DRAFT

Biotechnology and agriculture : Capacity building projects

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1.Introduction

This report is a follow up of the report on the Biotechnology Assessment in Mali, drafted after the mission of Claude Fauquet, Oumar Niangado and Willy De Greef in March – May 2003. That mission and the subsequent exchanges have led to the formulation of a number of capacity building measures that may help Mali making informed decisions about the potential value of modern biotechnology developments in the formulation and implementation of its agricultural innovation policies.

This follow-up is an attempt to translate a number of the measures sketched briefly in the previous reports into more granular project outlines, with a first approach to budgeting of human, time, infrastructure and financial resources. It also tries to take on board a number of unsolved issues that were identified in the previous missions, either because they were not in the mission brief, but were identified by the team as "need to address", or because they do not fit within the narrow definition of the biotechnology field used by USAID in the previous mission, but were identified by the team as important in creating the enabling environment.

Many of the actions we propose will fit easily in a biotechnology research capacity building programme, while others may be more suited for inclusion in other programmes. Therefore, the actions outlined below for consideration fit into one (and sometimes more than one) of the following categories:

1. Science and technology capacity building.
2. Institutional and societal capacity building
3. Enabling measures in the agricultural environment

In addition, we will point to some areas where USAID should consider doing additional assessment, because the current team found them important, relevant for a complete overview of biotechnology, but outside the field of competence of the team.

We have also timed the proposals in three time frames:

- Short term: key deliverables in 18-24 months
- Medium term: key deliverables in 5 years
- Long term: key deliverables in more than 5 years

In most cases, we were able to structure projects such that key intermediate deliverables could be identified and formulated for the short term, allowing a strategic review and stop-go decision in an 18-24 month time frame. In the detailed discussion of the proposals below, we have tried to subdivide the activities for each project along these timing constraints and to create key deliverables wherever possible, to allow decision makers and funding providers to create clear intermediate decision points.

Many projects contain actions that cross the boundaries of technological innovation, societal capacity building and agricultural enabling. Wherever possible, the actions have been differentiated along those three major lines of activity.

2. Overall objective of the proposals

The overall objective of the proposals below is to create an environment in which modern biotechnology innovations can be assessed, utilized for solving local problems in agriculture, and fully developed and disseminated in an acceptable societal governance model.

To achieve this broad objective, each action below was developed because it met the following requirements:

- It responds to an already defined agricultural need in the country or the region
- It develops capabilities in the country to respond to other innovation challenges

3. Proposed actions.

We divide the proposed actions up in three broad categories:

- "Product development" actions. These are projects on materials or technology for which proof of concept (COP) already exists. Usually these projects also have already been evaluated for their potential socio-economic impact potential. If not, socio-economic impact analysis is straightforward and can be executed as part of the first phase of the project. Such projects may also lend themselves well for public-private partnership projects.
- Research actions. These are projects for which there is not yet a verified POC available. They require more upstream work to develop **technology**, before being able to deliver **products**. In most (but not all, e.g. marker assisted breeding) cases these projects will deliver economic impact at a later time than the previous category.
- Enabling environment actions. These are activities outside science and technology development that serve the path for practical use of the two previous categories. They are usually in the sphere of capacity building on regulatory affairs, public information, and stakeholders relationships. They also include the development of skills such as expertise in IPRs and impact analysis.

Important comments :

The proposed activities below have not all been reviewed for their potential relevance in a competitive way. For some, the technical and the socio-economic impact analysis already exists, while for others it remains to be done. This will be indicated for each project for as far as it is known to the writer.

It would be advisable for the agricultural policy decision makers, the IER and the funding donors to develop these impact analyses at the earliest opportunity, and to prioritize projects on the basis of their outcome.

Action plans have been developed only for a 5-year time horizon.

3.1: Product development actions

3.1.1.: Evaluation of insect resistant cotton in the agricultural environment of Mali

Cotton is the most important export crop in Mali and a major component of the agricultural economy. Almost the entire crop is exported and competes on the world cotton market. Among the major crops, cotton is unusually sensitive to insect damage. It is estimated that slightly more than 25% of the world total insecticides is sprayed on cotton. The most important technical innovation in cotton farming of the past decade has been the development of genetic control of the most important pests (Lepidoptera) by the insertion of insect resistance genes into cotton. The technology used to achieve this is genetic engineering.

