Science, Technology and Globalization Project
Agricultural Biotechnology for Development – socioeconomic issues and institutional challenges*

Belfer Center STPP

Kennedy School of Government

Adding value to agriculture through biotechnology:

Priority setting process in West and Central Africa

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Paper presented at a workshop held at Bella Villagio, Bellagio Italy, 30 May – 1 June 2005.

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Introduction

Agriculture is the most important sector of West and Central African (WCA) economy. It is the major occupation of the people and offers employment to about 70% of the population most of whom are living in the rural areas, and are women involved in traditional production and processing systems. It contributes to about 15.3 % of the total export earnings in terms of goods and services, and if Nigeria is excluded, this figure can go up to 30%. It also contributes to between 35% and 60% of its total gross domestic product (GDP), and supplies raw materials to agro-industries.

The agricultural potential of the sub-region is still yet largely under-exploited. The agricultural base is spread over a wide range of agro-ecologies, representing a high potential for producing enough staple food and cash crops to feed its populations as well as generate viable and competitive markets for a wide range of cereals, legumes, roots and tuber crops, livestock, forestry products and fisheries. There is high availability of agricultural land of which 284 millions hectares are arable. This includes fallow lands, of which only 60 hectares are actually exploited, corresponding to 24.6 % or 2 ha per rural habitant. To this potential of arable land could be added over 215 millions hectares of grazing land, mainly situated in the Sahel and Sahelo-soudanian zones, and more than 10 millions hectares of irrigated land, of which less than 10% are used very often for producing rice and vegetables. The rate of population growth in the sub-region has remained high and is currently 2-3% per year. In 1997, the rural population represented 64% of the total population. The maintenance of a high population growth rate provides a regional market consisting of more than a quarter of a billion of consumers, most of whom get their food supplies from imports from the international market. The regional market should offer opportunities for able farmers to successfully commercialize their products.

West African agriculture is, nevertheless, in full evolution. Though agriculture is still dominated by family farms, the sector has nonetheless undergone serious changes over the last twenty years. Production of almost all commodities, with the exception of cattle, has more than doubled between 1980 and 2000. This excludes all of the zones and countries confronted with conflicts where food aid is significant source of food commodities. These recent

past years have been marked by significant production increases strongly stimulated by urban demand, especially garden crops and small ruminant production. There is an emergence of better organized stakeholders at the regional level, who are eager to play an important role as true partners in the definition and implementation of policies and strategies, with strong consideration given to the rural area in particular.

Despite all of this potential, West African agriculture is generally performing poorly. Yields and productivity per farmer are among the lowest in the world and the region must devote about 19% of its imports to food supply. The countries of the sub-region are among some of the poorest on earth. More than 120 million of the sub-region’s total populations of 280 million people live below the poverty line of one US$ a day as defined by the United Nations. In the twenty two countries of the sub-region, this represents between 45% and 78% of the rural population and between 32% and 37% of the urban population. Hunger, poverty and malnutrition are the main factors interacting to create an enormous set back to socio-economic development, especially in the rural areas.

The region lacks sufficient human capital development, appropriate macroeconomic and sectoral policy frameworks, efficient marketing systems, access to credit facilities, adequate rural infrastructure. Effective institutions for supporting initiatives to energize agriculture, rural development and reduce poverty are also non existent. Development strategies initiated and implemented by West African States over the last twenty years accentuated the compartmentalization of national agricultural policies and, consequently, their poor articulation with those initiated at the regional level. Agricultural policies, often defined without the participation of grassroots stakeholders and inadequate attention paid to women’s specific needs in the production-distribution-consumption chain were poorly articulated with the macro-economic policies. They often, therefore, resulted in action plans, programs and projects, whose implementation are largely dependent on external financial assistance. This, therefore, thwarted the agricultural policy goals, i.e. food security, rural employment and integration into the regional market.

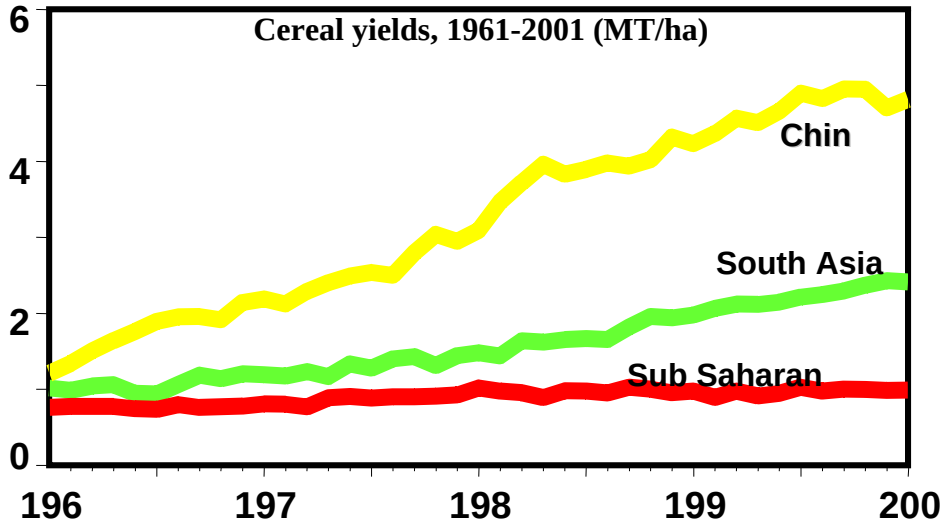
Inadequate investment in agricultural research has contributed in part to the underdevelopment and underperformance of agriculture in the sub-region, which since independence is at the core of the long-standing

problems of hunger, poverty, malnutrition, and the disappointing growth of the sub-region's economies. African agricultural productivity stagnated, whilst food productivity decreased in the 1970s and 80s, the decades during which other regions experienced rapid productivity increases (Figures 1 and 2). In countries where production has been recorded to be marginally keeping-up with population, this could largely be attributed to expanding land under agriculture.

Notwithstanding, this situation varies, and some positive impacts have been recorded as regards the production of some specific food crops in some specific countries in the region. Production figures published by FAO show a steady increase in the output of some crops and in some countries from the mid-1980s onwards, after the release by several NARS of improved varieties and the introduction of new plant protection approaches. Moreover, World Bank records indicate that per capita food production increased considerably in the 1990s as illustrated by a 24% increase for Benin, 19% for Nigeria, 12% for Ghana, and 11% for Guinea. However, these improvements are limited and have not made a significant impression on general trends as far as the sub-region as a whole is concerned. As such, there is still a big gap between food supply rate and population growth, which needs to be closed to ensure food security and facilitate poverty reduction.

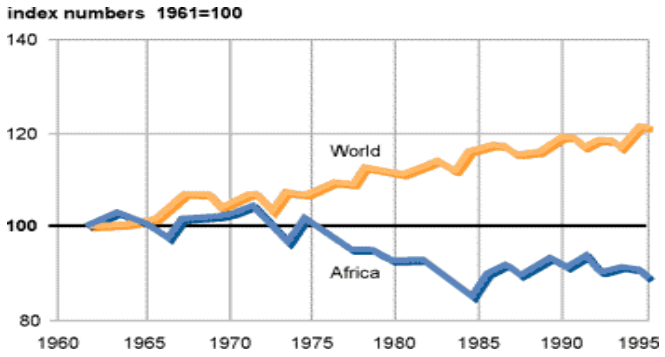
The most important challenge facing the sub-region, therefore, is to triple current food availability by 2025, while maintaining the natural resource base in the context of increasing urbanization. It is expected that the increasing urban markets, which are closer to production areas would provide the required incentives to intensify production. In the three main agro-ecological zones of the sub-region (Semi Arid Sahel, Humid Coastal, and Humid Central), urban-rural linkages are expected to be stronger, thus strengthening the competitiveness of production and ensuring income for producers.

Figures 1 & 2: Cereal yields data from 1961 to 2001 (MT/ha) Source FAOSTAT (2001); Food production per capita



Food Production per Capita:

Africa vs. rest of World



Section 1 Biotechnology in the context of national/sub-regional priorities

1.1 Potential of biotechnology in meeting national priorities

Improvement of plants and animals by human ingenuity is not new. The traditional and still very important way of developing desirable traits in plants and animals is through selective breeding and cross-fertilization. This method can be somewhat arbitrary and it can take several years to develop a new variety. Three basic groups of biotechnology that can be applied to improve conventional crop and animal production are tissue culture, molecular breeding and genetic modification. Tissue culture is relatively the simplest and most inexpensive technique. Molecular breeding technology is relatively sophisticated and requires fairly expensive facilities, equipment and highly trained scientists, whilst genetic modification is the most sophisticated of the three techniques. These techniques cannot replace conventional approaches to developing and disseminating crop varieties but could be utilized to complement them. Although they can be used separately, yet their effect on production is most significant when used together.

Tissue culture is the cultivation of plant tissues or organs on specially formulated nutrient media. It is seen as an important technology for developing countries including those in West and Central Africa because it offers the advantage of producing plants that are generally stronger, reach maturity earlier than ordinary plants, free of pests and likely to be free of most diseases, except viral diseases that may be present in the mother plant. Moreover the ensuing plants produce higher and better quality yields. The yield advantage is increased further when the mother plants are of improved varieties developed by crop breeders, because they are genetically identical to one another. There is a greater, though not absolute certainty, that they will all perform in the same way when grown in the field. This method greatly increases the rate of multiplication of plant materials and is therefore a powerful means of disseminating improved crop varieties to farmers, especially those with low multiplication ratio, such as cassava, sweet potato or banana. Tissue culture is also used to bulk up genetically identical raw material for other biotechnology processes especially genetic modification. **Several countries of the sub-region are**

emerging from armed conflicts, and tissue culture could be a rapid means of providing such communities with improved and clean planting materials to meet the food self-sufficiency needs of the population. Investments in this regard could quickly reduce dependence on food aid.

