1 INTRODUCTION, BACKGROUND AND CONTEXT

1.1 Introduction: Background to IITA's mandate - The African Challenge

By the time of the founding of the International Institute for Tropical Agriculture (IITA) in 1967, the symptoms of deterioration in African agriculture were apparent. An earlier assessment[9] observed that between 1965 and 1973, agricultural production in Africa was growing at a paltry annual average rate of 2.4 percent, while the population was increasing at 2.6 percent. Between 1973 and 1980, the annual rate of agricultural production fell drastically to 0.3 percent, while the population rate increased to 2.8 percent. Then between 1980 and 1987, though a slight improvement in agricultural growth could be observed, production performance was still depressed in a period when population increase was accelerating to reach an annual rate of over 3.0 percent.

According to the 1989 World Bank indicators for Africa and other parts of the world, nowhere else had the situation evolved so negatively and so rapidly (World Bank, 1989). This grim assessment was also confirmed by FAO statistics of the time which showed that, among all continents, only the African index of agricultural production per capita had been negative since 1965 (FAO, 1987). The consequence of this situation was that Africa was fast becoming unable to feed its population, and its economic situation sharply deteriorated simply because agriculture continues to represent over 33 percent of gross domestic product (GDP) in sub-Saharan countries, and for some countries up to 76 percent of the GDP.

It is against such a grim situation that the nascent IITA started its work in Ibadan, Nigeria, in July 1968, with a preliminary mandate of working on important African crops and cropping systems premiered by cowpea and other grain legumes as well sweet potato and yam. IITA was expected to collaborate with IRRI on rice, CIMMYT on maize and CIAT on cassava. As time went on, IITA expanded its mandate to include banana and plantain. Even at this very early stage some in the founding fraternity were not convinced as to the wisdom of one Center being mandated to handle such a large array of crops and cropping systems in a region as vast and as diverse as Africa.[10] It was however argued convincingly to the sponsors that a diversified IITA program would provide immense benefits to the developing national research systems that required information in a multiplicity of crops and cropping system approaches.

1.2 The Current and Future Challenges for African Agriculture and IITA

Hunger affects more than 840 million people worldwide. More than 300 million of these people are in Africa. According to the World Bank Development Indicators (WDI) for 2007, the number of people living on less than a dollar a day in the world reduced by 260 million in the period 1990-2004. However, in Sub-Saharan Africa (SSA) the number rose by over 60 million[11], indicating the rampant and ever increasing poverty in Africa compared with the rest of the world. The Millennium Development Goal of halving the proportion of poor people is still within reach at the worldwide level, with a projected decline from 29 percent to 10 percent between 1990 and 2015. But many individual countries will most likely not reach it, particularly those in Sub-Saharan Africa, where average poverty rates remain above 40 percent, raising concerns of widening inequalities between regions. Poverty is often partnered by severe food insecurity

[9] Paraphrasing Jacques Diouf's assessment of the situation during the 1989 Sir John Crawford Memorial Lecture
[10] R.F. Chandler
[11] World Development Indicators for 2007

which in turn leads to malnutrition. The overall picture for Africa is one in which the total human health and wealth is severely challenged under the current developmental strategies.

For Africa, more than anywhere else, agriculture is a key contributor to the overall development portfolio[12]. This fact has been recognized for a long time and many documents "parrot" the importance of African agriculture to development but so far no real solution has been found to work. Recently, the Africa Union's NEPAD has developed a strategy for catalyzing agricultural growth under its Comprehensive African Agricultural Development Program (CAADP)[13] with the hope that this will help revitalize African agriculture. The program has been endorsed by African leaders and aims to provide a framework for harmonized and responsive action through four key thrusts:

- Extending the area under sustainable land management and reliable water control systems;
- Improving rural infrastructure and trade related capacities for market accesses;
- Increasing food supply, reduce hunger, and improve responses to food emergency crises;
- Improving agriculture research, technology dissemination and adoption.

The NEPAD goal for the sector is agriculture–led development that eliminates hunger, reduces poverty and food insecurity while at the same time opening the way for enhanced agricultural export trade. The NEPAD-CAADP vision for agriculture is not very different from some of the Millennium Development Goals (MDG) and neither is it far removed from the CGIAR core priorities, but the CAADP envisages that the continent should, by the year 2015:

- Improve the productivity of agriculture to attain an average annual growth rate of 6 percent, with particular attention to small-scale farmers, especially focusing on women;
- Have dynamic agricultural markets within countries and between regions;
- Have integrated farmers into the market economy and have improved access to markets to become a net exporter of agriculture products;
- Achieved a more equitable distribution of wealth;
- Be a strategic player in agricultural science and technology development
- Practice environmentally sound production methods and have a culture of sustainable management of the natural resource base.

According to the NEPAD secretariat, the challenge that is now facing the CAADP process is to move beyond and build upon the political commitment to prepare bankable projects and programs as well as mobilize funding and expertise to implement these projects and programs. Now more than ever before IITA has a script from which to read and craft its programs for an even more meaningful contribution to agricultural development which is concomitant with the priorities of the African governments and consequently the African people, and hopefully the future yardstick for the IITA's performance will be reflective of these aspirations.

It is clear though, that in the past, and particularly the period under review by this EPMR panel, IITA has made substantial efforts to understand the impediments of growth to African agriculture and also articulate its contribution towards resolving these hurdles. Detailed analysis of IITA's interpretation of its role in African agriculture is presented in the Center's Medium Term Plan (MTP) covering the period 2007-2009 (current at the time of the 6th EPMR). In the MTP, IITA has re-evaluated its resources and its ability to apply new technologies and describes a

[12] Marsha Felecia Benjamin (2006) The Contribution of Agriculture to Development

[13] Implementing the Comprehensive Africa Agricultural Development Program and Restoring Food Security in Africa- The Road Map

revamping of its Project structure and its partnerships with NARS, other CGIAR Centers and the ARIs. The Panel's detailed analysis of the MTP Projects is presented in Chapter 3. Importantly for this EPMR is that, in the MTP, IITA responded to the specific recommendations of the preceding, 5th EPMR which should have guided the actions taken by the Center over the last five years or so.

