Opportunities and Investment Strategies to Improve Food Security and Reduce Poverty in Mali through the Diffusion of Improved Agricultural Technologies

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Executive Summary

This document reviews the potential agricultural technologies that exist or can feasibly be produced to help promote poverty reduction and food security in Mali in the next 5 to 10 years. Overall there are a plethora of good technologies either available, in the pipeline, or feasible with a small amount of research effort. In many cases succeeding in poverty reduction and increasing food security will not be about choosing the exact right technology, but about helping farmers access and know about a panoply of available technologies from which they can choose the right one to maximize their future potential.

Mali has seen significant agricultural growth in the last 20 years, with increases both in areas cultivated and yields in almost all sectors and large increases in livestock production. The next decade could be a key moment when the country turns the corner from self-sufficiency toward a producer of quality food for its people and major agricultural exporter to the region and internationally or one in which it slides back toward subsistence production. The generation, adaptation, adoption, and diffusion of new agricultural technologies will be a key ingredient in determining which of these two directions becomes a reality.

A number of forces external to the agricultural sector are likely to have a significant effect on the ability of the agricultural sector to grow in the next decade. The Malian economy is likely to continue growing at a reasonably fast pace (3-5%) with new mineral and oil discoveries as well as a likely future up-tick in remittances pushing the economy forward. This mineral export led growth will likely produce increased competition with agriculture for labor and combined with international migration and an increased emphasis on schooling for children, will produce labor shortages and higher labor costs in rural areas. That said, persistently high levels of population growth will continue to demand agricultural production. If economic growth continues as predicted, wealthier urban populations will start demanding higher quality and higher protein foods, fish and livestock products, for which Mali has great as yet mostly untapped potential.

The predictions for climate change are for increased volatility of weather patterns although they are unclear on whether that means less or more rain on average. Since Malian farmers are already well versed in how to deal with a stochastic environment this may not affect Malian agriculture as much as it would other places in the world. Climate change, however, will likely make it harder for farmers to specialize in types of production or crops, which is often a result of adopting modern techniques. We should expect climate change to push Malian farmers to keep their diversified risk-reducing portfolio of activities, making technological change based on intercropping and multiple production processes more attractive whereas mono-cultures and specialization will become more difficult. This may also increase demand by farmers for soil and water

conservation (SWC) technologies, although this effect may be mitigated by labor shortages.

With the continuation of road building and airport and airline service improvements, Mali is likely to have improved access to the world economy at lower costs than currently available, which can help open up export markets. But it will still be a high cost place for all types of transport. We expect world commodity prices to stay reasonably high for most commodities produced by Mali (corn, wheat, sorghum, rice) with a smaller likely rebound in cotton due primarily to a stronger dollar. Meanwhile input costs especially fertilizer are likely to maintain their current relatively high levels.

Mali will continue to have imperfectly operating land, credit, labor, and insurance markets. Innovations in some of these markets, especially credit markets have the potential to help foster new technology adoption, but we are not optimistic on this front. Further there seems very little likelihood of an agricultural insurance scheme having any positive effect on poor rural producers.

1. The Needs of Malian Agriculture

Agriculture provides two related benefits to the people of Mali. First and foremost it provides rural and peri-urban people with their own livelihood in terms of partial (or full) self-sufficiency and security in food. Second it provides a source of income to farmers, traders, and a source of foreign exchange for the government. The choice of new technologies should take into account these dual roles (food security and poverty alleviation) and provide new technologies that address one or both of these concerns.

We divide potential technologies along these lines into those that can improve agricultural production intended to provide food security, self-sufficient livelihoods, and those that can provide significant income benefits. Malian farmers readily make these distinctions in their own choice of technology (planting one variety of sorghum as a cash crop and another as a subsistence crop), so are likely to appreciate and adopt new technologies based on how they respond to one or both of these needs.

Before reviewing the most promising technologies it is worth noting that there are a great deal of promising technologies to increase Malian agricultural production, profitability, and sustainablility. It would be a mistake to take too narrow a view and choose only one or two as the best, because while each of these is individually promising the uncertainties associated with each one are high. It is likely that promoting a diversity of technologies for a range of farmer needs and capabilities as well as varying ecological niches will have the greatest impact on food security and poverty throughout the country.

