Options for Economic Growth in Mali through the Application of Science and Technology to Agriculture

Prepared By

Valerie Kelly*, Michigan State University
Janet Carpenter, USAID/EGAT/ESP/IRB
Oumar Diall, ILRI
Tom Easterling, Weidemann Associates
Moctar Koné, Weidemann Associates
Peter McCornick, USAID/EGAT/NRM/Water
Mike McGahuey, USAID/AFR/SD/ANRE

For

The United States Agency for International Development
Initiative To End Hunger In Africa

April 2005

*Report coordinator

Table of Contents

List of Tables

List of Figures

List of Text Boxes

List of Appendices

List of Acronyms

ABSPII	Agricultural Biotechnology Support Project II (USAID funded)
AI	Artificial insemination
Approtec	Appropriate Technologies for Enterprise Creation
APROFA	Agence pour la promotion des filières agricoles (World Bank funded)
ARD	ARD, Inc. A Vermont corporation working in development
AVRDC	The World Vegetable Center, an independent, not-for-profit NGO
Bt	*Bacillus thuringiensis*
CBPP	Contagious Bovine Pleuropneumonia
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
CMDT	Compagnie Malienne pour le Developpement des Textiles
CNRA	Comité National de Recherche Agricole
CRU	Commission Regionale des Utilisateurs des Resultants de la Recherche
CRSP	Collaborative Research Support Program (USAID-funded agricultural projects)
DAD	Project in Djéné
DNAER	Direction Nationale de l'Aménagement et de l'Équipement Rural
DNAMR	Direction Nationale d'Appui au Monde Rurale
DNH	Direction Nationale de l'Hydraulique
DGRC	Direction Générale de la Réglementation et du Contrôle
ECOFIL	Economie des Filières, a division of IER
EIER	École Inter-États d'Ingénieurs de l'Équipement Rural – an international francophone training centre located in Burkina Faso
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	FAO statistical data base available on the internet
FAST	Faculté des Sciences et Techniques, University of Bamako
GIS	Geographic Information Systems
GIS/RS	Geographic information systems and remote sensing
GRM	Government of the Republic of Mali
IARC	International agricultural research center
ICRAF	International Agroforestry Center
ICRISAT	International crop research institute for the semi-arid tropics
IDE	International Development Enterprises - Non-profit organization that employs market principles to promote on-farm water management
IER	Institut d'Économie Rurale
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
INTSORMIL	The International Sorghum and Millet Collaborative Research Support Program
IPM	Integrated Pest Management CRSP
IPR/IFRA	Institut Polytechnique Rural de Formation et de Recherche Appliquée
ISFRA	Institut de formation et de recherche appliquée (University of Bamako)
IWMI	International Water Management Institute
LCV	Laboratoire Centrale Vétérinaire (Central Veterinary Laboratory)
MOE	Ministry of Environment (Mali)

NGO	Non-governmental organization
NIH	National Institutes of Health (US organization)
OHVN	*Office de la Haute Vallée du Niger* (Malian development office)
ON	*Office du Niger* (Malian development office for irrigated rice)
PASAOP	Agricultural Services and Producer Organizations Project (World Bank)
PASIDMA	*Projet d'Appui au Système Décentralisé du Marché Agricole*
PPR	*Peste des Petits Ruminants* (small ruminant disease)
PRODEPAM	*Programme de Développement de la Production Agricole au Mali*
PRSP	Poverty reduction strategy paper
rDNA	Recombinant DNA
S&T	Science and technology
SANREM	Sustainable Agriculture and Natural Resource Management
SOW	Scope of work
TYLCV	Tomato yellow leaf curl virus
UC Davis	University of California at Davis
USAID	United States Agency for International Development
AFR/SD	Africa Bureau Office of Sustainable Development (USAID)
USAID/Mali	USAID Mali country mission
USAID/W	USAID Washington
WARP	USAID West African Regional Office
WARDA	West African Rice Development Association

Executive Summary

Recognizing that science and technology research (S&T) is one of many inputs into the broader development process, USAID/Mali, via its Initiative to End Hunger in Africa, requested an assessment of the current S&T situation in Mali. USAID asked the assessment team to produce a comprehensive strategic options plan for a Malian S&T agenda that would identify priority short-term actions to stimulate uptake of S&T results likely to make significant contributions to the attainment of Mali's broad development goals, while simultaneously developing a coherent longer-term action plan to maintain and improve the human, physical, and financial capital needed to generate future streams of S&T results. The scope of work for the assessment team included six points:

- Review the current status of agricultural and natural resource programs of Mali's research institutions, with particular attention to IER, IPR/IFRA, LCV;
- Review and assess the programs of International Agriculture Research Centers (IARCs) and other international foundations supporting research in Mali;
- Annotate the range of USAID-supported S&T programs in Mali;
- Identify available production technology packages and needed support services to achieve rapid (medium-term) impact and identify gaps in S&T programs that hinder attainment of GRM development goals;
- Develop a strategic options plan to build needed S&T capabilities, including those for research and supporting institutional development;
- Make recommendations for potential USAID/Mali actions, including building partnerships with public and private organizations that would enhance the effective use of S&T for achieving USAID programmatic goals

The team included expertise in institutional development and capacity building, water management, natural resource management, animal science and animal biotechnology, plant biotechnology, and agricultural economics (with a focus on value-chain and production systems analyses). The team used an integrated S&T value-chain approach. This framework views the research-dissemination process as an integrated system starting with the establishment of adequate research capacity that generates S&T research products. These products must then be multiplied, disseminated, and integrated into the agricultural production and marketing chain where inputs are distributed, crops are produced, and post-harvest activities such as storage, processing, transport, and marketing take place. The chain ends with the purchase and use of a final product by consumers. Much too often the full potential of S&T research is not realized because the S&T product development is not demand driven or various constraints come into play at levels of the value-chain that are normally considered outside the realm of research.

Strategic options identified for improving S&T in Mali are divided into two groups: those relevant to expanding the use of existing S&T products and those relevant to maintaining or improving S&T capacity to generate new S&T products.

The team has identified four short-run strategic options that appear to hold the most promise for (a) rapidly expanding uptake of productivity enhancing S&T products, (b)

stimulating a virtuous cycle of subsequent S&T product adoption, and (c) reducing poverty. They include:

- Promotion of proven soil and water conservation and management practices
- Development of a commercial seed sector
- Promotion of improved breeds and disease control products for poultry and small ruminants
- Promotion of improved animal feeds

Two supporting activities are also recommended: (a) exploration of technical assistance options enabling Mali's principle agricultural training institution, IPR/IFRA, to close temporary gaps in teaching and research capacity and (b) increased information and training for both researchers and users of S&T products on the potential benefits of improvements in the regulatory environment.

Strategic options likely to produce results in the medium term include a program of regular, systematic monitoring and evaluation of S&T product dissemination and scaling up activities, the introduction of insect-resistant biotechnology products such as Bt cotton and Bt maize, and a reduction in the costs of artificial insemination and potato seed through input substitution.

Table 1-EXSUM provides a bit more detail on the actual situation concerning these S&T products, recommendations, and anticipated outcomes for natural resource and water management technologies. Table 2-EXSUM is a similar summary of key findings and recommendations for S&T products in the crop and livestock sectors.

Concerning institutional capacity issues, the team found that despite improvements in capacity realized during the past decade and the availability of numerous S&T products, there are a number of weaknesses in the research, teaching, and extension system that will need to be addressed during the next decade if Mali's S&T community is to continue to respond to the changing demands of its clientele. Among the key weaknesses identified were:

- Weak research and teaching capacity in disciplines of growing importance to Mali's evolving agricultural sector (water management, agribusiness, agricultural economics, GIS/RS);
- Need for increased attention to regional S&T strategies that would increase efficiency at both national and regional level (particularly important for future work in biotechnology);

Table 1-EXSUM. Summary of S&T Products Available and Recommendations for Improving Natural Resource and Water Management

Subsector	Current Situation	Recommendations	Potential Results
Natural resource management	Strong evidence on the availability of yield-increasing and resource conserving products and practices, but dissemination is not widespread. Growing evidence of complementarities between activities to promote NRM and other development objectives such as improved governance, poverty reduction, and health. Some evidence of local communities managing forests in a sustainable manner. Grafting techniques to speed production of local trees and shrubs of economic value improved and being disseminated.	Conduct research to understand factors facilitating and constraining past NRM adoption; Launch major effort to promote rapid and wide-spread adoption of proven practices (especially soil and water conservation and fertilizer use efficiency practices) based on lessons learned; Oblige researchers to participate in dissemination process, with particular attention to developing M&E systems providing user feedback that contributes to improved research and extension; Explore opportunities for financial support to NRM promotion from health and governance programs; Expand training in grafting techniques and develop M&E system to assess impacts.	Improved responsiveness of research and extension to user needs; Better understanding of how farmers adapt S&T products to their needs and exchange information with other farmers; Significant increases in yields for rainfed zones through improved soil moisture, less erosion, and increased use of fertilizers; Less clearing of new land; improved incomes, health, and governance.
Water management	Inadequate teaching/research and decision making capacity in water management (technical, economic, and social aspects); Low use of water pumps results in high labor demand/costs for *bas fond* and horticultural production; Inadequate technical support to help farmer groups solve water management problems.	Long-term training (MS/PhD) for key teaching/research staff and short-term training for extension agents, interested teaching/research staff and private sector actors in water sector; Promote a wider option of small/medium scale irrigation packages, via private sector to the extent possible; Develop GIS/RS and modeling capacity for improved water management decision making by building on existing IER/ICRISAT capacity; Promote more intensive management practices to better utilize existing irrigation infrastructure; Strengthen user groups (PRODEPAM already working in this area).	Improved teaching, research and decision making in a domain that is pivotal to Mali's agricultural development strategy; More efficient use of available water and infrastructure likely to reduce production costs and consumer food prices; Increased rural incomes, poverty reduction, and improved local governance of water resources (with potential spillovers to other sectors such as health)

Table 2-EXSUM. Summary of S&T Product Availability and Recommendations for Selected Crop and Animal Sectors

Subsector	Current Situation	Recommendations	Potential Results
Tomatoes	Virus-resistant varieties needed Varieties to extend production season needed	Focus on conventional breeding; Test existing varieties to identify options for extending season.	Avoids costs associated with regulatory package development; Reduces potential for market gluts.
Potatoes	Virus-free seed production techniques using tissue culture developed at IPR	Explore b/c of launching local seed production enterprises and do farm-level seed multiplication tests	Reduction in seed costs; Increased production and lower consumer prices.
Cotton	High pesticide use; low yields	IER explore potential for use of Bt cotton in Mali	Reduced pesticide use and higher yields
Cereals and Pulses	More productive and higher nutrient varieties available but not widely used; Promising sorghum results (photosensitive varieties), but more research needed; Aflatoxin detection kits and training programs available.	Increase activities to stimulate private seed sector development; Continue sorghum breeding; Promote aflatoxin education and detection kits and nutrient-rich cereals and pulses through joint efforts with health and governance programs	Increased productivity of cereals and pulses; improved human and animal nutrition; reduced aflatoxin induced disease and increased exports.
Maize	Low maize yields due to insects	Explore potential for Bt maize	Increased yields and maize availability for animal feed.
Animal nutrition	Poor quality fodder Absence of animal feed industry	Improve dissemination of information on improved fodders; Continue sorghum stover research; Promote private investment in feed industry (financial analyses, improved regulatory and enforcement framework, credit availability).	Improved animal nutrition and value in rural areas; Expansion of peri-urban production of milk, eggs, and animal fattening to increase incomes and lower consumer costs,
Livestock processing	Low value added in livestock sector	Explore potential for meat exports in regional markets; Address quality/certification issues; Develop adequate cold-chain	If potential exists, value added in Malian livestock sector would increase.
Animal health & productivity	High disease rates; Low vaccination coverage due to problems with cold-chains; High cost of artificial insemination to improve cattle	Expand diagnostic services; Explore biotech diagnosis kits; Develop thermo-tolerant and rDNA vaccines; Explore b/c of local semen production.	Increased productivity and income; lower consumer prices; less animal/human disease transmission; Reduced AI costs.

- No capacity in teaching and research establishments to deal with "downstream" constraints to adoption such as product certification, regulatory and enforcement, finance, and general agribusiness issues[1]
- Weak research links to extension, particularly with respect to disseminating information about new products and participating in monitoring/evaluation efforts of S&T product uptake;
- Less than optimal collaboration among Malian research and teaching institutions, leading to less than optimal use of limited infrastructure and human resources.

In the short-run, there is a need for IPR to find ways to fill in staffing gaps using part-time faculty and technical assistance so it can train students in key emerging areas. In the medium to long-term, there is a clear need to build teaching and research capacity in the areas of water management, GIS/RS, agribusiness, and agricultural economics through long-term training. There is also a potential need for long-term training in disciplines that would contribute to biotechnology research programs, but specific strategies for long-term training need to be derived from regional and national strategies for development of specific types of biotechnology products—these strategies are still under discussion.

Table 3-EXSUM summarizes key recommendations for resolving these capacity issues at research and teaching institutions, including MS and PhD level training in selected disciplines, inter-institutional sharing of laboratory facilities and other expensive infrastructure, and modifications in the newly instituted competitive research grant system to redress long-standing weaknesses in research funding and capacity at IPR.

A major constraint to rapid uptake of S&T products is poor monitoring and evaluation of the dissemination process. The failure of researchers to be actively engaged in the dissemination of information about their results and in regular monitoring and evaluation of the entire dissemination and scaling up process exacerbates the situation. Research and extension need to work together to develop monitoring and evaluation systems that will result in more rapid and widespread adoption of S&T products. For this to happen, research institutions will need to broaden their concept of where S&T research ends and create an incentive structure that rewards not only technology development but also technology uptake. In addition to developing better research-extension links, Mali will need to develop a more responsive and efficient extension system that is capable of getting beyond that first group of adopters, usually represented by the wealthier, more progressive farmers, who are frequently also the only adopters. Poor skills and lack of incentives for extension agents may be part of the problem, but there are major structural and conceptual problems that also need to be addressed; this is a problem Africa-wide.

[1] This has not traditionally been considered an area of interest for the agriculture research and teaching community as the DGRC has primary responsibility for regulatory issues, but it is recommended that some expertise be developed by IPR and IER given the extent of the regulatory issues that seem to be constraining dissemination of S&T products and limiting effective demand for laboratory analyses. This would improve the scientific community's ability to communicate their needs to DGRC.

At present, research on the downstream opportunities and constraints to S&T product dissemination is left largely to donor funded projects or short-term consultants, while IER focuses most of its efforts on developing S&T products to improve farm productivity. Malian capacity for dealing with these downstream issues (e.g., marketing, business plans, regulatory, processing, finance and trade) needs to be developed both in the public and the private sector. This may require some changes in the mix of disciplinary skills and the incentive structure of Mali's research and teaching institutions if they are to remain relevant and responsive to an evolving clientele.

The report ends by identifying a number of areas where USAID/Mali is well placed to offer support to Malian S&T programs. Among the most important options are increasing the opportunities for collaboration between Malian research and training institutions and USAID's ongoing projects, taking advantage of inter-sectoral synergies among USAID-funded health, governance, and agricultural projects, providing financial support for capacity building through long-term training of Malian scientists and short- to medium-term technical assistance to fill in current human resources gaps, and working with the GRM and other donors to promote inter-institutional and regional collaboration in S&T activities capable of increasing the quality and reducing the costs of agricultural research and training programs throughout West Africa. Section 7.2 provides a number of examples of how USAID might provide support in these areas.

Table 3-EXSUM. Summary of Institutional Research and Training Capacity Issues and Recommendations

Type of Capacity	Institution	Current Situation	Recommendations	Anticipated Outcome
Human	IPR IER LCV DNAMR	Weakness in water management, agricultural economics and agri-business at IER, IPR, and DNAMR; IPR fills some gaps by contracting with IER/LCV staff to teach and provide thesis support; Career advancement at IPR often slower than elsewhere due to inadequate funding for research; Concern about aging staff and lack of replacements pervasive; Concern about building research capacity in biotech-related disciplines exists at IPR, IER, and LCV.	Short- and long-term (sandwich) training to fill gaps for technical and research staff; Increased funding to IPR for contracting to fill staffing gaps; Donor support to hire young researchers on contract until permanent positions available; Identify biotech training needs as integral part of national and regional biotech strategy based on clearly defined S&T programs.	Improved quality of teaching, research, and extension for weak areas; Better use of existing capacity across institutions; Bridging mechanism to encourage young researchers to stay in national system; Focused approach to biotech training to increase benefits and reduce costs.
Physical	IPR IER LCV FAST	No existing laboratories or facilities for modern plant biotech research; IER sees need for a laboratory and greenhouse to work on Bt-cotton and maize; FAST has facilities for medical biotech research, but no mandate for agricultural research; IARCs now use FAST facilities for some biotech research; IPR has lab for tissue culture (traditional biotech), but some equipment needs replacement. IPR labs in other areas (e.g., soils and water analysis and animal nutrition) are not adequate for teaching or research; LCV has excellent facilities, some underutilized due to lack of effective demand for services.	Explore options for inter-institutional collaboration in use of existing biotech facilities to meet short-run while building national/regional strategy for long-run plant biotech programs; Identify infrastructure needs that cannot be meet through institutional collaboration and develop funding strategies; Identify certification and regulatory and frameworks that would increase effective demand for LCV food safety and animal health tests.	More cost-effective use of existing facilities; Increased institutional collaboration and possibly lower costs for future infrastructure investments; Increased revenue from existing facilities.
Financial	IPR IER LCV	LCV covers >60% of costs with GRM funds and income from sales/services; IER's heavy dependence on donor funding for research programs leads to program discontinuity; Funding shortages for lab supplies affect all; IPR (often not recognized as a research institution) has limited research funding and difficulty attracting part-time faculty because of pay scales and budgetary constraints.	Promote adoption/enforcement of certification/regulatory frameworks to increase service and sales income; Officially recognize and fund research mission of IPR through PASAOP and other sources; Revise IPR regulations and budgets for hiring of part-time faculty to better respond to existing needs/realities; Promote joint IPR/IER research projects.	Increased financial self-sufficiency for IER/LCV; More balanced financial support to research activities at IPR that will lead to better training and improved research capacity at IPR.

1. Background and Objectives

Mali is seeking to transform its economy from a low-income agricultural economy to a higher-income, diversified economy. This transformation requires increased productivity and specialization. At the farm-level it involves increased use of science-based inputs that will be purchased by farmers with income generated from sales of farm products. Numerous studies have shown the important contribution that agricultural research and extension can make to this transformation process (Oehmke and Crawford 1996; Alston et al. 2000). However, success in the transformation process depends on (1) how well the research results and extension services meet evolving stakeholder needs and (2) the extent to which the socio-economic environment (financial systems, regulatory and legal systems, human resources, etc.) is favorable to rapid generation and dissemination of scientific and technological innovations not only at the farm-level but throughout the entire production-processing-storage-marketing chain.

Recognizing that science and technology research (S&T) is one of many inputs into the broader development process, USAID/Mali, via its Initiative to End Hunger in Africa, requested an assessment of the current S&T situation in Mali. USAID asked the assessment team to produce a comprehensive strategic options plan for a Malian S&T agenda that would identify priority short-term actions to stimulate uptake of S&T results likely to make significant contributions to the attainment of Mali's broad development goals,[2] while simultaneously developing a coherent longer-term action plan to maintain and improve the human, physical, and financial capital needed to generate future streams of S&T results.

2. Assessment Tasks, Team, and Methods

The scope of work for the assessment team included six points:

- Review the current status of agricultural and natural resource programs of Mali's research institutions, with particular attention to IER, IPR/IFRA, LCV;
- Review and assess the programs of International Agriculture Research Centers (IARCs) and other international foundations supporting research in Mali;
- Annotate the range of USAID-supported S&T programs in Mali;
- Identify available production technology packages and needed support services to achieve rapid (medium-term) impact and identify gaps in S&T programs that hinder attainment of GRM development goals;
- Develop a strategic options plan to build needed S&T capabilities, including those for research and supporting institutional development;
- Make recommendations for potential USAID/Mali actions, including building partnerships with public and private organizations that would enhance the effective use of S&T for achieving USAID programmatic goals.

[2] Goals of particular importance are those outlined in existing government documents such as the Poverty Reduction Strategy Program, the Millennium Development Goals, the National Food Security Strategy Paper, and the New Economic Partnership (NEPAD).

The assessment team included expertise in institutional development and capacity building, water management, natural resource management, animal science and animal biotechnology, plant biotechnology, and agricultural economics (with a focus on value-chain and production systems analyses). Representatives of IER (*Institut d'Economie Rurale*), LCV (*Laboratoire Central Vetérinaire*), DNAMR *(Direction Nationale de l'Appui au Monde Rurale*), CNRA (*Centre National de Recherche Agricole*), ICRISAT (International Crop Research Institute for the Semi-Arid Tropics), ICRAF (International Center for Research on Agro-Forestry), and USAID-funded projects (particularly PRODEPAM, Mali-Trade, PASIDMA II, and Mali-Finance) made significant contributions to the team effort by providing access to documentation, identifying S&T opportunities and constraints, and actively participating in the development of the strategic options plan. The team collected additional information through numerous field visits and discussions of capacity building issues with representatives of Malian research and extension services.[3]

The team used an integrated S&T value-chain approach (Figure 1). This framework views the research-dissemination process as an integrated system starting with the establishment of adequate research capacity (outer circle) that generates S&T research products (second circle).[4] These products must then be multiplied, disseminated, and integrated into the agricultural production/marketing chain where inputs are distributed, crops are produced, and post-harvest activities such as storage, processing, transport, and marketing take place (central circle). The chain ends with the purchase and use of a final product by consumers. Much too often the full potential of S&T research is not realized because the S&T product development is not demand driven or various constraints come into play at levels of the value-chain that are normally considered outside the realm of research. Box 1 provides a fuller description of the value-chain approach and Figure 2 provides a matrix that can be used to examine the potential constraints to development and scaling up a particular S&T product. Given the time and data constraints, the team did not attempt to do a full value-chain analysis for each S&T product identified, but the conceptual approach was used to identify key constraints and recommendations. Appendix 2 provides an example of a relatively complete value-chain application, using the Malian tomato subsector to illustrate the method.

3. Organization of the Report

This report represents a synthesis of individual reports and notes prepared by each team member. Section 4 responds to the first three points in the terms of reference (TOR), providing an overview of current S&T research institutions and programs in Mali. In Section 5 we identify promising S&T products and needed support services to encourage

[3] Appendix 1 provides a full list of all contacts and field visits made by the team.

[4] Typically, a value-chain approach starts at the farm level (i.e., inside the top circle). Given the concern in Mali that research capacity be maintained and improved, we have integrated these capacity issues as a preliminary stage of analysis in the value-chain framework. We have also highlighted some of the early stages of the scaling up process (product multiplication and dissemination) in the value-chain as many of the blockages in Mali appear to be at these levels.

Figure 1. The S&T Value-Chain Framework

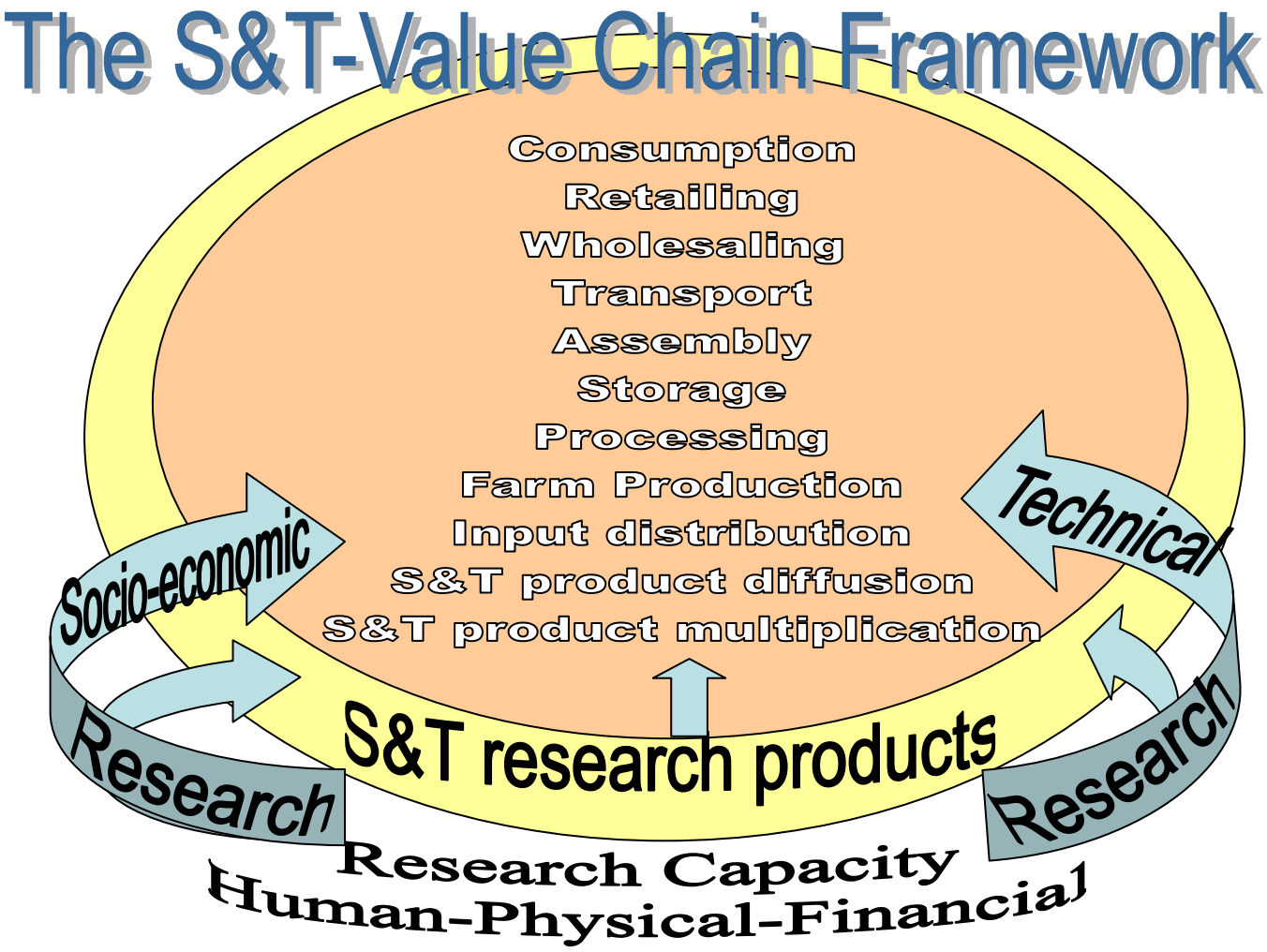

Figure 2. Matrix for Analysis of Constraints to S&T Product Development and Application

S&T Product:_____Subsector:_____Relevant Farming Systems:_____

Level of V-C	Current situation	Actors		Potential Constraints					Addressing Constraints	
		Public Sector	Private Sector	Technology	Environment	Finance	Regulatory	Other	Actions	Research needed
Research capacity										
Research products										
S&T multiplication										
S&T diffusion										
Input distribution										
Farm production										
Processing Primary Secondary										
Storage										
Assembly										
Transport										
Wholesaling										
Retailing										
Consumption Primary products By-products										

Box 1. Using a Value Chain Framework for Effective Technology Development and Dissemination

A conceptual framework for use by science and technology decision makers that ensures appropriate consideration of market demand during technology development planning uses a market-led, agribusiness commodity systems approach. An agribusiness "system" can be defined as all the steps in the chain of events that are required to produce, transform, market, and distribute an agricultural commodity. The agribusiness system starts with the genetic material used for seed stock and continues all the way through the chain of events until the final product is delivered to the customer. The commodity produced, or the product derived from that commodity, fills a market need. "Market-led" means there is a home for the product being offered in whatever form the market requires, where the volume of the product can be sold over a defined seasonal period, and the price received is sufficient to be profitable after deducting all real costs.