1.3 IITA's Historical Approach up to the Last EPMR

IITA's historical approach has been to focus on the genetic improvement of its mandate crops and on the sustainable intensification of the farming systems in which they are found in SSA. Germplasm improvement research introducing disease resistance into its target crops has had large agricultural and economic impacts in Africa – notably in combating cassava mosaic disease. IITA was a past leader in integrated pest management approaches, and the control of cassava mealy bug has illustrated the large return to research investments from this approach[14]. It continues to place emphasis on management of major disease threats (e.g. cassava brown streak disease, banana wilt), post harvest contaminants (fungi producing mycotoxins on maize) and pests such as the parasitic weed *Striga*. The Center augments this approach by conservation of targeted species for agriculture; for instance, in 2006, IITA held 6500 germplasm accessions of yam, cassava and banana/plantain. Formerly, the Center adopted an agroecological zone (AEZ) approach to SSA, defining its researchable problems in relation to the intensification of agriculture in the dry and moist savannas, the mid-altitude zone and environmentally appropriate exploitation of tree crops in the humid forest zone. This included collaborative interactions with livestock research provided by others. Increasing emphasis has been placed on the diversification of income-generating activities. IITA engaged in substantial capacity building of national partner scientists and organizations in SSA, holding large numbers of individual and group training courses until the latter were phased out in 2002.

1.4 Present and Future Challenges for IITA's Mandate Crops and Agroecological Regions

IITA's traditionally mandated crops are cassava, yams, cowpeas, plantain, banana, and maize. The human population in SSA is estimated to be growing at 2.5% per annum, and it is of interest to compare rates of change in productivity gains of IITA's crops against this rate. Estimates of gain for production, planted area or yield fell below 2.5% /yr in 4 of the 7 crops, 5/7 and 6/7 crops, respectively, in east and southern Africa (ESA) from 1990-2005. Similar figures for West and Central Africa (WCA) for production, area and yield showed gains of less than 2.5%.yr in 3/7, 5/7 and 6/7 crops, respectively. Relaxing the standard to a 1% annual increase in production, area and yield shows that this was not met in 2/7, 2/7 and 5/7 crops in ESA, and in 1/7, 3/7 and 5/7 crops, respectively, in WCA. Thus yield increases failed to reach the performance criterion more frequently than did gains in crop area. Recent data (2000-2005) show some improvement in gain in yields, especially for cassava, cowpeas, plantain, banana, and maize in WCA, and for plantain, banana, maize and yams for ESA. It is clear that sustained and increasing yields, in response to the need for intensification, will remain a major challenge for IITA's scientists in coming years.

(For the table below, the Panel recognizes the limitations of FAOSTAT data for this purpose, and notes that bean data are included with cowpea data. It recognizes that most of the data for ESA is generated by beans, and that for WCA is a mixture of the two crops. It is, however, unaware of better data sources at this time.)

[14] see Nature 432: 801-802, 2004

Table 1.1 Crop statistics and trends for IITA's mandated crops (FAOSTAT, 2007)

	Eastern and Southern Africa			Western and Central Africa		
	Production m ton	**Area m ha**	**Yield t/ha**	**Production m ton**	**Area m ha**	**Yield t/ha**
Cassava						
Current[a]	22.16	2.57	8.62	83.90	8.61	9.75
Slope 90-05	0.62**	0.02**	0.18**	1.87**	0.14**	0.08**
Percent/yr	3.35	1.00	2.35	2.68	1.83	0.85
Yams						
Current[a]	0.23	0.03	7.14	44.58	4.60	9.72
Slope 90-05	-0.003ns	-0.002*	0.16**	1.40**	0.12**	0.06ns
Percent/yr	-1.12	-3.05	3.45	4.01	3.24	0.69
Beans & cowpea						
Current[a]	2.19	3.65	0.60	4.35	13.02	0.33
Slope 90-05	0.02ns	0.08**	-0.01**	0.15**	0.51**	-0.003ns
Percent/yr[b]	1.17	2.59	-1.51	4.58	4.89	-0.91
Soybean						
Current[a]	0.49	0.39	1.27	0.57	0.65	0.88
Slope 90-05	0.02**	0.02**	0.003ns	0.03**	0.001ns	0.05**
Percent/yr[b]	5.66	5.48	0.22	7.76	0.20	7.35
Plantain						
Current[a]	13.39	2.41	5.56	9.95	1.83	5.43
Slope 90-05	0.13**	0.02**	0.01ns	0.17**	0.03**	0.02*
Percent/yr[b]	0.98	0.88	0.11	1.93	1.54	0.39
Banana						
Current[a]	3.57	0.61	5.86	2.14	0.28	7.59
Slope 90-05	0.04**	0.01**	0.01ns	0.003ns	0.002*	-0.05ns
Percent/yr[b]	1.36	1.19	0.22	0.14	0.73	-0.68
Maize						
Current[a]	24.08	13.65	1.76	13.37	9.70	1.38
Slope 90-05	0.57**	0.24**	0.02ns	0.17**	-0.09ns	0.03**
Percent/yr[b]	2.65	1.81	0.94	1.45	-0.94	2.35

[a] Current level is the mean of 2003, 2004 and 2005 data. Zambia data not included.

[b] Percent of mean production level 1990-2005

*, **, ns: slope significantly different from zero at P<0.05, P<0.01, and P>0.05.

1.5 The Evolution of IITA's Current Focus and Themes

In response to the EPMR of 2001, IITA held a meeting of its then Research Program and Executive Committee (RPEC) to review the compartmentalization and arrangements of the IITA research agenda and the structure needed to manage the projects and the stations. This was driven by the feedback of the EPMR, the need to strengthen the agro-ecological zone approach in the 2001-2010 Strategy, to simplify structure, and reduce involvement of scientists in administration and management task. This was suggested for approval by the Board and for elaboration in November 2001.

