credit.

Crop diversification

Crop diversification and intensification make food available to population and production of high value crops. Increased and diversified crop production make food prices stable and low, therefore enhance food security. Better and affordable food improves nutrition and health which in turn has a favorable impact on learning capacity. Higher income improves human capital which in turn improves productivity. Construction of the dam allows crop diversification and intensification.

New germplasms could be introduced in the area (short duration crops, new crops). Farmers in Zignasso believe that new crops like "courgette" which are short duration and new crops, could provide more cash. With the cash they buy fertilizer, equipment or diversify their food. Villages with a dam in their inland valley produce more crops during a year than those which don't have a dam. Africa Rice introduced a new upland rice variety "NERICA4" which is high yielding and short duration. Farmers are adopting this new germplasm and abandoning their old ones. Other inland valley rice varieties are also being introduced, they are also high yielding and short duration compared to local varieties. The constraints farmers face for adoption of the varieties are access to fertilizer, equipment to do in time necessary land works, etc.

Agro forestry

Villagers leave on their fields trees that they think are important in terms of nutrition, health, animal feed, land protection, etc. But, increase of population and water stress made trees rare in the area. Ladies used to harvest firewood not far from the village and large ones, actually they have to travel very far to get very thin wood for cooking.

Farmers to avoid firewood stress plant trees (ladies in the village have planted 5 ha of eucalyptus), but which species to plant are not known by producers.

In fact, Eucalyptus is known as a water pumping tree, it outweighs all other trees near it and even can dried up wells. Traditional trees could be planted by using new technologies and give good results. Trees like Shea nuts, Arabic gum, baobab, “Nere”, etc. can procure income because there is an external and internal market for them.
Agro forestry could enrich the soil, improve food security and alleviate poverty. It is highly related to climate change.

Seed priming
Seed priming is a practice known by farmers long time ago. The accuracy by which they apply the technology is questionable. Farmers attest using the technology for growing rice and maize, but the time frame in which they left the seed in water is not very accurate. Most of farmers do it more than ten hours, while eight hours are sufficient.
Seed priming is very effective with current situation because since moisture is not enough and does not last long time in the soil, the technology allows seed to germinate in two or three days.
This technology does not require investment, farmers could learn from an extension agent in the village.

Equipment
Access to equipment is a constraint in the village. They don’t grow cotton; therefore don’t have access to credit for equipment. Working by hand does not allow farmers to respect the crop calendar timely. With non-adapted equipment farmers can’t work on dry land and do soil managements which keep moisture in the ground. Since temperatures will be high and rainfall reduced, it is important to manage the land in a way to keep soil fertility and soil water for a relatively long period. Farmers in Zignasso ask for carts, multi-purpose plows, dry seeders, etc. To have access to these equipments they should be put in relation with financial institutes.

Incorporating crop residues
After harvest farmers use stalks for animal feed, fencing, roofing and the rest is grazed by animals on the field, or burned. Practices to incorporate residues in the soil are not applied because they don’t have the appropriate equipment’s for it.
This practice is relevant in climate change situation because of reduced rainfall and warm temperature (moisture will not last long), incorporating residues in the soil will keep moisture as long as possible in the soil and enrich it. Adoption of the technology requires possessing appropriate equipments. The time to carry over the activity is during dry season when most of the labor force of the village migrates temporary to larger cities for off-farm works to make cash for the wet season. Unless the adoption of technology provides benefits that outweigh those gained from migration, its’ application will be difficult.

Communication outreach
Most farmers are illiterate. Information given by radio stations are mostly in French, a few time is allocated to local languages.
Farmers have radios (about 80%) and are very interested in rainfall information. This information is broadcasted by region, circle and station on a daily basis during all the rainy season. But information doesn’t forecast the weather and doesn’t link prices, crops and the weather.

Scenarios Analysis

A discussion with a group of key informants conducted to two scenarios:
1. If the situation (climate) remains as it is, what will be the village in 30 years?
2. If the situation gets worse, what the village will be in 30 years?

The above scenarios have been analyzed at social, economic, environment, cultural and institutional levels.

1. **If the situation remains:** Resources will continue to degrade and heavy weight will be given to cereal production for food security. Although they know that cereals have low productivity even if fertilizer is applied with new genotypes. Human pressure will be high on natural resources, access to fertilizer and improved inputs will become expensive. Institutions like extension services will have to increase their interventions for farmers to produce. Capacity building of farmers will be at a lower place. Investment to improve natural resources will not be done.
   In conclusion this will conduct in the long run to a famine and most of the population will migrate.

2. **If rainfall gets lower:** In the short run there will be an ecological crisis where all resources are devastated. A major social crisis will occur and strikes will happen at political level and will affect the production system in place. A huge disaster will take place, and civil war can happen because poverty will be around everywhere.