The agribusiness systems approach can be used to develop specific marketable commodities or final agricultural products for which the producer has a competitive advantage. Well-developed agribusiness systems are typically composed of different players who are responsible for different links in the chain of events required to produce, transform and market a product. This chain of events is often referred to as the "value chain" for a product or commodity.

Traditionally, agri-food commodities are undifferentiated and move through the system using arms length transactions. For example, a farmer may sell a commodity at farm gate. It is consolidated by a consolidator and sold to a third party at a packing house or processing plant. Producing a consumer product in modern agriculture may involve producing a long sequence of intermediate products. Each one is used as an ingredient or raw material to make the next product in the sequence. This is the meaning of the term *value added*, because value is added at each step.

Instead of all the products being produced by one farm family, many different agribusinesses are normally involved. These include companies directly involved in the process, such as seed companies, fertilizer suppliers, and commercial traders. But supporting each of these groups in the system are agricultural researchers, financial institutions, equipment suppliers, farmers' associations, government agencies, and agriculture universities.

By focusing the use of science and technology on solving problems and removing constraints within the different steps required of the value chain to create a particular product that can be sold profitably in a given market, S&T products become tools that help to fill a market. In this sense, specific science and technology products are used to serve the market for commercial purposes. They become responsive to market demand. If science and technology are designed to serve commercial purposes, then public-private partnerships quickly evolve for the purpose of applying in the private sector the knowledge that is gained in the public sector.

rapid uptake (4th item on the TOR). This discussion is divided into two sub-sections: one presents the key findings concerning crops and the other deals with livestock. These sections include the team's recommendations for product- or subsector-based activities to be pursued in Mali by researchers, extension services, and public and private sector actors involved in different levels of the value-chain. Section 6 analyzes cross-cutting issues that affect technology development and uptake across multiple products and subsectors (5th item on the TOR). Key issues discussed in this section are research and extension capacity; the role of natural resource and water management in stimulating agricultural productivity growth and reducing production risk; and downstream institutional constraints such as regulatory issues that limit uptake and dissemination of S&T products. The nature of the cross-cutting problems and strategic options for their resolution are discussed. Section 7 summarizes the key findings, reviews strategic options proposed for consideration by Mali's S&T community, and makes recommendations for USAID/Mali actions that have potential to enhance the effective use of S&T products for achieving both short- and long-term programmatic goals.

4. Current Status of Agricultural Research Programs in Mali

4.1. Malian Institutions

In the early 1990s, Mali's agricultural research system was reorganized as part of the PNRA (*Programme National de Recherche Agricole*). Support for the reorganization came primarily from the World Bank, FAO, ISNAR and the Dutch. Key changes included placing plant and animal research activities into a single institution (INRZFH, *Institut National de Recherche Zootechnique Forestière et Hydrobiologique*, became part of IER), decentralizing research activities through the creation of regional centers, and improving management and planning. By 2001 IER had become an *Etablissement Public à caractère Scientifique et Technologique* with budgetary autonomy and a management system based on performance contracts signed with the GRM. A new type of CNRA (*Comité National de la Recherche Agricole*) was created as well as regional CRU (*Commission Regionale des Utilisateurs des Resultants de la Recherche*) and a CNU (*Commission Nationale des Utilisateurs*) to improve coordination between researchers and their clients. At present, efforts are underway to create a true national research system (SNRA or *Système Nationale de Recherche Agricole*) that will improve research coordination across multiple research and teaching establishments (e.g., IER, LCV, IPR/IFRA) and increase the responsiveness to stakeholders. There are numerous documents describing the various institutions participating in the SNRA system (IER 2003 and Stads and Kouriba, 2004, for example), so we note only the most salient characteristics of the key organizations here.

CNRA (*Centre National de Recherche Agricole*) is a coordinating, advisory body supported by the World Bank-funded PASAOP (*Programme d'Appui aux Services Agricoles et Organisations Paysannes).* The CNRA assists the various ministries involved in the agricultural sector with the design, implementation, and evaluation of national agricultural research policy. It consists of representatives of technical services, producer organizations, processors, the scientific community, and development partners. It has an executive secretariat and three working committees dealing with scientific matters, finance issues, and research-stakeholder interaction. The CNRA manages the

bidding process for allocating agricultural research funds as part of the World Bank funded PASAOP that began functioning in 2002. The PASAOP is designed to improve the relevance and effectiveness of the SNRA by providing support to:

- Strengthen the CNRA and make it operational
- Develop strategic, applied research programs to support national development objectives
- Develop SNRA capacity to respond to user demands
- Improve the scientific and managerial capacity of research institutions
- Put in place an efficient system of monitoring and evaluation of agricultural research

The long-term vision is for Mali's agricultural research system to be client-based. The decentralization and regionalization of IER in the mid-1990s was an important step toward accomplishing this goal, as was the building of partnerships with user groups such as the CRU. The CRU consists of representatives of producers' and processors' associations. With the PASAOP, CRU members are involved in discussions of research awards and the evaluation of performance; they are also expected to assist in the dissemination of research results. The assessment team met with representatives of the Bamako/Koulikoro CRU to discuss their role in the research-extension process and their concerns, which focused on training needs, lack of financial resources to set up an office (phone, data bank, files), and inadequate funding for travel to consult with the individuals they represent. They presented the team with an October 2004 unsolicited proposal developed by CRU members in an effort to find funding to cover training and other institutional support deemed to be essential in the short-term—until CRUs have proven themselves and can generate some of their own financial support (see Appendix 3). Resolution of these problems will be important if the PASAOP system is to achieve its goal of being client focused.

IER (*Institut d'Economie Rurale*) is the principal agricultural research institution with 814 agents (250 are researchers) and six regional centers (Kayes, Sotuba, Sikasso, Niono, Mopti and Gao), which operate through a network of nine stations and thirteen sub-stations. Its mission is to:

- Design, manage, and carry out agricultural research programs;
- Provide technical assistance to agricultural development projects;
- Provide staff training;
- Disseminate the results of agricultural research;
- Create, conserve, and protect national scientific assets.

There are three laboratories operated by IER specializing in (a) food technology; (b) soil, water, and plants; and (c) animal nutrition. There is also a genetic resource unit. IER works in five major research areas: (a) rainfed crops; (b) irrigated crops; (c) animal production; (d) forestry, wildlife and fisheries; (e) production systems, natural resource management and subsector economics. In 2001, 18% of IER researcher time was devoted to crop genetic improvement, 14% to crop pest and disease control, and 7% to livestock genetic improvement. In terms of commodities, rice, sorghum, and cotton received the largest shares of researcher time (30%, 21% and 17%, respectively with all

institutions combined). Researcher time allocated to livestock focused primarily on beef (51%), followed by sheep and goats (26%), and poultry (16%).

LCV (*Laboratoire Central Vetérinaire*) provides public services such as disease diagnoses, health and hygiene control, epidemiological studies, and research on animal health. It also functions as a commercial enterprise producing and marketing vaccines and other animal health supplies. LCV has 137 agents of which 111 contribute to research programs and 26 have the status of researcher. Research activities focus on infectious diseases, parasitic diseases, and pesticides; planning for work on metabolique diseases is underway.

IPR/IFRA (*Institut Polytechnique Rural/Institut de Formation et Recherche Appliquée*) is one of the main institutions of higher learning in Mali's university system. The IPR/IFRA mission includes (a) the provision of formal and continuing education programs for students, technicians, and professional staff working in the rural sector and (b) the conduct of research in the areas of animal sciences, agriculture, forestry, and rural economics. The institution plays a critical role in linking teaching and research activities in the SNRA.

ISFRA (*Institut de formation et de recherché appliqué),* based in Bamako, is another institution in the national university system with some collaborative links to agriculture. ISFRA is the only Malian institution able to grant a Ph.D. in agriculture. The institute is understaffed and relies on a pool of Malian professionals drawn from the private sector and research institutes. Although faculty at ISFRA often teach at IPR, ISFRA is not actively involved in agricultural research activities.

FAST (Faculté des Sciences et Techniques) is also based in Bamako and part of the University of Bamako system. FAST has no agricultural teaching or research mandate; but it currently participates in a NIH funded project that has provided it with excellent biotechnology laboratory facilities. These facilities are used primarily for research on human health and medicine, but ICRISAT and WARDA have made arrangements to use some of the laboratories and equipment for agricultural research; IER, LCV, and IPR are exploring various options for collaboration (Section 6.1.2 and Table 11).

A major overriding constraint facing all of the agricultural research and teaching institutions is their heavy reliance on donor funding for the conduct of research activities and the difficulties this imposes in terms of program continuity. Total public spending as a share of agricultural output is a common indicator for cross-country comparisons of government support to agricultural research; recent studies recommend that African countries allocate 2% of their agricultural GDP to research. Mali's public spending on agricultural research in 2001 was 1.03% of agricultural GDP, significantly higher than Africa in general (0.85%), but a reduction in share from 1981 (1.62%) and 1995 (1.07%). Donor support for research comes primarily from the World Bank, France, the United States, the Netherlands, Syngenta Foundation, and the Swiss Cooperation program. At present, PASAOP (a project supported primarily by the World Bank) is the principle source of funding for agricultural research.

An overview of agricultural research capacity in Mali covering the period 1991 to 2001 reported that:[5]

- Mali outperformed its neighbors in many key indicator areas.
- R&D spending per researcher increased approximately 20% from 1991 to 2001 due to reductions in personnel and relatively stable expenditures, which are higher per researcher in Mali than in most West African countries.
- The share of researchers with MSc training increased from 13% in 1990 to 48% in 2001; the share with PhDs increased from 17% to 26%; World Bank funding through the *Projet National de Recherche Agricole* (PNRA) covered many of these training costs.
- Eleven percent of Mali's researchers are female (up from 5% in 1990).

Section 5 discusses recent research programs and products of these institutions and Section 6.1 discusses current and future capacity issues.

4.2. International Institutions[6]

IER collaborates with a broad array of regional and international institutions conducting research on agricultural issues such as INSAH (the Sahel Institute), Winrock International, IITA (International Institute of Tropical Agriculture), ICRAF (World Agroforestry Center), the WARDA (West Africa Rice Development Association), the ILRI (International Livestock Research Institute), ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), KIT (the Royal Tropical Institute of the Netherlands), CIRAD (Center of International Agricultural Research Cooperation for Development), and IRD (Institute of Research for Development), the latter two from France. In addition, IER is a member of various regional networks such as the West and Central African Sorghum Research Network (ROCARS) and the West and Central African Millet Research Network (ROCAFREMI). Twelve of IER's 17 research programs are now executed in collaboration with regional and international partners, which has seriously enhanced research quality. The nature of these exchanges ranges from on-demand research contracts to exchanges of research results. IER also has numerous collaborative research programs with U.S. universities (e.g., Texas A&M, Michigan State University, Purdue, Nebraska, Virginia Polytech).

The scientific partners of LCV include the IAEA (International Atomic Energy Agency), ILRI, CIRDES (International Center for Research and Development of Livestock in the Subhumid Zone) and the Virginia Polytechnic Institute. IPR/IFRA works closely with national partners such as IER, CNRST (*Centre National de Recherches Scientifiques et Technologiques*), and CMDT (*Compagnie Malienne pour le développement des textiles*), as well as with international agencies such as IAEA, ICRAF, and ICRISAT.

[5] Drawn from Stads and Kouriba 2004.
[6] This section is drawn from Stads and Kouriba 2004 pages 2 and 3.

The assessment team met with representatives of ICRISAT, ICRAF, WARDA, INSAH, and CIRAD to obtain information on their programs and recommendations for S&T products available for broad dissemination in Mali (see sections 5 and 6).

4.3. USAID Contributions

USAID contributions to agricultural research and extension in Mali are so wide-ranging that the team was not able to do a full accounting. Many Malian researchers were trained in the US through various USAID training programs. Others have benefited from short-term training programs. A number of current research programs are funded through various Collaborative Research Support Programs (USAID funded CRSPs such as SANREM, INTSORMIL, and Soils), and many of the joint research programs with IARCs benefit from USAID support directly to the IARCs. Current USAID programs such as Mali-Trade, Mali-Finance, and PRODEPAM are making important contributions to Malian understanding of economic and institutional constraints to the dissemination of S&T products through various types of economic analyses and subsector studies.

Given the diverse activities that USAID is supporting in agricultural research and subsector analyses, it will be important for the Agency to coordinate programs with other key donors to ensure strategic and balanced support across institutions, subsectors, and research areas.

5. Available S&T Products and Needed Support Services

The discussion in this section covers S&T products that were recommended to the team as having good potential for making a significant contribution to increased agricultural productivity and farm incomes in the short- to medium-term. It is divided into a crop and an animal section.

5.1. S&T Products for Improving Crop Subsector Performance

5.1.1. Tomatoes[7]

Tomatoes are one of Mali's largest horticultural crops, with an estimated 50,000 tons of production annually since 2002 and an annual growth rate of 10.2% between 1994 and 2004 (one of the highest growth rates in West Africa). Mali's tomato production has been expanding along with that of Côte d'Ivoire (3% annual growth with an average aggregate production of 149,000 tons from 1994-2004) while the production of neighboring Senegal and Burkina Faso has been declining; overall, however, West African tomato production represents only 1% of world production.[8] At present, Malian tomatoes are

[7] More information on tomatoes is available in Appendix 1, which is an application of value-chain analysis based on Mali's tomato sector; Gilbertson et al. 2004 was used as a resource document for the discussion of biotechnology and virus resistance in tomatoes.

[8] Unless otherwise noted all production figures in this report come from data available on FAOSTAT the week of 7 March 2005.

produced primarily during the dry season for domestic consumption.[9] Centers of production are peri-urban areas and the irrigated perimeters in the *Office du Niger* and Baguineda. Women are heavily involved in tomato production and marketing. The two most important technological constraints to increased tomato productivity are producers' inability to avoid market gluts through staggered production and the prevalence of tomato yellow leaf curl virus (TYLCV).

Production gluts result in wide intra-seasonal price fluctuations. To reduce the problem the annual tomato harvest should be expanded from approximately three months (April to June) to a minimum period of six months. This will require research to identify (from existing varieties) and test plants that have potential for extending the harvest. IER has conducted some research to identify such varieties, but at present most attention is being given to virus resistance.

Recommendation:

- Continue programs to test new tomato varieties while evaluating the pros/cons of different models for conducting such tests:
    - Entirely private sector variety testing by horticultural seed importers
    - Joint private sector/IER testing, with roles of each actor clearly defined
    - Use of irrigated zones such as the *Office du Niger* and Baguineda

Two USAID-funded activities are currently looking at tomato virus problems. The first is an effort by the IPM CRSP (UC Davis) to evaluate conventional varieties with TYLCV resistance as part of a program that also includes host-free period and other practices to reduce the pressure of the virus and its vector. The further development of this program has been explored in the context of the establishment of a breeding program to introduce conventional TYLCV resistance into locally adapted varieties.[10] The second is a program to develop a transgenic tomato in Mali that has resistance to TYLCV; it is supported by USAID/Mali and USAID/WARP through the Agricultural Biotechnology Support Project II (ABSPII) and implemented by UC Davis, Cornell, AVRDC, and IER. As viruses continue to evolve to overcome resistance, there will be a continuing need to develop novel approaches to combat them. At present, however, the assessment team questioned whether the size of tomato producing areas where TYLCV is present in West Africa are sufficient to justify the high cost of developing a novel transgenic product for the region, in relation to other technology opportunities for crops that are grown much more widely in the region, such as sorghum or maize.[11] Further, the particular approach that is being

[9] Mali has a history of processing tomatoes into tomato paste, but poor profitability brought this operation to a halt in 1998. Appendix 2 provides a detailed discussion of the tomato subsector and the issues that must be addressed to re-establish a processing industry.

[10] Information drawn from "Concept Note: Protecting tomato production in Mali against TYLCV," Willy de Greef, PRODEPAM)

[11] IER's view is that TYLCV is a major problem throughout West Africa and substantial resources have already been invested in conventional variety research with poor results. If the problem of tomato processing could be resolved, the economic potential of tomato production in West Africa would significantly increase, perhaps justifying the research investment (personal communication, Bino Teme, IER).

pursued through the ABSPII project, host gene silencing, is upstream and unproven in tomatoes. If successful, it might offer broader spectrum virus resistance for West Africa than more downstream (i.e., further developed) transgenic approaches. Thus, in selecting TYLCV research approaches, the spectrum of resistance against the diversity of strains that are prevalent in the region should be one of the factors considered. In general, however, approaches using lower cost conventionally bred varieties of tomatoes with TYLCV tolerance or resistance should be more fully exploited before turning to transgenic approaches.

Table 1. Transgenic TYLCV Tomato Research: Benefits and Constraints

Potential Benefits	Identified Constraints
May increase efficacy over alternative approaches	Upstream and risky research with long time horizon
	High costs of research and product development relative to conventional breeding
	Full regulatory package development needed given absence of prior work on this product elsewhere.

Recommendations:

- Expand current screening program of conventional TYLCV resistant varieties
- Reevaluate the ABSPII TYLCV resistant tomato project in relation to other approaches and the potential target market

5.1.2. Potatoes[12]

Potato is another horticultural subsector that has expanded rapidly in Mali during the past decade. FAOSTAT has no current data on production, but it was in the 30-35,000 ton range during the late 1990s and covered most of the domestic demand and some demand in neighboring countries such as Senegal and Côte d'Ivoire (Yiriwa 2001). The principal production zones are the *cercles* of Sikasso and Kati. In the late 1990s about 1680 ha were cultivated on 44 cites (*bas fonds*) by producers in 105 villages located within a radius of 50 km of Sikasso. Land is not a constraint to expansion of potato production during the dry season given the large number of *bas fonds* in southern Mali and the irrigated perimeters available in the *Office du Niger* and Baguineda. Malian yields outperformed those of regional neighbors in the late 1990s (23 tonnes/ha on average versus only 6 tons in Nigeria, 15-20 in Senegal and Guinea). Two major potato sector constraints at the farm level are the high costs of imported seed and storage prior to marketing the harvested crop.

The IPR biotechnology laboratory has successfully used tissue- culture technology to produce potato microtubers in-vitro; these microtubers can provide the foundation seed for the development of an integrated supply chain of disease-free seed potatoes in Mali. IPR is interested in pursing this option, which is under study by USAID's PRODEPAM

[12] This section draws on "Concept Note: Development of the local seed market, a viable seed potato sector in Mali," by Willy de Greef, PRODEPAM, and field notes from team member Tom Easterling.

Table 2. Domestic Production of Potato Seed: Benefits and Constraints

Potential Benefits	Identified Constraints
Would capitalize on IPR success in mircrotuber breeding	Need to find disease-free seed production zone with experienced potato farmers[13]
Would substitute imports with local production for an industry roughly valued at $3 million annually	High levels of financing needed for 4 yrs of seed multiplication and 8 months of cold storage each yr
Could reduce input costs and increase income for potato produces	High management and investment costs imply need to analyze financial and economic benefits/costs
	Need to create seed certification and enforcement program to ensure competitiveness with imports
	Lower seed prices may spur over production; need good analysis of potential demand in region

and Mali-Trade projects. It is believed that local seed production could significantly reduce seed costs, which now represent roughly 50% of production costs. However, accurate numbers on the full costs of local production are not available.[14]

To further increase the productivity of the potato sector, improved storage permitting farmers to stagger potato marketing with minimum losses will be important. Knowledge of improvements in storage and harvesting procedures that would reduce losses exists (Yiriwa 2001); greater efforts are needed to diffuse and apply this knowledge. For example, use of anti-sprout spray and careful selection of potatoes allows for a 5-month storage period with an estimated price differential of at least 60%. Variety selection can also help as some varieties (e.g., Claustar) store better than others. Another productivity issue concerns labor-intensive watering methods used, particularly in the Sikasso Region. The introduction of low-cost pumps or moving to zones in the *Office du Niger* with gravity flow irrigation systems could reduce labor costs.

General recommendations for the potato sector:

- Establish a research program to prove that potato seed production and multiplication can be successfully done as a commercial practice in Mali:
    - Establish a commercial trial on a pilot scale
    - Conduct a benefit/cost analysis of domestic versus imported potato seed taking into account the potential seed demand in the region and the costs of seed cold storage and management
- Develop new international potato markets in promising locations such as Senegal and Mauritania, and work to expand local markets
- Improve storage facilities and storage techniques at the village level to reduce storage losses and to extend shelf life for greater revenue
- Conduct benefit/costs analyses of various post-harvest potato storage techniques, including both on-farm and off-farm methods

[13] It is not advisable to produce potato seed in current production zones where prevalence of potato viruses and other potato disease is high.

[14] To date, the production of microtubers has been financed through public research and teaching institutions, making it difficult to separate these production costs from other research activities.

- Further explore availability/development of varieties to extend shelf life, and incorporate the use of anti-sprouting chemicals into storage practices
- Increase the available supply of potatoes by extending the producing area into the *Office du Niger* irrigated areas
- For labor efficiency, encourage the use of mechanical water pumps in *bas-fonds*[15]

5.1.3. Cotton

The cotton sector affects the livelihood of one-third of Mali's population, while also contributing nearly half the export revenue, about 7% of GDP, and 6 percent of the government's total tax revenue. The CMDT--a vertically coordinated joint venture of the government (60%) and the French company Dagris (40%) currently manages the sector. Donor-backed reforms to increase competition through privatization of many of the CMDT support functions are under way, behind schedule, and politically sensitive. Given cotton's important role in the overall economy, attainment of PRSP goals is heavily dependent on the sector. The potential for reducing poverty through S&T applied to the sector is contingent on resolving a wide range of technical and management problems as well as addressing equity and gender issues.[16] Available evidence suggests relatively unequal distribution of productive assets (land and equipment) across households in the cotton zones; this leads to unequal distribution of agricultural income, which could be either exacerbated or improved by the introduction of improved S&T products.[17] Also, increased cotton yields will do little to improve women's personal income (women work in the cotton fields, but they seldom have access to income from cotton production because it is managed by the household head).

Growth in cotton productivity in the recent past has been disappointing. From 1980 to 2002 aggregate production grew at an annual rate of 7%; but, growth was based on area expansion (8% annually) rather than yield growth (-0.91% annually). Future growth will come increasingly from intensification as land becomes more limiting. Although cotton farmers represent the major source of Malian demand for purchased agricultural inputs such as fertilizers and pesticides, production remains extensive rather than intensive. Declining cotton yields suggest that there is room for improvements in the application of S&T products to soil fertility and pest problems. There is good evidence that rapid uptake of improved soil and water management practices could substantially increase soil moisture, soil organic matter, and yields while also contributing to environmental goals (carbon sequestration, raising water tables, reducing water and wind erosion, etc.). Because the potential benefits of these natural resource management practices have relevance well beyond the cotton sector, they are discussed below (section 6.3.1).

Transgenic insect-resistant cotton. This is a modern biotechnology product that offers substantial benefits and that may be adapted to Malian agricultural systems at a relatively low cost. Insect-resistant cotton was among the first transgenic crops commercialized and has been adopted in many cotton producing countries, including South Africa, India,

[15] This is discussed more fully in section 6.3.2.
[16] See Lamb et al. 2004 for a broad assessment (beyond biotechnology) of cotton sector development interventions that USAID might support in West Africa.
[17] See Tefft et al. (2004) for a discussion of income and asset distribution in the cotton zone.

China, Mexico, and the United States. Preliminary field trials of insect-resistant cotton are planned or in progress in several African countries, including Burkina Faso, Kenya, Tanzania, and Zimbabwe. Although insect-resistant cotton is not effective against all insects, adoption has lead to substantial yield increases and reductions in pesticide use under diverse production conditions. Ex-ante estimates of the benefits of insect-resistant cotton in West Africa suggest a $7 to $67 million benefit in Mali, depending on adoption rate and yield advantage (Cabanilla et al. 2004). Initial field trials of Bt cotton in Burkina Faso showed an average yield advantage of 20%, and four fewer insecticide applications, compared to conventional varieties (Monsanto 2004).