IITA's MTP Projects between 2002-2004

- Improving Yam based systems (A[15], E)
- Improving cassava based systems (A, D, E)
- Development of integrated annual and perennial cropping systems (E)
- Biological control and functional biodiversity (B)
- Integrated management of cassava pest (B)
- Impact, policy, and system analysis (C)
- Improving maize-grain legume systems in WCA (A, F)
- Conservation and use of biodiversity (A)
- Improvement of high intensity food and forage crop systems (F)
- Improving cowpea-cereal systems in the dry savannah (A, F)
- Improving plantain and banana based systems (A, D, E)
- Protection and enhancement of vulnerable cropping systems (D)
- Integrated management of legume pests[16] (B, F)
- Integrated management of maize pests (B, F)

and the SP-IPM (B) and the Ecoregional program for the humid and sub-humid tropics of SSA (EPHTA) (E).
The 14 projects were subsequently reorganized into 3 disciplinary projects and three agro-ecological projects. The RPEC reaffirmed the research agenda should be driven by the needs of the agro-ecologies. The support stations were assigned to the three agro-ecological projects. The new projects were put forward in the 2003-2005 MTP. This reorganization was planned by scientists, the RPEC and the DG at the Work Planning Week (WPW) in 2001. The RDC used WPW 2002 to further refine the MTP projects from goal to activities and for streamlining activity list and milestones.

Revision of IITA's MTP Projects between 2003-2005

A: Preserving and enhancing germplasm
B: Developing biological control options
C: Impact, policy and systems analysis
D: Starchy and grain staples in ESA
E: Diverse agricultural systems in the humid zones of WCA
F: Grain-based systems in the WA savannah

In 2005, the projects were designated as programs because of the diverse nature of research included in them. In March 2005, new Guidelines were sent to the Centers for the development of MTPs. These guidelines had many changes in the definition and required reporting of projects. In order to accommodate these, the six programs were retained but IITA identified Project entities based on the milestones and activities given in the previous MTP. This was considered an interim step since in the short timeframe the RDC and PCs had very little time to consult scientists. The Center also had very little time to reconsider the financial reporting on the basis of new projects.

[15] Reference to new projects into which the activities were subsequently incorporated
[16] The Integrated management of legume pests was combined from two other Projects

IITA's MTP Programs and Projects in 2006-2008

Program A. Preserving and enhancing germplasm and agrobiodiversity with conventional and biotechnology tools

- Project A-1 Sustaining biodiversity of staple crops for current and future generations
- Project A-2 Producing more food at lower cost through genetic improvements of staple crops
- Project A-3 Biotechnology tools (e.g. molecular markers, gene identification, transformation) developed and applied for germplasm management and crop improvement
- Project A-4 Biofortification of staple food crops

Program B. Plant health management program

- Project B-1 Identifying and characterizing pest problems and assessing their interactions with the environment
- Project B-2 Developing and implementing biological control options
- Project B-3 Implementing host-plant resistance and habitat management options
- Project B-4 Developing safe crop protection products and practices

Program C. Supporting innovation processes

- Project C-1 Socio-economic technology assessment on micro-level
- Project C-2 Recommendations for policies, institutions, and legal frameworks supportive of generated innovations and the innovation process
- Project C-3 Improvement of efficiency in research and dissemination of research results

Program D. Eastern and southern Africa agri-food systems

- Project D-1 Eastern and Southern Africa banana-based cropping systems
- Project D-2 Eastern and Southern Africa roots and tubers systems

Program E. Enhancing livelihoods in the humid and sub-humid zones of West and Central Africa

- Project E-1 Productive plantain systems
- Project E-2 Profitable root and tuber systems
- Project E-3 Market-oriented peri-urban crop and crop–livestock systems
- Project E-4 Multi-product perennial food and cash crop systems

Project F. Improving and intensifying cereal–legume–livestock systems in the savannas of West and Central Africa

Systemwide program on integrated pest management

The SC's Commentary on the 2006-2008 MTP was very critical of the lack of science outputs and output targets in the Agroecological zone projects. They concluded that the discipline-based projects were strong in science while the agroecological projects were more focused on development activities. This was also evident in the lack of integration between the projects. Scientists continued to focus efforts in discipline-based projects, rather as they had done under the previous Division structure. Strategic planning at the annual work planning week in 2005 considered alternative approaches to project formulation that would enhance integration of science along the R4D continuum and more in line with the Center's stated approach. This resulted in the realignment of the 6 programs to 7 "MTP projects". Originally, this rearrangement was more conceptual than practical, but the Projects are in the process of further refinement, beginning with the Center's Strategic Planning for 2006.

IITA's MTP Projects in 2007-2009 (letters in brackets indicate the former distribution of work now collected under the new headings)

- Agriculture and Health (A-4, B-4, C-1)
- Agrobiodiversity (A-1, A-3)
- Banana and Plantain systems (A-2, A-3, B-3, C-1, D-1,E-1)
- Cereal and Legume Systems (A-2, A-3, B-3, C-1, F)
- High-Value Products (B-1, B-4, E-3, E-4)
- Opportunities and Threats (B-1, B-4, C-1, C-2, C-3)
- Root and Tuber Systems (A-2,A-3, B-3, C-1, D-1, E-2)
- Systemwide Program on Integrated Pest Management

In summary: In the Review period, IITA has made extensive changes in its Project and program arrangement. Initially IITA tried to dissipate the competitive tensions which the new Management perceived had built up within the former Division-based structure. It also attempted to respond to reporting guidelines and the criticisms of the Science Council about the balance between research and development activities. It was conscious of the need to move towards a more effective research format to accomplish the R4D approach. The efficacy of the final formulation of four commodity-oriented projects linked by three more cross-cutting projects and the SP-IPM is considered in Chapter 3. However, much of the alteration, although time-consuming, seems in fact to have been a realignment of IITA's existing competencies and grant funded research. At the time of the EPMR, planning for the new functions of the Projects has only been undertaken for four Projects and the cross-cutting Projects, in particular, await appropriate development to meet the needs of the R4D approach.

