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Smallholders adaptation to climate change in Mali

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Abstract This study was undertaken to assess the potential impacts of climate change on agriculture in the Sikasso region of southern Mali, as part of an effort by the U.S. Agency for International Development (USAID) to integrate climate change adaptation considerations into their development projects. The region is considered to be the breadbasket of Mali, providing a substantial amount of the country's food supplies as well as cotton for exchange earnings. The project had two components: modeling how climate change could affect production of cereal and cash crops in southern Mali; and conducting a stakeholder-driven vulnerability and adaptation assessment to identify potential options for addressing current and projected risks to agriculture from climate change. Projected changes in crop yields were based on a previous analysis that was extended for the purposes of this study. The projections suggested that the sensitivity of maize to changing weather conditions is relatively small (generally less than 10% change) under both dry and wet scenarios in 2030 and 2060. White (Irish) potatoes, the primary cash crop, are the most sensitive to changing weather conditions, with yields decreasing under both dry and wet conditions; yields could decrease by about 25%

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by 2060. Stakeholder workshops, field interviews, and an expert analysis were used to assess current and future climate-related vulnerability and to identify potential adaptation options. The main focus of the assessment was farmers in a village of about 3,000 people in the Sikasso region that practiced a rice-potato rotation system typical to the region. The farmers emphasized adaptation measures that require outside financial and technical assistance, for example installation of a water gate that would retain more water in the inland valley and increase the water table to flood rice fields during the rainy season and for furrow irrigation of potatoes during the dry season. Adaptations emphasized by both the farmers and representatives of regional technical services were crop diversification and germplasm improvement; soil and water management; access to equipment (plows, carts, oxen, and improved stoves); *credit stockage villageois* (CSV); and fertilizer.

1 Introduction

Mali has multiple vulnerabilities to climate variability and change. Located in West Africa and landlocked, it is one of the least developed countries with an economy that relies heavily on rainfed cereal production. Farming and fishing account for 45% of Mali's gross domestic product (GDP), and employ about 80% of the workforce (Butt et al. 2005). Agricultural production is inadequate to feed Mali's population, which is growing at a rate of nearly 3% per year. The Food and Agriculture Organization (FAO) estimates that over a quarter of Mali's population is undernourished, with little progress made since 1990 (FAO 2007). This level of food insecurity puts Mali into Category 4 of FAO's ranking of countries at risk of hunger, with Category 5 being the highest.

According to Mali's Direction Nationale de la Meteorologie (DNM), Mali has become hotter and drier over the last several decades. Analyses of recent temperature records show an increase in temperature over the latter part of the 20th century. Analyses by Butt et al. (2005) on recent precipitation trends for Sikasso for 1960–2005 indicate that overall annual precipitation decreased slightly, with a significant reduction in the wettest months (July and August), while precipitation at the beginning of the rainy season (May) increased. Projections based on MAGICC/SCENGEN by Butt et al. (2005) suggest that average temperatures could increase approximately by 1°C by the 2030s and by 2–3°C by the 2060s, compared with a 1990 baseline, with an uncertain trend in precipitation. Even if precipitation does not decrease, crop available soil moisture would likely decrease due to increased evapotranspiration caused by higher temperatures.

Agro-climatic conditions vary considerably across Mali. Pastoralism and agro-pastoralism predominate in the Sahelian eastern and central regions of the country, which receive approximately 200 to 400 mm rainfall per year, while the Guinea savannah zone of southern Mali receives approximately 1,200 mm of rainfall per year. Mali's most productive agricultural area is Sikasso, located in the southwest near the border with Burkina Faso and Cote d'Ivoire. This region produces a significant amount of the country's food supplies, as well as cotton for exchange earnings. In addition to cereal and cotton production, Sikasso is the country's principal white (Irish) potato growing region, producing potatoes for Mali, as well as for burgeoning export markets in Senegal and Mauritania. Given the importance of Sikasso to Mali's current and future food security, this region was selected for a pilot study to test a process for factoring climate change into U.S. Agency for International Development (USAID) development projects. The two main components of the study consisted of an analysis of changes in yields of principal crops (rice, potato, and maize) for Sikasso for the years 2030 and 2060 under wet and dry scenarios, based on climate model projections, and a stakeholder-driven assessment of potential adaptation options to address current and projected climate risks to crop production in the Sikasso region.