Bt cotton is used on a large scale by cotton growers in the USA, Argentina, China, India, South Africa, and has been approved for large scale release in Colombia and Indonesia. Its most important impact is reduction of pesticide use in intensive cotton farming, and increased yield in farming systems where insecticide use in the past has not been as comprehensive as needed to protect the crop.

A socio-economic impact analysis for insect resistant cotton was presented at the 7th ICABR International Conference: "Economic Cost of Non-adoption of Bt Cotton In West Africa: With Special Reference to Mali" by Cabanilla, Abdoulaye and Sanders. The study concluded that in all cases the introduction of GM cotton would have a positive impact, varying from 7 – 67 million $/year, depending on the starting assumptions.

Another important enabling factor in cotton is the existence of a reliable seed supply chain for the farmers. Cotton seed is provided by CMDT, and we can therefore postulate an effective distribution and quality control system for the seed material, two important conditions for success on the farm.

The purpose of the cotton project proposal is to evaluate different insect resistant cotton lines available against the insect pest spectrum of Mali, to develop locally adapted varieties including the most interesting genes, and to introduce them to the cotton growers of Mali. The project has scientific, societal and agricultural components, and short, medium and long term objectives. They are summarized in table 1 below.

There are several insect resistant cotton lines in development and/or cultivation today. We have identified five sources, but others may be in development. The purpose of the project will be to (1) evaluate these different products for their efficacy against the spectrum of insect pests in Mali, (2) introgress the relevant genes by traditional breeding into locally adapted varieties, and (3) multiply the resulting locally adapted insect resistant varieties for wide distribution to farmers. The research and development project for cotton fits logically in three distinct time frames, which can be coordinated with the regulatory and societal aspects.

Short term objectives and activities:

In the short term, the objective is to evaluate the different existing insect resistant cotton lines currently available. In parallel, the process of introgressing these sources of insect resistance into local varieties will be started. This second action allows the project to win up to 2 years in the next stage, which is the development of locally adapted varieties that incorporate the new genes. This requires the following actions:

- Technical actions:
  - Invitation to technology developers to present their material for evaluation
  - Negotiation of appropriate Material Transfer Agreements (MTA) with technology developers
  - Training of local cotton researchers for working with GM cotton
  - Application for importation and experimental use of GM insect resistant cotton in controlled environment (contained glasshouse and small scale field trials in experimental stations of IER)
  - Execution of the entomological evaluation of the insect resistant cotton in confined bio-assays and small scale field trials
  - Production of F1 crosses with a small number of elite local varieties and subsequent production of backcrosses in controlled environment (up to BC2 – BC3 by the end of year 2 of the project).
- Regulatory actions:
  - Creation of regulatory process for controlled research work with GM plants in containment (laboratory and glasshouse) and in controlled field conditions (small scale field trials).
  - Training of scientific personnel in operating under the regulatory constraints imposed by biotechnology regulations.
  - In cooperation with the technology developers, applications for, and regulatory decisions on, the relevant permits for the stages of work described above.
- Societal actions:
  - Development and dissemination of factual information adapted to two distinct types of public: farmers and non-farm civil society actors.

The societal actions are essential for an orderly continuation of the project. It has already been noted that much confused and confusing information circulates in Mali about insect resistant GM cotton. This leads to unrealistic expectations among the professional community (including policy makers and farmers) about the time frames and the work needed to turn the potential of insect resistant cotton into real value on the farm. It also creates unfounded concerns among civil society about the nature and the mode of development of these crops. A well conceived and appropriate communication project with all stakeholders will do much to increase the chances of success of both the technological and the regulatory projects.

It will be noted that the technical actions will require a significant strengthening of the existing cotton breeding capacity of the IER. This is a common characteristic of development projects with genetically modified crops. Contrary to a commonly held misconception outside the technology world, genetic engineering does not **replace** breeding. All it does is to introduce new and usually highly effective effect genes into existing programmes. A programme of this type depends more on the development of existing breeding capacity than on the creation of new molecular biology capacity.