1.6 The EPMR

IITA is one of the longest established Centers of the CGIAR. The current EPMR is the 6th such review of the Center. Since the 5th EPMR in 2001, the CGIAR has approved (June 2005) policy document guidelines for the Monitoring and Evaluation System for the CGIAR Centers. The new components of the monitoring and evaluation (M&E) system include annual performance measurement (PM), Center-Board Commissioned External Reviews (CCERs) and streamlined EPMRs commissioned by the Science Council on behalf of the Group and organized jointly by the SC and the CGIAR Secretariat. The EPMRs, conducted at roughly five-year intervals complement the annual Science Council (SC) assessment of Center's Medium Term Plans (MTPs). The specific and general terms of reference for the 6th EPMR of IITA can be found in Annex 1.

1.7 Response of IITA to the 5TH EPMR Recommendations

The fifth EPMR of IITA made an aggregate of 17 recommendations, which can be grouped as shown below (Table 1.2) which indicates the action taken. The details of the Center's implementation process are captured in the 2007-2009 MTP. It would appear that although the IITA was slow in starting to respond to the implementation of recommendations of the 5th EPMR, the process gained momentum as the current EPMR approached. Approximately 50% of the recommendations have been fully implemented while the other half is being addressed only now. In the area of the Governance and management, the Fifth EPMR panel had made five substantive recommendations four of which have been fully implemented even though not as urgently as would have been expected.

Table 1.2 Implementation of the 5th EPMR Recommendations

PROGRAM RELATED	PARTNERSHIP RELATED	GOVERNANCE/MANAGEMENT RELATED
1. Prioritization Process +	4. Regional Scientists forum particularly for GMO research +	**2. Appointment of DDG-Research ++**
3.Yam ideotype breeding to reduce labor demands +	11. Enhance NARS capacity through training +	**14. Program of BOM reforms ++**
5. Appropriate & targeted crop improvement research +		**15. Streamlining the HR management ++**
6.Review Plant Health Management Division (PHMD) declining output +		**16. Revamp the Internal Audit capacity ++**
7. Resource and Crop Management division (RCMD) business plan ++		**17. Upgrade status of External Liaison Office --**
8. RCMD-AEZs ++		
9. Strengthen Socio-economics +		
10. Emphasis on Geo-spatial analysis +		
12. Implementation of IPR new policy +		
13. Close collaboration with policy institutes +		

*Action taken expressed as; Implemented ++ Partially Implemented + No clear response--

The lag in implementing these recommendations certainly reduced IITA's capacity to achieve some of its obligations. As an example, the delay in hiring the DDG-R had serious implications in the capacity of IITA to address adequately the priority setting process at program level. One recommendation on the strengthening of the External Liaison Office was addressed through a completely different mechanism - that of dropping the post completely. This particular office was traditionally responsible for NARS and other stakeholder linkages, a responsibility that is now embedded in the programs under the ambit of the scientists - a process the Center terms 'active engagement'. There are also plans for a new Deputy Director post (in Project Development and Management) to take on the administrative functions of relationships. At the time of the current EPMR, this post had not yet been filled. During the field visits, the Panel held a number of discussions with NARS representatives in which NARS implied that there has been erosion in the IITA-NARS partnerships especially in training and collaborative priority setting engagements. It is not possible to state whether this is directly attributable to the closure of the ELO but it is important to note that at least some NARS are less happy with the current arrangements.

The fifth EPMR also made two partnership-related recommendations, one specifically in training and one in the creation of an SRO forum particularly for the GMO issues. Both of these recommendations imply a capacity building effort. IITA responded that deliberate engagement with NARS has helped to build capacity in the specific area of the formulation of biosafety regulations, citing the cases of Nigeria and other countries in Africa. Following more recent planning, training will be largely re-organized and IITA is about to experiment with the out-sourcing of training to NARS and other relevant organizations. This is an effort to build capacity

in the traditional NARS but focuses more on regional universities. In its new training approach, IITA admits that there are reduced resources for training and IITA has therefore structured a training format that is more program-based. The details of this new training format are given in Chapter 3. While the Panel recognizes the constraints in training support it is the considered view of the Panel that IITA should put more effort in program –related training if the NARS are to be enabled to play there rightful role in the research and development continuum.

The remaining ten recommendations were largely related to program issues and, in general, there has been an effort to comply with the recommendations. The recommendations related to Resource and Crop Management Division (RCMD) have been completed while the others are in various stages of being met. It is hoped that as the adjustment to a new research management structure is finally made, IITA will in the future be able to respond quicker to advice and agreed recommendations.

1.8 Recent Center Commissioned External Reviews

A major instrument of monitoring and evaluation in the CGIAR is the commissioning of Center Commissioned External Reviews, in the period between CGIAR Reviews, of aspects of the main research, priority setting or governance components of the Center. The outcomes of such reviews, if effectively undertaken, serve as guides to any mid-course corrections required by Center Board or management. CCER Reports can assist the EPMR Panel in its overall reviewing function by providing intermediate snapshots of the progress of the Center and recommendations against which Center progress can be judged. IITA conducted 6 CCERs before the 6th EPMR panel convened (see Table 1.3) and one, although planned earlier, was conducted of the Systemwide Program on Integrated Pest Management between the two phases of the EPMR. The EPMR Panel considered all of these results and the results of an independent review of the earlier Project A conducted by a donor (Table 1.3).

Table 1.3 List of Center-Commissioned External Reviews and a donor-review of a Project conducted since the last EPMR

1. CCER: Systemwide Program on Integrated Pest Management (April 2007)
2. CCER: Governance and Management (June 2005)
3. CCER: Project B: Developing Biologically Based Plant Health Management Options and Conserving Biodiversity of Sustainable Agriculture (November 2004)
4. CCER: Project D: Research for Development Enabling Environment (October 2004)
5. CCER: Project E: Enhancing Livelihoods in the Humid and sub-Humid Zones of West and Central Africa through Profitable and Sustainable Intensification of Diverse Agricultural Systems (May 2004)
6. CCER: Project C: Assessing Impact, Formulating Policy Options and Systems Analysis (January 2004)
7. CCER: Project F: Improving and Intensifying Cereal-Legume Systems in the Moist and Dry Savannas (October 2003)

A Donor-commissioned Review of Project A: Preserving and Enhancing Germplasm and Agro-Biodiversity with Conventional and Biotechnology Tools (conducted between November 2004 – January 2005)

The collected recommendations of these CCERs and donor review can be found in Annex 2. Additional comments in relation to the findings of the CCERs can be found in Chapter 3 and the specific program or project subject matter under review.