Molecular breeding or marker assisted breeding involves the use of genetic markers or DNA sequences, to track down certain traits. They assist in the development of new crop or animal varieties, which could be resistant to biotic and abiotic stresses. They are used in detecting genes associated with important traits by simple laboratory tests. In the case of plants they are used on young plantlets, and it is, therefore, no longer necessary to grow plants to maturity in the field to find out whether or not they posses a particular trait. As such, the time it takes to develop a new variety could be greatly reduced through the use of accurate markers for a gene or genes. These markers are more useful when a recessive gene, the expression that often skips a generation, making visual selection in the field prone to error, determines a trait. The markers are also used to analyze genetic variability or to assess the relationships between populations or gene pools. This helps in the search for potentially useful materials, which could be used in breeding, or to decide on conservation measures, for example, where to collect specimens, representative of the diversity of a threatened crop. The markers could also be used in mapping genomes for specific traits. This involves crossing a variety known to have the trait with one without it and studying the expression of the trait in the progeny. **The use of molecular marker techniques in breeding programs in the sub-region is expected to be particularly useful in tackling the crop adaptation to drought and their increased resistance to pests and diseases that are responsible for the lion-share of food crop losses**.

Since 1951 when James Watson and Francis Crick described the structure of DNA, and since 1973 when Ti plasmids were identified in the bacteria ***Agrobacterium tumefaciens***, plant breeding has witnessed some revolution. Since the early 1980s, scientists have been able to extract individual genes from the cells of one species of plant (or animal) and insert them into the cells of another. This process was often known as genetic engineering in the 1980s and 90s, but is now more commonly described as genetic modification or genetic manipulation (GM). The process of genetic modification allows the transfer of useful and desired

traits by dealing directly with the genes concerned. This technology compared to conventional breeding ensures greater speed, accuracy or certainty in the transfer of traits. In conventional breeding, the genes of parents are mixed resulting in a more or less random recombination in the offspring, with some remaining linked together thus making it almost impossible to separate the traits for which they are responsible. On the contrary, modern biotechnology allows a more accurate transfer of just one or a few genes. As such, desirable traits are delivered alone rather than in the company of other unwanted traits. This is a very important advantage because it enables plant breeders to retain the gains made through thousands of years of breeding when they develop new varieties. Thus on the whole, the technology could lead to the development of a new plant or animal type, which might have been developed with great difficulty or not at all. Moreover, whereas traditional techniques can only cross-breed among different varieties of the same species, genetic modification can transfer a gene from one species, such as an animal, to another, such as a plant. For this reason, some GM organisms are described as ‘transgenic’.

Genetic modification has come with brighter prospects for increasing yields, improving crop quality, and reducing production costs, among others. Some of the spectacular results obtained include the development of saline tolerant tomato; rice resistant to some common viruses and nematodes; the golden rice rich in vitamin A, required in the control of childhood diseases; modified maize and Bt cotton (Bt cotton is resistant to insects and therefore does not require the use of insecticides).The application of this modern biotechnology as a complement to traditional and organic approaches has made a significant contribution to advancing agricultural production in many industrialized countries.

In WCA, the rapidly growing rural population is dependent on agricultural production systems that are highly vulnerable to climatic and other abiotic and biotic conditions. Moreover, available areas of arable land per capita are becoming scarce, and there is a strong need to improve the means of the livelihood of the people in the sub-region. New approaches that will empower the farmers are urgently needed. They need to adopt new farming methods and improved plant and animal varieties to meet present and future needs. The application of modern biotechnology, when accompanied with the appropriate farming practices could be

especially highly relevant where there is an urgent need for producing more food from the same or less land area while boosting nutritional value and reducing negative impacts on the environment. It should offer the opportunity to add to the tool kit of technologies that can be used to meet the vital productivity and sustainability goals of producing more food from the same or less land area, and/or with greater nutritional value and less negative impact on the environment and thereby contributing to income generation.

The majority of research carried out on roots, tubers and tree crops is on mass propagation through tissue culture. Few national laboratories are endowed with the capacity to carry out germplasm characterization and molecular diagnostics on these crops. In the case of cereals, very few national laboratories also work in the area of germplasm molecular characterization, and fewer still have the capacity for using molecular markers for quantitative trait loci (QTL) identification to assist breeding and selection. There is an urgent need, in order to bridge the gap in biotechnology research, to gradually assist those laboratories at the tissue culture stage to move into germplasm characterization while those on characterization move to specific molecular marking technologies to identify a desirable gene or groups of genes to solve the intractable problems of resistance to biotic and abiotic stresses. Important staple food crops in the sub-region with serious disease and pest problems include cotton, cowpea, maize, sorghum, cassava, cocoyam, cocoa, and coconut. Currently these crops are being researched on using conventional approaches, to improve their resistance, and by consequence their production. However, in view of the necessary urgency to resolve the food crisis in the sub-region these crops could benefit from genetic transformation. This could be a two step scientific process as described by Traxler. For some of these commodities, the transformation technologies are being developed elsewhere and for them to be adapted to local conditions, however, endogenous capacity has to be built. Traxler referred to this as the Plant Breeding step. This process would involve capacity for backcrossing the gene from the receptor variety into popular local varieties. This process is routine, relatively inexpensive and applied research. In other cases the technology has to be developed locally. Traxler referred to this step as the Biotechnology step, which includes the discovery of the useful event and transformation of receptor plant variety. For this has to

be received. This is advanced science, expensive research which will need biosafety approval.

In the case of animal biotechnology countries are faced with productivity and disease constraints. These countries need to develop research capacity in diagnostics, molecular characterization of livestock and poultry, and their linkage with breed improvement, as well as the development of recombinant vaccines against diseases such as contagious bovine pleuropneumonia (CBPP) and heartwater (cowdriosis) diseases. The potency of these vaccines needs to be tested within the sub-region in order to make the necessary modifications.

The use of modern biotechnology is therefore yet to become a true reality in effectively providing the desired food security drive or in economic terms. In effect, there are several constraints to its wider application in the sub-region. Modern biotechnology is often highly intensive in terms of facilities and expertise. A survey carried out by Alhassan (2002 include on list of reference) revealed that the most important of these constraints are the limited human capacity available for applying the technology, the lack of financial and infrastructural resources to implement promising biotechnologies beyond pilot scales, poor political commitment, poor private sector linkage, low public awareness, lack of access to information, and as a consequence the controversies surrounding many of the available agricultural biotechnologies, more especially genetic engineering and products resulting from its use. In terms of biotechnology capacity, the NARs in developing countries have been classed into three types (Byerler and Fischer, 2002). With regards to this classification, all the national agricultural research systems in WCA could be classed under type III NARS. These NARS are in countries with small to medium market size in terms of potential research and development impact. Their plant breeding programs are usually small and fragile and depend on a very small number of, usually one or two, individuals. They have very little or no capacity in molecular biology although many have capacity in tissue culture. Partnership with the private sector for food crops is almost inexistent. Though most of them now have a regulatory framework but with weak capacity to implement them.

The ability, therefore, to apply agricultural biotechnology successfully in WCA requires increased capacity, and supporting infrastructure and working links between the scientific community and end-users of the technologies.

Many countries in the sub-region, however, do not have sufficient resources to develop their own capacity for biotechnology research or training in biotechnology applications. Consequently, pooling such facilities and expertise is the most efficient approach to address priorities across the region for successful outcomes. Moreover, the West and Central African Council for Agricultural Research and Development (CORAF/WECARD) General Assembly representing 22 countries underscored the need for the WCA sub-region to be involved both in the debate and in the practical application of agricultural biotechnology for development. These constraints could be addressed through sub-regional co-operation and partnerships led by this apex research cooperation body in the sub-region. In effect CORAF/WECARD could facilitate the development of associated agricultural research networks with specific commodity mandates and the possibility to explore opportunities for sub-regional biotechnology platforms.

Despite all of these constraints, Burkina Faso in collaboration with the Mosanto Company is involved in some controlled field trials on Bt cotton. One would have expected a large cotton-based economy as Mali to be one of the major early players in field trials and eventually adoption of Bt cotton. However, such speculations have not yet materialized. One major factor hindering wide-scale adoption of this technology in the sub-region has been the absence of the necessary biosafety rules and regulations. Most of the existing rules and regulations on live-products concern phytosanitary issues and the importation and exportation of seeds. Though some countries have established national committees on biosafety, some of them are yet to agree on a formal position to be adopted with respect to modern biotechnology. In 2001, the defunct Organization of African Unity (now transformed to African Union - AU) proposed a model law based on the Cartagena Protocol on Biosafety. South Africa appears, however, to be the only African country south of the Sahara that has fully commercialized GM products.

1.2 critics

The skepticism of African policy makers on adoption of this technology appears, however, to be largely as a result of inadequate dissemination and internalization of the much desired information on the benefits of modern agricultural biotechnology, and the potential risks of GM products.

There has been a small but very vocal opposition to the technology, and policy makers appear to be taking a sit-and-wait attitude. Most of the opposition is focused on the following:

- ☞ Little or lack of interest by the multi-nationals in the traditional food security crops of the sub-region such as millet, sorghum, cowpea, fonio, cassava, yam, plantain, etc.
- ☞ The unwelcome need by farmers to renew their seed stocks regularly by purchasing from multinational seed companies.
- ☞ Absence of effective regulatory structures that should facilitate the handling and safe transfer across the porous borders of the sub-region of GM products.
- ☞ Fears of possible risks of the technology to human and animal health and to the environment e.g. induction of genetic anomalies, or some toxicological effects, or perceived possibility of inducing some allergies; or fears of creating monster weeds which may be resistant to herbicides and fears of transmitting to wild species via pollination, some genes resistant to pesticides, etc.