Table 1: Key deliverables of insect resistant cotton project

	Short term (24 months)	Medium term (5 years)	Long term (>5 years)
Research and Development	• test different sources of insect resistant cotton • start introgression into local germplasm	• Continue introgression with chosen source of resistance • Agronomic evaluation of the new germplasm • Development of insect resistance management programme • development of adapted crop management procedures	• upscaling of new varieties • dissemination of new varieties to farmers
Regulatory Environment Development	• develop regulatory capacity for review of experimental release of GM crops • Develop compliance capacity in local scientific community	• develop regulatory capacity for regulatory oversight of commercial release • Develop compliance capacity of local developers and operators	• Regulatory permits in place • Capacity for compliance in place
Stakeholders communication	• Communication with agricultural community • Communication with civil society	• Communication with agricultural community • Communication with civil society	

Key deliverables and milestones after 24 months:

- Technical track:
  - Detailed report on the insect control capacity of the different lines for Malian pests, and choice of the line that will be progressed into product development.
  - BC3 seed of the different GM materials introgressed in 3-4 important existing varieties and 3-4 new varieties under development at IER.
- Regulatory track:
  - Regulatory review system for experimental work with GM crops developed and tested by review of several applications for permits.
  - Research community and cotton operators familiar with regulatory requirements of work with GM crops.
- Stakeholders track:
  - Dialogue engaged with producers and consumers about the project
  - Visits of producer and consumer representatives as well as decision makers to relevant field trials
  - Realistic expectations created among cotton producers
  - Interest created among civil society organisations.

Management actions at the end of the period:

- **Choice of one (or more) sources of GM cotton for further development**
- **Destruction of the other materials as per the conditions of the MTAs.**

Medium term objectives and activities:

The overall objective of the medium term project is to develop the chosen GM cotton lines into finished locally adapted varieties. This will require the negotiation of the next step of cooperation with the chosen technology developer(s), and the conclusion of agreements covering the product development and commercialisation stages.

The medium term project requires the following activities:

- Technical activities:
    - Creation of locally adapted lines out of the back-cross project, and stabilisation of the Bt trait by the creation of populations that are homozygous for the transgene.
    - Agronomic evaluation of candidate varieties under development.
    - First upscaling of finished varieties.
    - Development of the adapted crop management system for the new varieties, including insect resistance management.
    - Collection of the local component of the biosafety file required for the large scale release permit application.
- Regulatory activities:
    - Creation of the regulatory process to assess applications for commercial release of GM cotton and other GM crops.
    - Creation of an application for a commercial release permit with the chosen GM cotton event, in cooperation with the technology developer.
- Stakeholder activities:
    - Progress reports to political and economic decision makers.
    - Demonstration trials for farmers.
    - Communication project with civil society about the progress and the prospects of the project, through direct means (demo visits, workshops and other meetings) and through the media.

Key deliverables at the end of the medium term project:

- Technical track:
    - Small quantities of finished varieties.
    - Finished processes for crop management and insect resistance management.
- Regulatory track:
    - Approval of the new varieties for large scale production and distribution
- Stakeholders track:
    - Broad understanding and realistic expectations among farmers and consumers about the nature and performance of GM cotton.

Management actions at the end of the medium term project:

- **Stop-go decision for large scale release of GM cotton to farmers in Mali**

3.1.2. Evaluation of insect resistant maize and rice for their relevance in Mali

The place of maize and rice in Malian agriculture is rapidly increasing in importance. Both crops have been the subject of massive R&D work in the private sector. In addition, rice is one of the most well-researched biotechnology subjects in the public sector. For both crops, there are many sources of insect lines. The major difference is that insect resistant maize is already widely used in commercial farming worldwide (it is the second biggest commercial GM crop, with >10 million Hectare planted in 2002). The release of GM rice developed for insect tolerance has been delayed by the difficulties of the major rice developing nations in the late nineties to develop the regulatory framework. Nevertheless, there is now insect resistant rice in the course of regulatory review for large scale commercial release in China. This rice was developed by the Chinese Academy for Agricultural Sciences.

These project proposals can not rely on an executed socio-economic impact analysis in Mali, of the kind already available for cotton. Likewise, the detailed technical analysis of the damage done by insects to these two crops is not as clearly quantified as for cotton. However, technical discussions with many IER scientists are consistent in mentioning insect damage as one of the most important sources of crops loss for both crops. The quantification of these impacts will have to be one of the first deliverables of this project. An additional issue to be researched is the development of the seed supply chain of these crops to the farmer. Maize in Mali is entirely grown in the form of open pollinated varieties at the moment. The conversion to hybrids is only being envisaged now, and most farmers save their seed. This has consequences for the choice of materials in which to back-cross successful insect resistance genes.

With these constraints, the project can again be divided in short, medium and long term objectives, with parallel action for maize and rice. It may be of course that only one of these crops is shown to be relevant for this project after the initial impact analysis, in which case the other would be stopped. (table 2)

It will be noted that many of **the steps** are identical to the ones proposed for insect resistant cotton. In fact, for the “regulatory environment development” and “stakeholders communication” sub-projects, **the actions** overlap largely. For this reason we refer to section 3.1.1. for the detailed description. It will not be repeated here. Regarding the technological project though, the situation is different.