The Panel found that there was a tendency for the CCER Reports to address process and Project structural issues rather than science quality. This may in part arise from a) inadequate terms of reference, and, b) inadequate preparation on behalf of the Center, particularly of materials that would allow reviewers to prepare substantive advice in short time-frames. Despite IITA's long research history, the new research management structure at IITA may have been unaccustomed to such reviews, and may have underestimated their potential utility. In general, the Panel suggests that CCERs should be conducted by panels of 2-3 people to obtain specific advice over the broad research and research-associated areas contained within specific IITA projects. The reviewers should be properly external to the work of the Center. These concerns notwithstanding, the Panel found the CCERs of Governance and Management (see Chapter 5), of Project F and of the SW-IPM, to be valuable inputs into the conduct of the current EPMR. The review of Project A (conducted at the request of the EU) was professionally conducted over a longer time-frame than allowed to the CCERs. However, those reviewers also drew attention to the difficulty in providing comprehensive analysis of the science encompassed in the large projects (Programs) as then formulated.

1.9 Scope and Method of Evaluation

1.9.1 EPMR Panel, terms of reference, mode of operation and acknowledgments

The Panel for the 6th External Program and Management Review of IITA was convened under the Chairmanship of Dr Cyrus Ndiritu. The composition of the panel, the background of panel members and the schedule for the conduct of the review are given in Annexes III and IV. The Panel first assembled at IITA's headquarters in Ibadan, Nigeria for the first phase of the review on the 5th of March 2007. The Panel Chair and members met with the Director General, Dr. Peter Hartmann and senior members of the administrative and scientific staff, including some from research locations sites. The Panel participated in presentations of the MTP Project activities, the Systemwide Program on Integrated Pest Management (SW-IPM) and the scientific support units and was able to interact with staff in plenary and in small group meetings (including with the Research for Development Council, RDC). Where necessary Panel members or groups of Panel Members held separate meetings with individual scientists or cross program discipline groups. Both the Director General and the Deputy-Director General-R4D kindly responded to requests for additional meetings or provided additional information on the evolution of the Programs and site activities. Panel members visited laboratories, field trials and exhibits as well as the support units at the Ibadan campus. The Governance Panel member and Finance consultant met with Administrative and Finance staff, the Auditors (in Lagos) and members of the Audit Committee of the Board. IITA held its Annual Board Meeting in the following week, the 14-17 May. The Panel Chair and Governance expert met with the Board Chair and held separate discussions with Trustees. They also monitored the conduct of the Board Meeting and its Committees.

The Panel members were able to consult Center policies, plans, strategic documents and other publications placed on a special website or provided to the panel in hard copy on request.

Prior to the main phase, the Panel secretariat administered three surveys a) a survey of staff *curricula vitae* and publications as part of the evaluation of science quality, b) a stakeholder survey to gain insights into the perceptions of IITA's scientific and regional collaborators and

funders, and, c) a survey of staff satisfaction (covering the scientific staff and senior unit managers). The latter two surveys were conducted anonymously through an on-line survey monkey format.

Members of the Panel visited selected outreach sites and contacted regional collaborators in the run up to the main phase of the review between the 17th to the 27th of May, as detailed in Annex 4 (the visit to Kano was conducted during the main phase; between the 1st to the 3rd of June). The purpose of the field visits was to validate the information obtained from documents and discussions with implementing partners. To facilitate wide field coverage the EPMR team partitioned itself into three groups:

- one group made visits to eastern African countries covering Kenya, Uganda and Tanzania;
- the second group covered southern African countries including Mozambique and Malawi;
- the third group was responsible for western African countries and made visits to Benin, Ghana and the host country Nigeria.

During the field visits, the evaluation team tried to obtain factual data and held focused group discussions with beneficiaries. The full list of persons met, institutions and associations visited are shown as Annex 4.

The Panel reconvened in Ibadan on the 27th of May and developed and wrote the Report, including the reports of the two consultants, between the 28th of May to the 8th of June, contacting staff on matters of clarification. During the main phase the Panel Chair conducted telephone interviews with (i) the current top ten donors to IITA to garner their perceptions on Center performance and challenges and (ii) with several Directors General of other major collaborating Centers in the CGIAR.

Draft chapters of the Report were shared with Center management (principally Dr Hartmann) for reviews of factual errors, and the Panel Chair presented the major recommendations and findings of the Panel verbally to Management and Staff on the 8th of June.

Acknowledgements: The Panel is pleased to acknowledge the substantial cooperation provided by IITA's Board, management and staff in the preparation and conduct of the review. The Panel is very grateful to all staff (including the Director General, scientific managerial and administrative staff, catering, transport, communications and liaison) that combined to make the Panel's stay as efficient and comfortable as possible during the period of the review. Thanks are also due to staff of the Center, particularly to the interim Deputy-Director General-Support, Dr Campbell Davidson, and the Director General's assistant, Ms Toyin Oke for taking care of the substantial logistical issues concerned with field visits, for organizing presentation schedules, and helping develop formal responses and material on behalf of the Center in response to requests for information.

2 STRATEGY, PRIORITIES AND PROGRAM

2.1 IITA Vision, Mission and Goals

IITA's current strategic plan was prepared in 2000 and covers the period 2001-2010. The mission statement of that plan states that:

"IITA aims to enhance the food security, income and well-being of people in sub-Saharan Africa by conducting research and related activities to increase agricultural production, improve food systems, and manage natural resources in a sustainable manner, in partnership with national and international stakeholders."