While this skeptic positions lasts, the farmers are continuing their traditional cropping production systems – traditional practice of seed production and distribution. There is therefore a challenge in marketing impact-oriented information, which should contribute to reversing the fore-going four points. Such information may not have to over-capitalize on the issue of ripping huge financial benefits by multinationals via the continued renewal of the farmers' seeds stocks especially if such monetary gains are intended to be derived from the wretched of the earth.

Information should focus on the benefits of modern biotechnology on food security situation for the hungriest of the hungry and the poorest of the poor. Such information should demonstrate how this cutting-edge technology may tackle the root-cause of today's famines, as is being witnessed currently in Niger and in Sudan – famines caused by marginal yields resulting from long drought complicated by severe locust (pest) infestations and armed conflicts. The desired information should demonstrate how this technology is positioned for contributing to the realization of the millennium development goals. This is an uphill task, especially if one has to put in perspectives that technology is the result of investments, which should yield dividends. However, the dividend most desired by

countries of West and Central African is self-food sufficiency.

One would naturally postulate that it is ethically wrong for anyone to persuade a famine stricken people to refuse GM products as food aid just based on a non-scientifically proven position that the products are not good for them. In other words, the negative perception of GM products in some African countries is not based on the result of any scientific analysis of the products, but more of the respect by the local decision-takers on the position of certain donors. Adequate science-based information is required to fill this gap and to change the mind-sets.

1.3 Embracing the new initiative – engaging the region

Biotechnology constitutes all the techniques, methods and procedures that use micro-organisms and plant and animal cells for producing goods and services for the benefit of humankind. The application of modern biotechnology, resulting in the development of GMOs, raises concerns related to the potential health and environmental risks. This issue was the theme for discussion during the Sacramento Conference in the USA held in June 2003. This Conference, attended by 112 Ministers of Agriculture, Environment, Health, and Water from 117 countries, discussed the needs of developing countries and formulated recommendations concerning their access to new agricultural and food technologies. The perspective of the discussion was geared towards ways of achieving the objectives of the World Food Summit, which will allow the reduction of hunger in the world by half in 2015.

Within the framework of the implementation of these recommendations, a West African regional conference was held in June 2004 in Ouagadougou, Burkina Faso on “The use of science and technology for increasing agricultural productivity in Africa: perspectives in West Africa”. This conference revealed the need to establish the following:

- ☞ A public information system on biotechnology by West and Central African nations;
- ☞ A partnership between West African research institutions and their counterparts in the North, particularly the USA, in the area of agricultural science and technology;

- A West African Centre for Biotechnology.

The Conference participants also agreed to:

- organize another Conference of the Ministers of Agriculture in West Africa under the aegis of the Economic Community of West African States (ECOWAS) in Bamako, for harmonizing biosafety regulations and adopting an action plan for promoting biotechnology;
- institutionalize a Conference of Ministers of Agriculture in West Africa, as a first step towards the creation of an African Ministerial Conference of Biotechnology.

In other respects, the West African Ministers of Science and Technology decided to organize a conference in Abuja, on 4th November 2004, under the aegis of ECOWAS. The ECOWAS found it useful to integrate into the discussions during this Conference, a component on "Agriculture and Biotechnology". The objective was to collate the necessary information for a better preparation of the Bamako meeting scheduled for June 2005. The ECOWAS 4th November 2004 meeting was held as scheduled, and the conference declarations included the need for centers of excellence in biotechnology, concerns on intellectual property rights, and appropriation of regional initiatives in the domain of biotechnology.

The Conference of the Ministers of Agriculture in West Africa, scheduled to be organized under the aegis of the Economic Community of West African States (ECOWAS) in Bamako was held in June, 2005. Amongst the issues raised during the ministerial conference the following:

With respect to biotechnology:

- Encouraging and increasing investments in agricultural biotechnology through the stimulation of private-public partnerships.
- Putting in place common phytosanitary legislation in ECOWAS member States and strengthening national legislations.
- Putting in place a regional regulatory biosafety framework and strengthening national seed production systems to facilitate the distribution of improved seeds;

- ☞ Encourage the establishment of a regional policy and the development of national systems on IPR management in order to facilitate the acquisition, development and dissemination of knowledge and innovations.
- ☞ Encourage networking of national laboratories specialised in the development of agricultural biotechnology; and mobilise African diaspora.

With respect to biosafety:

- ☞ The Ministerial Conference recommended that countries of the sub-region that had not yet ratified the Cartagena Protocol were called do so by end of June 2006 at the latest, to facilitate sub-regional harmonization of the biosafety system before the end of July 2008;
- ☞ Implement the regional strategic Plan on biosafety for the benefit and access of biotechnology in West Africa; and put in place an independent fund for assessment of the socio-economic impacts of the use of GMO.

With respect to information and communication strategy:

- ☞ Encourage and support countries in creating national information and communication units charged with raising public awareness on the benefits of application of biotechnology to agriculture
- ☞ Support ECOWAS to achieve its missions of advocacy and coordination of the implementation of the information and communication strategy on biotechnologies.
- ☞ Encourage ECOWAS to establish partnerships with other regional and international organisations having an

experience in the field of information and communication on agricultural biotechnologies.

After having examined the possibilities given by the revised ECOWAS treaty, particularly in its Chapter 3, the Ministers decided to institutionalise the organisation of annual Conference on Biotechnology.

It is clear from these recommendations that the leadership role of CORAF/WECARD in agricultural biotechnology research and development has of now been confirmed by the Economic Community of West African States (ECOWAS). This institution has integrated the CORAF-BBP into its strategic agenda, and considers CORAF/WECARD as its technical arm for the implementation of agricultural research and development activities concerning biotechnology and biosafety in the sub-region. This is also the position of the Permanent Inter State Committee for the Control of Drought in the Sahel (CILSS). Other intergovernmental organisations such as the Economic and Monetary Community of Central African States (ECCAS) and "l'Union Economique et Monétaire Ouest Africaine (UEMOA)" are engaged in discussions with CORAF/WECARD, bearing in the same direction.

Section 2. CORAF/WECARD approach in agricultural biotechnology research and development in the sub-region

2.1 The regional mandate of CORAF/WECARD

In an effort to establish regional collaboration, synergies and pooling together of resources to tackle common agricultural research and developmental problems, CORAF/WECARD was established in 1987 with the mission to:

a) improve the efficiency and effectiveness of agricultural research in West and Central Africa by contributing to the construction and the consolidation of the capacities of the NARS, through cooperation between its members, development partners, regional and international organizations, private sector, non-governmental organizations, and users of research results;

b) consolidate the position of the West and Central African sub-region within the context of the international agricultural research and development.

CORAF/WECARD is mandated to implement the sub-regional agricultural research policies defined by the political

authorities of member countries and has set, as its objectives, to:

a) promote cooperation, consultation, and information/data exchange between member institutions on the one hand, and the partners on the other hand;

b) define joint sub-regional and regional research objectives and priorities;

c) serve as a consultative body for research carried out by regional and international organizations operating at the sub-regional level;

d) develop joint research programs to strengthen complementary activities of CORAF/WECARD and its partners;

e) harmonize the activities of the existing research networks and facilitate the creation of new regional networks or other operational research units with a regional character.

2.2. SWOT Analysis of CORAF/WECARD member countries

The strengths weaknesses, opportunities, and threats for biotechnology application to agriculture were studied in selected countries in West and Central Africa by Walter Alhassan (personal communications) during a preliminary survey in 2000. The study revealed the general weak capacity of the national agricultural research systems (NARS) for biotechnology work. This study served as a catalyst for an in-depth survey (Alhassan, 2003) on the capacity for agricultural biotechnology application for food security in West and Central Africa at the request of CORAF/WECARD. The new survey focused on the following countries: Burkina Faso, Cameroon, Cote d'Ivoire, Ghana, Mali, Nigeria, and Senegal. The survey focused on the following:

- ☞ Preparing an inventory of ongoing or planned biotechnology activities
- ☞ Identifying gaps and opportunities for agrobiotechnology interventions that will address issues regarding food security in the region
- ☞ Developing a framework to assist in undertaking priority setting for biotechnology research and development from a regional perspective.

The study revealed that the biotechnology research capability in Burkina Faso as relates to trained manpower and infrastructure was low but generally better than Mali. In Cameroon, there is considerable strength in tissue culture and a growing potential for molecular biology work. Conventional plant breeding has failed to resolve the problem

with cocoyam root rot in Cameroon. Perhaps this could benefit from transformation of the plant. In Côte d'lvoire, however, the infrastructure for biotechnology is above average for the sub-region except for manpower, whereas the biotechnology infrastructure for Ghana is weak but the manpower base is relatively strong. For Nigeria the infrastructure in tissue culture work is strong but relatively weak in molecular biotechnology infrastructure. The study report, however, added that the situation in Nigeria was likely to change soon as Nigeria develops her state of the art infrastructure in biotechnology at the SHESTCO science village. Nigeria has in recent times exhibited great commitment to the use of biotechnology as a tool to enhance agricultural and general socioeconomic development. A biotechnology development policy has been drawn, biosafety guidelines drawn, and institutions to promote biotechnology research and development and its linkage with entrepreneurs established. The laboratory infrastructure and manpower for agricultural biotechnology in Senegal is among the best in the sub-region. The standard of biotechnology work is relatively more advanced than a number of countries in the sub-region.

A key constraint for which there was persistent requests by the NARS was training at both researcher and technician level for both biotechnology and biosafety. Next to this was laboratory infrastructure. Less than 50% of the NGOs surveyed had a positive attitude to biotechnology products like genetically modified foods.