2. Food Security: More productive, robust, and safer self-sufficiency production.

In improving the individual food security of Malian farmers there are three promising strategies both of which inject improved technologies into production systems farmers already know and use. The first is to improve the genetic material used in production of crops and livestock. The second is to intensify the intercropping that farmers already engage in for risk reduction by making it more productive as a food and income source. Third is to improve cultivation techniques to conserve soil and water.

I terms of genetic improvement, three areas stand out: improved millet/sorghum varieties, improved fonio varieties, better livestock genetics. With 73% of Mali's cereal land planted in sorghum and millet and that land producing 51% of Mali's cereal output and much of that land likely to continue to be in low input risk averse agriculture, technologies that improve that land's productivity without changing practices have great adoption and diffusion characteristics. Promising technologies here, in terms of both farmer acceptance and overall effect on food security for the poor, are ICRISAT millet and sorghum varieties with better genetics that can increase yields 20% for open pollinated (OPV) and 30% for hybrid varieties without farmers changing their agronomic practices. A potential 10-15% increase in cereal production nationally is possible with this technology.

Fonio is a highly valued crop for its low labor needs, early season production, drought resistance, and women are its primary producers. Unfortunately fonio yields are low and this has reduced the acreage devoted to fonio despite its evident benefits and high prices in the market. More research is needed to provide women farmers with higher yielding fonio varieties and better agronomic techniques.

Recent livestock research has shown a number of promising genetic improvements that can be used by livestock holders at all scales. These genetic improvements can improve the productivity, weight gain, without significantly changing herder practices or risk profiles. These include improve breeds of cattle, goat, sheep, and crosses of Rhode Island Red chickens with local varieties. This last one has the potential to greatly improve backyard chicken raising; an important income generation activity for women. More effort on getting these genetically improved varieties out into the general livestock population would be useful. There are also significant improvements in feeding practices, forage production, conservation and use that could increase livestock production.

A second important line of intervention is to push intensification of intercropping systems that have long since been developed in Mali. Better planting and fertilization techniques applied to intercropping of millet/sorghum with cowpea/soy/sesame/peanuts can increase farmer yields of both grains and legumes while reducing their risk profiles in terms of both climate and market risk as well as reducing the need to purchase expensive fertilizers. These techniques are well tested and can go directly to pilot extension programs. A second type of intercropping that shows great promise is the addition of fish raising to irrigated rice ponds. Adding fish can produce up to 1.5 tons of fish per hectare and at the same time maintain the same or better rice yields. With the correct control of

water, fish farming in rice fields could be more lucrative than rice farming. Intercropping of fish and rice will require both research and extension efforts.

A third line is to help farmers reduce their risks, through improving their planting, soil conservation, and water retention techniques. Integrated pest management also shows much promise where small changes in farmer practices; e.g., changing planting schedules by a few weeks, can reduce or eliminate pest damages. Most of these improvements require only an investment of time and change of technique from the farmer end, but a lot of investment in extension by the government and partners is necessary to bring the necessary information to farmers. Rather than focus on one or two technologies, this kind of work should provide farmers with a menu of planting, soil, and water conservation and integrated pest management techniques. This portfolio approach is especially important because in many parts of Mali farmers are still rotating their land through fallow periods, which severely reduces the incentives to invest in soil and water conservation techniques.

3. Cash Crops: More productive, less risky, and more lucrative cash crops

Malian farmers need new more productive, less risky, and more lucrative cash crops, in order to improve their incomes and step out of poverty.

A first way to provide this is to improve cash crops that are also consumable within the household such as corn, millet/sorghum, rice, wheat, and fish. Promising technologies include new seed varieties of drought resistant, fertilizer responsive crops such as corn. For women, intensifying their home corn-fields (*champs de case*) with hybrids and fertilizer represents an avenue for more extension work. Better varieties of rice for bas-fond, dry-land, and irrigated areas, which are more disease resistant and fertilizer responsive (e.g., NERICA). Improved rice and wheat farming techniques, such as the SRI (rice) and SBI (wheat) programs, show promise in raising yields through better techniques; but levels of farmer acceptance are still low and need further work. In addition the fertilizer responsive sorghum and millet varieties produced in the INTSORMIL program and used also by Sasakawa Global, show promise as a cash crop version of a subsistence crop.

Along with increased production of cash crops, better training and diffusion of simple methods to store grains could yield great dividends on the marketing end. Currently losses to pests and spoilage are very high for stored grain and simple improvements in storage techniques using existing facilities and equipment could reduce these losses and lower storage risks.