There have been significant changes at IITA since that plan was written, but according to a draft strategic plan for 2011-2020 the mission statement remains essentially unchanged. The draft plan also introduces a vision for IITA:

"To be one of Africa's leading research partners in finding solutions for hunger and poverty"

Despite the continuity in the Institute's mission, IITA's views on how it can fulfill its mission have changed and consequently its goals have been somewhat modified. Those changes, and the fact that in some sense the Institute is in transition, provide the basis of much of the discussion in this chapter on strategy, priorities and program.

2.2 Mandate and Geographic Scope

IITA's research and geographical mandates are described in the current Strategy (2001-2010): "IITA conducts research, germplasm conservation, training and information exchange activities in partnership with regional bodies and national programs including universities, NGOs and the private sector. The research agenda addresses crop improvement, plant health, and resource and crop management within a food systems framework and targeted at the identified needs of four major agroecological zones: the dry savanna, the moist savanna, the mid-altitude zone, and the humid forest. Research focuses on small- and medium-scale farmers and on all production systems to fulfill the ecoregional mandate with special emphasis on the following food crops: cassava, cowpea, maize, plantain and banana, soybean and yam."

The Institute's current thinking (as illustrated in the new draft Strategy document) offers a number of modifications. In terms of research agenda, although IITA continues to do research on resource and crop management and plant health, these no longer form the basis for organizing the research program. Instead, its MTP Projects are organized by commodity-based systems (roots and tubers, banana and plantain, cereals and legumes, high value crops), cross cutting projects (agrobiodiversity, agriculture and health, the System-wide program on IPM), and one which could address long term planning (Opportunities and Threats). Although an ecoregional orientation remains, agroecological zones are no longer seen as the prime determinant for technology generation.

In December 2005, the CGIAR endorsed new System Priorities for research (SPs) to guide and focus collaborative research across the system. There are 20 such priorities divided amongst five Priority Areas (roughly, 1. Germplasm conservation and characterization; 2. Germplasm improvement – including research on both biotic and abiotic stresses; 3. The identification and

exploitation of high value agricultural products for income for the poor; 4. Natural resources management; 5. Policy and institutional research, including producer organizations and markets). It is intended that the CGIAR Centers and donors will commit the bulk of research activities and funds to these areas. IITA's traditional strengths and the emerging focus on market-led agricultural production would seem to provide an appropriate match. The Science Council criteria for such choices include a focus on research, the comparative and competitive advantage of CGIAR Centers to undertake the research compared with other players, and the need for publicly funded research to produce international public goods i.e. that the research outputs should be applicable freely across the widest possible recommendation domains, preferably across several countries. Whilst the same strategic criteria are espoused by IITA, as noted in Chapter 1, they also raise important practical considerations in the design and implementation of the Center's research, particularly in the formation of public private partnerships and holding open the doors to equitable sharing and benefits. Among the most important examples of IITA's reorientation, in line with these new criteria, are its focus on diversification, high value crops and nutritional quality and food safety.

IITA's view of the African continent has changed as well. Although its research remains focused on SSA, IITA has a more explicit commitment to Africa-wide bodies in areas such as phytosanitary control, regional research, agricultural trade, and food health. This commitment is illustrated by growing attention to sub-regional and regional research organizations, but also to regional economic and trade organizations and to political bodies, particularly the African Union and its NEPAD program.

Although IITA has considered broadening its mandate to the whole of Africa, a paper commissioned by the Board and management concluded that a) IITA has a world mandate on cowpeas and yams and b) because of the limited use of its mandate crops in North Africa, and because of the possible perception by donors, partners and other stakeholders of a loss of focus on SSA, an Africa-wide mandate, including North Africa, was not recommended. The Panel concurs with this assessment not to extend the geographical mandate of IITA to North Africa.

2.3 Strategic Plans

IITA's current Strategic Plan covers the period 2001 to 2010 and was prepared under the former Center management. Its analysis was necessarily based on data and institutional arrangements from the late 1990's. It focused its analysis on the agricultural systems and agricultural research requirements of agroecological zones (AEZs). It identified common development challenges and proposed the strategy of addressing research through a number of benchmark sites. It provided rationale for three research programs or Divisions (Crop Improvement, Resource and Crop Management and Plant Health Management) which were in existence at the time of the last IITA EPMR.

In 2004, Hartmann, the current Director General, published "An Approach to Hunger and Poverty Reduction for Sub-Saharan Africa." which laid out IITA's approach to poverty reduction. This would be focused on means to a) encourage local production, b) create wealth, and c) reduce risk for farmers and both the rural and urban poor. This was more of a "think piece" than an endorsed strategy at the time, but it started to alter the way IITA addressed its research mission.

IITA has shared with the Panel a discussion draft of its new Strategic Plan, tentatively called "Contributing to African agricultural development: Strategic Plan 2011-2020". This draft has

been developed subsequent to some major political and institutional changes affecting African agriculture (the formation of the African Union, the New Partnership for Africa's Development (NEPAD) and the Comprehensive Africa Agriculture Development Program, or CAADP). The draft plan adopts the same poverty reduction strategy as the 2004 paper, promotes a Research for Development (R4D) process which has implications for internal organization, and proposes emphasis on the most populous countries in sub-Saharan Africa which would be served through four regional hubs (one for each of the four major areas of sub-Saharan Africa – see Annex 5). In setting its future research agenda the Center would consider:

- Significantly increased agricultural productivity with emphasis on improved food quality and commercial competitiveness.
- Effective use of new technologies, particularly in high population countries, with the aim of achieving greater impact
- Poverty reduction by strengthening efforts on wealth creation and a broader range of crops, post harvest technologies, marketing and food quality.

It is instructive to compare the two Plans. Although the current (2001-2010) Strategic Plan lists enhancing commercialization opportunities as one of its principal objectives, the guiding principles in the new draft Strategy indicate significant differences. For instance, additional emphasis is placed on processors and agroindustries. While the current Strategic Plan lists "help strengthen national and regional research capacities" as one of its principal objectives, the draft Plan indicates that the traditional focus on NARS is inadequate. In terms of research strategies, the current Strategic Plan envisions "the effective management and conservation of natural resources for sustainable agriculture, and for adaptation to environmental changes" as a principal objective, while the draft Plan places more emphasis on "preventative approaches to deal with biological threats to crops and post-harvest losses."