Predicted Solutions

1. **If actual situation remains:** Promote cash crops and develop value chain. Develop policies which take into account concerns of rural population by putting in place decentralized institutions, water conservation systems. Preserve natural resources, access to a viable credit system, improve cooperatives management.
2. **If the situation gets worse:** Develop policies for external assistance, migration of the population; introduce very short duration and heat resistant crops. Develop soil and moisture conservation systems, health centers, access to clean water.

Summary and Conclusions

The study aims to get farmers' perception on the potential effects of climate change on agricultural productivity in Zignasso. Several stakeholders were interviewed (farmers from Zignasso and representatives of seven regional technical service officers in Sikasso) through focus group discussions, workshops and face to face interviews. In the Sikasso region, climate projections are for an increase of 1°C by the 2030s and an increase of 2-3°C by the 2060s (Butt et al. 2006). There is high uncertainty about whether precipitation will increase or decrease. It is highly probable that there will be an increase in variability, with possibly more dry years and more extreme precipitation events (Butt et al. 2006).
The priority adaptation options fit in well with the country's priorities, particularly crop diversification, soil management through integrated natural resource management,

facilitating access to credit for fertilizer, equipment, and storage, and communications outreach. The Government is currently implementing actions for sustainable development of the seed sector in Mali (funding seed enterprises, regulating the sector, enhancing improved seed production, etc.). Overall, the seed sector is not yet organized, and farmers hardly access to enough high-quality seeds when needed.

About 80% of farmers own a radio for capturing information on rural development (there are approximately 200 radio stations in Mali). The question is the information broadcasted is relevant enough to help farmers making right decisions. Through the discussions it appeared that the information broadcasted on weather should include short and medium-term climate predictions and consequences, planting dates, market prices, etc. A close collaboration between different stakeholders (OMA, the agency that collects agricultural markets prices, the Meteorological agency, agricultural extension service, donor agencies, etc.) could overcome this issue. There are daily weather broadcasts on the radio and TV on temperature and precipitation (at a cost of CFA 3000, or about $6). 10-day forecasts are provided in a bulletin that is distributed to relevant organizations in Bamako. Again, it is not clear if the farmers are getting this information in a timely basis.

Priorities vary whether an actor is a farmer or a technical adviser (extension agent). Farmers have expressed: Water gate, Equipment (plow, cart, oxen, improved stove), CSV, Fertilizer and Crop diversification and germplasm improvement as priority options. Extension agents have cited: Crop diversification and germplasm improvement, Soil management and Fertilizer as priorities.

References

Abbott, Kenneth W. and Gartner, David, The Green Climate Fund and the Future of Environmental Governance. 2011. EARTH System Governance Working Paper No. 16. Available at SSRN:
http://ssrn.com/abstract=1931066 or http://dx.doi.org/10.2139/ssrn.1931066.

Tanveer A. Butt1*, Bruce A. McCarl1, Alpha O. Kergna2: Policies for reducing agricultural sector vulnerability to climate change in Mali; Climate Policy 5 ([Q1]2005) 581–596.

Bougouna Sogoba, Andrieu Nadine, Howland Fanny and Zougmore Robert, (2015). Compte-rendu synthétique de l'atelier « Priorisation d'investissement en Agriculture Intelligente face au Climat au Mali »

Brookes, G. and Barfoot, P. (2009). GM Crops: Global socio-economic and environmental impacts (1996-2007). PG Economics LtD, UK.

Callaway, J. and M. Hellmuth, (2007): Assessing the incremental benefits and costs of coping with development pressure and climate change: A South African case study. Submissions from admitted non-governmental organizations on socioeconomic information under the Nairobi work programme. United Nations, Geneva, Switzerland.

Heltberg, R., P.B. Siegel, and S.L. Jorgensen, (2009): Addressing human vulnerability to climate change: Toward a “no-regrets” approach. Global Environmental Change, 19(1), 89-99.

Inocencio, A., M. Kikuchi, D. Merrey,M. Tonosaki, A.Maruyama, I. de Jong, H. Sally, and F. Penning deVries. (2005). ‘‘Lessons from Irrigation Investment Experiences: Cost-Reducing and Performance-Enhancing Options for Sub-Saharan Africa.’’ Report 6. International Water Management Institute,Colombo. African Water Investment Strategies. [www.iwmi.cgiar.org/africanwaterinvestment/].

IPCC (2007) Summary for Policymakers. In: Climate Change (2007): Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC (2007). Climate Change 2007: Mitigation of Climate Change. In ‘‘Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change’’. (B. Mertz, O.R. Davidson, P.R. Bosch, R. Dave, and L.A. Meyer, Eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, US.