Short term objectives and actions.

This project should start with the **technical and socio-economic quantification** of the importance of insect damage in the maize and rice crops. This action should be initiated as a prerequisite for all the others. It can be completed within the first 12 months of execution. We recommend that the team which performed the study for cotton (see above, section 3.1.1.) be contacted to apply their methodology to these other crops.

If this impact assessment shows that one of the crops, or both, would benefit greatly from being converted by introgression of existing insect resistant lines or varieties, the second year would be devoted to the technical evaluation of existing insect resistant maize and rice lines. As for cotton, it is recommended to contact technology providers to obtain research licenses for relevant material. In contrast to cotton, maize and rice are not pure cash crops in Mali, and it is quite likely that several technology providers will supply their material under a humanitarian license. This would preclude the need for future commercial negotiations, while supplying the project with access to the regulatory file.

Table 2: Key deliverables of insect resistant rice and maize project

	Short term (24 months)	Medium term (5 years)	Long term (>5 years)
Research and Development	• test different sources of insect resistant maize and rice • start introgression into local germplasm • make a technical and socio-economic impact analysis for insect resistance in rice and maize	• Continue introgression with chosen source of resistance • Agronomic evaluation of the new germplasm • Development of insect resistance management programme • development of adapted crop management procedures	• upscaling of new varieties • dissemination of new varieties to farmers
Regulatory Environment Development	• develop regulatory capacity for review of experimental release of GM crops • Develop compliance capacity in local scientific community	• develop regulatory capacity for regulatory oversight of commercial release • Develop compliance capacity of local developers and operators	• Regulatory permits in place • Capacity for compliance in place
Stakeholders communication	• Communication with agricultural community • Communication with civil society	• Communication with agricultural community • Communication with civil society	

Like with cotton, the key local genetic activity includes an ambitious programme of crossing the existing materials into locally adapted varieties or breeding lines. Therefore, the largest technical component of the project (if the impact assessment is positively concluded), would be the strengthening of the breeding capacity of the maize and rice programmes at IER. The breeding programme would start (as for cotton) in parallel with the technical evaluation of insect resistant maize and/or rice lines for their effectiveness against local pests.

- Technical actions:
    - Execution of the technical and socio-economic impact assessments of insect resistant rice and maize.
    - Invitation to technology developers to present their material for evaluation
    - Negotiation of appropriate Material Transfer Agreements (MTA) with technology developers
    - Training of local rice and maize researchers for working with GM crops

  - Application for importation and experimental use of GM insect resistant rice and/or maize in controlled environment (contained glasshouse and small scale field trials in experimental stations of IER)
  - Execution of the entomological evaluation of the insect resistant rice and/or maize in confined bio-assays and small scale field trials
  - Production of F1 crosses with a small number of elite local varieties and subsequent production of backcrosses in controlled environment (up to BC2 by the end of year 2 of the project).

- Regulatory actions:
  - Training of scientific personnel in operating under the regulatory constraints imposed by biotechnology regulations.
  - In cooperation with the technology developers, applications for, and regulatory decisions on, the relevant permits for the stages of work described above.
- Societal actions:
  - Development and dissemination of factual information adapted to two distinct types of public: farmers and non-farm civil society actors.

Management actions at the end of the period:

- **Stop-go decision for the technological project after 12 months based on the impact assessment**
- **Choice of one (or more) sources of GM rice and/or maize for further development**
- **Destruction of the other materials as per the conditions of the MTAs.**

Medium term objectives and actions

If the short term project is successfully concluded after 24 months, an intensive variety development project would form the core of the rice and/or maize development programmes, with activities that mirror those described for cotton.

3.1.3. Development of a regional centre for seed potato production in Mali

In Mali, as in most developing countries, the consumption of potatoes is rising. Mali still imports most of the seed potatoes it needs for its national production from Europe. Last year this import was over 1200 metric tonnes.

Mali already has a laboratory with a fully developed capability for in vitro multiplication of potato in the biotechnology laboratory in IPR/IFRA in Koulikoro. A small scale project to supply part of the Malian farming sector with seed potatoes is currently running in collaboration between this lab and an NGO. Two components are missing to make this a fully autonomous production centre:

- the capability to ensure quality control and project management throughout the production chain,
- the equipment in the laboratory and the nursery to upscale activities so that they can serve the needs of the region for seed potato.