These changes in emphasis have significant implications for IITA's strategies and priorities:

- The Institute's emphasis on Africa's most populous countries at first glance may appear to put it at odds with the CGIAR mandate of developing IPGs, but it may be argued that the number of people reached by a technology rather than the number of political borders that the technology crosses should determine its value. In addition, regional research and trade networks increasingly allow technologies to spill over from larger countries to their neighbors.
- The change in strategies has had contradictory implications for some of IITA's crop management disciplines. On the one hand, the reduction in emphasis on natural resource management and the environment in the draft Plan is notable and has implications for the type of science carried out by the Institute and its ability to address long-term issues such as soil fertility management. On the other hand, the increased emphasis on risk mitigation corresponds to IITA strengths in deploying disease or pest-resistant crop varieties and participating in large-scale biocontrol efforts; it also links to current interest in themes such as climate change.
- The increased emphasis on market chains implies a logical expansion in the range of organizations that IITA might work with as partners, but the current strategy may neglect to give sufficient attention to the potential of IITA's traditional partners, the NARS, for following its lead and expanding their capacities to promote a market-led approach.

The move towards a market-based approach requires IITA to get involved at the field level in development projects that it might not otherwise consider. The argument that participation in pilot projects is required in order to gain an understanding of these new areas is valid, but there

is the danger that such participation can lead IITA into heavy involvement in downstream project management. IITA's draft strategic plan includes consideration of an exit strategy for such projects which recognizes partners' roles in implementation. However, this conception of an exit strategy may place too much faith in the capacity of short-term projects to establish all the necessary links in a commodity value chain in order to leave behind an agro-industrial model that can be imitated by others. This may occur in some cases, but a more comprehensive vision would place emphasis on: lesson learning (even failed pilots can provide valuable experience); monitoring progress in a sector and providing key, targeted research-based inputs; and synthesizing experiences to provide widely applicable principles and guidance.

2.4 Positioning of IITA in the R4D Continuum

Two of the major features of IITA's new strategy and priorities are a proactive engagement with those involved in African agricultural development and the articulation of a Research for Development approach.

2.4.1 IITA'S Development Dialogue

Table 2.1 IITA's "Development Dialogue" 2004-2006

Year	Country	Audience	Topic
2004	DR Congo	Vice President Minister of Science & Technology	Approaches to Hunger and Poverty Reduction
2005	Ethiopia	AU Commissioner Rural Economy and Agriculture	Phytosanitary barriers to trade
2004	Japan	(former) Prime Minister Mori Select Members of Parliament	Approaches to Hunger and Poverty Reduction in SSA
2005	Liberia[17]	President	Development of agriculture
2004	Libya	AU	Pre-Heads of State preparations
2003	Malawi	Vice President	Emergency to Development
2004	Mozambique	Vice Minister of Agriculture (visited IITA - Nigeria)	Cassava Brown Streak threat
2005		Government and donors	Roundtable on food and agriculture
2005	Niger	AU and National Government FARA	Famine concerns
2004	Nigeria	President	Agricultural Initiative
2005		Ministers of Agriculture and Commerce	Commercialization of Cassava
2006		Senior Presidential Advisor	Plans for commercialization of banana
2003	Nigeria	Mr. L. Båge, President IFAD	General Development Strategies
2006		Mr & Mrs. Gates, Gates Foundation	Commercialization of cassava
2003	Sierra Leone	Vice President Parliament Minister of Agriculture	(designed) National food security strategy. Later invited to present it to Parliament.
2004	South Africa	NEPAD	Pan African Cassava Initiative
2006	Tanzania	Government officials Prime Minister Deputy Minister of Agriculture Permanent Secretary	Poverty reduction approaches

Since the arrival of the new DG, IITA has placed particular emphasis on ensuring that it is attuned to the major agricultural policy initiatives in Africa (at both the national and regional

[17] DG represented by Dr. S. David of IITA

level) and to broader development issues such as the achievement of the Millennium Development Goals. This effort is described as IITA's participation in the development dialog of Africa. Since the inception of this effort, the Institute has received invitations to important events and the DG has had audiences with a number of key decision makers (see Table 2.1). In addition, the DG has had a number of public speaking engagements, including presentations to banks, industry leaders and interviews for TV and newspapers in Botswana, DRC, Nigeria, and Tanzania.

2.4.2 Research for Development

IITA promotes its mission and programs through the concept of "Research for Development" (R4D). This is a vision of agricultural research that addresses major development problems in Africa rather than simply contributing to the body of scientific knowledge. R4D can be another reminder that the "supply-push" of technology is an inadequate strategy and that equal attention must be given to "demand-pull", principally by ensuring that market development provides adequate incentives for farmers to take advantage of new technology to diversify and intensify their production. R4D thus requires attention to a wide range of issues that traditionally have been beyond the immediate interests of most agricultural research institutes; these include innovative extension techniques, the organization of input markets and delivery systems, and the strengthening and diversification of output markets. IITA's current involvement in areas such as the rehabilitation of the West African cocoa industry and the expansion of industrial demand for cassava are examples of this new paradigm.

The R4D concept is an effective way to articulate the challenges facing agricultural research and to motivate scientists to focus on practical outcomes. At the same time, R4D offers some difficult challenges for an organization like IITA. The major questions include: the division of labor between IITA and partners; the role of the NARS (IITA's traditional partners); the degree to which IITA should play a leadership role in broad-based, location specific development initiatives; and the opportunity costs of the approach.

R4D traverses the research continuum from the discovery to the delivery of agricultural technology. This is a broad range of responsibilities that no single agency can be expected to cover. IITA's role in much of the discovery stage is unquestioned, although IITA's traditional strengths are not at either extreme of the spectrum. It is difficult to provide general guidance to determine where IITA should take major responsibilities for activities closer to the delivery end of the spectrum (often by developing or expanding its own analytical skills) where it should rely on other organizations and be able to identify appropriate partners.