All countries in the sub-region took varying actions on biosafety ranging from taking steps to constitute biosafety drafting committees to bringing their biosafety framework documents to the point of legislation. The most advanced in this regard are Cameroon, Cote d'Ivoire, and Nigeria. In the case of Nigeria, there is cabinet approval to begin implementing the biosafety guidelines pending legislation. Cameroon is the only country that has ratified the Catagena Protocol on biosafety. All other countries have signed the protocol and are in the process of ratification.

The report proposes the prioritization and management of biotechnology activities in West and Central Africa within the current CORAF/WECARD network management process. The three laboratories in the sub-region with quantitative trait loci (QTL) mapping capacity, namely, Centre d'Etude Regional pour 1'Amelioration de 1’Adaptation a la Sécheresse (CERAAS) in Senegal, the Cocoa Research Institute Ghana (CRIG) in Ghana, and Centre National de Recherche Agronomique (CNRA) in Cote d'Ivoire should be targeted for initial support to bring technologies to the level of transformation. Such laboratories alongside others that may emerge can be used as

training grounds for biotechnology while solving sub-regional problems requiring high-level biotechnology intervention.

Modern biotechnological techniques are often highly intensive in terms of facilities and expertise. The most efficient approach that could be adopted by CORAF/WECARD to address priorities across the sub-region, which would lead to successful outcomes, will include pooling such facilities and expertise. Since most countries in the sub-region cannot afford to go it alone, a regional approach is the only logical way of tapping-into the potentials of this technology for the benefits of the population of sub-region. The transformation of some of the regional/international centers into centers of excellence for biotechnology work would serve as training centers for NARS scientists, would serve as centers for technology generation and adaptation for the sub-region. CORAF/WECARD would develop a strategy to mobilize experts from the countries in the sub-region and from the international community conduction biotechnology work in the centers.

2.3. Mobilizing partners for biotechnology application

CORAF/WECARD commissioned a working group to delineate the tasks and to propose a sub-regional position to stakeholders. The working group comprised country representation of experts in biotechnology and biosafety in the sub-region, intergovernmental organizations, international and regional research institutions in the sub region, CORAF/WECARD Executive Secretariat and a representative of the Scientific and Technical Committee of CORAF/WECARD, scientific partners and facilitators from the Agricultural Biotechnology Support Project II (ABSPII) coordinated by Cornell University and Program on Biosafety Systems (PBS) coordinated by the International Food Policy Research Institute (IFPRI). During the whole planning process, two working group meetings, one stakeholder forum and one strategic proposal document preparation meeting were organized.

Given the sub-regional mandate of CORAF/WECARD therefore, with regards to agricultural biotechnology, its role is to mobilize multi-disciplinary, multi-institutional and multi-stakeholder partnerships for building the necessary biotechnological and biosafety tools and expertise via product development (Figure 3). This would result in CORAF/WECARD promoting positive outcomes in agriculture through facilitating collaboration between all

participating partners in agricultural biotechnology.

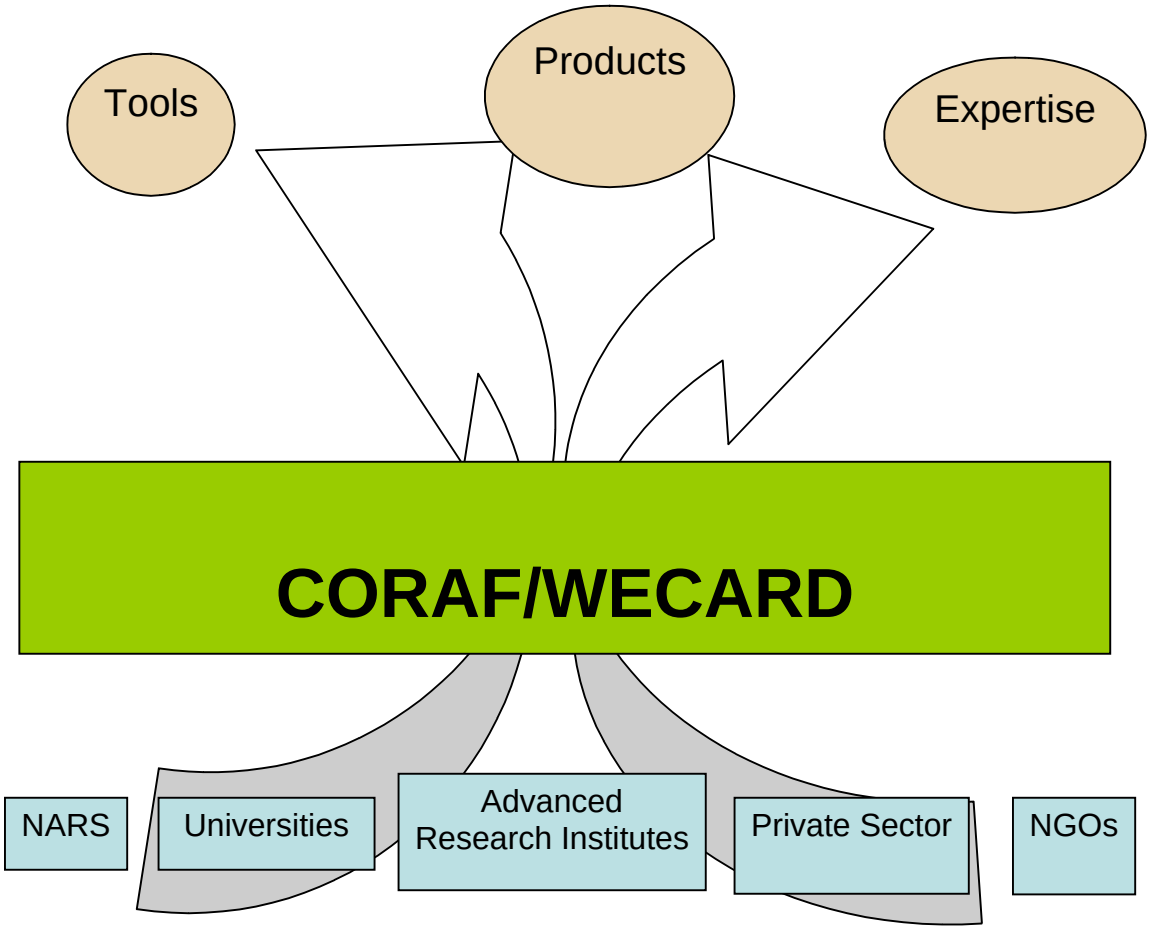


Figure 3: Schematic representation of the role of CORAF/WECARD and expected output from application of biotechnology

Section 3: Biotechnology agenda

3.1 General problems to be addressed

There has been a relative improvement of the food supply situation in the region as a result of increases in production resulting from release of improved crop varieties. For example in 1980, regional food supply lagged

5 years behind regional demand, i.e. the amount produced in 1980 was equal to the amount consumed in 1975. By 1993 the gap between supply and demand had been reduced to 3 years, with regional production in 1993 equal to consumption requirements of 1990. A significant gap still exists largely as a result of a combination of factors ranging from degradation of the natural resource base, through low production potential of animal and plant genetic material, susceptibility of these resources to biotic and abiotic stresses, poor use of agricultural products in agro-industrial processing, strong pressures exerted on the agricultural environment as a whole and on genetic resources and the soils in particular. Ensuring **food security and poverty reduction** would mean an effective closure of this food supply gap. This needs to be assured via target oriented research, and proper application of generated technologies. The sub-region needs the capacity to assess and use the tools of agricultural biotechnology in removing productivity and market constraints. These include the multiple interactions of the following:

Many set-backs in the use of biotechnology have been suggested by critics. The most serious of these, which can slow down the adoption of biotechnology and its products, are linked to the following:

- High cost of the technology aggravated by the poor investment of the public and private sectors;
- Problems related to the environment such as gene escape, and to human health;
- Intellectual property rights especially relating to patents, farmers’ rights, and biopiracy;
- Lack of explicit domestic biotechnology policies exacerbated by uninformed legal entities;
- Low biotechnology capacity including material and human resources;
- Low biosafety capacity including the lack of regulatory frameworks (policies and strategies, capacity evaluation, regulations and implementation mechanisms).

The regional approach hopes to create centers of excellence in which expensive research infrastructure can be concentrated thus making it unnecessary for every country in the sub-region to finance similar materials for the same purpose. As stated earlier such centers would also serve as human development centers in biotechnology research. Biosafety issues are similarly expected to be handled

through the constructive engaging of the various countries via regional ministerial and economic bodies. CORAF/WECARD believes for example, the regional harmonization of biosafety regulations in the sub-region will facilitate the movement of biotechnology products

3.2. Priority setting process for biotechnology and biosafety

The first step undertaken by CORAF/WECARD to define the modalities for integrating agricultural biotechnology and biosafety to the activities of the sub-region was the commissioning of some pre-priority setting studies, focused on the status of agricultural biotechnology in selected WCA countries (Alhassan, 2003). These studies came out with the following conclusions:

- ☞ Individual country research institutes possess insufficient capacity to undertake research independently for launching major biotechnology products due to funding and manpower constraints;
- ☞ The sub-region needs to collectively take advantage of the outcome of biotechnology work being undertaken by the IARCs in the sub-region in collaboration with selected national agricultural research institutes;
- ☞ Biosafety implementation requires a wide range of technical expertise, all of which may not be present in one country;
- ☞ The harmonization of biosafety regulations in the sub-region will facilitate the movement of biotechnology products.

In conclusion the individual countries of the sub-region are characterized by insufficient and unbalanced human capacity as well as poor financial resources to undertake research for launching major biotechnology products on their own.

Based on these conclusions, CORAF/WECARD, with the support of USAID, initiated a planning process aimed at developing a regional program integrating biotechnology and biosafety into the existing regional research activities of CORAF/WECARD, in order to contribute to solving the region’s food security problems in a safe and cost effective manner. The specific objectives were to:

- ☞ Identify the opportunities for integrating biotechnology and biosafety into existing research activities in the region;
- ☞ Build awareness towards establishing a regional program in biotechnology and biosafety;
- ☞ Determine the structure and implementation of a regional biotechnology and biosafety initiative.