Both these capabilities can be built up rapidly at low cost. This project can be designed, executed and brought up to speed entirely in the 24 month period that is seen as the limit for a short term project. It does not involve the development of any new technology, only the access of the institute to equipment, and a short term training in detection skills for potato diseases that would allow the centre to provide certified plant material.

The disease status control capacity comes in two major components:

- The technical capability to detect potato diseases. For this, the current in vitro laboratory would have to develop the capacity to do immunological and/or DNA based assays for the relevant range of diseases.

- The setting up of a quality control process beyond the delivery point of the minitubers to farmers-multipliers.

Short term deliverables:

- A working system for disease indexing using ELISA and PCR after 12 months
- A complete seed potato production system capable of supplying the entire Mali market after 24 month.

Building up the detection capability would not take more than 12 months to be fully established and tested. Building up and testing a seed production system would likely require 2 years, at the end of which a commercialisation project could take over the actual marketing of seed potatoes from local production in the region.

3.2. Research actions

3.2.1. Evaluation of insect resistance as a tool to improve sorghum and millet.

Sorghum and millet are key crops for the food security of the dry regions of Africa, but they have not been the subject of the amount of research done on the other major cereals, especially maize, rice and wheat. As a consequence, there are no fully reproducible high throughput transformation methods available for sorghum and millet. Any project that aims at creating a national or regional capacity in this field therefore has to start further upstream in the process of technology development than is the case with the other crops. Despite the difference in the nature of the work and the deliverables that may be anticipated after the short and medium term, it is possible to translate them into a set of verifiable practical objectives.

An insect resistance project in sorghum and millet would require the following components:

- Baseline research on the damage created by insect pests in these crops.
- A baseline study of the suitability of Bt proteins in collections as tools to control the relevant pests.
- A socio-economic impact analysis of insect damage on these crops, and the cost-benefit analysis of different pest management options
- A project to create the expertise in Mali to genetically engineer sorghum and millet with sufficient success to allow the selection of elite events including a Bt gene.

Actions to be taken:

- Entomology:
    - Impact assessment, including the use of historical data as well as new surveys in the main production regions. To deliver a report after 12 months that gives an updated and authoritative review of the insect damage and its causes
    - Bio-assays of Bt collections to identify and evaluate the potential of Bt proteins as insect control substances. To deliver a shortlist of potentially active proteins after 2 years
- Socio-economic research:
    - On the basis of the entomological information, a socio-economic impact analysis will determine if it is worthwhile to engage in a project aiming at the creation of insect resistant genetically modified sorghum and millet. To deliver the information for an informed strategic decision on the subject after 24 months.
- Biotechnology capacity:
    - Development of transformation techniques for sorghum and millet. Although both crops can be genetically engineered, the yield of the current techniques is not sufficient for high-throughput experiments typically needed to create the 100-1000 primary events from which elite events will be selected afterwards. It is proposed that this be achieved by creating a PhD project to train a Malian student in millet and sorghum transformation techniques. This project would require a 2-3 year stay at a recognized centre of excellence in plant transformation, and another 2-3 years to set up the system at a research centre in Mali.

3.2.2. Evaluation of GM sources of resistance against Rice Yellow Mosaic Virus (RYMV).

RYMV is rapidly becoming the top source of losses in the growing rice sector in Mali and the surrounding countries. Although sources of partial tolerance exist in the germplasm pool of rice, it is clear that there is no satisfactory control at the moment. There has been significant effort to engineer rice using proven techniques to confer virus resistance. Some of these are reported to confer resistance, but none has been tested in the field so far.

The purpose of this project is to achieve strengthening of the technical capabilities in the country to deal with this problem in three fields:

- Improve the capacity to assess the diversity of RYMV strains in the country by creating the molecular analysis tools needed.
- Improve the capacity to use marker assisted breeding (MAB) to speed up the development of improved rice varieties combining several sources of tolerance to RYMV.
- Evaluate existing sources of genetically modified rice developed to express resistance to RYMV.

If the these projects achieve their objectives, then the conventional and genetically modified sources of RYMV resistance will be combined by a marker assisted breeding project to produce a durable source of resistance for introgression into regional rice germplasm.

- Short term deliverables (24 months)
    - An inventory of the RYMV strains in the region, with an assessment of their diversity
    - An inventory of markers for RYMV tolerance genes in rice germplasm, and evaluation of the relationship between the diversity of the virus and the sources of tolerance.
    - A first evaluation of existing GM sources of potential RYMV resistant rice in field trials in Mali.