2 Methods

2.1 Site selection for the assessment

The village of Zignasso, located 20 km from the main departmental capital, Sikasso, was selected for the case study. USAID preselected three possible farming communities for the study. Zignasso was chosen because it produced a broader range of crops, the farmers evidenced greater interest during the site selection visit, and it was already the site of a USAID rural development project. Further information, such a population, ethnic groups, social institutions, incomes, health and nutrition status, etc., was not available. The farmers in Zignasso produce monsoon rice (double cropping) rotated with dry season potato. The predominant rotation system is rainfed rice and maize in the rainy season rotated with irrigated potato and vegetables during the dry, cool season, with rice and potato the two most economically important crops.

The USAID development project aims to enhance productivity of rice through the introduction of improved rice varieties such as NERICA 4, which matures in 90–100 days compared with the 120–140 days for rice varieties typically grown in the area. Short-duration varieties are particularly important in Sikasso, where the farmers reported the length of the rainy season has decreased in recent decades. The project also works with rural communities to improve dry-season water access through the construction of polders and small dams, and to improve nutrient use efficiency. The project had recently started when the study was initiated, with ongoing recruitment of farmers, so there had not been an opportunity to determine the effectiveness of the project for reducing vulnerability to the shortening rainy season.

2.2 Case study: Stakeholder workshops and analysis

The case study consisted of an initial stakeholder workshop, an analysis phase, and a second stakeholder workshop. The purpose of the first workshop, held in February 2006, was to solicit input of farmers from the village of Zignasso, Malian agricultural scientists, and representatives of regional technical services and local nongovernmental organizations (NGOs) for identifying potential options that would help farmers better manage current climate risks and adapt to near- and medium-term climate change (i.e. from the present out one to two decades), with an emphasis on identifying ‘no-regrets’ measures.

The analysis phase, carried out between the first and second workshops, was designed to evaluate the options proposed in the first workshop through (1) a quantitative analysis of projected changes in yields of cereal and cash crops using crop models and climate change scenarios; and (2) information gathering sessions held with farmers, representatives of regional technical services in Zignasso, agronomists, soil experts, and other agricultural experts to identify additional adaptation measures (beyond those identified in the first workshop) and to qualitatively evaluate the effectiveness, cost, and feasibility of all identified adaptation measures.

During the second stakeholder workshop, held in August 2006, the results of the analyses were reviewed and the adaptation options prioritized. In addition, the results from the model analysis of climate change impacts on potato and maize were presented in order to provide context for the discussion of adaptation options. Following the second stakeholder workshop, additional discussions on the content of the workshops and analysis were held with USAID's Mali Mission and the director of Mali's Direction Nationale de la Meteorologie. Both workshops were conducted in Bambara, the local language.

2.3 Model analysis on projected impacts of climate change

The projections for this study were an extension of an extensive study of the possible impacts of climate change on food security in Mali conducted by Tanveer Butt and colleagues (Butt et al. 2005). That group linked biophysical and economic models to project national level average yields of sorghum, cowpeas, groundnuts, maize, and millet. Climate change projections from the HadCM3 and CGCM models (as drawn from the Intergovernmental Panel on Climate Change (IPCC) Data Distribution Center) were used. Both climate models generally project a decrease in precipitation and, hence, drier conditions. Temperature in 2060 was projected to increase nationwide by 2.5°C, with the seasonal changes of 2.8°C in DJF (December, January, February), 2.7°C in MAM (March, April, May), 2.1°C in JJA (June, July, August), and 2.5°C in SON (September, October, November). Some grid cells showed a decrease in precipitation. Climate change projections were input into the EPIC (Erosion Productivity Impact Calculator; Williams et al. 1989) biophysical model. EPIC was used to project the crop yield effects on a spatial basis. The results from EPIC were entered as input into the economic model, the Mali Agriculture Sector Model (MASM), to assess the impacts of climate change on countywide and regional production of various crop commodities. Finally, the prevalence of hunger was projected based on model results for food supply, and consumption based on the percentage of the population that may be undernourished due to consumption of food below what is required to maintain physical health. This indicator considers per capita availability of food and a measure of inequality in access to food.