Table 3. Insect-resistant Cotton: Benefits and Constraints

Potential Benefits	Identified Constraints
Technology already developed	Lack of local experience with the technology
Mali has existing cotton seed distribution system	Need breeding effort to introduce insect resistance into local varieties
Reduced pesticide use has health and environmental benefits	Need to establish regulatory systems appropriate to the Malian situation
Increased cotton yields	Need to negotiate licenses with product developers
Bio-safety studies already thoroughly developed	National/regional opposition to biotechnology

General recommendations for the GOM and Malian researchers:

- Establish a biosafety framework for field trials and commercialization that is adapted to the Malian situation.
- Assess extent to which additional infrastructure and equipment will be needed at Sotuba to conduct field trials; identify funding sources if necessary
- Conduct field trials for product efficacy under local conditions
- With the private sector, breed Bt cotton into local varieties (perhaps in collaboration with efforts already underway in Burkina Faso)
- Evaluate impacts on non-target insect pests
- Develop insect-resistance management plan appropriate to local conditions
- Assess the socio-economic implications of the technology (potential impact on income distribution, gender, poverty reduction, etc.)
- Develop a biotech information program to inform the public about pros and cons of insect-resistant cotton in a manner that counters misinformation in anti-biotech campaigns conducted by various local and international groups

Due to the interest by private sector developers of the technology, there is no recommendation that USAID directly support the adaptation and introduction of insect resistant cotton in West Africa. Areas where USAID support would be helpful are:

- Capacity building in biosafety
- General training in marker assisted breeding for transgenic cotton
- Training in insect resistance management

- Technical support to assist Malians conduct and build capacity for economic assessments of transgenic cotton, including analysis of the likely impacts on income distribution across households and genders[18]

5.1.4. Cereals and Pulses

Coarse grains and pulses continue to represent the greatest research and agricultural productivity challenge in Mali. Millet and sorghum yields have been virtually stagnant for decades (annual growth from 1980-2002 of -0.13% for sorghum and -0.23% for millet). Aggregate maize production has been growing in Mali (8% annually from 1980-2002); but yield trends (based on FAOSTAT data) have been erratic since 1980, with an average annual growth rate of only 0.33% from 1980 to 2004. Area planted in maize has been increasing, yet it represents less than 10% of total cultivated area, primarily because the crop is grown primarily in higher rainfall zones. Data on production of pulses such as groundnuts (declining at an annual rate of -1.6% from 1994 to 2004) and cowpeas (increasing at an annual rate of 3.1% during the same period) is weak and its interpretation difficult due to significant amounts of intercropping with cereals. In both cases, yields appear to be declining (-1.01 for cowpeas and -1.60 for groundnuts). In addition to problems of low productivity, Mali also faces significant challenges due to aflatoxin contamination, which reduces export potential and posses domestic health problems. Coarse grains represent a large share of harvested area (38% for millet and 25% for sorghum in 2002) and important shares of total agricultural value added. Of the 34% of GDP projected to come from agriculture in 2004, 11% was estimated to be from coarse grains and pulses, 10% from livestock, 7% from cotton, 4 % from rice, and 1% each from other export crops and fishing/forestry.

Rice is the only Malian cereal with a strongly upbeat story.[19] Sectoral reforms and macroeconomic policies combined with the introduction of improved cropping practices (new varieties, transplanting instead of broadcast seeding, and improved maintenance of the irrigation infrastructure) significantly improved yields and aggregate production in the irrigated rice sector during the early 1990s. At present, the key challenge is to increase the dry/cold season use of the irrigated perimeters so that the capital costs per unit of output are reduced and farmers' incomes increase, enabling them to contribute more toward the investment costs, which continue to be covered in large part by the national budget. WARDA and IER have been working on ways to improve the productivity of dry/cold season rice; it was not clear to the team if more research in this area is needed or the effort should be turned toward the identification of alternative crops that would avoid the management and bird constraints associated with dry season rice.

Table 4 summarizes the key research programs for cereals and pulses identified by the team; most are joint ICRISAT/IER efforts with multiple funding sources. Although none

[18] USAID/AFR/SD is funding the economic assessment being conducted by Purdue University in collaboration with IER; further assessment will be necessary once more is learned about efficacy from field trials under local conditions.

[19] Many would also consider maize to be an "upbeat" story in Mali given the expansion in area and production, but recent yields seem to have stagnated at about 1.5 tons per hectare—the same levels that were achieved in the late 1980s.

of the S&T products listed appear likely to have a significant short-run impact on agricultural productivity or rural incomes, the team believes there is a need to support additional research and dissemination efforts for these products because of their importance in terms of food security, health, and poverty alleviation.

Table 4. Summary of Emerging S&T Products for Cereals and Pulses

S&T Products	Relevance	Benefits	Constraints	Possible Actions
Aflatoxin education and detection kit developed by ICRISAT and IER	Groundnut, maize, sorghum zones	Improve quality for local consumption and export. Educate stakeholders about dangers of aflatoxin and remedial actions. Improve children's nutritional status.		Collaborative health, agricultural research, extension effort to disseminate and evaluate the kit. Consider links with existing NIH health studies in Kolokani
Cereals and legumes bred for increased nutritional value	Millet and cowpea zones	Production/consumption enables women and children to increase intake of important minerals/nutrients (iron, proteins, etc.)	Need to evaluate acceptability for yields, taste, etc.	Develop education and diffusion program in combination with aflatoxin activities
5.2. Photosensitive varieties of sorghum		Research has shown photosensitivity in sorghum is important in breeding ability to adapt to variable starting dates for rainy season	More research needed before releasing to farmers.	Support continued research as potential for reducing production risks due to weather appears great.
5.3. Dwarf varieties of sorghum with improved stover quality		Would improve availability and quality of fodder during the dry season.	Needs more research on disease resistance before diffusion. Farmer acceptance needs to be tested.	Finish research on disease resistance. Evaluate farmer interest/acceptability of grain and fodder.

S&T Products	Relevance	Benefits	Constraints	Possible Actions
5.4. Bt maize		May reduce use of pesticides. Off-the-shelf so human health and environmental safety issues extensively studied	Lack of seed distribution system Attitudes and knowledge re biotech crops. Need for adaptive research. Need for regulatory framework and enforcement institutions	Study efficacy with local pests. If appropriate, breed into local varieties. Training in insect-resistance management
5.5. Cold-resistant varieties of irrigated rice	ON	Permits use of ON irrigation infrastructure for two full seasons. Would reduce capital cost per kg of output for irrigated rice in ON. Would permit expansion of regional rice exports and reduce consumer costs for local consumption	Improved varieties are available but management problems (birds, timing of labor/land use) remain.	Research on reducing management constraints. Research on alternative dry/cold season uses of ON irrigated perimeters (Maize? Soybeans? Horticulture?)

S&T addressing health and nutrition issues. Helen Keller International, ICRISAT, and IER in collaboration with local farmers groups, have developed a project proposal for testing consumer acceptability and health impacts of higher-nutrient cereals and pulses and for aflatoxin education programs (see Appendix 4). This type of inter-institutional and multi-disciplinary collaboration seems particularly appropriate for addressing these types of health and nutrition problems. The broad range of issues addressed by such a project suggests the need to go beyond traditional sources of agricultural research funding. Bilateral donors, for example, could be asked to provide support to these activities through funding devoted to food security, health and governance programs rather than funding allocated to S&T support activities.

Improved sorghum yields. Evidence is quite strong that recent work on the photosensitivity of African sorghum varieties represents a major breakthrough in terms of reducing the risk of crop failure due to erratic rainfall at the beginning of the cropping season. It is recommended that ICRISAT and IER continue this research and identify funding sources able to support the necessary work. Although earlier sorghum breeding efforts have resulted in the development of several improved varieties, recent research suggests that such varieties are used on less than 30% of the sorghum area planted (Yapi et al. 2002); improved tolerance to climatic risk should contribute to improved adoption rates.

Improved stover. Additional work on dwarf varieties of sorghum should be pursued in the context of the livestock feed sector, discussed more fully below (section 5.2).

Insect-resistant maize.[20] The introduction of insect-resistant maize in Mali could improve yields. It represents a modern biotechnology product that would be relatively inexpensive to introduce because it is already developed and much of the regulatory package development has been completed. The first steps would be (a) the screening of economically important maize pests against available insect resistance products to determine if there is potential for effective use of existing products in Mali and (b) the evaluation of the potential economic benefits. USAID/AFR/SD is currently supporting research led by Purdue on the potential economic impacts for West Africa in general.

Table 5. Insect-resistant Maize: Benefits and Constraints

Potential Benefits	Identified Constraints
Technology already developed	Lack of seed distribution system for maize
May increase yields if relevant insects are not currently controlled with pesticides, with spillover for food security and animal feed industries	Lack of local experience with technology
May reduce pesticide use (though Malian farmers use few pesticides on maize)	Need to breed insect resistance into local varieties
Bio-safety studies already thoroughly developed	Need to negotiate licenses with product developers or access technology from public sector, e.g. Insect-resistant Maize for Africa (IRMA) project
	Local/regional opposition to biotechnology

Recommendations concerning insect-resistant maize:

- Screen economically important insect pests of maize against available insect resistance products; this could be done in conjunction with screening against pests of sorghum and millet
- Build Malian capacity to conduct economic assessments of biotech cereal products, possibly in conjunction with USAID-funded Purdue study already under way.

Seed system issues. A pervasive problem in the cereal and pulse sector is the absence of a commercial seed multiplication and marketing system to disseminate improved varieties. Cotton seed is produced by the CMDT. Most horticulture seed is imported. Seed for coarse grains and pulses is produced by the National Seed Production Office, which has not had a strong performance record in terms of multiplying and marketing research results. This is a topic that has been under study by ICRISAT, the INTSORMIL CRSP, USAID funded assessment teams, and PRODEPAM, among others.[21] Recognizing the importance of this issue, Malian colleagues convened a committee to prepare a list of seed sector constraints and solutions for the assessment team (Table 6). Based on this list

[20] This section draws on de Greef et al. 2003.

[21] Because of the extensive literature available on this topic, we highlight only those recommendations that we consider the most pertinent for realizing the benefits of currently available varieties, referring the reader to other studies for details (Christiansen 2002, de Greef 2005, Sanders 2003).

and other documentation, the team's recommendation is that research and extension services work closely with the private sector to assess different options for introducing a commercial seed supply system in Mali. This discussion could be facilitated by USAID's Mali-Trade, Mali-Finance, and PRODEPAM projects and be linked to complementary efforts to develop a livestock feed industry (see section 5.2 below). Ideally, actors in the system would test market improved varieties recommended by IER for cereal and pulse crops as well as represent multi-national seed companies wanting to market horticultural or hybrid seed in Mali. USAID might consider funding visits by key stakeholders to learn about the development of seed industries in other African countries (Niger and Zimbabwe are two possibilities). Another means of increasing the demand for improved varieties of seed for these crops is to increase market demand for the output through the development of cereal/pulse processing industries that produce new products (baby foods, snacks, pre-processed couscous and porridge, animal feeds, etc.). ICRISAT, INTSORMIL, and IER have been working in this area, but need to do a better job of diffusing their results to

Table 6. Seed Sector Committee Report

Désignation Spéculation	**Contraintes**	**Solutions Technologiques**	**Recommandation**
Céréales sèches Mil – sorgho	- Peu de transformation valorisation - non disponibilité de semences de base	- Mettre en relation producteurs transformateurs et commerçants. - Produire semences de base - Organiser paysans semenciers	- Répertoires des intervenants de la filière. - Organiser des rencontres interprofessionnelles - Equiper les producteurs
Pomme de terre	Manque de moyens de diffusion	Technologie disponible	- Aller à la production par mini-tubercules dans une zone propice - Mettre des structures de conservation en place en rapport avec privés - Former et équiper les services de contrôle.
Mangue	- Vergers dépassés - Manque de moyens de conditionnement - Manque de moyen de conservation et de transformation	Les variétés appropriées existent.	- Installer les pépiniéristes. - Régénérer les vergers - Former et équiper les services de contrôle - Organiser l'exportation
Légumes (tomate – haricot vert etc.)	- Prolifération de maladies virales - Manque de moyen de conservation et de transformation	Produire des variétés résistantes et bien adaptées.	- Construire des unités de conditionnement, de conservation et de transformation
Blé	Insuffisance de superficies aménagées et de variétés performantes	Mise au point de variétés à haut potentiel de rendement	- Aménager des terres - Produire des variétés performantes. - Equiper les producteurs. - Rendre les intrants accessible
Cultures d'opportunité (Sésame Soja oseille de guinée, pois sucré etc..)	- Manque de semences améliorées - Peu de valorisation	Produire variétés améliorer	- Rendre les semences améliorées disponible - Construire unités de transformation . - Organiser les exportations.

potential users. Finally, marketing of improved seed will require improved performance of seed registration and certification services (see section 6.3.3 below).

5.2. S&T Products for Improving Livestock Subsector Performance[22]

Livestock accounts for around 12% of Mali's GDP and a little more than 17%t of national exports. It is the third most important export commodity after cotton and gold. Numerous analyses have been made of the sector, and its related sub-sectors including meat, milk, hides and skins. Average annual growth rates for meat production were 3.7% from 1980-2002; during the same period animal stocks also increased (1% for cattle, 0.12% for sheep, 2.45% for goats, and 2.79% for chickens). Export trends have been generally favorable (Table 7), despite challenges arising from political problems in the Côte d'Ivoire:

Table 7. Value of Livestock, Hides, and Leather Exports in Billions of FCFA

	1996	1997	1998	1999	2000	2001	2002
Livestock	30.0	31.3	28.1	33.0	44.3	44.9	27.3
Hides and Leather	2.6	3.1	3.2	3.4	6.8	8.8	7.9

Source: Integrated framework team report 2004.

This section of the report provides recommendations on the use of science and technology for the advancement of the subsector, and for animal feed, its related agro-industry. We have identified four broad subsector strategies, showing the order in which a value-chain analysis suggests they should be tackled and the approximate time horizon for their accomplishment.

a) Creation of an animal feed industry producing low-cost, high quality, balanced rations (accomplished within 1-2 years), supplemented with increased uptake of S&T products that improve the quality of traditional sources of fodder and feed
b) Improvement in the capacity to market live animals, and to transform and market animal products such as raw meat, skins, milk, etc. (within 2-3 years)
c) Improvement in animal health (within 3-7 years)
d) Improvement in the productivity of local breeds (within 5-15 years)

5.2.1. Improving Animal Productivity Through Better Nutrition

Inadequate feeding is one of the most serious limitations to livestock production (meat, milk, and eggs). The cost of feed represents more than 70% of production costs in the peri-urban farming system. Feed resources available for ruminants are natural pastures, bush straws, crop residues and agro-industrial by-products from cotton ginning and grain milling. Poultry feed is mainly cereals (maize), with fish or cotton cake used for protein. These items are in short supply and do not provide balanced rations.

[22] This section draws primarily on field notes and reports prepared by team members Oumar Diall and Tom Easterling.

The main limiting factor for local manufacture of animal feed is the absence of a low-cost source of protein. Soybeans are an ideal source of protein, and can be grown in Mali as a rotation crop. Animal feed rations could be mixed from soybeans, along with grain crops such as corn or sorghum, or with cotton by-products. With the availability of low-cost balanced rations, it would be possible to a) improve the value of export livestock, b) efficiently fatten animals at feedlots prior to slaughter, c) increase fresh milk production, and d) expand the production of eggs and low-cost broilers for meat production.

Strategic recommendations include better use of traditional feed resources (silage production, feed treatment with urea, use of molasses/urea blocks, etc.) in rural areas, continued breeding efforts to develop improved quality sorghum stover (see section 5.1.4), the introduction of hybrid soybean as an alternative source of protein, and feasibility studies for the establishment of an animal feed industry**.**

Recommended actions would include:

- Food ration composition studies by IER and improved collaboration with extension on dissemination of results, with particular attention to techniques for transforming natural forages into hay and silage.[23]
- Tests of hybrid soybean seed as a rotational crop under irrigated, as well as rain fed conditions (IER).
- If soybean tests are successful, extension services and/or potential feed companies should support rapid scaling-up of production plots designed to feed into a model milling operation.
- Develop a demand analysis, an investment analysis, and cash flow projections for an animal feed enterprise that could be offered as a proposal to potential investors in an animal feed manufacturing venture (Mali-Trade).
- If deemed necessary by potential investors, IER and the animal nutrition laboratory in Sotuba should develop grades and standards for animal feed in collaboration with GRM regulatory authorities; enforcement mechanisms will also need to be established.
- The costs/benefits of producing feed inputs (e.g., soybeans, maize) under irrigation in the *Office du Niger* should be evaluated.

5.2.2. Recommendations for Improving Livestock Processing and Export

The export marketing of live animals and the production and marketing of meat products are private sector activities that should be encouraged and strengthened, through improved information and technical assistance. Little *technical research* is needed to strengthen these sectors; the primary needs are (a) the *application* of technology and knowledge that is available in Mali and elsewhere, and (b) some improvements in the national data base on livestock production and sales.

Improving the export marketing of live animals. Markets for livestock are highly fragmented and characterized by numerous transactions from the time an animal is sold by its original owner until the time it is purchased by its final buyer. Transportation of animals is expensive. Shipments to neighboring countries are reportedly marked by

[23] Weakness in dissemination of S&T products is a cross-cutting theme addressed more fully in section 6.2.

illegal taxes levied along the way. There are no market standards within Mali related to the meat-producing quality of an animal. Markets for Malian exports may exist in countries such as Ghana, Nigeria, Gabon and Guinea, but they are not exploited by Malian livestock owners due to lack of information and perceptions that transport and cold storage costs render Malian products non-competitive.

Recommendations to improve marketing of live animals include:

- Support for a livestock exporters' association to disseminate information and lobby for joint interests such as combating illegal taxes on animals during transit.
- The establishment of feedlots in regional towns; commercial availability of low-cost balanced rations (section 5.2.1)will contribute to the success of this activity.
- Develop a data base on new export opportunities and contacts for potential exporters of live animals.
- Establish a valid animal health certification as a pre-condition for export.[24]

Improving the export marketing for raw meat: Presently Mali has no exports of meat or meat products; this represents a loss of potential value-added and employment. The lack of refrigerated transport severely limits the sale of raw meat. The first step in stimulating meat exports is to determine their competitiveness delivered to different markets within the sub-region, taking into account the higher value for animal by-products (whose value would be lost in switching from live exports to meat) in some coastal countries.

In locations where meat from Mali appears competitive:

- Provide potential exporters with market information and market contacts.
- Develop investment profiles and cash flow analyses for meat exports, and provide this information to the potential exporters.
- For export products, establish a procedure for certifying the health of the live animals before slaughter, and the resulting meat products after slaughter.
- Create a cold chain for chilling and storing fresh meat, and for transporting fresh meat to export markets.

In the short-run, donor funded projects such as Mali-Trade and Mali-Finance can provide technical assistance with analyses of competitiveness and development of investment profiles; however, Mali needs to build its own capacity in both the public and private sector to collect relevant market information and carry out such analyses.

Improve the processing and marketing of animal products: The main factors limiting meat processing are the lack of storage facilities for perishable finished products, and the lack of technology for processing. The food technology laboratory at the Sotuba research center has done considerable work in developing recipes and technical instructions for conserving local products. The laboratory should develop recipes and technical instructions for livestock products with commercial potential in urban and peri-urban areas and train small and medium-scale entrepreneurs who want to use the information to

[24] Exports are now made with a provisional export certificate and an "informal" health certificate with little validity.

create a business. Technical assistance in business development could also be provided through projects such as Mali-Trade or Mali-Finance. In rural areas, the technology lab could promote meat preservation through drying and salting, and cheese making—products that do not require refrigeration.

While there is a major milk products industry in Mali, the percentage of local milk used for making processed milk products is low. Low demand for fresh milk discourages farmers from investing in improved breeds (section 5.2.3). The limiting factor is the processors' inability to collect and store raw milk at a lower cost than what they now pays for imported powdered milk. Milk processors could benefit from technical assistance to assess the potential for the collection of fresh milk over a broader area. Electricity costs will be critical here, and may result in this being long- rather than short-term recommendation. Another option to investigate is the LACTOPEROXIDASE (LP) system developed by FAO and recently tested in Bangladesh; it permits storage for up to ten hours in an ambient temperature of 30 degrees Centigrade.[25]

5.2.3. Recommendations for Improving Animal Health and Productivity

Recommendations in this area concern diagnostic and disease detection services, vaccines, and breeding.

Diagnostic/detection services. The team recommends strengthening of available diagnostic services. The high cost of diagnosis limits the availability of up-to-date information on disease status. This information is needed not only for planning animal health services, but also for engaging in global markets. Potential beneficiaries of improved diagnosis services include: producers, consumers, GRM, and the general public. The use of reliable commercial diagnostic kits to address the following problems would facilitate this task:

- Food safety: detection in animal products of relevant pathogens such as salmonella, *E. coli*, *listeria*, *campylobacter*, BSE, etc.
- Diseases of high economic importance: Trypanosomosis and Tick-borne diseases, and diseases that threaten the livestock of the poor (poultry) such as Newcastle Disease, Gumboro Disease, Avian Rhinotracheitis.
- Zoonotic diseases that impose a significant public health burden: tuberculosis, brucellosis, rabies etc.

[25] See www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/LPS/dairy/lactoper.htm; this reference was provided by Debbie Wagner, COP for Land O'Lakes dairy project in Albania.

Table 8. Improved Animal Diagnostic Services: Benefits and Constraints

Potential Benefits	Identified Constraints
Support to national disease control programs (reduction in economic losses due to morbidity and mortality, better zoo-sanitary status of national herd, lower transmission of zoonoses to people)	Need to increase zoo-sanitary data management capacity
Improved food safety monitoring (protection of public health, opens access to markets)	Need to improve system for sample preservation and transportation to laboratory
Increased knowledge of disease status in the country in relation to zoo-sanitary constraints for export markets (access to international markets)	

Recommended actions to support an expanded diagnostic program include:

- Develop program to identify priorities and outline system and procedures for expanding existing diagnostic program
- Assure financial support for LCV to buy needed commercial kits
- Carry out necessary training in zoo-sanitary data management and in some special diagnostic techniques
- Short-term LCV collaboration with *Laboratoire de Biologie Moléculaire Appliquée* at FAST, to begin developing expertise in biotechnology diagnostic tests of relevance to LCV's identified priorities
- Develop a longer-term plan to establish a laboratory at CVL devoted to biotechnological diagnostic testing that responds to needs identified in national and regional biotechnology strategies

Vaccine production. We recommend support for:

- Production of thermo-tolerant vaccines for Newcastle poultry disease and *Peste des Petits Ruminants* (PPR)[26] affecting sheep and goats (short-term)
- Large scale dissemination of these thermo-tolerant vaccines (medium-term)
- Development of a recombinant DNA vaccine for the prevention of Contagious Bovine Pleuropneumonia (CBPP) in cattle (long-term)

Newcastle disease is the major epizootic disease of poultry and is a serious constraint to the production of low-cost protein in rural areas. PPR is also the main epizootic of sheep and goats, which are the "cows of the poor". Current control of these diseases is dependent on standard vaccines, which require a cold chain. Due to the difficulty of maintaining cold chains, the development and improvement of thermo-tolerant vaccines is a priority. FAO has recently assisted with the transfer of technology to LCV for the production of thermo-tolerant vaccines for these two diseases. The next steps include local testing of vaccine efficacy and then scaling up production for large scale dissemination. The existing network of state and private veterinary services throughout the country would provide the distribution/marketing channel.

Contagious Bovine Pleuropneumonia (CBPP) is among the most devastating diseases of cattle in West Africa. The efficacy of currently available vaccines against CBPP is low.

[26] *Peste des petits ruminants* translates as "small ruminant disease".

A more effective vaccine would benefit producers, animal health services, and exporters. LCV is working in partnership with four other laboratories in South Africa, Portugal, Switzerland and France (CIRAD) to develop an rDNA vaccine against CBPP. The first four year phase of the project was recently completed; the next phase has not yet been approved. Development of this vaccine is a medium- to long-term activity.

Table 9. Improved Vaccination: Benefits and Constraints

Potential Benefits	Identified Constraints
Thermo-tolerant Vaccines	
Reduced vaccination costs by eliminating cold chain (savings for the users)	Need for additional equipment (freeze drier, CO2 incubator, autoclave, water distillatory, etc.)
Improved vaccination efficacy (reduced mortality and morbidity)	Need for field and laboratory trials to evaluate efficacy prior to dissemination
Extended coverage to village smallholders	Some marketing activities may also be needed
Simplifies distribution system through existing network of veterinary services	
Supports privatized veterinary services	
CBPP Vaccine	
Improved efficacy leading to reduced cattle morbidity, mortality and, perhaps, CBPP eradication	Need for collaboration with advanced laboratories
Opening of export markets (if vaccine successful *and* animal health certification system in place)	High cost of R&D, regulatory and biosafety package development
	Results will not be available in short-term

Recommended actions for the development of thermo-tolerant vaccines:

- Acquire resources needed (above identified equipment, and other inputs)
- Explore need for additional donor assistance (perhaps required for making vaccines available at the village level)

Recommended actions for the development of an improved CBPP vaccine:

- Explore whether existing funding (from the EU) is adequate
- Explore potential collaboration with others partners, e.g. ILRI, US universities
- Explore the possibility and the nature of USAID involvement

Breeding. In the field of animal reproduction and genetics, we recommend the reinforcement of IER capacities through the establishment of a Reproduction Unit and staff training.

Artificial Insemination (AI) was introduced in Mali in the colonial era. Initially, AI was subsidized, but these services are now provided by the private sector. Although AI is a well-established and accepted technology, it is used in <1% of breeding females. One successful AI costs about $120, putting this technology out of reach of all but the richest farmers. The difficulties are related to semen provision, liquid nitrogen supply (expensive and not always available), high costs and limited availability of complementary inputs (e.g., hormones and low-cost, balanced feed rations for the improved breeds).

IER has undertaken a breeding program to find the optimal crosses of European breeds (Montbéliard, Friesian and Rouge des Steppes) and local breeds (Zebu Peuhl and Zebu

Maure) in terms of productivity and adaptation to local conditions. It is estimated that a cross-bred cow produces twice as much milk as a pure local breed. The next step is to disseminate the results of the cross-breeding program through AI.

To accomplish this, IER would like to set up an animal reproduction unit with infrastructure for local semen production from elite progenitors and for liquid nitrogen production. The establishment of a local unit could reduce the cost of the AI program and increase the demand, thereby making scaling up more feasible. Additional staff training in reproduction techniques (including embryo sexing and transfer) would complement this effort and benefit selection programs based on Open Nucleus Breeding System already being conducted by IER to improve local stock in the pastoral system. Beneficiaries of these activities would be peri-urban commercial farmers, ordinary farmers in agro-pastoral system (cotton zone), milk processors and consumers.

Table 10. Animal Reproduction Unit: Benefits and Constraints

Potential Benefits	Identified Constraints
Lower cost semen production through import substitution	Importing and maintaining live bulls of exotic breeds locally is difficult and expensive
Increased milk production	Higher input requirements for maintenance of improved breeds (e.g. animal feed and management)
Support for recently privatized AI enterprise	
Improved skills for researchers in selection programs benefiting the pastoral system	

Recommended actions to improve breeding program:

- Evaluate potential demand for AI
- If potential demand strong, get PRODEPAM, Mali-Trade, and Mali-Finance in collaboration with IER and relevant ministries to design subsector development program (including attention to animal feed needs)
- Conduct a feasibility study for private sector expansion of AI
- Conduct a benefit/cost analysis to assess potential for reducing AI user costs through an import substitution approach to semen production
- If benefit/costs for import substitution favorable, identify funding sources for the development of a reproduction unit and related staff training

6. Cross-cutting Issues Affecting Development and Uptake of S&T Products

In this section of the report we move from a product-based analysis to one that examines S&T constraints and opportunities of importance across multiple sectors and multiple levels of the value-chain. The topics covered are not all-inclusive but represent the team's view of the priority constraints and opportunities now facing Mali's S&T community.