New cash crop potential exists in sesame and soybeans, especially where one can intercrop them with existing subsistence crops such as sorghum and millet. Both of these are likely to be technologies available and beneficial for women farmers. Another new crop with intercropping potential is jatropha-curcas, which can provide farmers with a steady source of income and potential fertilizer from the jatropha press-cake. More

research is needed on testing which crops are best for this intercrop. Women are likely to be involved in collecting and maintaining jatropha and it has a lot of potential around women's garden plots.

Mali is poised for large expansions in dairy production, something that should bring a steady income stream to rural households and women in particular within 20 km of a paved road. Most of the development can be done with the existing cow stock and technologies; key requirements are training, organization, and some minor infusions of technology. Further efforts to help push dairy development include better forage production, selection, and storage as well as improving local milk preservation and conservation techniques.

Increased development of fish farming also shows promise, both as an intercrop with rice and as either the stocking of existing local ponds or of specifically built fish-ponds. Mali has a perfect environment to expand fish farming where water is available. With a potential production of 9 tons/hectare worth 9 million CFA, the returns to fish farming are well above those of other crops, although the investment costs will be prohibitive for all but the most wealthy. Cooperatives may be able to alleviate some of these costs.

In terms of the export crops that compromise the USAID value chains such as onions, mangoes, garlic, potatoes, the biggest need is to start testing international quality versions of the crops grown here. It is not too soon to start testing to see how well the key varieties of these crops that sell internationally would potentially grow in Mali.

4. Labor saving technology

As set out in the introduction, the future of Malian agriculture will be increasingly determined by labor constraints. Herbicide use in Mali has doubled in the last 5 years in part in response to labor constraints and is likely to increase substantially in the future. Herbicide use has very positive spillover effects on women's time and ability to work on their own crops or collect karité nuts. More extension work and agribusiness training is needed, along the lines of USAID's IPM CRSP's work in pesticide literacy and safety, to ensure safe and effective use of herbicides, In addition Mali needs research work testing the safety and long-term consequences of increased herbicide use in a savanna environment.

Increased use of plows, multiculteurs, and tractors will likely also be warranted to face the lack of rural labor supply. Research and extension on the best use of tractors and multiculteurs in Mali in terms of soils, crops, and profitability is warranted. Further expansion of use of multifunctional platforms for grinding, threshing, and other post harvest chores is another area worthy of donor investment, because of the potential benefits in freeing up women's time.

5. **Improving Ecological system services**

Malian rural areas have a symbiotic relationship with their forests, grasslands, and tree-parklands in their fields. Increased mechanization of farming, the use of herbicides, and climate change has the potential for negative effects on the productivity and regeneration of these spaces. Relatively little is known about this and therefore more research is needed into how to maintain and regenerate the productivity of these spaces. Aside from natural regeneration, IER and ICRAF have done some promising research into making more productive, faster growing tree species that have yet to be diffused. In addition there is clearly a larger quantity of karité and other wild fruits that could be collected. Barriers to doing so include women's access to appropriate transport devices, market access, and creation of markets for locally eaten, but rarely sold local fruits.

6. Gender specific technologies

Among the various technologies described above a number are likely to have the largest impact on improving women's income and food security.

All labor saving technology, such as herbicide, is likely to have a gender impact not as much in women directly using it, but in it freeing up women's time for more lucrative activities. For example increased use of herbicide would free up women's time during the key time of year when they collect karité nuts, July-August, potentially engendering an increase in the production of karité butter and better women's incomes. Multi-functional platforms also provide a large labor savings for women, which can help income and food generation.

Improvements in fonio seeds and cultivation techniques would go directly to addressing women's income, especially in the dogon plateau and southwest Mali where fonio is grown extensively. Better fonio cultivars could also extend the reach of fonio cultivation into other areas where it was formerly grown.

More efforts at extending existing techniques for intensifying intercropping of cereals and legumes can also have significant income and food security benefits for women. This could also help women in forage production or provide forage for their own livestock raising activities.

Dairy development is likely to also have strong income and food security benefits for women. In addition moving more productive Rhode Island red and local chicken crosses out to more households is likely to help women's income and food security.

Finally women are the major collectors and beneficiaries of the ecological system services of forests, grasslands, and in the field tree parklands. Efforts to regenerate and make these areas more productive can have significant benefits to women.