- Medium term deliverables: (5 years)
    - Rice breeding material combining several sources of conventional tolerance with GM resistance for durable control of RYMV
    - Advanced development of local varieties including these different sources of RYMV control.

3.2.3. Control of Tomato Yellow Leaf Curl Virus (TYLCV) by biotechnology approaches

The problems with TYLCV are similar to those with RYMV. The virus is widely present in Africa, and its diversity causes severe damage to an important crop for the provision of essential nutrients to large populations. Existing sources of tolerance to TYLCV have been widely used, but all seem to fail against the diversity of the virus, and in any case seem to confer only partial tolerance, not a durable source of resistance. Recent advances in molecular biology of the geminiviruses (of which TYLCV is a member) suggests that a generic source of resistance is achievable. No such plants exist today. However, given the global importance of the TYLCV virus and the tomato crop (it is the most important vegetable in the world by value), it may be assumed that genetically modified sources of resistance will be developed for evaluation in different environments.

We propose a TYLCV research project with the following components:

- Characterisation of local TYLCV strains (some of this is already underway in an existing cooperation)
- Evaluation of existing conventional varieties and (if and when available) genetically modified tomatoes produced to confer resistance to TYLCV)

3.2.4. Marker assisted breeding of Striga resistant sorghum

This project does not require GM approaches. It will try to develop a sustainable control of a major pest (Striga, a parasitic plant) in Sorghum. A potential source of good resistance is identified, but it is located in germplasm of unacceptable quality for farming in the region. It therefore has to be transferred as efficiently as possible to locally adapted varieties. Marker assisted breeding is the most appropriate technique.

A project for marker assisted breeding for Striga control has the following components:

- Molecular biology: the development and use of molecular markers associated with the Striga resistance genotype.
- Breeding: the use of marker assisted back-crossing programmes to introgress the resistance genotype into locally adapted varieties.

Short term objectives and deliverables:

- Molecular biology:
  - Creation of the skills base and the equipment for high throughput marker development work at a centre of excellence in molecular biology
  - Contact with other projects already underway for developing marker sets for sorghum, and use of these marker sets to provide guidance on the location of the Striga resistance trait.
- Field genetics:
  - Development of segregating populations for the Striga resistance, to attach a functional analysis to the molecular markers sets.
  - Development of good field bio-assays for Striga infestation and experimentation with segregating populations of sorghum for the resistance trait.

Medium term objectives and deliverables:

  - Back-crossing to local varieties of the Striga resistance gene
  - Development and agronomic evaluation of the new varieties in preparation for their dissemination to farmers.

Key requirements:

Marker assisted breeding requires significant laboratory and computer infrastructure. The molecular genetics part should therefore be developed in an enabling environment with existing experience in handling this complex equipment, and with human resources for expert advice in close proximity. We recommend that **all** the molecular marker work for this and other marker assisted breeding projects in Mali be concentrated in one centre of excellence for molecular biology so as to create critical mass effects and optimal use of human, infrastructure and knowledge resources. In this configuration, the project would create a nucleus of excellence in marker assisted breeding which would develop the ability to serve all breeders in Mali with marker work, through short term detachements and training in state of the art facilities.

3.3: non R&D actions needed for the success of the programme.

The development of a biotechnology capability to serve agriculture in Mali requires technical capacity building, which has been the subject of sections 3.1 and 3.2. However, it can not function and deliver benefits to the agricultural economy without a number of other enabling measures. The list of proposals below aims at creating a significant improvement in the enabling environment in Mali for modern biotechnology. This comes through two main avenues:

- Assist in the creation of an enabling regulatory environment in two distinct areas: intellectual property rights and biosafety.
- Assist in the improvement of access to information for policy making, policy implementation and technology development in Mali.

3.3.1. Widening the information base.

3.3.1.1. Availability of documentary base in the French language.

The limited ability of most actors (policy makers, scientists, regulators and stakeholders) to access English literature on biotechnology is the most important limitation to a better informed debate on biotechnology in Mali. Most Malian scientists do not read the English scientific literature and are thus unaware of much of the progress in the field. Among policy makers and regulatory authorities the problem is even more pronounced. It means that a lot of the information which is considered a given for policy making, technology planning and regulatory oversight in other parts of the world is simply not available here. For example, much of the technical literature which underpins the safety evaluation of GM crops in the world (such as the consensus documents of OECD and many others) exists only in English. Making this type of literature available in French would provide a massive boost to the quality of thinking about biotechnology in Mali, but also to the entire French-speaking community worldwide.