The analysis by Butt et al. (2005) for the Sikasso region indicated that approximately 45% of the population is undernourished and this could increase to 75% without policy adjustments. Modeling a set of policies and research-developed adaptations that included migration of cropping patterns, development of heat resistant cultivars, cropland expansion, adoption of improved cultivars, and changes in trade, the analysis indicated that undernourishment would be reduced if all policies were implemented. These results suggest that there is the potential to implement adaptations that could decrease current and future vulnerability.

The analyses of Butt et al. (2005) were extended for this study. Climate model projections for southern Mali from MAGICC/SCENGEN (Wigley 2004) and as published in recent literature do not agree on whether conditions are likely to become wetter or drier. The latest IPCC assessment also is indeterminate on the change in precipitation in West Africa (Christensen et al. 2007). However, some recent studies project drier conditions (e.g., Cook and Vizy 2006). Because changes in precipitation are uncertain, sole reliance on a dry scenario was judged to not be desirable. Consequently, MAGICC/SCENGEN was used to generate annual and seasonal changes in temperature and precipitation for Mali using a wetter scenario, HadCM2; the IPCC A1B emissions scenario with a sensitivity of 3°C was used. The CO_2 concentrations calculated by MAGICC for the A1B scenario are 460 ppm in 2030 and 575 ppm in 2060. These calculations are not actual output from the Hadley model, but from the HadCM2 scenario run through MAGICC/SCENGEN to project patterns of regional change in temperature and precipitation. MAGICC/SCENGEN organizes the climate output in 5° by 5° grid boxes. Climatic changes were projected for the region from 10° to 15°N and 0° to 10°W. Sikasso is close to the edge of a grid box, so that grid box and the adjacent grid box were averaged. Although this is a very coarse scale, it provides an indication of the magnitude of possible temperature changes. Providing output by high latitude seasons smoothed monthly variability. Under this scenario, annual temperatures increases by 1.1°C in 2030 and 2.6°C in 2060; precipitation increases 8.6% in 2030 and 11.9% in 2060.

For EPIC, Mali was divided into zones by differences in soil types and climate. EPIC was set up using weather conditions for 114 locations, with four major soil types for each location considered. Sikasso was divided into three sub-regions: North, Central, and Western. Zignasso is in the Central region. 1996 was chosen as the base year because it was the last normal rainfall year for which a consistent data set could be assembled. For each zone, EPIC simulates the relevant biophysical processes that include crop yields, soil erosion, heat and water stress, and nutrient balance. The model uses historical weather information; it also has an internal weather generator to create daily weather data based on climate change projections. The model simulations included information on farm management practices, such as irrigation, drainage, tillage, fertilization, manure management, and crop rotation (Butt et al. 2005). Note that appropriate data were not available for rice production, so rice was not included in the model analysis. In addition, simulated changes in yield variability were not available for this study. Also note that limitations of EPIC include that it is data intensive, requiring detailed inputs tuned to the local conditions. The model was used to provide insights into the possible direction of crop yields under the different scenarios considered.

The Prevalence of Hunger was calculated with a dietary energy supply approach. The index is a combination of the per capita availability of calories per person per day, inequalities in access to food, and the dietary energy supply requirements of different age groups. It measures the proportion of people who consume less than a minimum dietary energy supply and so are undernourished.

Models were run considering no adaptation and two levels of adaptation: use of heat-resistant varieties alone, and early planting along with use of heat-resistant varieties for all crops except potatoes. Heat-resistant varieties were assumed to be an important adaptation because soil moisture was expected to decline with higher temperatures, even under projections of increased precipitation. For potatoes, an additional adaptation option was an increase by 20% in water application to lower the water stress caused by higher temperatures.

3 Results and discussion

3.1 Modeled impacts on agriculture

The possible impacts of climate change on crop yields are summarized in Table 1. For the years 2030 and 2060, yield sensitivity of maize to increasing temperatures is negligible under both wet and dry scenarios, whereas potato sensitivity to warmer temperatures is high, with projected yield losses, averaged over wet and dry scenarios, of −5% in 2030 and nearly −26% in 2060. Adaptation measures for potato of increased irrigation and development of heat-tolerant varieties were projected to cancel out productivity declines from climate change in 2030, and in 2060 these adaptation measures were projected to substantially reduce the magnitude of yield loss due to climate change under both dry and wet scenarios. Projected maize yield reductions in this study are lower than that modeled by Jones and Thornton (2003).