To facilitate the planning process, a working group made up of experts in biotechnology and biosafety in the sub-region and their partners, was constituted in November 2003. Their role in order to achieve these objectives were to:

- harness capabilities of member countries in biotechnology and encourage partnerships with advanced institutions in biotechnology to accelerate the pace of capacity building and application of the tool;
- examine strategies and mechanisms for a sub-regional biotechnology initiative;
- determine the sub-regional priorities and framework for biotechnology integration into network programs;
- examine the possibility of sub-regional biosafety harmonization and recommend regional framework for biosafety and its integration with sanitary and phytosanitary measures in the sub-region;
- create sub-regional awareness on Intellectual Property Rights and Technology Transfer relating to Biotechnology;
- make recommendations on effective public awareness on issues of biotechnology and biosafety;
- develop work plans, budget and a full proposal for implementation of biotechnology and biosafety programs for submission to development investors/donors.

3.2.1. *The priority setting process*

Priority commodities in the sub-region were established based on a set of relevant agricultural development criteria such as economic growth, social welfare, environmental quality, capacity development and potential impact at the sub-regional level. WCA comprises 22 countries covering an area of 11.5 million km^2 made up of a diverse agro-system ranging from the system of oasis of the Sahara, through the various levels of the Sahel and savannah systems, to the equatorial forests and the coastal humid zones. In the CORAF/WECARD strategic document, this diverse agro-system has been narrowed down to cover three

zones: the Sudan-Sahelian zone, referred to as the Sahel Zone, the Wet Sub-tropical West Zone, referred to as the Wet Coastal zone, and the Wet Sub Tropical Central zone, referred to as the Wet Central Zone. Further prioritization of crop commodities was, therefore, made by zone. On this basis, scores from 1 to 5 were attributed per crop and per zone, with 1 being the most important value. In the case of animals, however, prioritization was based on animal products rather than animal species. This approach took into account the organization of the professional sectors within the context of the agro-industry sector, capable of supporting and making better use of research results, and also the fact that genetic engineering is a powerful tool that could be used to improve animal production systems independently of the species. This process resulted in the ranking (per ecological zone in the case of crop commodities) of a long list of priority crops and animal products. This process was followed by the identification of a relatively large group of common priority constraints to the production of priority crops/animals. A summary of the top ranking priority crops/animals and the most important problems associated with their production, is shown in Appendix 1. The commodity/constraint rankings are meant to be used by the CORAF-BBP to determine priority targets for the application of biotechnology research in agriculture, to ensure that research is demand-driven and that the research results will be used to solve real problems in the sub-region.

This process, which included the identification of priorities and opportunities to adapt existing research from the international community, also focused on near-term results, which can be adopted or adapted to West and Central Africa within a 2 – 5 year time frame. It also analyzed near-term impact of various agricultural biotechnology options to help CORAF/WECARD rally support from investors and the political caucus in the West and Central Africa sub-region. It considered a number of potential research projects/programs including current research efforts, where biotechnology applications are already under consideration. The potential impacts domains included economic, social, environmental, technical, trade and health.

Through this process, the WG led stakeholders in identifying priority opportunities for research and

existing technologies and also for their transfer and adaptation. The WG surveyed and synthesized into a short list of priority opportunities:

- ☞ Current CORAF/WECARD sub-regional research priorities
- ☞ Existing research in the international community which could be applied in the CORAF/WECARD region;
- ☞ The scope of technologies to be reviewed, including the following: tissue culture, molecular marker and marker assisted breeding, diagnostics, microbial biotechnology, and genetic modification applied to plants, animals and micro-organisms.

The WG did the following:

- ☞ Reviewed CORAF/WECARD sub-regional commodity research priorities, whilst matching commodity constraints with biotechnology opportunities
- ☞ Reviewed Biotechnology Research and Development (R&D) ongoing in the region by for example, research networks
- ☞ Reviewed Biotechnology R&D ongoing in the international community with potential relevance to regional research priorities
- ☞ Identified the most appropriate opportunities for regional intervention in biotechnology
- ☞ Identified approaches to awareness creation for policy makers and the public at large on biotechnology issues in order to create public confidence in the technology
- ☞ Proposed regional mechanisms for managing and coordinating agricultural biotechnology research and development under CORAF/WECARD, within the existing framework of CORAF/WECARD research and training units (base centers, poles and networks)
- ☞ Recommended mechanisms for engagement of the private sector and farmers in the use of the technology.

These results were adopted by a wider stakeholder forum which included the following: policy-makers within national governments and Regional Economic Communities (RECs), managers and scientists of National Agricultural Research systems (NARS) and International Agricultural Research Institutions (IARCs), Development partners, Non Governmental Organizations (NGOs), the Civil Society, Farmers Organizations (FOs), Professional Agricultural

Organizations (PAOs), the private sector, the media and donors.

3.2.2. Outcome of the process

The outcome of this whole process was the documentation of a sub-regional approach towards the adoption of biotechnology in the sub-regional research cooperation for development. This includes the following accomplished steps:

- ☞ A new CORAF biotechnology and biosafety program (CORAF-BBP) has been developed; with a management structure and an plan outlined for implementing priority activities;
- ☞ Priority plant and animal production constraints have been identified and a mechanism to direct competitive funds towards addressing these constraints has been conceptualized;
- ☞ Opportunities for regional cooperation in instituting biosafety policy and regulations and critical steps in moving towards a functioning sub-regional biosafety system have been identified.

The strategy of the CORAF-BBP is based on three main principles namely, demand-driven priority setting, a strong focus on product development and delivery involving South-South and North-South collaboration, and a dual, complementary approach to supporting these activities through a combination of a competitive grants system (CGS) and commissioned projects. The anticipated products range from urgently needed new crop varieties and crop propagation methods to novel diagnostic kits for the detection of animal or plant diseases, new vaccines and reproductive technologies for improved livestock production. Such a product-driven approach to capacity building will provide practical, “real life” experience for scientists, regulators, extension workers and farmers. It will also improve the general public’s ability to make informed decisions based on the benefits and possible risks associated with each product rather than on generalized debates. Meanwhile, the **biotechnology products themselves are expected to directly contribute to boosting food and nutrition security, economic growth stimulation, and environmental quality**.

In the ECOWAS region, the agro-ecological zones cut across countries. In the present circumstances, therefore, where most research institutions are facing severe financial crisis due to reduction in budgetary allocations by governments and grants from donors, many NARS have been trying to participate in co-operative research networks and programs. This CORAF-BBP is expected to ensure efficiency gains, which should benefit individual countries. Moreover, it provides an opportunity for creating a new dynamism in agricultural research cooperation and investment programs, in which regional research priorities will be more efficiently addressed by pooling facilities and expertise.

It is important, however, to note that there may not be either a need for a biotechnology solution or currently, any technologies available to address some of the constraints identified during the process. Also, by its very nature, the described CORAF/WECARD priority setting process reflects the experience of the respondents involved in the priority setting process. The limitation of this process, which depends totally on respondents, has been demonstrated by the fact that the priorities tend to evolve depending on the stakeholder group that is being addressed, and may therefore need to be revised in the future. This represents some weakness in the priority setting process for the identification of priorities for animal biotechnology. The process has, therefore, to integrate supporting analytical and quantitative analyses. The strategic importance of such an approach is that it will take into consideration issues such as the linkage between commodities and sub sectors to agricultural development domains, interactions between supply and demand, prices and traded quantities, and also the linkage between agricultural and non-agricultural issues and the overall economy. Moreover, for the process to be meaningful and objective, set agreed development targets for Africa such as the millennium development goals have to be taken into consideration.

Another key issue to be considered is how the results of this process could be modified to guide biotechnological interventions while addressing differences between ECOWAS and West and Central Africa (WCA). This could be realized through an approach involving the setting of investment principles so as to enhance the activities of farmers, the private sector and local governments in ECOWAS. These principles can be summarized in ‘three Cs’, namely

Concordance, Catch-up, and Complementarity. Concordance involves targeting research and development investments proportionally to the resource allocation decision of farmers; *Catch-up* involves targeting investments proportionally to the probabilities of success, in the light of breakthroughs that have been achieved elsewhere; and *Complementarity* involves targeting investments to support rather than replace the activities of private entrepreneurs and public agencies. The strategic implication of this approach is that it will provide information on some of the most worthy target commodities in the ECOWAS if agricultural biotechnology investments are to be focused.

To fill up this gap an economic analysis of the priority commodities and constraints, based on these limitations, is presently being conducted by CORAF/WECARD in partnership with the International Food Policy Research Institute (IFPRI).

3.3. Product development and delivery focus

The CORAF-BBP for West and Central Africa is focused on a product development and delivery approach with the aim of demonstrating the potentials of agricultural biotechnology in responding to farm productivity needs (Figure 4). The approach is expected to offer a practical, “real life” experience for scientists, extension workers and farmers as well as regulators and policy makers (see Figure 4). The approach also focuses on improving the general public’s opportunity to make informed decisions based on the benefits and any plausible risks associated with specific products rather than on generalized debate.

Important issues to be considered for the sub-region are: whether or not the end-user will have access to the product, how such a product will be made available to the end-user and how would the end-user have access to the necessary information to make a rational choice. In this respect, therefore, a product delivery strategy to users of the technology in sub-region is desirable. This, in effect, is an approach that should ensure that capacity and experience could be built throughout the product development and delivery chain. In the process of product development, near and longer term technology opportunities are expected to form the basis for the selection of specific projects.