6.1. Building Research and Teaching Capacity[27]

A specific item in the team's TOR was to develop a strategic options plan for building science and technology capabilities needed to develop and scale-up promising S&T

[27] This section draws primarily on a report and field notes prepared by team member Moctar Koné.

products. One element of this task entailed a review of human, physical, and financial resources available at Mali's research and training institutions and the identification of weaknesses. To collect the necessary information the team consulted with representatives of IER, LCV, ICRISAT, ICRAF, WARDA, IPR/IFRA, FAST, CNRA, the CRU for Bamako/Koulikoro, DNAMR, OHVN, CMDT, and the USAID-funded PRODEPAM.

6.1.1. Highlights of the Resource Situation for Research and Teaching

Problems of inadequate human capacity, laboratory space and equipment in the fields of water management, geographic information services (GIS), agricultural economics and biotechnology were frequently brought to the attention of the team, but with differing degrees of severity across institutions. IPR is better endowed than IER in traditional biotechnology labs (i.e., tissue culture) and skills but poorly endowed in social sciences. IER feels particularly disadvantaged in having no biotechnology capacity given that they are the institution designated to advise a number of ministries on technology matters. At present there is no significant infrastructure specifically for modern plant biotechnology at any institution, but there is laboratory infrastructure for biotechnology research in veterinary sciences (LCV) and human health (FAST).

IPR has recently launched a degree program in agricultural extension, but a lack of qualified personnel blocks the implementation of an officially approved program in agricultural economics. IPR has proposed a degree program in rural engineering to resolve the acute shortage of agricultural engineers with expertise in water management (a serious gap in a country counting heavily on improved use of water resources to boost agricultural productivity growth); this program also is not yet functional due to lack of qualified personnel. IER has somewhat more socio-economic capacity than IPR (e.g., researchers in ECOFIL and the farming systems program) but there has been deterioration in economics capacity during the past ten years as several economists have left IER to pursue other employment.

FAST, due to a collaborative project with NIH, has the best biotech capacity of all research and training institutions. This facility can also serve some agricultural biotechnology research needs; for example, ICRISAT and WARDA are already using FAST laboratories and equipment. Expanded use of FAST biotechnology facilities for agricultural research would most likely require investments at FAST for equipment such as plant growth chambers, insect and animal houses, and field test sites. The cost-effectiveness of making such investments at FAST versus supplying IPR, IER, and LCV with improved biotechnology equipment and laboratories needs to be examined jointly by the GRM and all of Mali's research and teaching institutions to ensure that scarce resources are used in an optimal manner that takes into account the mandates and resources (financial and human) of each institution and responds to a coherent national strategy for biotechnology research.

All institutions appear to have problems covering the costs of recurrent supplies and small equipment for laboratory work, relying heavily on a somewhat erratic stream of donor funding for assistance. The central veterinary laboratory (LCV), benefiting from a long association with USAID, has a more balanced personnel and equipment situation

and manages to cover approximately 60% of its expenses with non-project funding from commercial activities and government support. There appears to be some excess capacity at LVC because effective demand is weak for many of the food and animal tests that they are capable of performing.

Another problem is the dearth of scientific publications produced by staff at Mali's research and teaching institutions. IER has recently established a working paper series that is open to submissions from non-IER researchers (*Les Cahiers de l'Economie Rurale*); it also has archives containing numerous project reports and unpublished documents. IPR and LCV do not have an established in-house publication series. All institutions have some researchers who have published in international journals, but the number of publications is limited. Faculty at IPR feel particularly disadvantaged because the institute's limited funding for research makes it difficult to do publication-quality work.

Recommended actions to resolve infrastructure and laboratory constraints:

- Increased use of infrastructure and scientific equipment for food and animal safety testing as a means to cover personnel and equipment costs[28]
- Improved inter-institutional collaboration in the management of existing infrastructure and laboratory facilities to cover the short-term
- Long-term planning undertaken collaboratively by IER and IPR to develop complementary facilities in agricultural biotechnology that serve both national and regional biotechnology development needs without creating over-capacity.[29]

Recommended actions to resolve human resource constraints:

- Long-term training in water management should be given top priority because of the extremely limited number of Malians with this type of training in research, teaching, and extension positions; complementary training in the use of GIS for water management activities would be a useful addition.
- Long-term training in agricultural economics or agribusiness is strongly recommended given IPR's need for faculty with skills in this area, deterioration in IER capacity in economics, and the growing need for economic analysis of private investments to multiply and disseminate S&T products.
- Implementation of recommendations for long-term training in the USAID-funded capacity study (Edwin et al. 2003) should be pursued, but the relatively high priority given to biotechnology versus water management and agricultural economics should be reconsidered; the lack of Malian capacity in the latter two fields is severely hindering the development of teaching and research programs on topics of critical importance and the exact nature of needs for biotechnology capacity are not yet well articulated given the lack of an overall biotechnology strategy at the national and regional levels.

[28] This may require some changes in the regulatory system and enforcement mechanisms (see 6.3.3 below).
[29] By "over-capacity" we are referring to the situation where laboratories exist but there is not enough day-to-day funding to keep them operating at capacity (small equipment, renewable supplies, etc.); this is an area where Malian institutions can seek donor support, but heavy reliance on short-term donor support makes it difficult to implement longer-term strategic plans .

- In the short-term, high priority should be given to increasing the level of biotechnology awareness for agricultural researchers so that they can understand the issues, provide policy makers and the general public with reliable information about the topic, and participate in the development of national and regional strategies for biotechnology research and applications.[30]
- A census of individuals already trained in disciplines that would support a national biotechnology strategy and working outside Malian research and teaching institutions should be made to evaluate the possibility of offering them employment within the system or using them as resource persons at IER and IPR, in the context of a national biotechnology strategy.
- IPR should work with donors to set up exchange programs or distance teaching activities where faculty from US and EU universities could teach courses at IPR or help develop curricula in fields where local capacity is weak, while faculty at IPR could improve their knowledge and skills thorough donor-funded training programs or sabbaticals abroad.

The team notes that there is a divergence of views concerning biotechnology training needs. Two earlier assessments have addressed this subject: as part of a biotechnology assessment (de Greef et al. 2003) and as part of a larger assessment of long term training needs (Edwin et al. 2003). In the biotechnology assessment, the authors concluded that there exists already "a remarkable number of scientists in the country with PhD level training in molecular biology, cell biology and agricultural sciences". However, it is noted that this expertise is spread across institutions, working largely in isolation, instead of as part of coordinated strategy.[31] The results of the long term training assessment indicate a high level of interest in advanced degree training in biotechnology by IPR and IER. Biotechnology was the field with the highest estimated need for MS and PhD level training (28 of 354 total degrees covering all disciplines). While it is unlikely that there will be adequate resources to fulfill this request, it is also questionable, whether the emphasis on biotechnology, at the expense of other disciplines, is justified.

6.1.2. Need for Greater Inter-institutional Collaboration

In view of the differences in human resources and infrastructure across Malian institutions, the potential for inter-institutional collaboration appears much greater than that actually observed by the team. In several areas IPR/IFRA lacks human resources that are available at IER and CVL, but in biotechnology, for example, IPR has more expertise. There are numerous examples of IER and CVL researchers contracting with IPR to supervise students conducting research. The are some cases of IER and CVL researchers contracting with IPR to teach courses. More of this type of collaboration would be helpful as well as expanding the base of potential instructors to the private sector and

[30] de Greef et al. (2003) provide a number of concrete recommendations in this regard, including information gathering trips to African countries already using biotechnology products and workshops to train both researchers and regulators about biosafety issues and the development of appropriate regulatory frameworks.

[31] de Greef et al. did not specifically identify these scientists and indicate if they were likely to be available to conduct research; their ages and current roles (e.g., research or administration) would influence the extent to which they might contribute to Mali's future biotechnology research programs.

qualified project personnel, but the relatively low level of monetary incentives (hourly salary rates, transport) that IPR is able to offer is a drawback. There are also several examples of joint IPR/IER research projects. Again, more of this type of cross-institutional work needs to be encouraged but working out the financial arrangements for the collaboration seems to be an issue. FAST, IPR and CVL are better endowed in biotech skills and laboratories than IER, but there is no formal agreement that would encourage these institutions to train IER researchers and technicians or to provide them access to existing laboratories. LCV also has staff that is skilled in areas where FAST has gaps. IPR has access to over 300 hectares of land available for research and training activities, and a relatively good endowment of existing buildings (some in need of repair). IER also has access to land while FAST has no land available for agricultural experiments. IER expresses a need for more laboratory space for both conventional and biotech research.

There are some structural issues that contribute to this apparent lack of coordination. Research and training institutions belong to different ministries (some to education, others to agriculture, livestock, or environment). The recent decision to divide the former ministry of rural development into three line ministries further complicates the picture by increasing the uncertainty (nothing has been officially implemented yet) and introducing challenges for extension agents who must work at the farm level where crops, livestock, and forestry all fit into one integrated package of activities. Limited public funds for research and recently introduced bidding procedures encourage institutions to compete with each other rather than fostering collaboration that efficiently uses existing resources while building future capacity. Institutions that have been weak in research in the past (e.g., IPR relative to IER in the PASAOP bids and University of Bamako relative to IPR in the Ministry of Education bids) are unable to capture enough funding to improve their research standing under the current system. Furthermore, IPR was not recognized as a research institution by PASAOP and therefore not eligible for the types of non-competitive institutional support that PASAOP provided to IER and LCV in the recent past.

Following initial contacts with these organizations, the team determined that too much inter-institutional competition and too little inter-institutional collaboration was fostering less than optimal use of existing capacity. This is a problem identified in an earlier assessment specifically in relation to biotechnology (Alhassan 2003). Confronted with this observation mid-way into the two week assessment, representatives of the different institutions agreed to form committees to discuss the issues and develop a set of recommendations for increased collaboration that they would present to the team. Significant progress was made in developing a short-term plan for improved sharing of laboratory facilities and better collaboration on research, teaching and training. The approach was to (a) identify the strengths and weaknesses of each institution in terms of human resources and physical infrastructure, and then (b) identify areas where good or excess capacity of one institution could be used to compensate for weaknesses in another. The committee's recommendations are summarized in Table 11. It will be important for the institutions involved to implement this plan through written agreements that clearly spell out institutional responsibilities (particularly with respect to financial obligations)

and provide enforcement mechanisms. Without the implementation of these short- to medium-term improvements in use of existing capacity, it will be difficult to justify increased external assistance, particularly for laboratory facilities, many of which are not yet used at capacity. Donors involved in funding research through PASAOP and other competitive processes as well as bilateral donors supporting individual institutions should consider changes in the funding and bidding process that might stimulate inter-institutional collaboration and more efficient use of existing resources.

Recommended actions to improve inter-institutional collaboration:

- Use of written agreements for inter-institutional collaboration
- Monitoring and evaluation of the written agreements
- Promotion of joint research/training activities involving students and researchers of different institutions in an effort to use existing resources more efficiently
- Joint publications, starting with a working paper series
- GRM-donor coordination to provide incentives for inter-institutional collaboration and reduce competition among institutions leading to duplication of expensive infrastructure and equipment
- Recognition of IPR as a research institution eligible for support similar to that provided to other agricultural research institutions

Table 11. Missions, Capacity, Needs, and Suggested Collaboration for Teaching and Research Institutions in the SNRA

Institution et missions	Points forts	Points faibles	Appuis nécessaires
LCV : Santé animale (Diagnostic et Production de vaccins)	Une capacité en biotech. : ▪ Equipement/matériel ▪ Personnel formé ▪ Quelques applications biotech. en cours	▪ Sous-financement des activités de diagnostic ▪ Insuffisances en équipement/matériel et en formation	▪ Formation(FAST et hors SNRA) ▪ Equipement/matériel complémentaire (FAST pour séquenceur et hors SNRA) ▪ Financement pour le fonctionnement (hors SNRA)
Domaines de recherche de l'IER : .Productions animale .Cultures pluviales .Cultures irriguées .Ressources forestières, fauniques et halieutiques .Systèmes de production/gestion des ressources naturelles et économie des filières	▪ Large couverture de spéculations et de domaines de recherche ▪ Large couverture du territoire national ▪ Importante et Diversité des Ressources Humaines ▪ Expérience confirmée dans la programmation et dans la gestion de la recherche ▪ Grande expérience dans la rédaction et dans l'exécution des projets de recherche	▪ Insuffisance des financements ▪ Insuffisance en Ressources Humaines spécifiques (biométrie, informatique, SIG, économie, sociologie…) ▪ Manque de capacité en biotechnologie	▪ Capacité en biotechnologie végétale (FAST, IPR, hors SNRA) ▪ Capacités en biotech animale : reproduction et génétique (hors SNRA) ▪ Contrôle des nuisibles et ravageurs (FAST, hors SNRA) ▪ Transformation agro-alimentaire (hors SNRA)
IPR : Formation de jeunes cadres/chercheurs dans les domaines de l' agriculture, l'élèvage et la foresterie. Recherche agro-sylvo-pastorales	▪ Capacité en formation de cadres ▪ Diversité des RH ▪ Possibilité « d'utilisation » des étudiants dans les programmes de recherche ▪ Présence d'un labo de biotechnologie végétale (Tissuculture) ▪ Capacité en sylviculture en GRN (labo) ▪ Un domaine de 300ha dont 100 cultivables	▪ Faible niveau de financement pour la recherche univ. ▪ Insuff. en certaines RH spécifiques ▪ Faible capacités en biotech (transformation des gènes) ; ▪ Contrôle de qualité des semences ▪ Faible niveau d'équipement du labo GRN	▪ Formation en biotech. (FAST, hors SNRA) ▪ Analyse des sols (IER) ▪ Contrôle des nuisibles (IER, FAST)
FAST : formation de jeunes cadres en sciences Recherche	▪ Capacité de formation ▪ Equipement conséquent en biotech. ▪ Personnel formé en biotech.	▪ Etroitesse du champ d'application ▪ Manque d'animalerie ▪ Manque d'insectarium ▪ Manque de parcelles exp., et de serres	▪ Programmes conjoints de recherche adéquatement financés (SNRA et hors SNRA) ▪ Mise en place d'une animalerie et d'un insectarium (hors SNRA) ▪ allocation de parcelles et serres (SNRA)

Source : Prepared by the following representatives in response to the assessment team's request : IER : Bino Témé, LCV : Saidou Tembely et Mamadou Nyang, FAST : Madama Bouaré, IPR : Fafré Samaké, CNRA : Adama Traoré, CIRAD: M. Renou, Consultants: Moctar Koné et Oumar Diall.

6.1.3. Providing Incentives for the Next Generation

Because of GOM efforts to streamline the civil service, there has been a hiring freeze that has prevented the recruitment of young researchers by the key research institutes. Young graduates interested in research have difficulty finding employment in Mali. Some work for several years without salary as trainees, gradually moving up to temporary (insecure) positions funded through donor projects. As soon as a more secure employment opportunity presents itself, the trainee leaves and the process begins again. The most talented graduates often find immediate employment with the private sector or international organizations. This is not an effective way of building human capital capable of implementing a long-term S&T program in Mali. Representatives of all the research and training institutions expressed concern about what they referred to as the "aging" of existing research and teaching staff. Their concern embraces both the issue of hiring young staff so that they can learn by working with more experienced colleagues prior to replacing them, and the reduction in donor support for graduate study.

Recommendations to address the need to get "new blood" into the system include:

- Solicitation of a steady stream of donor support to fund new graduates who would be integrated into existing research and teaching programs at facilities that do not have positions open for recruitment (funding would need to be of five or more years duration to ensure coverage until currently staffed positions are vacated).
- Use of exchange programs (Fulbright, Rockefeller, or other) to help promising new scientists work with experts from international organizations.

6.2. Weak Dissemination and Scaling-up of S&T Products[32]

Mid-way through the two-week assessment the team met with representatives of the research and extension community to report preliminary findings. A key team observation was that there seemed to be numerous promising S&T products ready for dissemination (improved seed varieties, soil and water conservation practices, soil fertility management practices, livestock feeding recommendations, improved animal breeds, etc.) but a lack of follow-through to inform stakeholders about these products and to identify and address blockages to widespread uptake. There was an initial tendency for Malian colleagues to argue that the root of the problem was the recent termination of the World Bank funded training and visit program that left DNAMR with insufficient funding. The team recognizes that an extension service without operating funds is not likely to be effective; yet the problems appear more fundamental than funding and merit more thought on the part of the Malians to develop strategic options and identify improvements that they can implement themselves in the absence of external funding.[33]

[32] This section draws on field notes and reports prepared by team members Mike McGahuey, Moctar Koné, and Valerie Kelly.

[33] There is an extensive literature on various approaches to extension in Africa, many concluding that the record has been one of expensive donor-funded programs (e.g., World Bank training and visit program and the FAO supported farmer field schools) with the measurable results not justifying the costs. A recent paper by Anderson and Feder (2004) discusses various aspects of extension system performance, with attention to efficiency gains from decentralization and private provision.

A committee was convened to draw up an action plan that would identify causes of inadequate S&T product dissemination and suggest remedial actions. The committee identified the following constraints:

- Lack of accompanying measures to support adoption (credit, agro-industry)
- Poor technology development due to low involvement of extension and farmers
- Low level of extension agent skills and training
- Poor coordination of multiple actors (NGOs, different ministries, donors, etc.)
- Inadequate or inappropriate skills and training for extension management and supervisory staff
- Failure of extension to consolidate technical information and disseminate it for stakeholder use
- Poor research-extension links for both research and dissemination activities
    - Inadequate dissemination of research results to extension services and the general public
    - Lack of researcher interest/involvement in the dissemination process
- A monitoring and evaluation system that fails to provide credible information on adoption levels and to identify opportunities for improving performance

Appendix 5 contains a full copy of the committee's report, including a table that summarizes recommendations and provides some cost estimates. Given the amount of time available for preparing this synthesis, the team found the identification of constraints and potential solutions a commendable first step. Nevertheless, we encourage the committee members to pursue their discussions in an effort to:

- Develop an implementation plan that would prioritize recommendations, taking into account the importance of the constraint, resource availability, the time horizon needed to implement the recommendation as well as which S&T products to target and where.
- Better explain how these recommendations differ from past programs and why they would be more likely to succeed.

In the rest of this section, we would like to focus on team recommendations for at least partially addressing the problems of research-extension collaboration and monitoring and evaluation. The team suggests that the research establishment recognize "dissemination" as an important area of research that must be addressed, in collaboration with extension services, if the economic returns to S&T research are to be realized. To better understand why there is not more uptake, research and extension need to better understand the points of blockage—both biophysical and socio-economic. But, identifying these blockages is only the first step. The next step is developing a data base on what has been done thus far to overcome the blockages. To accomplish this, we recommended a collaborative research-extension program to take stock of cases where technologies have been adopted and work backwards to identify impacts, constraints overcome, and actions or support services that helped to overcome the constraints. Box 2 describes in more detail what a program like this might include and the potential benefits.

The lack of a collaborative research-extension effort to monitor and evaluate S&T product uptake on a regular basis means that S&T product developers lose track of what

happens to their products shortly after they are released to the extension services. There is no systematic effort to evaluate how many adopters there are, where they are located, whether they continue to use the product over time, what constraints they had to overcome to adopt the product, whether they made modifications in the product or the way it was applied, etc. Even in some of the more recent research efforts that have involved farmers in participatory research processes, the farmer-researcher feedback link seems to be broken once the initial product development is completed. IER, in collaboration with IPR and the extension services needs to develop a monitoring and evaluation system that provides farmer feedback to researchers during the entire dissemination and scaling up process. Farmers in Mali are not a homogeneous group. As the circle of adopters grows wider, encompassing less skilled farmers with fewer and lower quality productive resources, the need for researcher assistance to adapt S&T products to different situations may well be increasing rather than decreasing. Monitoring and evaluation programs need to become an integral part of research-extension activities and be used as learning exercises rather than for perfunctory reporting of accomplishments to justify donor funding. Given that the CRU are expected to play a role in promoting the dissemination of improved S&T products, their potential involvement in a monitoring and evaluation system should also be explored.

6.3. Increasing Productivity and Reducing Risk Across Multiple Subsectors

The team examined two technical areas (natural resource management and water management) that have potential through existing S&T products to significantly increase productivity and reduce risk across multiple subsectors, particularly those found in rainfed production systems, which provide livelihoods to the majority of Mali's smallholder farmers. In addition, the team identified the following three constraints as the most important non-technical barriers to uptake of a wide range of S&T products:

- Regulatory frameworks and enforcement mechanisms
- Packaging, storage, and processing supplies and equipment
- Financing

We briefly describe these opportunities and constraints the next several sections.

Box 2. The Discovery/Action Approach to Improving S&T Uptake: An Application to NRM

Instead of asking, "What do we think needs to be done to overcome the constraints to broad-based investments in NRM?", we asked, "Where have people overcome these constraints, what were the impacts, and how were the constraints overcome?"

We term this assessment the Discover/Action Approach (DAA). The short-term objective of the DAA would be to identify actions to accelerate the uptake of economically-viable, environmentally-sound technologies. The longer-term objectives would be to speed up the process of scaling up S&T products through (a) improved research-extension collaboration and (b) identification of policy and regulatory constraints to adoption.

The research would be carried out jointly by research and extension services. It would provide substantive case studies of where NRM has already been a vehicle for rural growth by asking:

- Where have people invested in NRM practices and at what scale?
- What were the impacts?
- What were the constraints to investment that were overcome? (e.g., lack credit, lack of labor, lack of equipment, weak tenure security, poor markets, etc.)
- What were the actions that were taken to overcome the constraints? (e.g., training, policy and institutional reforms, communication, etc.)

The point of departure is to identify sites where NRM practices of interest have been adopted. The use of GIS, aerial photography and satellite imagery may be a cost-effective means of doing this is some cases. Using these tools, several layers of data can be integrated permitting analysts to gain a better understanding of how representative selected sites may be in terms of soils, topography, climate, market access, and population density.

The next step would compare adopters with non-adopters. Conditions associated with adoption would be identified first, then the actions and support programs that created these conditions. Researchers and extension staff would interview farmers who have adopted selected practices and work backwards to identify the constraints that were overcome. Special attention would be given to including poorer farmers, particularly those who have adopted the practices, so that the strategies that they used to overcome constraints can be documented.

This approach is recommended to compensate for the absence of a permanent monitoring and evaluation program that could provide similar information. It is recommended that an ongoing monitoring and evaluation program be developed and implemented collaboratively by research and extension services in view of establishing a more constant flow of information among the key stakeholders in the S&T process (research, extension, users of S&T results, and consumers of final products produced with S&T results).

6.3.1. Natural Resource Management: A Complement to Other Subsectors and A Vehicle for Poverty Reduction and Good Governance[34]

The team treated natural resource management (NRM) as a cross-cutting topic. First, it is a critical complement to crop and livestock production. For example, if Mali fails to address constraints to broad-based improvements in soil productivity, farmers will not achieve optimal returns to investments in biotechnology and other forms of cultivar improvement. Second, NRM has been shown to be an effective vehicle for both rural poverty reduction and improved governance. In order for Mali to capitalize on these synergies, additional research and advocacy will be required. Moving forward involves two research challenges: (1) learning how to promote more rapid uptake of NRM practices, and (2) documenting the role that NRM can play in reducing poverty and strengthening democracy and governance.

Promoting rapid uptake of NRM products and practices. The team did not conduct an exhaustive review of all available NRM products. Table 12 (a-d) summarizes information collected on the most promising products and practices mentioned to the team for soil and water conservation, improved soil fertility, forest management, and agroforestry and range management. In setting priorities for the promotion of these different NRM practices and products, the team recommends using the following screening questions:

- Does the NRM product or practice have relevance for a large proportion of Mali's producers?
- Are positive farm-level impacts likely to be realized in the short-run?
- Is the product/practice ready for farm testing or dissemination?
- Will use of the product/practice set the stage for the use of other productivity enhancing S&T products?
- Does adoption have potential for spillover effects on other development objectives such as poverty reduction, improved governance, or better health?
- Is the product/practice already being used in one area of Mali (or elsewhere in West Africa) but not in other places with similar agroecological characteristics?
- Has the product/practice been used at one time by a substantial number of producers but then discontinued?

We discuss key gaps in knowledge preventing the rapid uptake of the four categories of products and practices identified in Table 12.

Soil and Water Conservation. The soil and water conservation practices listed in Table 12(a) have affirmative answers to most of the screening questions posed above. SWC has been adopted by significant numbers of producers on a range of soils and slopes; benefits include stabilization of the production area,[35] increased yields, and reduced fallow periods. Communities in Mali, Burkina Faso and Niger have reported that establishment

[34] This section draws primarily on a report and field notes prepared by team member Mike McGahuey.
[35] Once the field is "stabilized," farmers are more likely to apply purchased inputs such as improved seeds and inorganic fertilizers.

of SWC measures on a microcatchment level is coincident with higher water levels in their wells. In addition, IER researchers are in the process of quantifying the effects of SWC on carbon sequestration, deep drainage, and the ground water table. This research should be continued and expanded to a variety of soil types and topographies.

Table 12(a). Illustrative S&T Products Available to Improve Soil Management and Conservation

Technologies	Zones	Benefits	Constraints	Recommended Actions
Contour Plowing	Rainfed with sandy loams to clay soils	**Household Level:** higher yields; less erosion; greater input efficiency; reduced need to fallow ; increased soil carbon **Community Level: r**echarge of soil water profile and water table; decrease in flooding; increased possibility for dry season irrigation; may contribute to increased soil carbon and natural regeneration of forests.	-Producers require assistance and/or equipment to find the contour lines, to acquire equipment to transport materials (stones, planting materials, etc.) -Communities need minimal levels of organizational capacity to manage water at a catchment level.	Learn from past experience to rapidly scale up adoption using DAA methods described in text: Identify sites where producers have adopted SWC measures; catalogue biophysical and socioeconomic attributes; identify characteristics that distinguish adopters from non-adopters; identify actions/policies that enabled adoption. Ensure research-extension collaboration in DAA implementation and scaling up activities. Continue research on measuring impacts on soil moisture retention, water tables, and yields.
"Zai"	Hardpans		Labor intensive, particularly on harder soils	
Rock lines on the contour	Rainfed Rocks available All soils		Same as for contour plowing, but rocks may be more important than finding contours.	
6.4. Vegetative bands or hedgerows	All types of soils but easier on sandy to sandy loams	Can be used when stones are not present; Certain species produce multiple benefits (e.g., construction materials, food, forage, etc.) Less erosion Higher yields	Establishment of plants and protection of young plants against animals during first year require labor. Plants in hedgerows take up space and/or compete with crops.	