This has already been recognized by other actors in the development scene. A small scale project to boost availability of relevant French language information has recently been agreed upon between IER and ISAAA. The project is on sound grounding, but is of insufficient size to handle the needs of the situation. The current project intends to create a web-page on the website of IER that will show existing documentation in French (which is already available through the combined efforts of ISAAA and IBRS), and a small capability to translate key documents in French for dissemination through this website. To this end, an experiment to identify local translators who can be trained to produce regular translations of texts related to biotechnology is underway.

We propose to expand this effort in two ways:

Information sources and translation capacity.

- There is much more information that should be translated than the current project can handle. An estimate by IBRS has identified a minimum of 200 documents (legislation, science, socio-economic literature, risk assessment and biosafety regulation) that should be made available to the French speaking community. This results in about 5000 pages of text. If the entire translation project were done in Mali, it would be feasible at a cost of about 25-35 million FCFA (+/- 50000$) (information gathered so far indicates that professional translation will be possible in Bamako for 5000-7000 FCFA per page).

- It is proposed to set up a project wherein a full time local translator be hired to produce a regular output of French documents from authoritative English sources. The documents would be proposed by ISAAA and IBRS. Quality control of the translations will be needed. IBRS and ISAAA have each identified a group of individuals in the scientific and regulatory community who are intimately familiar with the subject matter and thoroughly bilingual, and who have expressed an interest in donating time to this project for a critical reading of raft translations.

Improving the accessibility of the translated materials:

- It is proposed to set up a mirror website for the IER site. Given the poor connections of the local and regional internet connections, the IER website has a problem of accessibility. IBRS has obtained an expression of interest from AfricaBio, the South African biotechnology stakeholders association, to provide this service. AfricaBio has the services of a full time IT support and excellent IT infrastructure. IER has experience with the use of mirror websites and has expressed interest in the approach.

- The region is generally poor in terms of access to internet, and even more handicapped by the almost total lack of training in the use of the internet as an information source. Trial runs by IBRS of “internet literacy” of advanced scientists in Mali, many of whom have studied abroad, shows that just making computers and telephone data lines available to them has almost no effect on their access to information, because they have never been taught the elementary skills which anyone needs to navigate the internet. In most countries this aspect of capacity building receives very little attention, because the peer development system works. People learn from each other, and from the IT-savvy pioneers who work their way into the internet on their own. The same model of diffusion does not work in this environment, and more structured training of users of internet information will be needed. To ensure real and sustainable results, we propose training methods that are motivational, such as linking specific internet training and capacity building to another training programme for selected individuals, rather than going for the traditional method of workshops and training seminars. This would allow very directed training, focused on creating a **relevant and personalized database** of internet sources for each person undergoing training. Such training does not have to be onerous. Generally, a few one-on-one sessions of half a day with each individual will provide the basis from which the person can then develop their own knowledge base.

3.3.1.2. Bringing Malian actors in contact with existing biotech based farming systems.

No amount of discussions of the pro's and con's of biotechnology replaces direct exposure to its application in the field elsewhere. This is well understood by the Malian authorities as well as the donor community. It is proposed that an information gathering mission be organized for a Malian team to South Africa, where the practical use of biotech crops, as well as the working of the regulatory systems and the research community, can be assessed.

Components of the proposed mission:

- Visit to African farms growing insect resistant maize and cotton.
- Visits to the regulatory authorities and discussion of the South African regulatory system for GM crops.
- Visits to centres of excellence in biotechnology research in South Africa, differentiating between university based basic research and application based research in the Agricultural Research Council centres.
- Meetings with stakeholders in the biotechnology debate I South Africa.

Logistics of the mission.

- Contact has been taken with AfricaBio, the stakeholders association on biotechnology in South Africa. They are ready to organize the visit logistically, provided that funding donors are found.
- Timing: it would be highly desirable to organize the visit during the late cultivation stage of the crops in South Africa. Sources in South Africa indicate that this should be in the period from mid-December to Mid-February.
- Size of the mission: to be manageable, it is recommended to make the mission not large than 6-8 persons, representing government, the research community and key stakeholders.
- Language issue: it may be necessary to fund the supply of a full time interpreter English-French for the duration of the tour, since several members of the mission are likely to have difficulties with the English language. AfricaBio can organise the finding of a competent interpreter.