Near-term technology opportunities will focus on the transfer and use of proven biotechnologies, which must be adapted to priority local crops and livestock and their production constraints in the sub-region. These activities are expected to catalyze capacity development, and include:

- ☞ development and use of molecular tools for plant and animal breeding, characterization of genetic resources and epidemiological studies – a review of the research priority of the sub-region in the area of plant and animal production clearly reveals the need to characterize local genetic resources in order to accelerate their use in genetic improvement programs and also to conduct epidemiological studies on important diseases.
- ☞ In vitro culture, micro-propagation, and conservation of local genetic resources: there are already various on-going programs in the sub-region that need to be encouraged through special initiatives for relevant priority crops in order to ensure a regular supply planting materials with low disease load, high performance planting materials, etc.
- ☞ Production of diagnostic tools and recombinant vaccines: these activities must involve the improved characterization of local viruses and the extension of these studies to unknown viruses in order to produce more specific tools (monoclonal antibodies, molecular probes and primers). The activities must also focus on the identification of immunogenic components in virus genomes of local strains, which will lead to the production of more efficient vaccines.

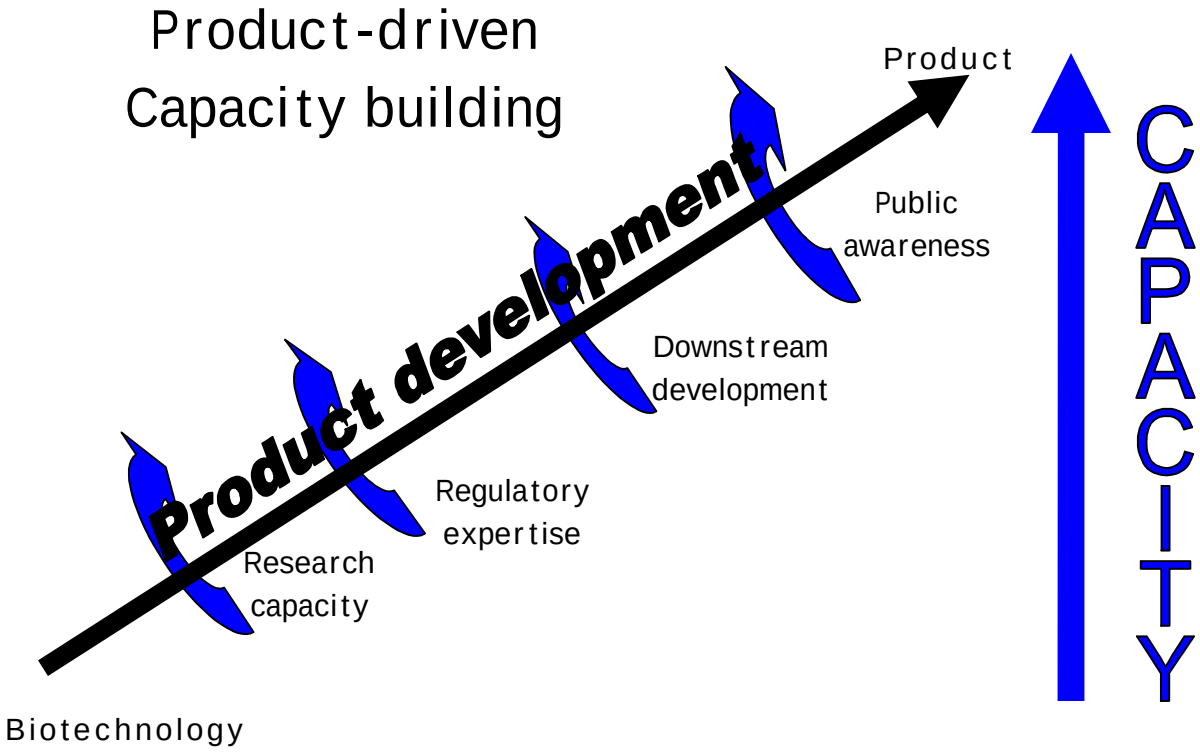


Figure 4: Product-driven capacity building biotechnology and biosafety program

Longer-term technology opportunities: It is necessary to put in place the necessary scientific, human and material capacities before proceeding with certain activities. Actions promoted by the private sector, which should stimulate the development of seed production and commercialization of biotechnology products are important in the longer term. The sustainability of this sector will depend on the degree of involvement of private companies, including the multi-nationals, in the implementation of such activities such as:

- ☞ The transfer of genes of interest contained in existing genetically modified organisms (GMOs) to local varieties: this is expected to be conducted through all the existing channels (involving conventional breeding or modern biotechnology). In certain cases, it might be possible to create the same gene constructs from local genetic resources in order to create GMOs appropriate to local needs and enterprises.

- ☞ Production of GMOs to overcome local constraints: the priorities of the region are to proceed with evaluation studies under local conditions, and environmental and socio-economic impact studies of GMOs already developed by other research institutions (e.g. Bt cotton, herbicide resistant cotton, cassava resistant to the ACMV). The transfer of these technologies must be conducted within a legal framework.
- ☞ Search for novel genes and promoters within the African germplasm: the biodiversity of the region is very rich but poorly characterized. It is, therefore, necessary to concentrate on the research for genetic traits of agricultural relevance at both the inter- and intra-specific levels.

In terms of product delivery the principal challenge will be to adapt and utilize biotechnology as an integral part of the seed multiplication system.

The inadequate financial support provided to scientific research by the political authorities reduces the possibilities of adapting the technological solutions available to solve farmers' problems. Even when financial support exists, the inadequacy of the activities conducted in the research institutions with respect to the actual needs of the farmers does not often stimulate the adoption of new technologies. On the other hand, poor extension services resulting in low technology transfer actions, a situation further complicated by inadequate communication systems in the sub-region, constitute significant limitations to the exposure of farmers and other beneficiaries to innovations. Farmers are seldom involved in the development of these innovations and are often poorly informed of the benefits that may accrue from these new technologies. The NARS of the sub-region are presently trying to strengthen these weaknesses.

Moreover, the sub-regional approach would be focusing on the following:

- ☞ Commissioning of research which would focus on the following target crops/livestock commodities: sorghum, maize, cassava, cattle, goat and sheep, based on the near and long-term technology opportunities identified above (see Table 1).
- ☞ Scaling-up investments so that the technologies produced can reach the millions of the dispersed, resource poor farmers who need them.

Table 1: Summary of top ranking crops and livestock and the most important problems associated with their production derived from the CORAF/WECARD priority setting exercise

Crop	**Constraint**
Sorghum	Striga resistance
	Insect resistance (bugs, borers, etc.)
Maize	Grain protein quality
Rice	RYMV resistance
	Pyriculariose resistance
	Aflatoxin control
Groundnut	Resistance to rosette and clump viruses
	Control of storage insects (weevils)
	Resisance to fungi (rust, Cercosporia,)
Cowpea	Resistance to Striga
	Resistance to post-harvest insects (weevils)
	Resistance to insect pests affecting production (bugs, pod borers)
Tomato	Resistance to Tomato geminivirus
	Modified ripening
	Nematode resistance
Coconut	Resistance to lethal yellowing
Banana/Plantain	Nematode resistance
	Resistance to viruses (CMV, BTV, BSV)
Cassava	Resistance to the ACMV
Cotton	Resistance to *Bemiscia tabaci* and Helicoverpa
Cacao	Resistance to *Phytophtora sp*.
Forestry crops	Seed production
All crops	Maintenance and evaluation of genetic resources

Livestock	**Constraint**
Goats	PPR
	CBPP/PPCB
	Maintenance/Evaluation of genetic resources
	Heartwater
	Helminthiasis
Sheep	PPR
	Maintenance/Evaluation of genetic resources
	Heartwater
	Helminthiasis
	Trypanosomiasis
Bovine	CBPP/PPCB
	Maintenance/Evaluation of genetic resources
	Tsé-tsé,
	Heartwater
	Foot and Mouth Disease
	Helminthiasis

Pork	African Swine Fever
Poultry	Newcastle Disease Helminthiasis

3.4 Investments required for agricultural biotechnology in West and Central Africa

Investments from the public sector: Most agricultural research in Africa is done by publicly-funded national agricultural research institutions (NARIs) and the contribution of universities and the private sector has been well below their potential. In general, the performance of the national agricultural research systems (NARS) has been poor, with the relevance and efficiency limited by:

- poor linkages with end-users who are rarely able to influence the research agenda;
- shortages in the number and quality of scientist and poor staff incentives;
- inadequate strategic planning and poor internal management; and,
- low and unreliable funding especially for recurrent costs.

Investments in human capital and in infrastructure development are of paramount importance for an effective delivery of agricultural biotechnology. The proposed sub-regional program on biotechnology is aimed at products delivery coupled to capacity building (see Figure 4) of the sub-region to conduct development oriented agricultural biotechnological research. There would therefore be some initial phase of **apprenticeship** with partner institutions notably the advanced research institutions (ARI) from the north, the international agricultural research centers (IARC) of the consultative group of international agricultural research (CGIAR), and possibly from multi-nationals. Whereas it may be difficult to quantify the financial requirements for this, it may worthwhile to give an example of the investments CGIAR.