While SWC adoption was found on a variety of sites, the vast majority of Malian farmers do not use recommended practices. Research on overcoming the constraints to broader

use of SWC measures has the potential to produce substantial results in the short-term and to set the stage for broader agricultural intensification. We recommend that the DAA research approach described in section 6.2 (Box 2) be applied in an effort to gather pertinent information for developing a program to rapidly scale up the adoption of SWC practices. The implementation of the DAA research should be a multi-institutional collaboration (e.g., IER, DNAMR, IPR, NGOs working on SWC) involving researchers, teachers, students, and extension agents. The following five paragraphs identify the key topics needing research.

a. Identifying rapid, low-cost means of marking contours. Finding the contour (a line across the slope where each point on the line is at the same level so that water will not run off) is fundamental to installing anti-erosion structures needed for SWC. One reason for the slow uptake of SWC is that the equipment and skills to mark the contours are usually available only through extension agents. Whether the solution to rapid uptake is training farmers to mark contours, finding more effective tools for doing it, or something else is not clear. Fortunately, there is a plethora of experience with contour-based SWC practices to draw upon. A substantial number of farmers in the OHVN and CMDT zones have established SWC on the contours. Reports from Burkina Faso indicate that over 100,000 hectares have been treated with SWC on the contour. These and other cases offer a viable "laboratory" to identify appropriate, cost-effective techniques.

b. Improving access to equipment needed for SWC: Developing effective SWC measures often requires the transport of materials (stones, planting materials) or plowing furrows. An analysis of the various ways that farmers have overcome equipment obstacles could inform both program and policy decisions. For this particular question, it would be critical to give particular attention to strategies used by poorer farmers.

c. Decision-trees to improve the choice of SWC structures. The most appropriate type of SWC structure will vary according to the soil, topography, climate, etc. Sandy soils with slight slope would require one type of design while hardpans (*glacis*) with large slopes would require another. The availability of materials for barriers (plants, rocks) is also a factor. Research and extension need to consolidate information on alternatives and make it available to farmers in simplified decision trees so that they can make their own choices.

d. Achieving SWC on a watershed scale. While individual producers can improve their productivity by treating their own fields, optimal benefits would be achieved by treating a watershed. An assessment that identifies where this has been achieved in Mali and neighboring countries and describes how communities overcame the organizational, tenure, labor, technical, and other constraints would contribute substantially to the knowledge base needed to stimulate use of SWC on a watershed scale.

e. Land tenure. Understanding the extent to which tenure limits adoption of SWC practices will be an important ingredient in scaling up adoption; research to compare the tenure situation of current adopters and non-adopters would provide policy-relevant information to those working on land tenure reforms.

Soil fertility management. Again, most of the screening questions have positive responses for products and practices in the soil fertility management area. If Malian are going to get the most from investments in biotechnology, variety selection, and plant breeding, then they will have to provide improved cultivars with more nutrients through increased use of mineral fertilizer. However, Malian soils are weathered and lacking in capacity to efficiently supply fertilizer nutrients to plants. It is estimated that on many of Mali's soils plants use 30% or less of the nutrients applied in the form of inorganic fertilizers; the rest is tied up by acid soils, leached through the soil profile, or lost to run-off.

The research challenge in Mali is to increase the fertilizer use efficiency (FUE) by identifying the right fertilizer formulations and timing, but, more importantly, by identifying soil amendments that improve plant uptake of applied fertilizers. Fortunately, there are research results to build upon (Table 12(b)).[36] Research shows that by raising the soil organic matter, the soil's cation-exchange capacity (a measure of the capacity of soils to hold onto nutrients and make them available to crops) is substantially increased. These increases can raise the fertilizer-use efficiency from around 30% to 50% or higher, making the purchase of mineral fertilizer much more attractive to producers. Once the capacity of soils to supply nutrients to plants is improved, a second constraint remains: low-cost, efficient fertilizer supply. This is a non-technical challenge that also needs serious attention, particularly in zones that do not have cash-crops such as cotton and irrigated rice that can be used as collateral for fertilizer credit.

[36] IER researchers in Sikasso are collaborating with IFDC in implementing the Integrated Soil Fertility Management Program, an initiative aimed at increasing FUE through soil amendments.

Table 12(b). Illustrative S&T Products for Improving Soil Fertility Management

Technologies	Zones	Benefits	Constraints	Recommended Actions
Compost Pits	In areas where farmers have animals, preferably traction animals	Composting increases the efficiency of the organic matter and reduces weed problems. Soil organic matter buffers the effects of acidity and builds up the capacity of soils to retain nutrients and moisture.	Composting often requires stabling and watering of animals, both which require labor. Transporting manure requires both labor and equipment.	Promote greater uptake by using DAA to take stock of areas in Mali where farmers are using compost pits and apply lessons. Identify ways of making use of compost easier for poor farmers to use.
Improved night parks	Households owning relatively large numbers of animals	Bringing animals together concentrates manures and allows them to be mixed with vegetative residue.	Labor demand high to tether and feed animals. Poorer farmers may lack animals and labor.	Promote greater uptake by using DAA to take stock of areas in Mali where farmers are using parks and apply lessons. Identify ways of making parks more relevant to poor farmers
Soil amendments to increase fertilizer use efficiency (FUE)	All agricultural lands, particularly weathered, acid soils	Can increase plant's use of inorganic fertilizer by 25-60%. Can decrease expenditure on inorganic fertilizer. Increase yields and incomes	Access to complementary inputs (lime, equipment)	Promote greater uptake by using DAA to take stock of areas in Mali where farmers have increased FUE and soil fertility levels and apply lessons. Identify ways of making parks more relevant to poor farmers.

The team recommends research to answer the following questions as a first step in expanding FUE.

- Where are the soils whose productivity could be substantially improved through soil amendments that raise cation exchange capacity located?
- What is the potential for economically increasing FUE through soil organic matter amendments? Through other soil amendment options?
- What are the most effective ways to increase soil organic matter (e.g., types of plant materials, composting, etc.)
- Given the potential market for sequestered carbon, what are the relationships among carbon sequestration, soil amendments and crop productivity?

Forestry Management. The forestry sector is an important income generator for the rural economy. By some estimates, annual use of fuel wood in Mali has a value of over 30 billion CFAF; adding the value of marketed poles, fruit, nuts, and medicinal products

Table 12(c). Illustrative S&T Products to Improve Forestry Management

Technologies	Zones	Benefits	Constraints	Recommended Actions
Improved forest code and management practices to protect forests and encourage natural regrowth	Throughout Mali	Improvement in forest management can improve the economic potential of forests, particularly for the poor, many of whom have forestry-based livelihoods.	-Relatively little is known about growth and regeneration of natural forests in W. Africa -Weak knowledge of silvi-culture of some native species. -Decentralization demands new legal arrangements over forest management; if rural populations fail to get sufficient incentives, their reasons to provide responsible management will be low	-Continue research on the growth and regeneration rates of natural forests (e.g., IER research on the effects of timing and height of harvesting on survival and regeneration rates of native species). -Monitor impacts of decentralization process on forest management and distribution of benefits. -Document the relative contribution of the Forest Sector to the rural economy and the poor.
Private woodlots	Throughout Mali	-Private woodlots did not exist 20 years ago but now supply much of construction wood. -Reduces construction costs through import substitution. -Provides supplementary income to rural households and communities.	-Need seed nurseries. -Labor and water needed to establish woodlots.	-Promote greater uptake by using DAA to take stock of areas in Mali where farmers are using woodlots and apply lessons. -Assess relative importance of private vs. community woodlots, levels of financial returns, and equity implications. -Explore potential of woodlots for producing fuel wood.

would significantly increase estimates of the forestry sector's contribution to GDP. As suggested by information in Table 12(c), management and governance are probably more important 'inputs' into improved forestry than S&T products. In addition to the importance of the sector to the national economy, Mali's progressive Forestry Code reforms provide new and substantial opportunities for reducing poverty and environmental degradation while improving local governance. However, these reforms will mean new management practices and new organizational structures that will most likely require trial and error in order to produce optimal benefits. Consequently, we suggest that the following questions be answered as part of Mali's forest research agenda:

- What is the economic contribution of the forestry sector to the national economy in terms of GDP, employment, and, poverty reduction? Solid, quantitative data is lacking in this area and is needed to promote collaboration with other sectors.
- What is the potential for meeting Mali's future needs for construction and fuel wood through better management of natural forests, woodlots, and plantations?
- What should be the relative place of woodlots and plantations versus natural regeneration in Mali's long-term forestry plan?
- What is the historical record on community-managed forests? For example, how do forests managed through local forest management schemes (e.g., OHVN communities and Siwa) compare to forests managed by government authorities in terms of sustainability, income generation, and distribution of incomes among different socio-economic groups?
- For each forest type, what are the best natural forest management techniques for sustained-yield harvests?

Agroforestry and range management. Mali is well-known for its livestock tradition. Given challenges brought on by demographic pressure and land degradation, the sector is experiencing stress. In many production zones the quality and quantity of forage and water supplies are diminishing. Table12(d) summarizes S&T products and practices identified by the team as having relevance to improved agroforestry and range management. Areas that merit further research include:

- Identification of S&T products/practices to reverse the current trend of annual grasses replacing the perennial species that had traditionally provided high-quality feed to grazing animals.
- Expansion of earlier IER/ICRAF research on browse to identify new agroforestry systems that provide high-quality animal feed while producing other services.
- Continued research on variety improvement and grafting of native trees that produce economically important fruits and nuts (shea, jubjubier, baobab, etc.) with simultaneous research on storage, processing, and marketing of the products.

NRM scaling up and zonal complementarities. Mali's recent boom in the irrigated rice sector has encouraged the GRM and donors to prioritize irrigation investments. Given Mali's goal of reducing poverty among the rural poor, the GRM and donors must not lose sight of the fact that most of Mali's rural population lives in rainfed agricultural zones.[37] There is a need to balance GRM and donor support to potentially high payoff but expensive irrigation projects versus lower cost NRM applications with medium to high payoffs that can affect a much larger share of the farming population and also have positive spillover effects on irrigated agriculture. For example, there is a tendency to accept that farmers in irrigated agricultural systems not be held individually responsible for the full costs of infrastructure investments permitting them to increase productivity,

[37] Currently, about 30,000 hectares of land in southern Mali are estimated to be under irrigation out of a total of over 4.5 million hectares of cultivated area. This represents less than 1%. The potential is estimated to be about 300,000 hectares, or about 6.5%.

Table 12(d). Illustrative S&T Products for Improved Agroforestry and Range Management

Technologies	Zones	Benefits	Constraints	Recommended Actions
ICRAF developed grafting practices to speed up regeneration of trees producing traditional fruits and nuts	Throughout Mali	- Foreign markets have become increasingly interested in West Africa's forest products –-Production cycle for many of these products can be speeded up through grafting. -Large number of farmers and extension agents have been trained in grafting techniques.	-Potential producers are not aware of production and marketing opportunities -Commodity chains for many products are poorly developed. (e.g., it appears that the Karité chain is better organized in Burkina thus giving them an advantage) -The quality of processing of forest products is spotty.	-IER/ ICRAF should continue to research improvements in grafting (jujubier, shea, baobab) as a way to improve orchards and reduce time to develop crop, etc. IER/ICRAF should work on improved storage and processing methods -Develop an information system on agroforestry and natural products to inform rural producers (include technical and market information)
Improved management of pasture and range land in view of increasing nutrient content of natural vegetation	Throughout Mali	-Mali has a comparative advantage in livestock production -History of innovations such as 'domesticating" the *Piliostigma reticulata* as an agroforestry tree used as a primary feed for animal fattening -Would improve quality and quantity of diminishing rangeland	-Rangeland being converted to farmland -High-quality perennial grasses being replaced by lower-quality annuals. -Conflicts between herders and farmers put people and livelihoods at risk -Poor diffusion of information about innovative range and livestock management practices	-Document and disseminate information on successful resolution of range conflicts and information about innovative uses of range and livestock resources to increase household revenues -Continue research on options to stem the deterioration Mali's rangelands, particularly on ways to repopulate ranges with nutritious perennials.

while farmers in rainfed zones are expected to bear the full costs for similar infrastructure that not only contributes to agricultural productivity but also to a decrease in environmental degradation. Because the potential productivity and income benefits of the recommended NRM investments are substantial and likely to affect many more farmers than the very high investments per hectare in irrigated agriculture, the team recommends that some analysis of the returns to increased incentives or assistance to stimulate more rapid, widespread adoption of these practices be undertaken. The costs of <u>not</u> rapidly disseminating these S&T products (e.g., environmental degradation and persistent poverty) may be greater than the costs of speeding up adoption through the use of carefully targeted incentives.

Furthermore, complementarities between irrigation and NRM investments are substantial. Water for Mali's irrigated bottomlands comes from rainfed lands that make up the water catchment system. To protect the productive capacity of these bottomlands, one needs to improve the management of the whole toposequence. Also, irrigated and rainfed agriculture share common constraints to their development (e.g., access to S&T information, financial capital, and markets); addressing these constraints in rainfed systems will have application for irrigated production systems and visa-versa. Experience shows that there is not always a clear-cut winner when comparing the relative costs, benefits and risks of irrigated and rainfed agriculture. There is a need for Mali to develop research capacity that would contribute to better ex-ante and ex-post analyses of benefits to irrigation versus NRM investments; this calls for more capacity in both economic analysis and water management (see section 6.1).

Reducing poverty and strengthening local governance. In the introduction to this section on NRM we noted that there were two key NRM challenges: scaling up and documenting the contribution that NRM activities can make to broad development objectives such as poverty reduction and improved governance. We address the second challenge in this section.

There is a need to better document and publicize NRM's contribution to other development objectives such as poverty reduction and improved governance because many working in the poverty and governance area do not recognize NRM as being integral to achieving their objectives. Consequently, the team urges those working in NRM to conduct research to document the potential for NRM to contribute to these broader development goals. This research should promote closer collaboration between the various ministries and services working at the local level and may lead to greater budget allocations for NRM initiatives that have a proven track record in reducing poverty and strengthening local governance. The following are examples of research opportunities that would increase appreciation of NRM as a vehicle for promoting broad economic and social development:

- The GRM needs good information on the pros and cons of local forestry management if they are to make good decisions about sustainable management of forest resources and ensure a reliable fuel wood supply well into the future; documenting the role of local forestry management agreements (*convention locale*) in preserving resources, providing incomes, and improving local governance skills will fill an important knowledge gap.
- The team believes that the economic importance of natural products (fuelwood, construction wood, wild fruits and nuts, medicinal products, etc.) is vastly underestimated and the sector is not organized in an optimal manner; research is needed on both the (a) importance of natural products to the national economy and (b) strategies to optimize the income generated from the exploitation of these products, particularly by the rural poor.
- With increasing pressure on the land, traditional ranges and corridors have been lost to other uses, such as cultivation or fishing, leading to conflict between herders and other users; current research on ways to mitigate conflict once it

threatens and on negotiation mechanisms that would allow herders to negotiate with other land users on ways to work together should be continued.

Recommendations for USAID-funded Activities. USAID supports several programs that could complement the research agenda discussed above.

PRODEPAM. Implementation of DAA studies for scaling up NRM products and practices should be a joint effort by research, extension, teaching, and development institutions. During the initial phases of developing the DAA methodology, USAID could provide technical support through PRODEPAM for selected studies. PRODEPAM is already helping people to overcome many of the technology dissemination constraints discussed above. In particular, PRODEPAM aims at helping individual farmers and community-based organizations manage critical operations like a business. NRM is a critical community-based activity. The team recommends that PRODEPAM take stock of cases in Mali where good organizational principles have been used to undertake NRM activities. The team knows of two cases where this applied research could take place. One is Siwa near Koutiala. The second is in the OHVN. In both cases, rural communities—in response to outside threats—organized themselves to manage forest resources on community lands. They set and implemented rules. In some cases people organized themselves to manage problem areas in watersheds. We think that research on the impacts of these initiatives, the constraints overcome, the actions that allowed people to overcome them, and their sustainability would produce lessons for Mali, USAID and PRODEPAM.

Soils CRSP. The Soils CRSP is currently doing research with IER scientists on, *inter alia*, the effects of SWC measures on run-off and deep drainage. The preliminary data support anecdotal evidence that SWC not only contributes to increased productivity, but also to a higher water table (and more available water in wells and bottom lands). This research should continue and be expanded. Currently, it is being conducted on one type of soil on one site. It should be extended to other soil types and slopes. In particular, IER should set up medium-term research on several toposequences that include bottomlands.

IFDC-IER. Increasing fertilizer-use efficiency (FUE) is absolutely essential for rural development. Given the critical need to increase FUE on a variety of landscapes, the team recommends that the IFDC/IER research in Sikasso to develop economically-feasible ways to amend the soil to increase FUE be continued and extended to other agroecological zones.

6.3.2. Water Technology and Management[38]

In Mali, there is an estimated to 250,000-ha of land under some form of irrigated agriculture and a further 150,000-ha where crops are grown on the residual moisture following natural flooding, known in Mali as *culture de decrue*. The irrigated area is further divided into three general classes, namely *maitrise totale* [fully controlled]; *maitrise partielle* [controlled flood], and *bas-fond* [irrigated agriculture formed around

[38] This section was written by team member Peter McCornick.

natural depressions]. The majority of the land irrigated by *maitrise totale* is in the *Office du Niger* (75,000 ha.). A further 10,000-ha of *maitrise totale* are within smaller village-run systems such as the *perimeters irrigués villageois* (PIV). *Maitrise totale* systems can theoretically have a high degree of water control and, therefore, productivity. Because they also involve the highest level of investment, it will be important for Mali to compare the relative costs and benefits of *maitrise totale* systems with alternative types of irrigation infrastructure as it moves forward with the development and implementation of water sector strategies.

The extent of the *maitrise partielle* systems varies depending on the hydrology in a given year but is estimated to be around 115,000 ha. The area of land irrigated within the *bas fonds* is around 80,000 ha. of rice during the wet season and a reduced area of non-rice crops in the dry season. An overview of the various approaches and specific systems can be found in ARD (2002). PRODEPAM is in the process of conducting an inventory of the existing and planned irrigation systems throughout the country.

Irrigation management. In the recent past, Mali has significantly improved the management of *maitrise totale* zones and made some advances in the *bas fonds* and selected areas of *maitrise partielle* (e.g. the DAD project in Djéné) (ARD 2002). Many of these systems now produce a relatively high yielding rice crop in the wet season, and are producing some horticultural crops or field crops in the dry season. That said, apart from the *maitrise partielle* systems where potential for improvement is limited, the level of intensification in many of these systems remains well below the potential, particularly for the dry season crops.

During the wet season, the conveyance and delivery systems are surface canals, and the field application systems are also via the surface. In the dry season, there are a wide variety of methods for both accessing water sources and delivering it to the field. In many cases the water has to be lifted from the canal to the crop. In others, the available supply is in the form of shallow groundwater underlying or adjacent to the cropped area, which necessitates the construction of seasonal wells. With the shallow groundwater source and in some cases with the canal-delivered water, the crops are irrigated by hand using either a bucket or watering can. In other cases, such as the system visited by the team at Farabana (OHVN), the dry season crops require that the water be lifted up to 10 meters by pump. In this case, a temporary pipe is used to convey that water to the surface delivery system and the water is applied to a range of horticultural crops via rudimentary surface application approaches.

Irrigation issues and constraints. There are a range of issues and constraints facing irrigated agriculture in Mali. Some apply to the agricultural sector in general, such as access to credit and markets and limited information on appropriate crop-system selection. Others, such as lack of information on water allocation for crops, poor choice of water related technologies, unreliability of equipment and poor access to spare parts, and water users' groups lacking capacity to manage their systems, are of particular relevance to irrigated crops regardless of irrigation methods. Problems such as poor drainage and salinization, competition for water, and increased prevalence of water borne

diseases, are less prevalent and relatively localized; although they do have the potential to become more common if not mitigated.

Knowledge needed to address Mali's irrigation constraints exists in Mali or is available elsewhere. However, other than for the more generic constraints, such knowledge requires specific understanding of a given site; this requires the availability of a minimum number of specialists able to apply this knowledge at a variety of sites. That is, the capacity to utilize the available science and technology to address the specific issue needs to be available at the appropriate level. This is not currently the case in Mali.

Research capacity. Institutions that have been involved with science and technology for the agricultural water sector in Mali include public sector organizations such as IER, CMDT, OHVN, ON and IPR; NGOs, regional and international research organizations including WARDA, ICRISAT and IRD; and donor funded projects. IER involvement has been limited (e.g., collaboration in the *Pôle Système Irrigué* project in Niono, work on soil degradation in irrigated systems with the DNH and collaborative work IRD), and primarily in rainfed systems.[39] In addition, the direct involvement of other public organizations, including CMDT, OHVN and ON, has been significantly scaled back as part of the on-going decentralization and government down-scaling. Mali's low level of activity in agricultural water management research (ARD 2002) appears to be driving the overall dearth of knowledge and expertise and, ultimately the absence of improved technologies, including management practices, in the sector. There are many challenges in managing water for agriculture, and in Mali's case many of these can be addressed by strengthening the human capacity of the sector.

Training capacity. The sub-sector is constrained by a limited capacity to adapt and adopt the available science and technology. Although IPR students do get some general course work in watershed management, presently there is no focus on water, either in the training or applied research, and there are few laboratory facilities.

There is a regional arrangement for training in agricultural water management. Graduates from the National Engineering School (ENI) in Bamako go to the EIER in Ouagadougou, Burkina Faso where after two years they graduate with what would be considered a first degree in irrigation engineering. It is reported that from five to ten Malians enter this program every year and those who return to Mali find positions in NGOs, the private sector and, to a lesser extent, in the public sector.

Edwin et al. (2003) recommended that the long-term training include 5 PhDs for IER, one PhD for IPR, and 5 MSs for the extension service--all in what is termed "irrigation technology". While concurring with the need for this capacity, it is recommended that the training be broader than "irrigation technology" exposing the students to the multi-disciplinary nature of agricultural water management, particularly the sociology and the economics. When possible, student's research should be undertaken in Mali and, given the absence of a similarly qualified cadre of professionals in the country, under the supervision of international organizations. However, the key concern with such an

[39] As of 2001, there were no IER researchers working directly in the water sector (Stads and Kouriba 2004).

undertaking is the capacity to employ graduates in government research and extension programs, which appear to be struggling to support their existing programs.

With regards to short-term training, the recommendation by Edwin et al. (2003) is for short-courses in irrigation system management for 40 persons, all from extension; such courses should also be offered to the staff of Mali's research and training institutions, and, if practical, for staff from NGOs and the private sector, who are likely to be quite effective in applying these skills.

Application of S&T to irrigation. At present there is limited application of information technology to the sub-sector (GIS, aerial photography, satellite imagery). In addition, on-farm water management practices to capture, deliver, and apply water to the crops, particularly in the dry season, remains quite low-tech and inefficient. These methods are generally highly labor intensive and waste water, which can be very significant when water is short.

There have been various attempts to improve the situation with regards to technology for on-farm water management in Mali, including the on-going introduction of the Approtec treadle pumps under the PRODEPAM project. Other efforts include

- A limited program of adaptive research on small-scale irrigation technology, low-cost well drilling, and motor pump testing under the Private Irrigation Promotion Project (PPIP);
- Introduction of drip systems by ICRISAT, including a regional effort supported by USAID/WARP;
- Promotion of the multi-use of water under the West Africa Water Initiative (WAWI);
- Introduction of drip systems near Baguineda by Winrock;
- An NGO (SFA) has introduced a basic drip and bucket system for a women's organization near Mopti;
- Promotion of irrigation pumps in northern Mali by Hari Goumo (local NGO) and the HIPPO foundation (www.hipponet.nl), and
- Chamber of Agriculture in Kidal is importing drip kits from Algeria with small motorized pumps.

Strategic options. There are some opportunities where the improved application of science and technology to water in agriculture will improve the overall performance of the sector, specifically in on-farm water management technologies and information systems. However, a fundamental constraint in the case of Mali is that there is limited capacity in research, training and extension in applying such knowledge in the range of conditions found in Mali. A significant impact on the sub-sector can be made by addressing this issue.

As detailed in Tables 13(a-b), the four recommended water related actions are:

- Establishing agricultural water management training and research capacity,
- Promoting small and medium scale irrigation application packages,

- Developing capacity for decision support & planning technology (e.g. GIS/RS; integrated modeling, etc.), and
- Promoting/facilitating more intensive management practices to better utilize the existing infrastructure.

Recommendations for USAID support. USAID's main involvement in the agricultural water sector is through the PRODEPAM project, which is aiming to work in a number of irrigation systems throughout the country by strengthen users groups and providing them with knowledge and skills to improve water management. As part of this, PRODEPAM is promoting the Approtec treadle pump through a promising marketing and private-sector approach.[40]

USAID should provide support to create the human capacity needed to apply the available science and technology. This should include long term training for researchers/educators, improved facilities, and technician training for those in the public, NGO and private sectors.

Promote, either through PRODEPAM or other activities, a wider option of water related technologies, including motorized pumps and drip irrigation systems, which could possibly by promoted in a similar manner to the Approtec pump. A study of experience to date with these technologies (the "hot-spots") should be undertaken and an assessment of potential private sector involvement in local manufacturing of the drip tubing should be implemented.

[40] In the past USAID has supported other water related projects in the agricultural sector, specifically the DAD project in Djene, implemented by CARE (ARD 2002), and, in coordination with other donors, the development of some infrastructure in the ON.