Table 1 Projected effects of climate change on average yields in Sikasso (% of base scenario)

Year	Scenario	Adaptation	Potato	Maize
2030	Dry	No	−6	−1
	Dry	Heat-tolerant varieties; Irrigation for potato	+14	−1
	Wet	No	−4	+1
	Wet	Heat-tolerant varieties; Irrigation for potato	+13	+2
2060	Dry	No	−27	−1
	Dry	Heat-tolerant varieties; Irrigation for potato	−5	+2
	Wet	No	−24	−1
	Wet	Heat-tolerant varieties; Irrigation for potato	−5	+2

The performance of adaptation options differs between dry and wet weather projections. Heat tolerant varieties provide more gain under dry conditions than under wet conditions. In the modeling, implementation of adaptation options substantially reduces the adverse impacts of climate change.

3.2 Farmers perceptions

In both workshops, farmers were highly interested in discussing recent climate variability and projected climate change, and learning what strategies they could adopt to increase their ability to cope. As noted, potato is the primary cash crop, and rice is both a staple and cash crop. The farmers reported that, during their lifetime (40 or more years), the weather has been getting warmer and drier, with more year-to-year variability, which they partially attributed to deforestation. The perception of increasing temperatures and precipitation variability are consistent with data collected by the Direction Nationale de la Meteorologie. Reduced water availability was reported to be a growing problem. The farmers also stated that historically, rainfall and residual soil moisture and surface water reserves were sufficient to allow them to grow three crops annually, and local organic fertilizer sources were adequate. Pasturing livestock was easy because there was sufficient fodder in the fields, and livestock could begin reproducing after 2 years of age. There were no data to independently verify these perceptions.

The farmers reported that the length of the rainy season for rice has decreased and moisture stress increased; weather station data were not available to confirm these observations. They also reported decreasing yields of other crops, particularly potatoes, even with fertilizer use and changed farming practices. They used to plow twice before sowing; now they plow immediately after the first rain and sow after the next rain, and they plow more lightly to increase moisture retention. Overall, they stated that yields have decreased by about one-third over the past three decades; factors affecting soil fertility include soil degradation, lack of appropriate fertilizer, and climate variability and change.

The adaptation options identified by the farmers included: (1) continue planting early maturing rice and other crops; (2) continue planting earlier to avoid the highest temperatures; (3) training in soil management for higher water retention; (4) install more rock lines; and (5) install a water gate in the polder to allow some irrigation. The women suggested planting trees for firewood. The farmers requested additional technical support for implementing adaptations.

3.3 Evaluation of adaptation options with farmers and other stakeholders

The criteria used to evaluate the adaptation options were developed during discussions between USAID, contractors for the Mali pilot study, and agricultural experts in the Malian government who advised this project. The adaptation options identified and analyzed are described in Table 2, including farmers' evaluations of the effectiveness to address climate change impacts, costs, and feasibility; the degree to which assistance would be required; and the adequacy for addressing current climate variability. The scores are the consensus views of the farmers, supporting institutions, and representatives from the extension services at the stakeholder meetings. The comments and degree of assistance required were synthesized from the discussions.

The farmers were very concerned about recent and projected climate change; they believe climate change will be more severe than the projections. The farmers focused primarily on adaptation options that would have the greatest immediate impact on decreasing current vulnerability but that would require external financial and/or technical assistance. Their first priority was a water gate that would flood adjacent fields and would allow for furrow irrigation of the potato crop during the dry season. The farmers' second priority was to have better access to equipment, particularly plows, carts, and oxen, which would allow them to better manage production risks, and more efficient stoves. The third priority was to increase support for a recently implemented warrantee scheme called CSV (*credit stockage villageois*) that provides credit that allows for storing of rice for several months until market prices have increased, well after harvest. Participants in the program are given monetary credit in the interim period when the rice is being stored, which allows them to maintain household purchasing power between harvest and the eventual selling of yields. The final key options were access to fertilizer and crop diversification and germplasm improvement.