Four of the 15 CGIAR centers are African-based, two (IITA, WARDA) have headquarters based in West and Central Africa. Africa alone absorbs half of the CGIAR’s total annual budget which in 2003 was US$ 398 million. The CGIAR Centres located in West Africa have major research infrastructures with sizable research programs ranging from upstream

biological research to ***capacity building depending on the needs of their NARS partners***. In addition to the CGIAR system, there are a number of independent international and regional agricultural research and academic institutions based in African such as the Centre International de Recherche-Développement sur l'Elevage en zone Subhumide (CIRDES) the International Trypanotolerance Centre (ITC) and Centre d'Etude Régional pour l'Amelioration de l'Adaptation a la Secheresse (CERAAS). These centers are involved in human capital development, not only in biotechnology, but also in other spheres of agricultural research for development. A number of national research systems are similarly developing building their capacities to conduct biotechnological research

Investments from the private sector: The private sector has always played a key role in technology generation and adoption and it is estimated that by the mid 1990s about one-third of the US $33 billion total investment in agricultural research worldwide was private. In OECD countries, most applied research leading to the development of new seed varieties, livestock strains, chemical inputs, and machines is now performed by the private sector. But little of this research takes place in developing countries (5.5%). In Africa, private research is concentrated on food processing and post harvest technologies (in 1995, only 12% dealt with farm-focused technologies) and the farm technology needs of commercial agriculture (seeds, vaccines, agrochemicals and farm equipment) where profits can be captured. The private seed and chemical sectors have flourished in some large developing countries such as Brazil and India, but remain very poorly developed in the smaller markets of Africa. This is also partly a legacy of the excessive reliance on public sector marketing of inputs and outputs, but also because the investment climate for the private sector remains poor in many countries. Excessive regulatory interventions and intra-African trade restrictions on agricultural inputs continue to fragment the markets for new seeds and chemical inputs and reforms in these areas are necessary.

In summary, private agricultural research relevant to African agriculture will develop in the long run as profitable markets develop. In the meantime African agricultural research will continue to rely overwhelmingly on public support through NARSs and international centres.

This is especially true for addressing the needs of the poorest farmers.

Section 4. Institutional challenges

4.1. Role of the seed sector in delivering biotechnologies in West and Central Africa

Seed refers to any living, organised plant propagule or organ that is capable of being planted and grown to produce another crop. It is the product of sexual, apomictic, pseudosexual or vegetative methods of asexual production. They have the greatest socio-economic benefit to human welfare of any known biological device. In effect, they concentrate useful technology into the most transportable, storable, nutritional, tradable, cheapest and functional format possible. They are first and foremost the source of all food. In the **region seed security is the key to food security**. In effect securing the supply of seeds and planting materials of important food crops is a most effective way to sustain food security. Effective seed security reduces the impact of widespread food insecurity. A functional and economically sustainable seed sector is important in realizing the millennium goal of reducing hunger and poverty in the sub-region.

Implementation of seed security is one of the major activities outlined in the Global Plan of Action for the conservation and sustainable Utilisation of plant Genetic Resources for Food and Agriculture, adopted by the FAO International Technical conference on Plant Genetic Resources at Leipzig in 1996. The increasing incidence of complex humanitarian emergencies, sometimes coincidentally with natural disasters, has escalated the cost of food aid. Establishing seed security is therefore fundamental to maintain and restore food security. Seeds have also gained global political importance because they are mainly a key component in the conservation and ownership of biological diversity. Over the last thirty years, approximately 6.1 million accessions of crop seeds have been stored in *ex situ* collections worldwide, including more than 500,000 stored as field gene banks, by many people and organizations. These genetic resources are now at the centre of the debate on ownership of genetic resources in the forum of the convention on Biological Diversity. The

countries of origin think they should have exclusive ownership of these resources, whilst others think they are the inheritance of all humanity. Others still think they should be locked into intellectual property of genetically engineered varieties.

4.2 Seed systems

Seed systems are varied, reflecting the diversity of climate, crop types, farming systems, culture and economics. According to Maredia and Howard (1998) a seed system comprises organizations, individuals and institutions involved in the different seed related functions. These functions involve research and development, seed multiplication, seed processing and storage and seed marketing and distribution. The formal and informal seed sectors are the two major components of a seed supply system. They are essential and complementary to insure an effective seed security strategy.

The informal seed sector is traditional and refers to the collective efforts of farmers and their local community. These farmer and community based seed acquisition and distribution channels form the basis of a dynamic but ill defined system. It is characterised by a seasonal crop cycle involving crop production, empirical selection of desirable types, farmers harvesting, cleaning and storing their own seed, exchange of seed between family and members and relatives, trade or barter in the local market place, planting and cultivation. Much of the information concerning agronomic performance, yield, disease resistance, quality, cultural preference and diversity of end uses is communicated by word of mouth and is seldom, if ever, subject to rigorous experimental evaluation. This sector relies largely on local resources and inputs. Therefore seed supply at this level can be very vulnerable to disaster and socio-political disruption. Among small holder farmers, this sector provides 85% and more of planting seeds.

The formal seed sector is generally regarded as comprising public (national, regional and international agricultural research and policy organizations) and private (private sector companies and business associations) research and development on plant breeding and related aspects of seed physiology and plant disease variety release, deliberate seed multiplication on seed farms, seed processing, storage marketing and distribution. They tend to focus on larger farming operations and to concentrate on seed of hybrid,

low planting density crops. This sector drives the establishment of rules and regulations to manage variety release, quarantine, plant variety rights, seed certification, product labelling, marketing, pricing, consumer protection etc. It is this sector that provides the basis for effective regional negotiation and agreement to achieve regional seed security.

4.3. Status of seed delivery systems

The informal and formal seed sectors should be complementary and highly interactive. This is, however, not the case in the sub-region. They operate as separate and non interacting entities.

Seed regulatory reform for both the informal and formal sectors – variety testing and regulation and seed quality control – is unsatisfactory because seed regulation is poorly organised, inappropriate standards are used, there is little or no opportunity for farmer and seed producer involvement and the seed regulatory process is not transparent. This could be attributed to decreasing national budgets for public sector research and declining donor support for long term breeding and variety development, erosion and control of plant genetic diversity, pressure to establish plant variety rights, emergence of variety development and seed production at the local level and the collapse of a number of parastatal seed organizations. The **private sector of the formal seed system has focused on species and crops that show high monetary returns; along with parastatals they have tended to focus on breeding, production and sales of hybrids crops of commercial or industrial interest rather than those for food security for the poorest of the poor** in the sub-region. In the general absence of Plant Breeders' Rights or other forms of Intellectual Property protection, it is simply not economic for private companies to market self or open pollinated varieties. The informal sector on the other hand has concentrated on those crops and seed systems which are the bases for local food production. This includes crops that are predominantly self-pollinating but also open pollinated crops. **The informal sector is responsible for ensuring sustainable supply of propagating material of asexually propagated food crops such as cassava, plantain, yams, potato and sweet potato**. This important role of the farmer and community based seed sector is often overlooked when seed systems are being considered from the perspective

of commodity crop production. The main source of planting seed used by the small farmers is from self stored seed or is obtained by purchase or barter from local sources. In effect the proportion of seeds changing hands is high, whilst only a small percentage is obtained from formal sector. There is therefore an overwhelming dependence on farmer and rural community based seed delivery system to sustain crop production and therefore food security.

4.4. Strengthening seed delivery

4.4.1. Research and development: Partnerships between the national research system and the international research centers and the seed producers needs strengthening via involvement of the private sector in research and development, and seed supply activities. Within the framework of this partnership, the private sector would be expected to indicate the type of seed varieties needed to the research sector, which must provide the technologies, monitor capacity and buy seed products based on contracts involving the two parties.

4.4.2. Production: The relationship between government departments in charge of seed control and the private sector seed producers should be strengthened from the stage of seed production through distribution and to commercialization. This relationship should include strengthening the capacity of public sector departments in handling private sector enterprises in seed production. The training should be carried out in the following areas: knowledge on the norms of control in the field and during seed collection, determination of seed density, varietal purity, rate of fertilizer contamination, packaging conditions, and treatment conditions of stored seeds and use of control forms in order to ensure the availability of sufficiently selected high quality seeds as well as the intellectual property issues pertaining to seed production, multiplication and distribution.

4.4.3. Control and harmonization: Some of the control in the field and in the storage areas could be attributed to the private sector under the supervision of the public services, which will be responsible for training and making available all the necessary technical documents, especially the control forms. The seed production scheme should be harmonized in conformity with the selection cycle of the different varieties cultivated in the countries in the sub-region. The scheme proposed should include the following generations, G0, G1, G2, G3, G4 to seeds destined for

multiplication, R1 and R2. The G0 seeds constitute the original seeds, the G1, G2 and G3, the pre base seeds and the G4, the base seeds. The R1 and R2 are certified seeds resulting from the first and second reproductive cycle respectively. The G0-G3 seeds must be produced by the research sector and the G4 by specialized technical services, the research sector and the private sector. The R1 and R2 seeds must be produced by specialized technical services, farmers, the private sector and NGOs.

The technical norms for seed production in the field and in the laboratory should be harmonized for the main crops cultivated in the region. In conformity with the UEMOA and ECOWAS treaties for ensuring better circulation of seeds the phytosanitary measures produced by AGRHYMET were adopted. In the nine member countries of CILSS, seed exchange is expected to conform to the phytosanitary rules of CILSS. The harmonization of quality control rules and phytosanitary conditions for seeds in member states based on the disengagement of the State from producing, collecting and commercializing seeds, which should in actual fact be left to the private sector. The States are expected to take the necessary steps which should facilitate the access of the private seed sector to profitable investments.

The seed policy of the member countries require the management of a security stock, which in case of peril, could be used; and for these, refrigerated seed stores are required. In each country, a national seed committee is needed; this should be responsible for the homologation of varieties and to provide advice and recommendations on seed issues. The following are required in this sector:

- Develop seed phytosanitary legislations for the whole sub-region.
- Furnish the competent services to develop new varieties and analyse the healthiness of seeds.
- Put in place a technical committee for developing the dynamics of pests transmitted by seeds in order to periodically up-date the list of parasites.
- Qualified staff should be put at the disposal of the private organizations as well as the appropriate operational means whilst waiting for them to perfectly master the realities of the national, regional and international seed markets.