Table 13(a). Strategic Options for Development of the Agricultural Water Management Sector

Action	Sector	Rationale	Strengths	Weaknesses	Unknowns	Gender
Establish capacity in agricultural water management research and extension	Primarily irrigated agriculture but may also contribute to livestock and fisheries	Virtual absence of Malians with these skills at both research and extension levels	Will address main constraint to uptake of improved irrigation technology and management	Employment of graduates could create new demand on limited public purse	Extent of market demand for technicians in NGO and private sector	Encourage women to enter training programs
Develop and disseminate integrated small to medium scale on-farm water management packages	Dry season horticultural crops; early wet season rice crops; some tree crops	Would reduce labor and water needs and improve crop uniformity	Frees up labor, increases product quality, and stretches limited water supply in critical periods	Cost, access to credit, and equipment support (training, spare parts, etc.)	Reasons for limited adoption of these technologies to date; availability of extension or marketing services to help farmers adapt technologies to their situations; best institutional model for diffusion and support.	Technologies could increase women's incomes and reduce demands on their time; might also encourage men to displace women
Develop capacity for decision support using GIS/RS and integrated modeling of water, agriculture and economics	Entire agricultural sector	Mali's water resources represent a comparative advantage; need to get best bang for the buck	USAID has experience in multiple irrigation sectors and could provide technical assistance	Capacity building expensive and high demand for skills will make it difficult to retain personnel	What other major donors in the water sector are doing in terms of decision support and modeling	

Table 13(b). Aspects of the Proposed Water Technologies/Actions

Technology/Action	Key Stakeholders & Partners	Illustrative Elements	Existing External Partners	New Partners
Establish Agricultural Water Management Training, Research and Extension Capacity	IER, IPR, DNAMR, NGOs, Water Users' Organizations, and other water-related organizations	Long-term training for researchers, extension agents & decision makers. Short-term training for technicians Establish training & research center. Small grants program for targeted research Introduce technologies below into the partner institution.	PRODEPAM, ICRISAT	IWMI (International Water Management Institute), US Universities (Colorado State, Utah State, U. Cal. Davis, Cal Poly, etc.), EIER, Ouagadougou
Integrated small to medium scale on-farm water management packages	IER, IPR, DNAMR, NGOs, private distributors & suppliers, private sector manufacturers	Study existing in-country "hot spots" for pumps, drip, etc. Assessment of in-country manufacture of drip/pipe systems. Feasibility of using Approtec distribution approach for broader package.	PRODEPAM, ICRISAT, WAWI, Winrock	IDE (Colorado), IWMI,
Develop capacity for decision support & planning technology (e.g.. GIS/RS; integrated modeling (water, agriculture, economics, markets, etc.)	IER, IPR, Ministry of Water	Mapping of water/land resources with population & access to markets ("water productivity & water poverty mapping") Multi-market/hydrological /poverty modeling. Strengthen IER unit, and create IPR capacity.	ICRISAT, CGIAR Challenge Program on Water and Food	IFPRI, IWMI

Most likely in conjunction with the capacity building effort described above, USAID should assist with the establishment of capacity for decision support and planning technologies for the agricultural water sector using GIS and other appropriate technologies . This could build on the work of the group at IER which has been supported by ICRISAT, but should include other institutions.

6.3.3. Policy and Institutional Constraints

Although many of the constraints to uptake of available S&T products lie within the confines of the research and extension system, the team's application of the value-chain framework reveals numerous situations where commercial investment in S&T products is constrained by factors much further along the value chain than the levels normally considered to be the responsibility of Malian research and extension services. There is a consensus among team members that the most widespread and damaging constraint to the expansion of agro-industries needed for large-scale production of S&T inputs (e.g., animal feed and improved seed varieties) and to the efficient use of existing laboratory facilities (CVL in particular) is the lack of a regulatory framework and enforcement mechanism to ensure that agricultural products and inputs are safe and correctly labeled in terms of quantities and quality. Without this type of system, potential investors are unable to protect themselves against competition from others selling lower quality products charading as high-quality equivalents.[41]

Discussions above have alluded to these problems in the seed sector. Seed certification legislation does exist, but it is not enforced. For other inputs such as animal semen for artificial insemination, fertilizers, and animal feed, there are no published standards and, therefore, no systematic controls of these products. Overall, the effective demand for quality control of agricultural inputs and outputs (including food products) is low, despite the existence of laboratories capable of testing these products. Biosafety legislation is currently under consideration, but clear understanding of the issues and terms involved is lacking among the diverse actors, suggesting a need for short-term training or information gathering trips for key actors.[42] Respect for existing property rights legislation is not widespread in Mali; the music industry is a striking example, but does represent a sector where some progress is being made. In brief, the framework for quality control and enforcement is lacking in many areas. In the rare cases where it exists, it is out-dated or not respected. Strategic options for the S&T community to pursue include:

- As a means of raising demand for certification and regulatory services, disseminate information on the role that certification and other regulatory institutions can play in Mali's efforts to increase agricultural productivity.
- Work with authorities to develop enforcement mechanisms for existing and future regulatory and certification programs.

[41] A related "enforcement" issue concerns the inability of the GRM to impose taxes on the informal sector. This puts formal sector operators at a competitive disadvantage if they are producing goods that can also be produced on a small scale by informal sector operators who do not pay taxes and licensing fees.

[42] See de Greef et al. (2003) which discusses various options for improving access to reliable information on biotechnology issues and short-term training opportunities aimed at increasing researchers' and policy makers' understanding of biotechnology issues.

- Develop capacity/procedures for certification of seeds (both animal and plant) and other inputs (fertilizer, pesticides, animal feed), using to the maximum extent possible existing laboratory facilities at LCV, FAST, and IER
- Develop and disseminate information about biotechnology in a manner that will bring all stakeholders (policy makers, researchers, technicians, and general users) to an informed level of understanding of the strengths and weaknesses of such technologies (to counter the misinformation now being popularized)
- Work with authorities (DGRC and MOE) to develop a biosafety regulatory framework, starting with plant biosafety so that researchers will be able to begin biotechnology trials and tests on insect-resistant cotton (as recommended earlier).
- Lobby the government to create a political environment that supports regulatory enforcement.

USAID has a number of centrally funded activities to assist developing countries establish standards and grades for agricultural products and to help exporters meet import requirements in the US and EU;[43] representatives of the appropriate Malian regulatory institutions and representatives of processors and exporters associations should investigate with USAID/Mali the possibility of getting assistance from these projects. Another recent seed sector assessment conducted for USAID/Mali provides useful insights (Christensen 2002).

The team also identified financing of private sector investment in the multiplication and marketing of S&T products as a "downstream" constraint to scaling up the promising products that are available. Coupled with this is the lack of farm-level credit for agricultural equipment and inputs, particularly outside of the irrigated rice and cotton zones. Given the magnitude of the financing problems in Mali and the amount of work that is being done on this issue by USAID's Mali-Finance project, the World Bank, and other donors, the team did not attempt to do more than note the importance of this constraint.

Another downstream constraint of particular relevance to exporters of agricultural products concerns packaging, storage, and processing supplies and equipment. Such constraints are causing loses and reducing profits from mango exports and represent potential constraints for the export of other fresh fruits and vegetables to the EU. The reader's attention is again drawn to the value-chain analysis of the tomato sector presented in Appendix 2, as it elaborates on the nature of these and other "downstream" constraints and offers potential solutions. Continued efforts to provide technical assistance to exporters through projects such as the now ended World Bank APROFA effort and USAID's Mali-Trade program are probably the best short-run means available for resolving these problems. In the medium- to long-run, Malian capacity for providing these types of services will need to be developed in both the private and public sectors.

[43] Assistance for Trade Capacity Building in Relation to the Application of Sanitary and Phytosanitary Measures (SPS) and Partnership for Food Industry Development- Fruit and Vegetables (PFID) are two examples.

7. Summary of Key Findings and Recommendations

From 1990 through 2001 Mali made good progress in terms of building S&T research capacity, improving research planning and management, and producing a wide range of S&T products. The decade was characterized by significant improvements in the number of scientists with advanced degrees in research and teaching institutions and with some improvements in the amount of funding available per researcher. An increasing number of students from Mali and elsewhere have been trained in agricultural sciences at IPR. Malian researchers have produced a steady stream of new S&T products capable of increasing farm-level productivity (e.g., improved plant and animal breeds, improved animal feed and diagnostic products, productivity increasing and resource conserving natural resource and water management practices).

7.1. Strategic Options for Mali's S&T Community to Pursue

Strategic options identified for improving S&T in Mali are divided into two groups: those relevant to expanding the use of existing S&T products and those relevant to maintaining or improving S&T capacity.

7.1.1. Expanding Use of S&T Products to Meet National Development Goals

Short-run options (results in 1-5 years). The team has identified four short-run strategic options that appear to hold the most promise for (a) rapidly expanding uptake of productivity enhancing S&T products, (b) stimulating a virtuous cycle of subsequent S&T product adoption, and (c) reducing poverty. They include:

- Promotion of proven soil and water conservation and management practices
- Development of a commercial seed sector
- Promotion of improved breeds and disease control products for poultry and small ruminants
- Promotion of improved animal feeds

Two supporting activities are also recommended: (a) exploration of technical assistance options enabling IPR to close temporary gaps in teaching and research capacity, and (b) increased information and training on the potential benefits of improvements in the regulatory environment.

Top priority should be given to a strategy of rapidly and widely promoting proven soil and water conservation practices (section 6.3.1), water management products to increase the productivity and efficiency of water use for small scale irrigation systems (section 6.3.2), and practices that increase fertilizer use efficiency (section 6.3.1). These products and practices have the potential to substantially reduce poverty in large parts of Mali's rainfed agricultural zones and to stimulate the adoption of intensification practices involving purchased inputs such as improved seeds and fertilizers. Furthermore, promotion of these S&T products has been shown to have important spillover effects that contribute to improved governance and health (through better access to water).

Given weaknesses in existing S&T monitoring and evaluation systems (section 6.2), there is not adequate knowledge about where these recommended practices have already been

adopted and the enabling factors; hence, the promotion strategy should include as a first step an assessment of common constraints to adoption and how they were overcome by the early adopters (Box 2). This information should then be used to develop strategies for scaling up the S&T products to the next group of potential adopters. In situations where there appears to be a need for government investment or external resources to stimulate adoption (e.g., transport of rocks for rock lines, low-cost services for marking contours, project assistance to develop a commercial supply of small scale pumps), analyses of the costs and benefits of such assistance should be conducted by researchers in collaboration with extension services and farmers to see if there are economic grounds for assistance.

The team views the development of a viable commercial seed multiplication and marketing system as the second priority item in terms of strategic options likely to increase the uptake of improved S&T products (section 5.1.4). Mali's traditional approach using a government-run seed service and contract farmers is not working. Alternative strategies need to be developed collaboratively with potential investors and by studying successful seed systems elsewhere in Africa. A major component of this strategy will be the development of effective seed certification and enforcement mechanisms (section 6.3.3).

The short-run strategy recommended for the livestock sector is to prioritize the dissemination of improved S&T products for poultry and small ruminants; these are the animals that are most important to women and the poor. Available products include improved breeds and disease control products (section 5.2.3). A related activity would be the promotion of improved animal feeds, with attention to disseminating information and training on improved fodder in rural areas and support to the development of a feed industry in urban areas (section 5.2.2). As with the seed sector, effective certification and enforcement mechanisms will be needed to protect investors in a commercial feed sector (section 6.3.3).

An option that should be pursued to support the priority actions mentioned above is the identification of temporary solutions to compensate for lack of teaching capacity at IPR in agribusiness analyses, agricultural economics, and water management. Because IPR is currently unable to provide adequate training in these areas, it is recommended that they solicit donor assistance to (a) obtain short-term curriculum development and teaching assistance from EU and US universities specializing in these areas, (b) explore the possibility of using qualified personnel associated with in-country projects as sources of part-time instructors or research advisors in these fields, and (c) explore options for distance learning or visiting faculty programs.

Improved access to documentation and short-term training for both public and private sector actors on the benefits of developing grades and standards, product certification programs, and enforcement mechanisms is essential to support the strategic options listed above. The importance of these topics appears to be underappreciated by the S&T community in Mali. Improved understanding by researchers, the commercial sector, and policy makers of the potential benefits could considerably speed of the process of putting

in place a regulatory framework that would serve the seed, feed, and biotechnology sectors.

Medium- to long-term options (results in 5-10 years). Strategic options likely to produce results in the medium term include a program of regular, systematic monitoring and evaluation of S&T product dissemination and scaling up activities, the introduction of insect-resistant biotechnology products such as Bt cotton and Bt maize, and a reduction in the costs of artificial insemination and potato seed through input substitution.

Monitoring and evaluation programs need to become an integral part of research-extension activities and be used as learning exercises rather than for perfunctory reporting of accomplishments to justify donor funding. There is no systematic effort to evaluate how many adopters there are, where they are located, whether they continue to use the product over time, what constraints they had to overcome to adopt the product, whether they made modifications in the product or the way it was applied. Farmers in Mali are not a homogeneous group. As the circle of adopters grows wider, encompassing less skilled farmers with fewer and lower quality productive resources, the need for researcher assistance to adapt S&T products to different situations may well be increasing rather than decreasing.

The evidence (based on growing global experience and recent field trials in Burkina Faso) is quite strong that Bt cotton can significantly increase yields and reduce pesticide costs, making Malian cotton more competitive in international markets (section 5.1.3). The evidence on maize is less strong at present, but merits further research (section 5.1.4). The sooner the S&T community mobilizes resources to begin addressing the identified constraints, the more likely Malian farmers will be realizing the benefits by the end of the decade. A major hurdle will be dealing with biosafety and regulatory issues (hence the recommendation in section 6.3.3 for information campaigns to increase both researcher and stakeholder understanding of the benefits to be gained from improved regulatory measures).

To realize the full potential of Mali's cattle breeding program to increase milk and meat production, it will be necessary to reduce the costs of artificial insemination and make it more widely available (section 5.2.3). Benefit/cost analyses need to be conducted of the potential for local production of animal seed to respond to these needs; if the results are promising, development of this capacity should be undertaken as a medium-term strategic option. Success in this effort will also depend on success in developing low-cost commercial sources of balanced feed because improved breeds will have more demanding feed requirements.

The situation for developing a local potato seed sector is similar; there is a need for solid analyses of the potential costs and benefits of scaling up microtuber multiplication to a level that would meet national and regional potato seed demand; if the results of the financial analysis are promising, downstream constraints such as financing, cold-storage, and quality certification will need to be addressed.

7.1.2. Strategic Options for Addressing Institutional and Capacity Constraints

Despite the improvements in S&T capacity realized during the past decade and the availability of numerous S&T products, the assessment team identified a number of weaknesses in the research, teaching, and extension system that will need to be addressed during the next decade if Mali's S&T community is to continue to respond to the changing demands of its clientele. Among the key weaknesses identified were:

- Less than optimal collaboration among Malian research and teaching institutions, leading to less than optimal use of limited infrastructure and human resources;
- Need for increased attention to regional S&T strategies that would increase efficiency at both national and regional level (particularly important for future work in biotechnology);
- Weak research links to extension, particularly with respect to disseminating information about new products and participating in monitoring/evaluation efforts of S&T product uptake;
- No capacity in teaching and research establishments to deal with "downstream" constraints to adoption such as product certification, regulatory and enforcement, finance, and general agribusiness issues[44]
- Weak research and teaching capacity in disciplines of growing importance to Mali's evolving agricultural sector (water management, agribusiness, agricultural economics, GIS/RS).

Strategic short-run options for improving inter-institutional collaboration have been identified (Table 11); the challenge will be implementing these recommendations in the short-run while developing appropriate long-run strategies to increase the capacity of the overall system in a manner that avoids overcapacity in some institutions while there is under-capacity in others.

The importance of regional collaboration in S&T research and extension is increasingly evident (Eicher 2003). A quick look at any map of soil and climate characteristics for West Africa shows that each country includes multiple agroecological zones that are shared with neighboring countries. Because S&T products need to be designed and disseminated by agroecological zone, more attention needs to be given to the development of cross-country collaborative efforts and strategic planning at the regional level. This strategic planning should aim to create regional centers of excellence for both teaching and research rather than a proliferation of small, mediocre training and research institutes with inadequate human resources and infrastructure.

The team has identified weak research links to extension as probably the single biggest constraint on rapid uptake of available S&T products. While much of the responsibility for dissemination of S&T products is given to the extension services, and they have not been performing well, the failure of researchers to be actively engaged in the

[44] This has not traditionally been considered an area of interest for the agriculture research and teaching community as the DGRC has primary responsibility for regulatory issues, but it is recommended that some expertise be developed by IPR and IER given the extent of the regulatory issues that seem to be constraining dissemination of S&T products and limiting effective demand for laboratory analyses. This would improve the scientific community's ability to communicate their needs to DGRC.

dissemination of information about their research results and in regular monitoring and evaluation activities during the entire dissemination and scaling up process appears to be a major constraint to rapid uptake. Moving toward the type of monitoring and evaluation system described above (section 6.2) will be a first step. For this to happen, research institutions will need to broaden their concept of where S&T research ends and create an incentive structure that rewards not only technology development but also technology uptake. The use of joint appointments where individuals are contracted to devote a specified share of their time to both research and extension activities, is one option among many that could be considered.

In addition to developing better research-extension links, Mali will need to develop a more responsive and efficient extension system that is capable of getting beyond that first group of adopters, usually represented by the wealthier, more progressive farmers, who are frequently also the only adopters. Poor skills and lack of incentives for extension agents may be part of the problem, but there are major structural and conceptual problems that also need to be addressed; this is a problem Africa-wide.

Another significant problem, which will grow in importance during the next decade as Mali's agricultural sector becomes more market oriented, is the lack of capacity to address "downstream" constraints to adoption. At present, IER is focusing most of its efforts on developing S&T products to improve farm productivity, leaving research on the downstream opportunities and constraints largely to donor funded projects or short-term consultants. The team believes that Malian capacity for dealing with these downstream issues (e.g., marketing, business plans, regulatory, processing, finance and trade) needs to be developed both in the public and the private sector. This may require some changes in the mix of disciplinary skills and the incentive structure of Mali's research and teaching institutions if they are to remain relevant and responsive to an evolving clientele. It is too soon to tell if the innovations introduced through PASAOP are a step in the right direction for addressing these problems. The team's contacts with CRU members suggests that much remains to be done if the CRU is to provide a useful liaison between research and clients, particularly poorer farmers (section 4.1 and Appendix 3). Also, the initial distribution of funding through the PASAOP institutional support program and competitive bidding process did little to improve the very uneven access to research funding that is apparent across institutions.

In the short-run, there is a need for IPR to find ways to fill in the gaps so it can train students in key emerging areas (sections 6.1 and 7.1). In the medium to long-term, there is a clear need to build teaching and research capacity in the areas of water management, agribusiness, and agricultural economics through long-term training (sections 6.1, 6.3.1, and Edwin et al. 2003). There is also a potential need for long-term training in disciplines that would contribute to biotechnology research programs, but specific strategies for long-term training need to be derived from regional and national strategies for development of specific types of biotechnology products—these strategies are still under discussion.

7.2. Strategic Options for USAID Support to Malian S&T Development

The assessment team identified a number of areas where USAID/Mali is well placed to offer support to Malian S&T programs. Among the most important options are increasing the capacity for collaborative research and training through ongoing projects, taking advantage of inter-sectoral synergies among USAID-funded health, governance, and agricultural projects, providing financial support for capacity building through long-term training of Malian scientists and short- to medium-term technical assistance to fill in current human resources gaps, and working with the GRM and other donors to promote inter-institutional and regional collaboration in S&T activities capable of increasing the quality and reducing the costs of agricultural research and training programs throughout West Africa. Each of these options is discussed briefly below.

USAID is now supporting three major agricultural development projects, all of which are well positioned to assist in the implementation of the strategic options outlined above. The work being done by these projects provides an excellent environment for on-the-job training of students and faculty at IPR and researchers at IER. A key recommendation is that USAID consider the extent to which the existing projects could be modified to include capacity building components that would address the short-term capacity gaps in agribusness, agricultural economics, and water management at IPR and IER (e.g., part-time teaching assignments or collaborative subsector analyses involving project personnel; project add-ons that provide for technical assistance in curriculum development and staff training from US universities; financial support for IPR students and faculty wanting to conduct research on topics of relevance to USAID projects).

PRODEPAM can be used as a workshop for testing alternative approaches to extension, for implementing the DAA research recommended for scaling up adoption (Box 2), and for helping the research-extension system to develop sound monitoring and evaluation programs. PRODEPAM should encourage IER, LCV, and DNAMR to work with them on the dissemination of S&T packages of relevance to targeted PRODEPAM zones.

Because of the synergies between NRM and other development goals in poverty alleviation, governance, and health, USAID should promote inter-sectoral collaboration within their own project design and implementation framework. Health and governance projects can be used as vehicles for promoting NRM and the dissemination of high nutrient cereal varieties and aflatoxin kits developed by S&T research; similarly, agricultural programs can be used to support health and governance activities.

USAID has a long experience and excellent reputation in terms of long-term training in Africa. US universities are particularly strong in the areas where S&T capacity is weakest…water management, agribusiness and agricultural economics. While some short to medium term support to fill the current gaps in human capacity at IPR will be essential, longer-term training to provide qualified faculty in these three key areas of emerging demand will be essential and USAID should not miss the opportunity to be involved. In addition, USAID should work with the GRM to ensure the training of a new generation of scientists to replace those who are nearing retirement age. This support should include long-term training through “sandwich” programs recommended by the

recent USAID capacity assessment (Edwin et al. 2003) and medium-term funding to provide employment for recent graduates while they await the opening of more permanent positions through retirements (section 6.1.3).

Finally, GRM-donor coordination of funding for agricultural training, facilities, and research budgets is needed. In the absence of donor coordination, Malian institutions will have a tendency to compete with each other for government and donor funding rather than to collaborate in building a solid research system that responds to both national and regional needs. The mid-term evaluation of PASAOP revealed substantially less bilateral support to the SNRA through this coordinating mechanism than anticipated. This results in individual institutions relying on multiple bilateral programs that may well be increasing administrative costs, not contributing directly to overall Malian strategic objectives, and, in some cases, reducing incentives for intra- and inter-institutional collaboration among Malian researchers working on similar topics. The team was presented with multiple examples of situations calling for better GRM-donor collaboration, not only in terms of support to S&T product development but also in terms of support to subsector analyses and investments to break downstream bottlenecks (e.g., cold storage, transport).

References Cited

Alhassan,W. 2003. Agrobiotechnology Application in West and Central Africa. 2002 Survey Outcome. Unpublished report.

Alston, J.M., C. Chan-Kang, M.C. Marra, P.G. Pardey, and T.J. Wyatt.. 2000. A Meta-Analysis of Rates of Return to Agricultural R&D: Ex Pede Herculem? IFPRI Res. Rep. 113, International Food Policy Research Institute, Washington, DC.

Anderson, J. R., and G. Feder. 2004. Agricultural Extension: Good Intentions and Hard Realities. The World Bank Research Observer, 19:1:41-60.

ARD. 2002. Mali: An Analysis of the Benefits and Costs of Alternative Irrigation Investments. Burlington, Vermont, USA.

Cabanilla, L. S., T. Abdoulaye, and J. Sanders. 2004. Economic Cost of Non-Adoption of Bt Cotton In West Africa: With Special Reference to Mali. Unpublished project report.

Christiansen, P. 2002. Mali seed sector development plan. Draft report prepared by Abt Associates for USAID/Mali.

de Greef, W. no date. Concept Note: Protecting tomato production in Mali against TYLCV, PRODEPAM report.

de Greef, W. no date. Concept Note: Development of the local seed market, a viable seed potato sector in Mali. PRODEPAM report.

de Greef, W., C. Fauquet, and O. Niangado. 2003. Consolidated Report: Biotechnology Assessment Mali. Unpublished report.

de Greef, W. 2005, Seed Sector Note. Unpublished document prepared for the S&T Assessment Team.

Dorsay, J., and S. Kouyaté. 2004. Le Risque du Crédit Agricole dans les Zones de l'Office du Niger et de la CMDT. Report prepared for USAID/Mali by Chemonics International, Inc.

Edwin, J., W. DeLauder, N. Traoré, and M. Koné. 2003. Mali Long Term Training and Capacity Building Needs Assessment. Africa Agriculture Capacity Development Training Initiative Strategic Technical Assistance for Results with Training (START). Report prepared for USAID/Mali by The Academy for Educational Development, October 2003.

Eicher, C. 2003. Flashback: Fifty years of donor aid to African agriculture.Revised version of a paper presented at an International Policy Conference "Successes in African Agriculture: Building for the Future", sponsored by InWent, IFPRI, NEPAD and CTA, Pretoria, South Africa, December 1-3, 2003.

Gilbertson, R., M. Jahn, V. Lavasseur. and K. Gamby. 2004. Application of Biotechnology to the Tomato Virus Crisis in West Africa, ABSPII.

IER (Institut d'Economie Rurale). 2003. Etat de la Recherche Agricole au Mali. December 2003. IER Report, Bamako.

Integrative Framework Team. 2004. Expanding and Diversifying Trade for Growth and Poverty Reduction: A Diagnostic Trade Integration Study. Draft report (copy used did not include full attribution).

Lamb, J., M. Alvarez, L. Beach, J. Becker, C. Bonsi, J. de Voest, S. Gavian, J. Knowlton, W. Norman, T. Pomeroy, and M. Satin. 2004. Summary and Findings of the West African Cotton Assessment. Unpublished report prepared for USAID.

Monsanto. 2004. Unpublished report on Monsanto Field Trials, Burkina Faso.
Oehmke, James F., and Eric W. Crawford. 1996. The Impact of Agricultural Technology in Sub-Saharan Africa. J. of African Economies 5(2):271-92.
Sanders, J. 2003. Economic and Sustainability Evaluation of New Technologies in Sorghum and Millet Production in INTSORMIL-Priority Countries. The International Sorghum and Millet Collaborative Research Support Program (INTSORMIL). Annual report 2003.
Stads, G-J., and A. Kouriba. 2004. Agricultural Science and Technology Indicators, Country Brief No. 17, July, 2004. IFPRI and IER, Washington, DC and Bamako.
Tefft, J., and V. Kelly with LICNAG Research Team. 2004. Understanding and Reducing Child Malnutrition in Mali: Interim Research Findings for the Project on Linkages between Child Nutrition and Agricultural Growth. Dept. of Agricultural Economics Staff Paper 04-27, Michigan State University. E. Lansing, MI.
Yapi, A.M., A.O. Kergna, S.K. Debrah, A. Sidibé, and O. Sanogo. 2002. Analyse economique de l'impact de la recherché sur le sorgho et le mil au Mali. IER, Bamako.
Yiriwa Conseil. 2001. Etude pour la promotion des filières agro-industrielles. Unpublished report prepared for USAID Mali.