3.3.2. Needs assessment and capacity building in the regulatory system.

Mali has more work to do in two essential areas of regulation to be able to benefit from biotechnology applications:

- It has to establish a suitable IPR system
- It has to finalize a workable biosafety regulation

Both areas would benefit from short term actions to improve the information base.

3.3.2.1.: developing the IPR capacity of Mali

Mali has signed a number of relevant international agreements related to IPRs in agriculture, but has not translated them into national legislation or regulation. Moreover, some of the international commitments may be contradictory, such as the adherence to the Convention de Bangui on PVPs and the support for the African Model Law on intellectual property. There is a need for a more detailed information base on which the national authorities can make informed choices.

We propose to create a small capacity building project on IPRs in Mali, using a model that has already been tested in practice in other developing countries. Cornell University has a department which specializes in this type of training, and could be approached to develop a project, to be initiated and executed by end 2004. The objectives of the project would be to enlarge the knowledge base of the relevant authorities in Mali about the specificities of IPRs related to agriculture, and to prepare options for a suitable national regulatory system.

3.3.2.2.: Developing the biosafety regulatory capacity of Mali

Mali is already engaged in the process of creating a national system for biotech regulation. The process so far suffers from a wide information base. Several of the actions described elsewhere in this report will help expanding that base. In addition, we recommend the following specific actions:

- Widen the regulatory compliance capacity of biotech practitioners and other stakeholders. The entire international capacity building effort generated by the Cartagena protocol focuses on capacity building among the regulatory authorities. Almost nothing is done to prepare scientists and agricultural professionals so that they can comply with newly imposed constraints. To fill that gap, we propose that an already tested approach of workshops for practitioners be expanded to include members from the agricultural research community and the seed sector, the two groups of professionals who will be most exposed to the regulations. A workshop on this model for decision informers was held in Bamako 9-11 September 2003, and was generally seen to be successful by participants.
- Widen the knowledge of political decision makers about biotech and regulations. Politicians create the legislative environment, but in highly technical fields such as biotechnology, this is routinely done with very limited actual knowledge of the technical and socio-economic issues. We propose the organisation of a series of working seminars specifically targeted at political decision makers, in adapted language, to broaden their knowledge of biotechnology, its achievements, its environment and its relevance for Mali.

4. Other unmet needs

The biotechnology strategy in Mali requires more attention to two fields which have not been sufficiently explored so far:

- The applications of biotechnology in animal farming
- The preparation of the seed sector for the use of modern biotechnology tools.

4.1. Applications of biotechnology in animal farming.

The biotechnology assessment and capacity building efforts have almost totally focused on the crop sector of agriculture. But cattle and other ruminants are the most important source of capital and revenue in Malian agriculture. Biotechnology has made massive contributions in this sector, and it is as important to associate Malian agriculture with that branch of biotechnology as it is for crop production. Biotechnology applications in animal farming fall broadly in three categories:

- Reproductive techniques
- Veterinary applications
- Animal nutrition improvements

The team which has performed the current assessments and advice on biotechnology in Mali is not competent to make a similar assessment for animal farming. We recommend that USAID at the earliest opportunity invite a mission of relevant experts to perform a mission similar to the one the current team has done on the plant sector.

4.2. Preparation of the seed sector for the use of modern biotechnology

None of the technologies introduced by the implementation of this programme will reach the farmers community in Mali unless there is a strong seed sector capable of accepting the high tech seed developed and of producing this seed with the rigorous quality control required for full effect.

At the moment, the seed sector in Mali is under-developed. For some crops, farmers are totally dependent on a single government entity for seed supply, and there are no technical and managerial tools in place to bring innovations to the farmers as is done in most of the rest of the world.

We recommend that USAID establish as a top priority of its biotechnology programme in Mali a number of specific actions to strengthen the ability of the seed sector to take on the innovations that are coming through the system. This will require:

- Development of technical skills related to breeding and producing quality seed:
    - Quality control procedures for varietal purity protection during upscaling and production of commercial seed
    - Seed treatment
    - Modern detection techniques to identify genetic material
    - Detection technology for seed health and seed health management technology
- Development of business and management skills specific to the seed sector:

- The management of inventories of seed varieties
- Financing techniques for seed production and credit tools for farmers.
- Marketing and farmers information techniques.

It is important to establish a state of the art on the subject in the country, as a prerequisite for a capacity development plan in this distinct field of the agricultural economy.