4.5. Intellectual Property Right (IPR) issues

Practically all the countries of the West and Central African sub-region are currently members of the World Trade Organization (WTO)[1], and are thus obligated to implement minimum standards for IPRs under the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs) by enacting new, or amending their old, laws accordingly. The critical importance of IP issues in the sub-region is indicated in the fact that several regional institutions have direct mandate and/or undertake major activities in this area. Two regional organizations in Africa specifically deal with IPRs. These are the African Regional Industrial Property Organization (ARIPO) and the African Intellectual Property Organization (OAPI)[2] headquartered in Harare and Yaoundé respectively. The African Union (AU) has also held discussions and carried out activities of relevance in IPR issues especially with respect to the interface between IPRs and genetic resources. This is exemplified in the African Model Law relating to access to genetic resources, benefit sharing, breeders rights and the protection of community rights. While all the francophone West African countries belong to OAPI, only the Gambia, Ghana and Sierra Leone belong to ARIPO (with Nigeria as an observer). These institutions could also collaborate in capacity building and policy implementation activities. One of the major challenges for the region in seeking to harmonize rules in this regard has been the different levels of legislative development and different approaches being adopted by different countries.

While the application of modern biotechnologies to agriculture has brought the prospects of new economic opportunities, it is also posing new challenges to existing policy frameworks and legal regimes especially with regard to intellectual property rights (IPR). IPR features in practically every aspect and at every stage of biotechnology research and development, from inputs through pertinent processes to the resultant products. IPRs are, therefore, one issue that must be taken into account from the onset by all stakeholders (regulators, researchers, private operators and consumers alike), kept in view through the planning processes and factored into the eventual implementation and/or related activities. The key

[1] Only Cape Verde and Liberia are not members.
[2] Organisation Africaine de la Propriété Intellectuelle

issue for the region would be to seek to acquire, produce and disseminate products and knowledge with the fewest constraints possible, but with due respect for the rights of other individuals, organizations, and nations recognized by the new international agreements. In this context, institutions and initiatives like the Afican Agricultural Technology Foundation (AATF) could play a pivotal and catalyzing role in negotiating IPR issues. This in fact is the principal mandate of AATF.

Much of modern and advanced research tools and processes used in agricultural biotechnology tend to be proprietary and held as intellectual property by the industry or other institutions, who seek to protect breeders rights as a result of their massive investments in research and development. It is, therefore, important that researchers know the proprietary status of the technologies as well as related materials that they intend to access and utilize.

IPRs are also central to the issue of technology transfer, where it is sometimes seen as the vehicle by means of which transfers are effected, for instance, through licensing or similar agreements. Proper management of IPRs will, therefore, aid delivery of products to farmers and serve to increase awareness of these issues among the research and development institutions of the region and the partners who implement the research.

Consequently, appropriate IP policy framework needs to be in place to facilitate an effective implementation of a biotechnology program. By and large, the overall strategy for biotechnology acquisition and utilization (e.g., development of indigenous technological capability, transfer of technology, trade in products) should determine the nature and the likely pathways of implementing the related intellectual policy framework. The following steps should be encouraged:

- Institutions involved in relevant research activities should be encouraged and, where possible, assisted to establish intellectual property management policies to facilitate access to enabling technologies and the introduction of agricultural biotechnology.
- Additional efforts and resources should be geared towards building or enhancing capacity in the knowledge and application of IP policies and regulations.

- Appropriate IPR regimes (intellectual property management plans or components) should be considered in developing and implementing regional research activities based on the near and long term technology opportunities identified, and involving the development and delivery of products.
- Furthermore, the development of appropriate technology transfer policies should be fostered to facilitate the acquisition, development and dissemination of new knowledge and innovations.

4.6. Dual approach to supporting product development and delivery

The West and Central African Biotechnology Program led by CORAF/WECARD proposed a dual approach – i.e. focused on the competitive grants scheme and on commissioned research. Financial support under both schemes will be conditional on potential grantees forming sub-regional consortia between and within countries in the sub-region and the international research community, wrapped-up with a pragmatic plan to deliver products of their research to the end-users while building the sub-regional capacity in research and product development.

Both modes of support will be managed through the existing CORAF/WECARD decision making organs. A newly created CORAF/WECARD Biotechnology and Biosafety Coordination (BBC) Unit, which will include national focal points within NARS, NARS components and Centers of Excellence within the sub-region, will be mandated to implement activities.

All activities will be conducted in the context of the following issues:

- The sub-regional research priorities;
- Demonstration of high quality science, feasibility of scientific approach and impact-focused;
- Strengthening of collaboration between key stakeholders in the sub-region and beyond;
- Transfer and commercialization;
- Accountability to clients and stakeholders.

The competitive grants scheme will be based on a two-stage process and comprise a call for concept notes followed by a call for full proposals to those teams that have submitted

successful concept notes. Certain highly specific research activities will be commissioned to regional Base Centers and Centers of Excellence existing in the sub-region, which are specialized in specific research themes, for implementation.

4.7 Public Information and communication for biotechnology

As an emerging technology that holds considerable promise for improving the well being of Africans, it is vitally important that comprehensive and adequate information on biotechnology is widely available to all parties involved in the development, application and use of biotechnology for development. Recent international public, and sometimes acrimonious debates on the merits of the use and adoption of certain products from biotechnology, reveal serious information gaps and misinformation which therefore underscores the very urgent need for and importance of more effective information dissemination and exchange amongst development partners, stakeholders and the target beneficiaries of biotechnology as well as the general public.

Emphasis needs to be place on promoting, supporting and facilitating biotechnology information dissemination as well as information exchange using the entire range of available audiovisual and modern ICT tools and systems. Information dissemination here means the distribution of information to interested partners, while information exchange relates to the active process of voluntary information exchange between participants with a common interest in this instance biotechnology. Furthermore, because of the wide and diverse range of clients for biotechnology, there is need to focus on the dissemination of specific biotechnology information targeted at specific clients. The clients include:

- Scientists; extension; teachers, Agricultural extension agents and farmer facilitators; teachers, policy, farmers, food processors, distributors, pharmaceuticals, private sector, medical and para-medicals, cosmetologists, environmentalists, legal practitioners and intellectuals, development partners, journalists, media, general public, etc.

A policy framework on biotechnology information and communications should provide a functional platform and facility to access, manage and effectively disseminate

information on all aspects of the development and application of Biotechnology and Bio-safety for agricultural production and productivity. In summary such framework should address the following issues

i. Identification and characterization of the variety of clients, stakeholders and beneficiaries for the development, application and use of biotechnology
ii. Development of biotechnology information and communication systems and programs that are targeted at relevant stakeholders and development partners and beneficiaries.
iii. Wide-scale public awareness programs on biotechnology and bio-safety
iv. Public awareness and understanding of the legal instruments enacted for the development and application of Biotechnology and Bio-safety.
v. Capacity building and strengthening in the processes and techniques to access and manage biotechnology information for effective communication to clients and stakeholders.
vi. Strategies for the efficient implementation of the biotechnology policy

Section 5 Future perspectives and directions

5.1. Who's benefiting what?

Modern biotechnology or the gene revolution may not be a panacea to solving the sub-region's food security problems. It is, however, being considered by various regional bodies as a tool not to be ignored. This is especially so if one has to resorts to reflecting on institutional lapses that caused the green revolution to bypass Africa.

Scientists and extension workers operating in the sub-region will be provided with a better equipped environment for biotechnology research and development and improvement of their scientific knowledge for a more promising career in biotechnology research and development.

Plant breeders and animal breeders will apply molecular markers in breeding and germplasm evaluation programs and will, through genetic engineering, introgression transgenic materials into varieties for local use. Crop breeders will use plant cell/tissue culture and micro-propagation techniques to speed up and increase their selection procedures and in the conservation of genetic resources. Plant and animal pathologists will use molecular diagnostics technology to detect major diseases affecting

cops and animals. Agricultural extension workers will be engaged in popularizing the improved crop and animal.

Small holder farmers will be provided with some concrete solutions and products that could be of immediate use and impact on both a food security front and on the economic front. They will have access to more improved seeds and benefit from healthy and productive animal and planting materials. They will also benefit from vaccine development and production, thereby reducing the risk of losing their production due to livestock diseases. Those particularly living in close contact with their animals will benefit from reduced exposure to disease causing agents.

The Ministries of Agriculture and private sector seed distributors could be involved in getting seeds or other planting material of improved crops to farmers. Plant and animal regulatory service will use molecular diagnostics for plant and animal diseases

The exploitation of the potential offered by the rich biodiversity in the region will open the seed, food and vaccines industries and markets to the rest of the continent. Private companies and firms will apply molecular diagnostics and *in vitro* techniques to produce healthy seeds, plant and animal materials and secondary metabolites, with agricultural as well as medicinal interests. The development of new vaccines will provide an incentive for local production to evolve into private sector production. The improved productivity of livestock will increase opportunities for the production and processing of animal products such as meat, milk and eggs, and will also encourage private investment in these areas.

5.2. Conclusions

- ☞ The regional biotechnology program would commissioned research focused on the following target food security crops/livestock commodities: sorghum, maize, cassava, cattle, goat and sheep, based on the near and long term technology opportunities identified above.
- ☞ The sub-region intends to mobilize the flow of investments so as to scale up produced technologies to reach the millions of the dispersed, resource poor farmers.
- ☞ A regional scientific research collaboration program under the leadership of CORAF/WECARD is expected to be

established. This would draw on the existing strengths from within the region and from the Northern partners.

- ☞ The regional approach is expected to catalyse the development of seed phytosanitary legislations in the region or to adopt and extend the CILSS phytosanitary legislation to the rest of the region.
- ☞ Ensuring seed security is a priority activity needed in food security drive. The regional approach thus envisages organizing seed producers to occupy their rightful position in the agricultural sector of the economy.
- ☞ The appropriate IPR regimes (IP management plans or components) would be considered in developing and implementing regional research activities based on the near and long term technology opportunities identified, and involving the development and delivery of products.

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