Appendix 1. Principle Contacts

Approtec: Nick Moon, Africa Director
CIRAD: Renou Alain
CNRA: Adama Traoré
Coordination National des Operateurs Economique du Mali: Souléman Nymaga
CRU Bamako/Koulikoro: Aissa Touré, Dramane Niaré, Mme Diarra Tata Keita, Mamadou Traoré, Ibrahima Diakité
DNH: Almoustapha Fofana, Sidi Toure, Chef de Division Inventaire Ressources Hydrauliques
DNAMR: Amidou Sangaré, M. Samaké (encadreur Konobougo)
FAST: Ousmane Koita, ?? Bouaré
ICRAF: Bocary Kaya, Antoine Kalinganire, Brahima Koné
ICRISAT: Benoit Clerge, Pierre Sibiry Traoré, E. Wettzien, F. Rattunde, Fabrice Sagnard
IER/CRRA, Sikasso: Boubacar M. Cisse, Deputy Director
IER: Bino Teme, DG; Siaka Dembelé, Lassine Diarra, Scientific Coordinator; Mamadou Doumbia, Head of Soil, Water & Plant Laboratory; Dor Guindo, Hamidou Nantoumé, Mamadou D. Coulibaly, NGolop Koné, Bamory Koné, Moctar Traoré, Mme Cissé Oumou Traoré, Abou Berté
INSAH: Idriss Alfaroukh, DG; Laomaibao Netoyo, Anguibou Coulibaly, , Boubacar Diallo
IPR/IFRA: Fafré Samaké, Alhousseini Bretaudeau, Drissa Diallo, Issiaka Dembelé, Bakary M. Traoré, Lassine Diarra, Lassizze Solimano, Kardigi Coulibaly
LCV: Mamadou Niang, Dir; Boubacar Diallo, Deputy Director; Saidou Tembely, Mme Traoré Aissa Koné
Mali-Finance: Warren Chase,
Mali-Trade: Harvey Schartup
Office du Perimetre Irrigué de Baguineda: Silikou Sanogo, DG; Ibrahim Ajara, Irrigation Engineer - Infrastructure
OHVN: Malick Tessougué, Békaye Traoré, ?? Bagayoko
PASIDMA: Nango Dembelé
Private Sector: Pascal Achcar
PRODEPAM: Benjamin Lentz, Chief of Party; Mamadou Kabirou N'Diaye, Aly Coulibaly, Fatoumata Salamanta, Ryan Roberge, Robert G. Wilkens, Bernard ??, Willy De Greef, Dick Cook
Soils CRSP: Russel Yost
Syngenta Foundation: Oumar Niangado
USAID: Pam White, Jean Harman, Dennis McCarthy, Ram Shetty, Gaussou Traoré, Augustin Dembelé
WARDA: P. Justin Kouka, Assistant Director - Corporate Services; Phillippe Moran, Director - Inland Valley (Bas Fonds) Consortium

*This list is missing some of the contacts made by Tom Easterling and Mike McGahuey

Appendix 2. Illustrative Value-Chain analysis using Mali's Tomato Sector

Processing tomatoes[45]

The tomato agro-industry is a study in duality, with two distinct sub-sectors: fresh tomatoes and processing tomatoes. Not surprisingly, these two sub-sectors are entirely different throughout their respective value chains. For example, processing, or "industrial" tomatoes are special varieties that are grown intensively, and will normally produce tomatoes at much higher yields than do fresh tomatoes. Furthermore, the percentage of soluble solid content in processing tomatoes is nearly double that of fresh tomatoes. As a result, a smaller amount of processing tomatoes is required to produce a kilo of tomato paste than would be needed to make the same amount of paste from fresh tomatoes. Processing tomatoes normally have around 6 percent solids, whereas fresh tomatoes have only about 3% solids. The remainder is water and consequently, the process of extracting the water from the solid particles to produce tomato paste is expensive. More water must be removed from fresh tomatoes than from processing tomatoes to make equal amounts of paste. Since water removal requires energy, and energy is costly, the manufacturing process to produce tomato paste from fresh tomatoes is more expensive than that for processing tomatoes.

While fresh tomato varieties are not desirable as processing tomatoes, the opposite situation does not hold: In Mali, tomatoes are consumed primarily as food condiments or sauces, and are not commonly consumed as a fresh fruit. Consequently, processing tomatoes could be easily sold into local markets. In fact, processing tomatoes are desirable because they are somewhat hardier than fresh varieties because they have tougher skin and can better withstand rough handling after being harvested.

Fresh-market tomatoes are sold through different distribution channels, normally at higher and more variable prices than industrial tomatoes due to larger production costs and greater market uncertainty. While fresh tomatoes are typically sold by the farmer at US $.55 - $.75 per kilogram in the United States, processing tomatoes are valued at about US $.07 per kilogram. In most tomato producing countries of Western Europe, as a result of government subsidies to their farmers, processing tomatoes are sold as little as US $.05 per kilogram.

The industrial tomato can be processed into a range of products, of which the principal commodities are the following:

a. Tomato paste
b. Canned, peeled tomatoes
c. Dried tomato slices, tomato powder and tomato flakes
d. Deep-frozen tomatoes, either whole or in pieces
e. Tomato juice and tomato sauce

Tomato Processing in Mali

Mali's history of processing tomatoes has been uneven. Since independence, there has been only one processing plant for tomatoes and other fruit. Installed in 1964, the Société des Conserves du Mali (SOCOMA) was a state-owned enterprise located in

[45] This appendix was prepared by team member Tom Easterling.

Baguineda, constructed with funds provided by the Government of Yugoslavia. The processing plant had two processing lines: one for processing tomatoes into double concentrate, and one line for mango pureé. The objective was to produce tomato paste to substitute for paste imports and to add value to surplus mango production that would have otherwise have been lost; and to market these finished products into local markets. In 1970, SOCOMA installed a processing line for fruit juice production from tropical fruit, including mango and tamarind.

Management and technical difficulties led to the partial privatization of SOCAMA in 1978, and a new enterprise was formed under the name Société des Conserves Alimentaires du Mali (SOCAM), a mixed company with 90% of its capital held by the Government of Mali (GOM) and 10% held by a French private company.

SOCAM was in existence for only two years. In 1980 the company was registered as a private company, and its name was changed once again to Société Malienne des Conserves, SA (SOMACO). The new company's ownership was GOM – 10% ,Malian private operators 40%, and the French group, 40%.

SOMACO continued with little progress into the 1990s, and in 1995 the French partners gave up their ownership. In 1997, under its Agribusiness Development project, USAID supported a program by the *Office de Haute Valle du Niger* to organize its farmer groups to produce 850 tons of tomatoes for processing by the factory. Around 3,500 small farmers participated in the effort. Despite these efforts, SOMACO finally closed its doors in 1998. Many of the small farmers who produced industrial tomatoes for SOMACO have continued growing fresh tomatoes for urban markets in Mali.

Potential for Using Science and Technology as Tools for Renewing the Processing Tomato Sub-sector in Mali

The following are science and technology (S&T) and key research activities that can potentially support the renewal of a processing tomato agro industry in Mali. Most of these concepts are applicable to virtually all agro-food processors:

a. Market research: The potential investor should conduct market research to determine the potential size of the market for processed tomato products in Mali, as well as the specific products that have the greatest demand, and the specifications for those products. For example, it was reported that SOMACO's products were pale compared to the rich, red color of the imported Italian tomato paste, which the Malian consumer preferred. This placed SOMACO's products at a market disadvantage. Research should also be conducted to determine the potential for exporting tomato products produced in Mali to regional markets.

b. Technology and equipment: The potential investor should select the technology and equipment that is most adaptable to the field conditions in Mali. For example, in view of the general difficulty of equipment repair and maintenance in Mali, it would likely be wise to choose equipment that is relatively easy to maintain. Equipment capacity will, of course, be guided by the availability of investment capital and the results of market research.

c. Volume of Tomato production: Let us assume that the potential investor assumes that market demand is 5 kilograms of tomato paste per capita for Mali's 4 million

urban residents and one kilogram per capita for its 8 million rural residents. Total annual demand would be 28,000 tons of paste, corresponding to 140,000 tons of tomatoes. All the tomato paste consumed in Mali is presently being imported. If the investor calculates that he or she could capture one-half the total annual demand of 14,000 tons of paste (corresponding to 70,000 tons of tomatoes), then the factory processing capacity should be scaled up to approximately 100,000 tons of tomatoes. Since most tomatoes are cultivated during the "contre-saison" and the annual harvest occurs during April-May-June period, considerable work will have to be done to spread the tomato harvest period over a longer period. Otherwise, the flood of tomatoes during the brief harvest period will greatly exceed the factory capacity.

d. Timing of harvest: To avoid exceeding the factory capacity even under a two-shift operation, the annual tomato harvest should take place over a minimum period of six months, and preferably longer. This will require staggering the planting so the annual harvest period occurs, say, between February-August. Extending the production season will require considerable adaptive research to select and test plant varieties that can be planted for harvest during the extended time period. Such a project could easily be carried out by ON with the support of the Institut d'Economie Rurale (IER), with possible funding from USAID.

e. Production source: If given the choice, most tomato processors would like to directly control approximately 35 – 40% f their raw material supplies, and contract with outside growers for the remaining amounts. To produce the annual requirement of 70,000 tons of tomatoes would require a production of 2,000 hectares, assuming an average yield of 35 tons per hectare. Under this scenario, the processing plant would obtain a long term lease for a maximum of 700 hectares, and use this area as a "mother farm". It would contract with local farmers to produce tomatoes on an additional area of 1,400 hectares of "satellite" farms. The satellite farms would be operated by experienced small farmers within the irrigated area within range of the processing plant. This arrangement would ensure the rapid dissemination or production practices and technology put into practice at the mother farm, onto the satellite farms as well. If it was not possible to develop an entire, large-scale "mother" farm, then a smaller, "model" farm should be operated commercially by the investor, for the purpose of demonstrating appropriate agricultural practices. In this case, the entire production volume would be provided by small farmers under contract with the factory. In either case, technical staff from the IER and the ON should be involved in the design and establishment of research and development plots on the mother (or model) farm, and for transferring the knowledge gained to the small tomato producers.

f. Planting material: High yielding plant varieties combined with intensive agricultural practices under irrigated conditions are critical elements in the economic success of a tomato processing agribusiness. In addition, as described earlier, the production season must be extended for a longer period during the year to smooth the production curve for efficient factory operations. For these reasons it will be necessary for the tomato processor to establish and operate a

plant nursery to produce tomato plants for distribution to the contracted small farmers. In this manner, the processor will control the timing of planting, the plant varieties, and the seasonality of production.

g. Pest and disease control: Yellow leaf virus (TYLCV) is a major problem for tomato producers in Mali, and was cited as one of the factors that led to the closure of the SOCAMO factory. This virus reduced crop production to the extent that few tomatoes were available for processing. While considerable work has been done by IER on selecting and testing virus-resistant varieties, much work needs to be done in this field. Developing the means to control the virus and/or to develop virus resistant plants would be a major element of a processing tomato agribusiness in Mali. Other prevalent pests and disease problems affecting tomatoes can be controlled through appropriate agriculture practices.

h. Contracting mechanism: Small farmers should be contracted to provide a specified, minimum quantity of processing tomatoes at a specified price, with the possibility that additional quantities produced might be purchased by the factory. Also, the farmers should be encouraged to produce additional amounts of processing tomatoes to be sold into local markets. It would be to everyone's advantage – the factory, as well as the small farmers' – that the local market for fresh tomatoes be fully supplied with industrial tomatoes, so that the local market price would be approximately in line with the factory price. That way, there would be little price incentive for the farmers to divert production from the factory into local markets.

i. Credit: Similar to the practice that prevails in the cotton industry, it may be required that the processor provides farm inputs to all its contracted small farmers. However, for commercial reasons it would be much more desirable if farmers' village groups and associations could obtain seasonal credit from the banking sector or micro-credit associations for its members, on the basis of the tomato purchase contract between the farmers' association and the processing plant. Otherwise, in-kind credit as farm inputs must be provided by the processor to the farmers, with their values deducted from the amounts paid to the farmers for tomatoes delivered to the processing plant. This practice will normally create a problem for the processor, since it is in the individual farmers' short-term interest not to deliver his or her tomatoes to the processing plant; instead, to sell the tomatoes on the local market even at lower prices, since no deduction for inputs is made from local market sales. In the event that the processing plant is required to provide farm inputs, it would be wise to have a collective agreement with the farmers' association, instead of individual farmers. In this manner, some degree of protection would be provided to the processing plant to ensure repayment for inputs and the delivery of contracted amounts of processing tomatoes through group solidarity.

j. Value of production: For competitive reasons the business of food processing is normally characterized by low unit margins and high unit volumes. To be competitive, a tomato processor in Mali must be capable of producing tomato products of equal quality, and at a cost that is no greater than the cost of imported

products. While there is some degree of tariff protection[46] provided to processors located within the West African Economic and Monetary Union (WAEMU), there is also a possibility that "leakage" may result in lower-cost products imported illegally, as is reported to be the case for imported sugar.

As shown by the following table, the landed cost of tomato paste imported into Mali from Italy, the nearest low-cost producer, is estimated to be US $2.25 per kilogram. This is the maximum amount that a tomato processor in Mali could charge if it is to remain cost competitive with imported paste.

Estimated Delivered Cost of Imported Tomato Paste

Item	Cost (US$ per kilogram of paste)
Processing tomatoes (1)	0.25
Manufacturing costs and margin	1.00
Transportation to Mali; handling	0.25
Import duties	0.75
Total	2.25

(1) In Europe, on average, 5 kilograms of processing tomatoes are required to make one kilogram of tomato paste.

The cost assumptions are the following: the cost of 5 kilograms of industrial tomatoes at US $.05 each, or a total of US $.25; the cost of producing one kilogram of paste, including manufacturers' margin, is US $1.00; transportation cost to Mali is US $4,000 per 20-ton container, or US $.20 per kilogram; import duties amount to US $.75 per kilogram, and handling charges amount to US $.05 per kilogram.

Despite the cost advantage of a manufacturing processing in Mali that is not subjected to import duties, however, much of the cost benefit will be eaten away by higher manufacturing costs. This is due to the requirement to import cans and labels, and greater processing costs caused by high electricity rates in Mali. To be cost competitive with imported tomato products, it will be necessary place a ceiling on the cost of tomatoes used as raw materials. Approximate manufacturing costs for tomato paste in Mali will be the following:

[46] Processed food items are assessed a duty of 60%.

Estimated Cost of Manufacturing Tomato Paste in Mali

Item	Cost (US$ per kilogram of paste)
Processing tomatoes (5 kilograms)	0.50
Manufacturing costs	1.50
Taxes and profit margin	0.25
Total	2.25

Under this example, given the price ceiling imposed by imported tomato paste, the maximum amount that the factory can pay to the farmers for processing tomatoes is the equivalent amount of US $.10 per kilogram (50 FCFA per kilogram), or US $.50 for 5 kilograms of tomatoes that are required to manufacture one kilogram of tomato paste.

However, the small Malian farmer who currently produces limited quantities of "contre-saison" tomatoes on irrigated farmland sold as fresh fruit into local markets enjoys higher prices, on average, than the processing plant would be willing to pay. Based on a recent study by the Mali Finance Project[47], small farmers, on average, produce 0.2 hectares of fresh tomatoes for self-consumption and for local sale, which are sold at an average price of 75 FCFA per kilogram. Their average production yield is 17.4 tons per hectare. As shown by the following table, for small farmers to obtain about the same income per hectare from selling industrial tomatoes to the factory at a lower price than they can obtain by selling fresh tomatoes into local markets, their production yield must approximately double, to around 36 tons per hectare.

Determination of Farmer's Yield to Maintain Income at Lower Price

Item	Fresh market production	Industrial production
Production yield: tons per hectare	17.4	36.0
Revenue per kilogram (FCFA)	75	50
Total revenue per hectare (FCFA)	1,305,000	1,800,000
Costs per hectare (FCFA)	389,350*	864,000**
Revenue per hectare (FCFA)	915,650	936,000
**ibid.* **Author's estimate		

Note that to achieve a yield increase of 106%, costs must increase by 122%. The reasons are because to achieve greater yields, proportionally greater amounts of inputs are required, and additional non-family labor is needed, at a higher unit cost than family labor.

The table illustrates that the success of tomato processing is dependent on improving the average production yield to ensure that the small farmers' incomes

[47] Dorsay and Kouyaté 2004.

are maintained, and that the factory can maintain its competitiveness in the face of imported processed tomato products. This not only will require careful management of the entire production process, including the availability of irrigation water, as well as using the latest production technology to ensure that high yields are achieved. This effort merits the support of USAID, through ON and IER.

Summary:

The preceding discussion was intended to highlight the team's belief that there is no technological "quick fix" that will have a dramatic effect on reducing poverty in Mali. Instead, the judicious application of science and technology in support of sound management, combined with private investment for economic growth and job creation, is the recommended approach.

For example, USAID might support the development of a processing tomato agro industry in Mali by sponsoring a feasibility study complete with an operating plan that brings together all the science, technology, research and extension services to support the venture, and promote the opportunity among local as well as international investors.

Donor project resources can be of enormous value to reduce the risk to private investors in locations such as Mali. First, project resources can be used to help create or strengthen a value chain for marketable products within a chosen agro industry. Project interventions must be structured to support the weak links in the value chain. Normally, what this means is that the producers must be helped to produce the product with the quality, quantity and consistency of supply that the market requires. Another way to look at it is that project resources are used to reduce the risks run by the risk takers who choose to participate in this venture.

It is unfortunate, but dealing with small producers normally increases transaction costs because they are too small, too inefficient, have irregular production times, and more often than not, attempt to sell low quality products. Consequently, project resources must be used to help producers overcome quality and supply problems and to combine their output for greater efficiency. In this manner, the risk of market failure due to poor product quality and timing will be considerably reduced.

Creating a value chain in a developing location is normally an iterative process, because there are interlocking constraints that have to be overcome. This is a bit like peeling an onion. As you remove one layer, or solve one problem, there is another layer, and another problem, directly underneath. Work must be done to remove the major constraints that limit the efficient functioning of the value chain.

A second means for donor projects to increase private investment is to reduce the financial risk to the investor. Under this process, risk capital provided by a donor acting as a silent partner in a sound investment within a key sector can reduce the financial risk to a tolerable level for a private investor.

Appendix 3. Bamako/Koulikoro CRU Project Proposal

MINISTERE DE L'AGRICULTURE

REPUBLIQUE DU MALI
Un Peuple – Un But – Une Foi

COMITE NATIONAL DE LA RECHERCHE AGRICOLE (CNRA)

Commission Nationale des Utilisateurs des Résultats de recherche (CNU)

Programme de Renforcement des Capacités des Commissions Régionales des Utilisateurs des Résultats de la Recherche (CRU) du Mali

Octobre 2004

INTRODUCTION GENERALE

Le présent document est un Programme de renforcement des capacités institutionnelles et organisationnelle des Commissions Régionales des Utilisateurs des Résultats de la Recherche (CRU) du Mali. Il s'agit d'une proposition non sollicitée faite par la Commission Nationale des Utilisateurs des Résultats de la Recherche (CNU) à la Coopération Technique Hollandaise au Mali. Ce Programme s'articule autour de deux (2) composantes majeures :

- la Composante Formation des Ressources Humaines des CRU et
- la Composante Implantation/autonomisation Institutionnelle des CRU.

Ces deux composantes concourent au renforcement des capacités institutionnelles et organisationnelle des CRU et s'inscrivent parfaitement dans les stratégies de promotion d'un système de recherche participative développées par le CNRA.

1. CONTEXTE

Les CRU constituent une innovation importante dans le dispositif institutionnel de la recherche agricole au Mali. En effet, elles constituent une reconnaissance institutionnelle du rôle que les producteurs et transformateurs de produits agricoles peuvent jouer dans le processus de la recherche.

Ainsi, en quelques années d'existence et en la faveur de l'accompagnement méthodologique assuré par le CNRA, chercheurs et utilisateurs se sont découverts mutuellement et ont collaboré à l'élaboration et la mise en œuvre de projets de recherche à partir de contraintes identifiées sur le terrain.

Cette nouvelle approche de recherche participative comporte cependant un certain nombre de limites au niveau général et au niveau de chacune des CRU. Ainsi :

- les préoccupations des organisations de base dépassent souvent le cadre de la recherche d'où la nécessité de revoir les modalités de prise en charge des contraintes qui dépassent le mandat de la recherche,

- les CRU tiennent leur légitimité institutionnelle de la recherche agricole du fait de leur attachement institutionnel au CNRA,

- les difficultés de mobilisation des ressources propres pour assurer la pérennité du système et la non diversification des sources de financement,

- la faible implication de certains types d'utilisateurs que sont les ONG, les organisations paysannes fédératives, les Offices et /ou Opérations de développement, les Opérateurs économiques (intermédiaires).

- ♦ la faible prise en compte par les chercheurs des (savoirs) ou connaissances paysannes en matière de génération de technologies dans un processus réellement participatif.

Le présent Programme vise à corriger ces insuffisances pour que les CRU puissent jouer pleinement leurs rôles et responsabilités dans le dispositif de recherche-développement.

II. Composante Formation des Ressources Humaines des CRU

Malgré l'uniformisation des appuis techniques et méthodologiques apportés par le CNRA, l'évolution des CRU a été marquée par les disparités régionales en matière de dynamique associative et de développement.

Ainsi, si à Sikasso et Ségou, l'organisation de la CRU a été fortement marquée par la présence et les mécanismes d'intervention de la CMDT et de l'ON, à Kayes, Koulikoro et Mopti, elle s'est davantage construite sur la base des modèles ou typologie des organisations existantes. A Gao, il s'est agi surtout d'une représentation zonale. Ces différences de profil institutionnel basées sur la diversité des contextes régionaux ont eu des influences considérables sur la façon dont les CRU se sont organisées et la qualité de leur participation au processus de la recherche.

Cette analyse pose alors le problème de l'adaptation des appuis méthodologiques à la situation institutionnelle spécifique de chaque CRU et au contexte régional dans lequel elle évolue. Ce qui nécessite un diagnostic institutionnel et organisationnel singulier pour chaque CRU afin d'en identifier les problèmes et les contraintes qui entravent l'implication des utilisateurs dans le processus de recherche.

2.1 Description

A cette étape du projet, il sera engagé une étude diagnostique dite « Diagnostic Institutionnel Participatif » de l'ensemble des commissions à l'exception de celle de Sotuba qui vit cette expérience en ce moment. Ainsi, sept (7) Commissions que sont celles de Kayes, Sikasso, Ségou, Mopti, Tombouctou, Gao et de Kidal seront concernées par ce diagnostic. Il va se mener en trois (3) étapes pour chacune d'elles comme il suit :

- identifier les forces et faiblesses ainsi que les opportunités locales qui s'offrent à elle
- analyser les faiblesses et les traduire en défis afin d'identifier des actions pertinentes à entreprendre pour son développement organisationnel et institutionnel
- planifier la mise œuvre des actions identifiées

2.2 Objectifs

De façon globale, le Diagnostic Institutionnel Participatif des CRU contribuera à rendre plus efficace la participation des producteurs/transformateurs aux processus de recherches agricoles.

De façon plus spécifique, il s'agit de :

- Identifier les caractéristiques fondamentales qui déterminent les performances actuelles de chaque CRU en rapport avec son contexte régional ;
- doter chaque CRU d'un programme de développement organisationnel et institutionnel pour les trois (3) prochaines années.

2.3 Résultats attendus

Au regard des objectifs, l'exécution d'activités appropriées permettra de réaliser les résultats suivants :

- Un diagnostic institutionnel et organisationnel est réalisé pour chaque CRU, à l'exception de celle de Koulikoro en vue d'identifier ses forces, faiblesses et les problèmes qui entravent la participation efficace des producteurs/transformateurs dans le processus de la recherche
- Un bilan des activités est établi pour chaque CRU, à l'exception de celle de Koulikoro.
- Les cadres régionaux de recherche/génération de technologies pour le développement sont analysés pour chaque CRU
- Chaque CRU dispose d'un plan d'action triennal et un plan de communication opérationnel
- Chaque CRU dispose d'un plan de renforcement de ses capacités pour les trois années à venir

2.4 Démarche méthodologique

Pour la réalisation de ces résultats, la CNU engagera un bureau de consultants privés qui aura la responsabilité d'organiser le travail avec les CRU individuellement.

III. Composante renforcement des capacités des CRU

Cette composante comprend fondamentalement deux (2) parties qui sont la formation et l'appui institutionnel en vue de conférer à chaque CRU une existence matérielle et autonome dans le contexte générale des Organisations Communautaires de Base dans sa Région. En effet, les CRU ont progressivement occupé une place prépondérante dans le dispositif de génération et de transfert de technologie. Grâce à leurs capacités de formulation de contraintes (paysannes) et d'élaboration de plates – formes de ces contraintes, les CRU ont efficacement contribué à l'élaboration de programmes et de projets de recherche pertinents. Pour y parvenir, elles ont pu imprimer aux organisations paysannes particulières le dynamisme nécessaire dans la constatation, la formulation et l'expression des contraintes auxquelles elles sont régulièrement confrontées.

Les résultats de nombreuses activités de recherche effectuées dans le cadre de ces projets font en ce moment l'objet de vulgarisation. Les thèmes identifiés sont efficacement élaborés, clairement exprimés par l'encadrement et facilement assimilés par les

utilisateurs paysans. A cet titre, la Commission Nationale des Utilisateurs (CNU) et ses démembrements régionaux ont acquis une notoriété considérable auprès des services techniques et des producteurs et transformateurs. En ce moment, des intervenants extérieurs, intermédiaires ou partenaires au développement apprécient à sa juste valeur la contribution remarquable des Utilisateurs au développement de la recherche.

Grâce à ces facteurs, le système des CRU a vite fait de s'implanter et de s'affirmer. Elles ont pu régulièrement répondre aux nombreuses sollicitations et se rendre crédibles aux yeux de leurs partenaires et de leurs membres. Mais, force est de reconnaître que cette capacité de mobilisation et l'efficacité des actions sont fortement dues à l'ancrage institutionnel des CRU au système de la recherche piloté par le CNRA.

Dans un contexte d'autonomisation intégrale, il devient nécessaire pour les CRU de s'assumer en tant qu'acteurs de l'interactivité entre les communautés et les services et partenaires d'appui au développement. Elles doivent se donner les compétences et les moyens de continuer normalement leur mission : partenariat et participation effective des acteurs (producteurs et transformateurs) aux processus de la recherche agronomique. C'est pourquoi, un travail de fond pour l'autonomisation des CRU fut inscrit à l'ordre du jour de l'évolution de ces structures depuis leur création.

En effet, plusieurs fois, les responsables des CRU ont été avertis par le CNRA de la nécessité d'exploiter la piste CRU dans la problématique de la constitution de pôles organisationnels forts comme le préalable d'interactivité entre les communautés et les services et partenaires d'appui au développement. Cette interpellation de la CNU, à travers ses responsables et même à travers des membres généraux des CRU, fut très claire et assez forte lors de la formation de la CNU en janvier 1999 à Bamako et un an plus tard, en janvier 2000, à Sikasso à l'ouverture de la formation des formateurs. Au cours de ces évènements, le Secrétaire Exécutif et son assistant ont fortement insisté auprès de la CNU que l'autonomisation ne pourrait se réaliser concrètement et efficacement que lorsque leur organisation (le conseil des utilisateurs des résultats de la recherche) s'affirme et s'assume pleinement dans la voie de l'auto - développement. C'est ainsi qu'un atelier de réflexion tenu en fin d'année 2003 a retenu l'idée de créer pour chaque CRU de rechercher les facteurs identitaires adéquats qui lui permettront d'affirmer pleinement sa personnalité morale. Au nombre de ces facteurs, il y a l'implantation ou la matérialisation des CRU par l'existence et le fonctionnement de bureaux Régionaux.