The priorities for the representatives of regional technical services differed from the farmers and reflected their technical role, with an emphasis on crop diversification and germplasm improvement, soil management, and appropriate use of fertilizer.

3.4 Implementation plan

Two key issues were identified that would affect the successful implementation of the adaptations identified. The first was the level of technical assistance, given the limited number of government extension agents in the Sikasso region. There are currently only seven agents for the entire region. As a consequence, extension agents do not have sufficient time to train farmers on the adaptations that could be implemented now, or to provide adequate technical support for routine agricultural production practices. Technical assistance from NGOs and community-based extension that emphasize farmer-to-farmer knowledge exchange supported by targeted technical assistance is needed to address the lack of formal extension services.

Land tenure was another potential obstacle to implementing natural resource management components of the adaptation plan. Many of the farmers in the study area are not landowners, and as such any changes in farming practices that improved the land could result in it being reclaimed by the landowner. Land tenure insecurity has been shown to be an important deterrent for investment in sustainable land management and land improvement (Neill and Lee 2001; Kabubo-Mariara 2007).

Based on expert judgment, the results of the stakeholder workshops were synthesized and the following activities suggested to the USAID Mali Mission as likely to reduce

Table 2 Evaluation of adaptation options for Zignasso

Adaptation option	Comment	Assistance required?	Assistance	Effectiveness to minimize the impacts of a warmer and drier climate	Cost	Feasibility	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.	Very high	Medium	Very high	Medium	Medium
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.	Very high	Very high	Low	High	Very high
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.	Very low	Very high	Very low	High	Very high
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.	High	High	High	High	High
Crop diversification and germplasm improvement							
Use of short-duration rice and maize (such as Kababléni).	PRODEPAM is currently working to promote wider adoption of NERICA.	Community could implement with financial assistance.	High	Medium	Low	Medium	Medium

Table 2 (continued)

Adaptation option	Comment	Assistance required?	Assistance	Effectiveness to minimize the impacts of a warmer and drier climate	Cost	Feasibility	Adequacy for current situation
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.	High	Medium	Very high	Medium	Medium
Introduce new crops (such as sesame) instead of potatoes and possibly other vegetables.	Need markets for new crops and technical support.	Research is required	Low	High	High	Low	High
Crop diversification.	Greater use of intercropping where appropriate. More use of crop rotations to break pest cycles.	Community could implement with technical assistance.	Low	Very high	Very low	High	Medium
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.	Community could implement, but assistance required to demonstrate value of strategy.	Very low	High	Very low	High	High
Agroforestry, including: • planting of trees around ponds (Moringa) • Live fencing (citrus, jatropha, Zizuphus, Acacia) • Interplanting species in fallow or grazing lands (for fire wood)	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	Community could implement with financial and technical assistance.	Medium	Medium	Medium	Medium	Medium

Table 2 (continued)

Adaptation option	Comment	Assistance required?	Assistance	Effectiveness to minimize the impacts of a warmer and drier climate	Cost	Feasibility	Adequacy for current situation
• Fodder bank with selected species such as Stylosanthes.	education about protection of naturally regenerated seedlings?						
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	Very high	Very high	Very high	Very high	Very high
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 strategy that would increase efficiency by 2 to 5 fold and bring immigrants to Zignasso.	Financial assistance required.	Very high	Very high	Very high	Very high	Very high
Food storage particularly 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.	Very high	Very high	Medium	Very high	Very high
Access to fertilizer through 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	Very high	Very high	Very high	Medium	Very high

Table 2 (continued)

Adaptation option	Comment	Assistance required?	Assistance	Effectiveness to minimize the impacts of a warmer and drier climate	Cost	Feasibility	Adequacy for current situation
Additional scoping strategies: • Feed for livestock • Improved stoves to reduce wood consumption • Loan funds for mechanized agriculture.	Assistance needed for testing and demonstration	Community could implement with technical assistance. Assistance needed for dialogue and consensus on indigenous learning.	Very high	Very high	Very high	High	Very high

current and projected vulnerability in Zignasso, and for which there was stakeholder interest:

- ***Crop diversification and germplasm improvement,*** including adopting high-yielding short duration rice and maize varieties; exploring approaches to improve potato yields in the short-term, and exploring the feasibility of eventually finding alternatives to white potato in the cropping system as a potential strategy for long-term adaptation; implementing practices to improve crop establishment for maize and rice as a drought-avoidance strategy; and providing incentives for intensifying agroforestry practices. These adaptations could be implemented with technical assistance. To be effective, some of the measures require better organization of the seed sector, which is a challenge throughout Sub-Saharan Africa (Sperling et al. 2004). For example, in a recent evaluation of NERICA rice adoption, Obilana and Okumu (2005) cited lack of seed as a key obstacle to varietal adoption.
- ***Improve soil and water conservation through integrated natural resource management*** by installing rock lines to reduce runoff and erosion; introducing contour ridge tillage; encouraging the retention of crop residues; and having a better understanding of biotic and abiotic stresses in rice, maize, and potatoes that impact water availability to crop root systems. The farmers gave ridge tillage and crop residue incorporation the highest rankings for effectiveness and feasibility. Ridge tillage applied elsewhere in Mali has been shown to increase yields and improve soil moisture retention and increase carbon storage potential in soils (Doumbia et al. 2009). Better understanding of biotic and abiotic stresses ranked high among both extension agents and farmers.
- ***Facilitate access to credit for fertilizer, equipment, and storage***, including installation of a small water gate for water impoundment and further promotion of an existing crop storage program. The farmers consider installation of the water gate as their top priority. Although the water gate would produce net benefits, land tenure and administration issues would need to be addressed. The recently implemented CSV scheme (as described in Section 4.3) was very popular with the women and many more want to join. Such a scheme could conceivably be extended beyond rice to include other regionally important crops. Enhanced food storage and access to credit, as would be afforded through a CSV-type scheme, are increasingly viewed as important for managing climate risks in developing countries (Leary and Kulkarni 2007).
- ***Communications outreach*:** A key issue is to get more information to the farmers for decision support. More accurate weather forecasts and improvement of access to seasonal forecasts, particularly the start of the rainy season, were considered important by both farmers and representatives of regional technical services. Products such as forecasts of whether there is likely to be a dry period during the rainy season could be made available to farmers by the Direction Nationale de la Meteorologie.

Institutional support for these adaptations is critical. Many of the recommended adaptations require initiating and/or continuing institutional commitment, such as organizing the seed sector and increasing the number of extension agents. This can be difficult in a world of annually changing budgets, such as the recent significant budget cuts at USAID; multiple institutions supporting a project may make the funding situation more stable.

Another issue is that model projections suggest that potatoes are not viable over the longer-term. Donors could support an analysis of options for gaining more from potato production in the short-term and for easing the farmers out of potatoes as their cash crop in the long-term. Also, this finding underscores the need to consider future climate when promoting commercial agricultural crops and infrastructure in rural development projects; the options selected need to be resilient to climate change.

4 Conclusions

The Zignasso pilot study demonstrates an approach for incorporating climate change risks into ongoing development projects that includes stakeholder input. Model projections were useful to inform the stakeholder discussions and the evaluation of proposed adaptation options, and were useful for USAID staff consideration of where future efforts are likely.

The stakeholders perceived that climate is already changing and are concerned about the potential impacts of future climate change, including variability, on agricultural yields in the Sikasso region. The measures identified by farmers were more focused on addressing risks associated with current climate variability, while those identified by regional agricultural experts and extension agents emphasized management options to reduce current and future vulnerability.

Taking projected climate change into consideration should not necessarily alter current priorities, as much as to focus attention on where current climate risk management can be enhanced as a first step towards adaptation to future climatic changes. The adaptation options that were identified, particularly crop diversification as related to improvements in the seed sector, soil management through integrated natural resource management, facilitating access to credit for fertilizer, equipment, and storage, and communications outreach are examples of relevant climate risk management activities. However, projected climate change is likely to place additional stresses on programs that aim to increase food security, making it urgent to implement these programs. Effective implementation of some adaptations, such as communications outreach, could involve coordination and collaboration among agencies and organizations with similar goals.

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