7. Key constraints to success

A number of key constraints stand in the way of the effective creation and diffusion of the new technologies sited above. They are: (i) imperfect input, credit, and output markets, (ii) the lack of an effective extension system, (iii) problems in the incentives for researchers in IER and elsewhere to connect to the diffusion of their technologies, (iv) transport problems including poor roads, trucks and high costs and levels of corruption, (v) donor incentives and desire for short-term measurable outcomes rather than more nebulous but potentially more important research outcomes, (vi) high levels of weather and health risk that cannot be easily mitigated by insurance products or credit, (vii) fragmentation of efforts across sectors, value chains, and actors which can lead to a lack of coordination.

(i) Imperfectly operating input, credit, and output markets will continue to be a problem in Mali. Most important of these is the lack of a developed seed market. The private seed sector is a vital cog in the diffusion of new seed varieties and despite some signs of growth it is currently a long way from the ability to provide seeds to farmers who need them. Continued effort in the seed sector by multiple actors is a necessary pre-requisite to the diffusion of most seed varieties in Mali.

Agricultural credit is also not available in Mali at the levels necessary. The access to credit situation is likely to get worse before it gets better with the dissolution of CMDT. Some possibilities of amelioration come from recent efforts to sell farmer cooperative grains under contract with credit given as part of the deal. However, this will still not reach most of those most in need of credit. Creative efforts to find new solutions to the agricultural credit problem are warranted, such as mobile and cellphone banking and commitment savings devices for fertilizer purchase.

A non-competitive fertilizer market also poses challenges to the adoption of fertilizer responsive crops, by often raising the cost of fertilizers and making access a function of connections rather than need. This sector would most likely be helped by the government reducing its interventions, since most of the evidence seems to point to government efforts to subsidize fertilizer as one of the causes of the lack of competition and supply problems. Continued efforts in improvement on the marketing side are also warranted.

(ii) The lack of an effective extension system is one of the key constraints that is currently and will in the future hold Malian agriculture back from its potential. The solution is quite simple, greater monetary investments to hire more personnel. Nothing will substitute for more personnel out in rural areas. If new people are hired, more effort can be made to increase the density of extension agents and more effort needs to be done in better training of agents. There are also not enough female extension agents. Efforts to hire more female agents and place them in rural areas are a necessary condition for the successful diffusion of a number of the gender specific agricultural technologies listed in this report.

(iii) Along with the problems in the extension system, the research system is as disconnected from the extension system as the extension system is disconnected from

farmers. Researchers often lack the incentives to produce easily adopted packages for farmers and if they do there is no help for them to extend them, thus PhD scientists end up doing the extension work. Some revision of the incentives within IER will be necessary to help push technologies out the door.

In addition, while the trained personnel in the Malian research establishment are hard-working and well trained, there need to be many more people in the system. Certain areas are clearly undermanned as for example in socio-economic analysis where there is not a critical mass of well-trained economists.

(iv) Problems in transport and logistics remain key constraints particularly to the production of cash crops and the integration of markets. The Malian government is investing heavily, with donor support, in new transport infrastructure including roads and airport improvements. This should help, but more needs to be done. More effort in reducing corruption on import and export fees and petty corruption on the roads of Mali and neighboring countries is also important.

(v) Most of the key donors who would finance the necessary research tend to have overly short-term thinking in their funding strategies. Often there is a preference for measurable and short-term outcomes rather than a number of the outcomes that the technologies listed above are likely to produce. They will tend to be long-term high value outcomes, but often progress in reaching them will not be measurable in convenient metrics such as number of hectares, seeds, trainings, etc. Success in the creation and diffusion of the technologies in this report hinges on donors who are willing to make long-term investments in people, research laboratories, research projects, extension systems, seed marketing infrastructure, and innovative credit schemes. Short-term goals measuring hectares of new varieties or numbers of fish-ponds will not achieve the goals of poverty reduction and food self-sufficiency.

(vi) Malian farmers face high and not easily mitigated weather and health risks. Financial market insurance schemes (e.g., index insurance) as risk reduction technologies can at best account for one of the risks that farmers face, low rainfall, and current efforts to do so have run into major institutional constraints (imperfect/corrupt regulatory structure, poor collection of weather and yield data) that could delay implementation for decades. This lack of insurance markets and potential climate change means that successful technologies will have to help farmers diversify their risk portfolio rather than specialize it.

(vii) Finally these technologies need efforts across the whole system in order to be successful rather than a fragmentation of efforts across sectors, value chains, and actors.