3.1 Description

La composante renforcement des capacités des CRU consiste à doter ces dernières, dans toutes les Régions, des moyens de fonctionnement autonomes et à exécuter le programme de formation élaboré à la suite du diagnostic institutionnel participatif. Ce diagnostic n'étant pas encore réalisées, le contenu de ce dernier volet ne peut être exposé ici ni les moyens financiers nécessaires à sa mise en œuvre. Cette mise en œuvre doit faire l'objet de négociations ultérieures entre la CNU et ses différents partenaires financiers. A cet effet, l'exécution du programme de formation après l'implantation des CRU est, à la fois, perçue comme une partie intégrante et un résultat du présent projet lorsqu'il sera réalisé.

Quant à la dotation des CRU aux moyens de fonctionnement, elle consistera en l'ouverture et l'équipement de bureaux régionaux, d'une part, et, d'autre part, la mise en place de moyens de fonctionnement pour une période de douze (12) mois.

3.1 Objectifs

De façon globale, le Renforcement des Capacités des CRU contribuera à rendre plus efficace la participation des producteurs/transformateurs aux processus de recherches agricoles.

Les objectifs spécifiques de la composante sont :

- Développer les capacités institutionnelles des CRU par la matérialisation de leur présence dans les huit (8) différentes Régions du Mali
- Accroître l'efficacité des CRU tant dans l'organisation de ses ressources que dans sa participation aux processus de recherches (remontée des contraintes et utilisation des résultats) par leur dotation de moyens de fonctionnement adéquats ;
- Développer les capacités institutionnelles et organisationnelles des CRU par la formation de leurs ressources tant dans la gestion de ses organisations que dans la réalisation de leur objet (utilisation optimum et efficace des résultats de recherches).

3.2 Résultats Attendus

Avec la réalisation du premier volet de cette composante, il est attendu les résultats suivants :

- Les CRU disposent, dans les Régions, des points de contacts et de communication (échanges et informations) permanent avec ses membres et ses partenaires dans le cadre de la promotion de la recherche pour le développement durable
- Les CRU ont une visibilité institutionnelle assez nette qui leur permet d'agir efficacement et avec professionnalisme dans la mobilisation des ressources propres.
- Les CRU ont engagé des processus de négociation en vue de la captation de ressources financières nécessaires à la mise en œuvre de leurs programmes de formations.
- Les CRU ont développé des initiatives en vue de l'appropriation des charges récurrentes de leur fonctionnement (loyer, personnel et activités)

3.4 Démarche méthodologique

Pour la réalisation de ces résultats, la CNU engagera un bureau de consultants privés qui aura la responsabilité d'organiser le travail avec les CRU individuellement.

IV. Coût estimatif de la mise en œuvre du programme.

4.1 Composante Diagnostic Institutionnel Participatif

Rubriques	Unité	Coût Unitaire	Quantité	Montant
Etudes prospectives des CRU				
• · Transports et déplacements	Région	280 000	7	1 960 000
• · Perdiem délégués CRU	Région	20 000	7	140 000
• · Rémunération des consultants	Région	800 000	7	5 600 000
Sous - total 1				**7 700 000**
Ateliers de diagnostic				
• · Transports et déplacements	Région	950 000	7	6 650 000
• · Perdiem délégués CRU	Région	500 000	7	3 500 000
• · Frais d'organisation des ateliers	Région	610 000	7	4 270 000
• · Rémunération des consultants	Région	1 000 000	7	7 000 000
Sous - total 2				**21 420 000**
Productions et multiplication des documents				
• · Secrétariat	Région	100 000	7	700 000
• · Reproduction des documents	Région	100 000	7	700 000
Sous - total 3				**1 400 000**
Communication & Couverture médiatique				
• · Informations (téléphone et courriers)	Région	50 000	7	350 000
• · Couverture radio de proximité	Région	150 000	7	1 050 000
• · Couverture télévisuelle	Région	210 000	7	1 470 000
• · Reportage photo	Région	40 000	7	280 000
Sous - total 4				**3 150 000**
Total Général I (1+2+3+4)				**33 670 000**

4.2 **Composante Renforcement des Capacités**

Rubriques	**Unité**	**Coût Unitaire**	**Quantité**	**Montant**
Loyer et charges locatives				
• Loyer	Région	300 000	8	2 400 000
• Eau & électricité	Région	120 000	8	960 000
• Gardiennage et entretien	Région	300 000	8	2 400 000
Sous - total 1				5 760 000
Equipement et matériel de bureau				
• Equipement informatique	Région	1 500 000	8	12 000 000
• Mobilier de bureau	Région	250 000	8	2 000 000
Sous - total 2				14 000 000
Personnel				
• Salaires	Région	900 000	8	7 200 000
• Charges sociales	Région	198 000	8	1 584 000
Sous - total 3				8 784 000
Fonctionnement & Activités				
• Transport et Déplacement	Région	2 000 000	8	16 000 000
• Fourniture de bureau	Région	600 000	8	4 800 000
• Communication	Région	360 000	8	2 880 000
• Représentation	Région	240 000	8	1 920 000
• Organisation de Concertation	Région	2 000 000	8	16 000 000
• Journées recherche - Développement	Région	1 000 000	8	8 000 000
• Visites d'échanges	Région	1 500 000	8	12 000 000
Sous - total 4				61 600 000
Total Général II (1+2+3+4)				**90 144 000**
Total Général I + II				**123 814 000**

Appendix 4. ***Project Proposal for Helen Keller International, ICRISAT, IER Collaborative Research-Action programs to improve nutrition through testing and promotion of new S&T products***

IMPROVING NUTRITION SECURITY IN MILLET- AND SORGHUM-BASED SYSTEMS IN WEST AFRICA

PROJECT TITLE	Making a Difference: Linking Agricultural Economic Growth and Nutrition
GEOGRAPHIC AREA	Mali: Dioila and Mande areas for sorghum and Cinzana and Dioura areas for pearl millet
PARTICIPATING ORGANIZATIONS	1. Helen Keller International (HKI) 2. International Research Institute for the Semi-Arid Tropics 3. Institut d'Economie Rural 4. Union Locales des Producteurs des Cereales 5. Association des Organizations Paysannes Professionelles 6. German Agro Action (Deutsche Welthungerhilfe)
PRIMARY CONTACTS	Fred Rattunde, ICRISAT; f.rattunde@cgiar.org Lina Mahy, HKI; lmahy@hkimali.org
PROJECT DESCRIPTION	An alliance of agriculture and nutrition organizations, together with participating farmer organizations, seeks to implement pilot initiatives to improve the micronutrient and overall nutritional status of children and young mothers through availability of new, superior crop and vegetable seeds and improved practices for their utilization. This project will develop and demonstrate a model to achieve major synergies by linking agricultural production, nutrition and market interventions that build on one another and multiply impact. The combinations of interventions offering greatest synergies will be documented for effective scaling-up.

Title: Making a Difference: Linking Agricultural Economic Growth and Nutrition

Introduction:

Mali ranks 174th out of 177 countries in the Human Development Index. Anemia is rampant, being highest in children (88%) and women of reproductive age (63%). Iron deficiency is the most important causes childhood anemia. Iron and zinc deficiency in children inhibits optimal cognitive and motor-skill development, and chances for later recovery are limited. Childhood mortality is elevated, since their weakened immune systems are unable to fight off malaria and diarrhea. Likewise, anemia is a major underlying cause of maternal mortality in sub-Saharan Africa.

According to a USAID supported study, "Despite over 10 years of health-sector reforms aimed at increasing access to basic health services, stunting and wasting rates for children under 5 years of age remain high, with no sign of decline" (Wise et al., 2002)[48]. Progress has been made however on developing individual components for enhancing nutrition. Key problems for child nutrition have been identified such as insufficient nutritional density of weaning foods, poor feeding practices, limited diversity in diets and lack of legumes and animal products. Promising interventions have been developed such as nutrient dense weaning foods developed by the Institut d'Economie Rural.

> Over the past twenty years or so, the development community has failed to build on the accomplishments of the Green Revolution. Agriculture has been neglected, but it offers crucial opportunities for improving the basic nutrition of the smallhold farmers in the developing world, while enhancing their means of livelihood. It brings benefits that are short and long term for both health and economic well being. To this end we have recommitted our Agency to programmes designed to promote sustainable agricultural productivity while enhancing the nutritional component of agricultural produce in ways that provide real, measurable improvements in health.
>
> Fredrick W. Schieck
> Deputy Administrator
> USAID

Agricultural research is currently developing improved varieties and crop management practices. These varieties combine better yields and superior stability under stress conditions (eg.,erratic rainfall). Recent research also addresses nutritional quality. For example, micronutrient dense sorghum and millet varieties are now being identified, thus enabling use of genetic variability for nutritional value already existing in local crops; crops that already provide one third to one half of Fe/cap/day to the 100 million people whose lives are dependent on this crops in West and Central Africa. New legume varieties are also available that provide not only better yields but resist infection by *Aspergillus flavus,* the causal organism of aflotoxin. Post harvest practices have also been developed that enable major reductions of aflotoxin contamination of groundnuts.

[48] Victoria Wise et al., 2002. Improving nutrition outcomes through community health initiatives. Policy Synthesis for Cooperating USAID Offices and Country Missions, Number 62.

Furthermore, agricultural development partners in Mali have joined forces to link experiment station and farmer's field activities. The established participatory testing and seed production and marketing activities will assure that superior varieties demanded by the end-users will reach the farmers' fields, where they will contribute to diversify and increase production and incomes.

Likewise an understanding of the process required to move forward is emerging. Wise et al (2002) indicate the importance of:

- Creating awareness of the nutritional problems at the local level, including the impact on child survival, development and growth, and thus create demand for nutrition interventions
- Full participation of communities in the assessment of the problem, analysis of causes , and choice of actions to assure successful change
- Local pilot initiatives that are monitored using process and impact indictors and the results documented so that lessons can be learned and initiatives scaled up.
- A coordinated effort between agriculture, nutrition and health sectors

An alliance of development organizations (Institut d'Economie Rural, ICRISAT, Helen Keller International, German Agro Action) and farmers' organizations (ULPC, AOPP) is interested to jointly implement a coordinated approach to enhancing nutrition and agricultural production. This alliance was brought together in response to the previous USAID call for Global Development Alliance. It seek ways to achieve the dynamic synergy required to address the linked scourges of malnutrition and poverty. The individual components are now available. This alliance seeks to put them together by pursuing the recommendations of a USAID supported study (Wise et al. 2002) which indicated the need for:

- Full participation of communities in the assessment of the problem, analysis of causes, and choice of actions to assure successful change
- Local pilot initiatives that are monitored using process and impact indictors and the results documented so that lessons can be learned and initiatives scaled up.
- A coordinated effort between agriculture, nutrition and health sectors

Objectives and Outcomes:

The main goal of the project is to improve the micronutrient and overall nutritional status of children and young mothers by introducing improved millet, sorghum and legume varieties. Specifically this project will

I. Provide pilot test cases of established and newly emerging practices and technologies,

II. Develop and demonstrate interventions integrating nutritional and agricultural practices/technologies to achieve synergies that will greatly enhance impact, and

III. Test and demonstrate methods for effectively scale-up interventions through product marketing and information dissemination to achieve impact throughout the savannah zone of West Africa. The expected outcomes would be:

1. Children's diets enhanced for quantity and composition of carbohydrates, proteins and micronutrients:
   - use of grain legumes in children's diets,
   - use of new sorghum and pearl millet varieties with enhanced micronutrient levels,
   - increased feeding frequency,
   - nutrient-dense weaning foods as developed by IER
   - vegetable/leaf sources introduced and made available

2. Collaborative and interactive inputs of agricultural and human nutrition research and development partners contributing:
   - superior staple crops and legumes
   - vegetable germplasm and cultivation practices
   - improved dietary and food processing practices and techniques
   - established involvement and linkage across production-consumption continuum: producers organizations, village post-harvest quality testing
   - seed production and marketing of new superior varieties
   - increased yields of staple crops required for food security and marketable surplus
   - diversification of the traditional cultivation system

3. Information/educational materials for enhancing awareness and promoting:
   - best feeding practices by women in the project areas
   - better grain processing (decortication, germination/fermentation)
   - best cooking methods, and
   - use of legumes and specific condiments for enhanced nutrition
   - better agricultural practices

4. Increase grain legume availability and consumption:
   - Increase seed availability of locally adapted varieties of groundnuts, Bambara groundnut, cowpea and possibly soybean and pigeonpea,
   - locally acceptable cooking practices for newly introduced species developed and popularized

5. Reduce mycotoxin contamination in locally produced foodstuffs such as groundnut and maize:
   - information about improved harvest and post harvest handling methods,
   - new varieties resistant to *Aspergilus flavus*

Partnership Description:

An alliance of research and development partners in Mali seeks to improve micronutrient nutrition in sorghum/millet based diets. This project will build on the ongoing joint research activities of IER and ICRISAT on participatory variety development, testing and seed distribution for sorghum, groundnut and pearl millet. These activities involve collaboration with two large farmer organizations, The "Union Locales des Producteurs des Cereales" (ULPC) in the Dioila Cercle of Mali, and the "Association des Organizations Paysannes Professionelles" (AOPP), in the Mande area of southern Mali.

The partners in this project would bring complimentary arrays of expertise and experience:

The Institut d'Economie Rural (IER) is acknowledged to be one of the strongest national agricultural research programs in the region because of its scientific capacity, its process of planning and review of research with stakeholders and financial credibility and transparency. IER has a strong record for effective collaboration with various NGOs and international research organizations. From the research station at Cinzana, where the pearl millet breeding program is based, there is also the option to collaborate with an integrated rural health project, funded by Novartis foundation.

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) strives to enhance livelihoods of poor in the semi-arid tropics through integrated genetic and natural resource management research and training activities. ICRISAT has conducted sorghum, groundnut and millet improvement work in collaboration with IER in Mali since 1976. ICRISAT, with IER, is currently collaborating with 52 farmer and village organizations, as well as 5 NGOs and technical services.

Helen Keller International (HKI), a private voluntary organization founded in 1915, plays a leadership role in the WCA Nutrition Focal Points networks and West Africa Health Organization to disseminate new scientific findings and lessons for enhancing nutrition. HKI is the lead PVO working on nutrition in Mali. It is well regarded as a source of expertise for nutrition by the Malian Government, national and international research organizations.

Union Locale des Producteurs de Cereales (ULPC) was established to assist farmers to cooperatively store and market cereal grains. The ULPC has been a partner of the IER/ICRISAT participatory breeding activities and will be an important partner in farmer-participatory varietal testing activities.

Association des Organisations Professionnelles Paysannes (AOPP) is a Mali wide umbrella organization for its member organizations. It has a working committee on cereal crops, which has as one of its key themes seed production

of improved varieties. AOPP and some of its members in the Mande area of Mali work with IER/ICRISAT on participatory sorghum variety testing, seed production and dissemination.

German Agro Action (GAA) was founded as the National Committee for the Freedom from Hunger Campaign of the Food and Agricultural Organization of the United Nations (FAO) in 1962. Today it is one of the biggest private development organizations in Germany. GAA is a non-profit and non-political organization that seeks to improve food security worldwide. GAA has facilitated participatory millet variety trials for the past three years.

Appendix 5. Extension Committee Report

COMPTE RENDU DES TRAVAUX DU GROUPE THEMATIQUE : LIEN RECHERCHE – VULGARISATION

Le groupe thématique Lien recherche – vulgarisation s'est réuni le jeudi 16 février 2005 à la DNAMR avec la participation des personnes ci-dessous :

Amidou SANGARE DNAMR
Abdoulaye SISSOKO DNAMR
Dalla DIARISSO DNAMR
El Hadji TAMBOURA APCAM
Finemory CAMARA DNAMR
Issa SIDIBE OHVN
Lassine DIARRA IER
Louis S KEITA DNAMR
Mamadou C. KONATE CMDT

OBJECTIF

L'objectif de la rencontre était de faire des propositions concrètes de solutions à la faible diffusion et adoption des résultats de recherche et de voir dans quelles mesures on pourrait améliorer les liens fonctionnels entre institutions de recherche et de vulgarisation.

METHODOLOGIE

La méthodologie adoptée a consisté à passer en revue (*brain storming*) les différentes contraintes qui freinent la *diffusion* et *l'adoption* des technologies générées par la recherche. Cet exercice nous a permis de retenir entre autres, **une dizaine** de contraintes à savoir :

A CONTRAINTES

1. le manque d'application des mesures d'accompagnement pouvant faciliter l'adoption des technologies ;
2. la faible capacité des agents de vulgarisation ne leur permettant pas le plus souvent de maîtriser les thèmes ;
3. la faible collaboration entre les multiples intervenants sur le terrain (Services de vulgarisation publics et privés) ;
4. le manque de professionnalisme du personnel d'encadrement ;
5. la multitude et l'inadéquation des fiches techniques ;
6. l'inadaptation de certaines technologies suite à la non implication de la vulgarisation, à la non prise en compte des préoccupations réelles et des

conditions socio-économiques et environnementales des producteurs et de leurs savoirs traditionnels ;

7. la faible diffusion des résultats de recherche les rendant inaccessibles (faible accès à la documentation de la recherche) ;
8. le manque de suivi et d'évaluation de la diffusion et de l'adoption des technologies ;
9. la faiblesse dans les fonctions de liaison recherche-développement ;
10. l'insuffisance de l'industrie agro alimentaire.

B. PROPOSITIONS DE SOLUTIONS

L'analyse des contraintes a conduit à l'identification d'axes de solutions en sept points que sont :

AXES DE SOLUTIONS

- La formation
- Les mesures d'accompagnement
- La collaboration entre services de vulgarisation
- Les fiches techniques
- La valorisation du savoir paysan
- Le suivi et l'évaluation des technologies diffusées
- Le lien recherche-vulgarisation

a) <u>La Formation des cadres</u>

- ☞ Renforcer et exécuter les programmes de formation des agents des différentes structures de vulgarisation à travers les stages de perfectionnement et de recyclage ; les visites d'échange d'expériences et la formation diplômante en vulgarisation.
- ☞ Favoriser le regroupement des agents de vulgarisation de différents services (Etat, Privés) lors des sessions de formation

b) <u>La mise en place des mesures d'accompagnement</u>

- ☞ Favoriser l'accès au crédit agricole
- ☞ Développer un système de communication rurale adapté à la diffusion des innovations techniques et technologiques
- ☞ Renforcer les services de communication, information et documentation des structures de vulgarisation et leur mise en réseau avec les institutions de recherche

c) **La collaboration entre les structures de vulgarisation**

- ☞ Redynamiser la collaboration entre les services de vulgarisation (Etat, Privés) en vue d'une harmonisation des interventions sur le terrain

d) **L'élaboration et la diffusion de fiches techniques**

- ☞ Favoriser l'élaboration et la diffusion de fiches techniques harmonisées et adaptées aux différents bénéficiaires

e) **La valorisation du savoir paysan**

- ☞ Valoriser le savoir paysan dans la mesure du possible dans la génération des innovations techniques

f) **Le suivi-évaluation de la diffusion des technologies**

- ☞ Renforcer les unités de suivi-évaluation des services de vulgarisation en vue de renseigner sur l'état de la diffusion et de l'adoption des technologies aussi bien que sur leurs impacts

g) **Le lien recherche-vulgarisation**

- ☞ Revaloriser la fonction de l'agent chargé de la liaison entre la recherche et la vulgarisation
- ☞ Doter les services de liaison recherche-développement de moyens suffisants et appropriés pour les permettre de jouer pleinement leur rôle
- ☞ Créer des cadres de concertation entre agents de liaison recherche-vulgarisation des différentes structures de développement rural
- ☞ Renforcer le partenariat entre institutions de recherche et de développement à travers la signature de protocoles d'accord.

PROPOSITIONS DE SOLUTIONS AU FAIBLE TAUX D'ADOPTION DES RESULTATS DE RECHERCHE

CONTRAINTES	SOLUTIONS	ACTIVITES	RESULTATS	COUTS ('000 FCFA)	RESPONSABLE
1. Manque d'application des mesures d'accompagnement pouvant faciliter l'adoption des technologies	-Favoriser l'accès au crédit agricole - Développer l'industrie agro alimentaire	-Susciter l'émergence d'OP fortes -Former les OP en gestion -Créer des caisses de micro-crédits adaptés -Créer de mini unités de transformation des produits agricoles -Créer l'usine d'engrais de Markala -Créer une unité de fabrique de produits de traitement de semences	-100 OP fortes sont créés -300 OP sont formées -100 caisses de micro-crédits pour l'équipement créées -150 mini centres de transformation de produits agricoles crées -l'usine de Markala est opérationnel -unité de fabrique de produits de traitement de semences est créée	200.000 500.000 1.000.000 225.000 PM PM	MA MA MA MA MA
2. Faible capacité des agents de vulgarisation ne leur permettant pas le plus souvent de maîtriser les thèmes	-Renforcer et exécuter les programmes de formation des agents des différentes structures de vulgarisation à travers les stages de perfectionnement et de recyclage ; les visites d'échange d'expériences et la formation diplômante en vulgarisation	-Tenir des ateliers thématiques de formation des cadres dans le domaine de la vulgarisation -Former les agents de vulgarisation à la diffusion des thèmes techniques -Organiser des visites d'échanges internes et externes à l'endroit des vulgarisateurs -Equiper les agents de vulgarisation en moyens de déplacement	-03 ateliers thématiques nationaux sont tenus -01 séminaire national sur la diffusion des thème est organisé -05 voyages d'étude sont organisés au Mali 02 voyages d'étude à l'extérieur -500 les agents sont équipés en moyens de déplacement	18.000 6.000 5.000 10.000 200.000	PASAOP IER ; DNAMR IER ;DNAMR // //
3. Faible collaboration entre les multiples intervenants sur le terrain (Services de vulgarisation publics et privés)	-Redynamiser la collaboration entre les services de vulgarisation (Etat, Privés) en vue d'une harmonisation des interventions sur le terrain	Créer un cadre de concertation régional entre services publics et privés (ONG) intervenant sur la terrain	09 fora régionaux de concertation entre intervenants sont tenus	90.000	MA
4. Manque de professionnalisme du personnel d'encadrement	- Mettre un accent particulier sur la professionnalisation des cadres	Former des spécialistes en techniques de vulgarisation ; en suivi-évaluation ; en liaison recherche-vulgarisation ; en marketing	500 spécialistes en vulgarisation 10 suivi-évaluateurs 10 spécialistes en LRVA 09 spécialistes en marketing sont formés	 200.000	MA // // //

CONTRAINTES	SOLUTIONS	ACTIVITES	RESULTATS	COUTS ('000 FCFA)	RESPONSABLE
5. Inadéquation des fiches techniques	-Favoriser l'élaboration et la diffusion de fiches techniques harmonisées et adaptées aux différents bénéficiaires	-Tenir des ateliers d'élaboration et de diffusion des fiches techniques	-09 ateliers régionaux sont tenus -01 atelier national est tenu -5000 fiches techniques sont produites en français et en langues locales	45.000 6.000 5.000	IER DNAMR
6. Inadaptation de certaines technologies suite à la non implication de la vulgarisation et la non prise en compte des préoccupations des producteurs et de leurs savoirs traditionnels	- Adapter les résultats de recherche aux réalités paysannes -Valoriser le savoir paysan dans la mesure du possible dans la générations des innovations techniques	-Démarrer le cycle de programmation de la recherche par des diagnostics sur le terrain en équipe pluridisciplinaire Capitaliser les savoirs paysans en matière d'agriculture, d'élevage et d'environnement en vue de leur valorisation	-30 villages par région ont fait le diagnostic participatif villageois avec l'assistance d'une équipe pluridisciplinaire -01 répertoire des savoirs paysans est fait dans chaque région et disponible à la DRAMR et au CRRA	150.000 4.500	CRRA ;DNAMR //
7. Faible diffusion des résultats de recherche les rendant inaccessibles (faible accès à la documentation de la recherche)	-Développer un système de communication rurale adapté à la diffusion des innovations techniques et technologiques -Renforcer les services de communication, information et documentation des structures de vulgarisation et leur mise en réseau avec les institutions de recherche	-Former les vulgarisateurs et les chercheurs aux techniques de communication rurale -Equiper les services de documentation, information et communication existants -Renforcer les radios de proximité -Connecter en réseau la recherche et les services de la vulgarisation agricoles	-01 atelier national est tenu -09 spécialistes en communication rurale sont formés à l'étranger -Des équipements et des matériels de communication sont payés et mis à la disposition de la recherche et de la vulgarisation -09 radios sont renforcées -01 répertoire des résultats est crée à l'IER et dans chaque CRRA et accessible via internet aux services de vulgarisation	6.000 45.000 100.000 90.000 100.000	IER ;DNAMR MA MA MA IER ;DNAMR
8. Manque de suivi et d'évaluation de la diffusion et de l'adoption des technologies	-Renforcer les unités de suivi-évaluation des services de vulgarisation en vue de renseigner sur l'état de la diffusion et de l'adoption des technologies aussi bien que sur leurs impacts	-Doter les services de vulgarisation de spécialistes en S/E -Equiper les agents de suivi-évaluation en moyens matériel adéquat -Equiper les unités de S/E des services de vulgarisation	-50 enquêteurs sont formés à raison de 01 par cercle -50 enquêteurs sont équipés en motos et autres matériels de travail -20 les unités de S/E sont dotées d'ordinateurs équipés	15.000 20.000 60.000	MA ;ME // //

CONTRAINTES	SOLUTIONS	ACTIVITES	RESULTATS	COUTS ('000 FCFA)	RESPONSABLE
9. Faiblesse dans les fonctions de liaison recherche-développement	-Revaloriser la fonction de l'agent chargé de la liaison entre la recherche et la vulgarisation	-Nommer par décision du Gouverneur de région des agents chargés des liens recherche-vulgarisation	-01 équipe de quatre agents LRVA (recherche, agriculture, élevage, environnement) est nommé par région sur décision du Gouverneur	PM	MA/ME/MATCL
	-Doter les services de liaison recherche-développement de moyens suffisants et appropriés pour les permettre de jouer pleinement leur rôle	-Créer une unité autonome de liaison recherche-vulgarisation dans chaque région et au niveau de chaque direction centrale	-Des unités autonomes de liaison recherche-vulgarisation sont créées et fonctionnent au niveaux central et régional	PM	MA/ME/PASAOP
	-Créer des cadres de concertation entre agents de liaison recherche-vulgarisation des différentes structures de développement rural	-Créer un réseau des agents LRVA	-01 réseau des agents chargés des liens recherche-vulgarisation est créer et fonctionnel	10.000	MA/ME
	-Renforcer le partenariat entre institutions de recherche et de développement à travers la signature de protocoles d'accord	-Elaborer des protocoles d'accord entre les services de vulgarisation et l'IER	-Plusieurs conventions de partenariat sont signés entre l'IER et ses partenaires	PM	IER/CNRA/ PARTENAIRES