There are certainly a number of areas where the R4D model can contribute to expanding the skills of IITA scientists and re-orienting the priorities of the institution. The crop varieties that IITA develops must have qualities that meet market requirements; IITA has always put emphasis on the assessment of consumer qualities and it is now addressing industrial processing requirements for crops like cassava and cowpea. Top-down extension messages are inappropriate for delivering many of the technologies developed by IITA, and the institute is acquiring experience with innovative extension techniques such as farmer field schools. The delivery of seed and planting material is crucial to IITA's success, and it has a very wide range of experience with alternative delivery mechanisms (although it needs more involvement and experience working with private seed and input producers). Producer organizations are an effective means of not only testing and developing technology but also marketing output, and IITA is learning how to exploit these synergies.

However, IITA's role cannot be to develop and deploy new producer organizations, seed enterprises or agribusiness ventures, but rather to assess which approaches and methods are most effective and to ensure that partners at the national level are able to act on this information. The distinction between investing research resources to engage in pilot activities in order to learn lessons from specific experiences, and assuming coordination responsibility for development projects conceived by external donors or national government production campaigns, needs to be made clear in IITA's policy and strategic vision.

The role of NARS (IITA's traditional partners) in R4D is a particularly important issue. Although IITA correctly emphasizes the need to cast the partnership net much more widely than before, the draft strategic plan indicates that IITA will be more selective in its collaboration with NARS in R4D, favoring those NARS classified as "strong". This would imply a significant shift in partnership strategies and is examined in more detail in Chapter 4.

A further dilemma in operationalizing the R4D strategy is the balance between involvement in location-specific activities and the derivation of broad principles and guidelines for multi-institutional participation in agricultural development. In particular, IITA increasingly assumes leadership roles in broad-based projects which may feature a relatively small research component. However, IITA believes that the impact assessment of such efforts will provide guiding principles for the replication that will then be the responsibility of other entities.

Finally, the R4D paradigm raises questions about opportunity costs that must be addressed in IITA's planning process. The participation in technology transfer projects implies substantial effort by senior scientists at IITA who provide key technical support and leadership, but at the same time have primary responsibilities in long term research. This additional demand on senior scientists could compromise their ongoing research and their capacity to generate more research results and technology, and IITA's planning and priority setting must acknowledge this trade-off.

2.5 Setting Priorities

This section examines issues related to the mechanisms that IITA uses to set priorities for its research. It includes a discussion of the Research for Development Council and the Research for Development Directorate; the institute's approach to planning the sites and activities for its outreach activities; the process for planning its MTP Projects; and the implications of the significant increase in the institute's budget for priority setting.

2.5.1 The Research for Development Council

The RDC was established in 2002 after a consultative process with scientists by the DG. The RDC was described as a 'think tank' for strategic planning. Membership initially consisted of the Director/R4D, one appointment by the DG, and three elected councilors. Many of the TORs recommended for the RDC in 2002 were more related to decision making rather than strategy so in 2005 the RDC reconsidered the TORs for itself (and for institute management positions). These were also shared with the Board in 2005. In 2006, the Management and Governance CCER recommended changes in the TORs of the RDC. Subsequent RDC modifications were further adjusted by the Board, and were once again considered in March 2007. Although the new TORs establish a more strategic role for the RDC and are in line with its original role as a 'think tank' for strategic planning, it is clear that the debates and reorganizations of the past few years have not allowed the RDC to play a significant role in strategic planning or priority setting. The Panel

believes that the recent additions of DDG-R and DD positions (which were recommended by the RDC itself), along with other changes in the management of the MTP Projects, will provide more clear-cut responsibilities for strategic planning and will allow the RDC to play a useful advisory role.

2.5.2 Project Development in the R4D Directorate

The development of individual projects is done by scientists but is managed by the relevant DD and DDG-R. The Contract and Grants Office also participates to inform management of the opportunities for proposal submission and serve as a focal point for the management of input from scientists and oversight from administration. Opportunities to submit proposals are also a result of resource mobilization activities of the DG, DDG-R, and individual scientists. RDC gives strategic input into the identification of specific initiatives or targets for proposal development. The identification of specific proposal development is a decision of the DDG-R with input from the DD. The approval for submission of proposals is from the DD and then the DDG-R. R4D management and scientists identify specific opportunities, develop concept notes or proposals, and implement approved proposals.

Whilst some advances have been made in tools and approaches for individual aspects of impact assessment, there is currently no overall scheme that defines the relationships between the Center's strategic planning, the planning of MTP Projects, and the development of individual grant projects. The RDC is not an effective or appropriate entity to oversee these relationships. The Institute's senior management needs to define this planning cycle (with input from the RDC). Such a cycle would also define the roles and expectations for annual planning meetings and for the "country strategies" that are currently developed without a standard format or clear role in the planning process. An effective planning process will also establish IITA's "impact culture" in such a way that more careful planning, monitoring and evaluation is every bit as important as the identification of particular "impact" stories. In addition, the institute needs to continue to develop more agile and useful ways to obtain input from SROs (beyond mechanically derived lists of priorities) and from other outsiders who could contribute to a more productive and transparent planning process.

2.5.3 Approaches to Regional planning and the geographical mandate

IITA has not expanded the number of sites where its staff is based in recent years, but there have been some significant readjustments in staff strength at various sites. The Institute currently has staff stationed at five sites in Nigeria (Ibadan, Abuja, Kano, Maiduguri, and Onne) and maintains offices and facilities in Benin, Cameroon, Ghana, Kenya, Malawi, Mozambique, Tanzania, and Uganda. Separately from site selection for research, there were initial plans to identify four support hubs (or administrative hubs) for the West, East, Central and Southern regions of Africa. To date, only West (Ibadan) and East (Tanzania) hubs have been formally selected by IITA, although there are aspirations to establish an additional support hub for Central Africa (potentially in DRC). According to Management, the selection of research locations, and the allocation of research staff is considered on other criteria, such as the subject to be addressed, status and facilities of partners, scientist preferences and aspects of critical mass. The Deputy Directors (DDs) have responsibilities which cut across agroecological or geographical boundaries (e.g. the DD in Mozambique also has responsibility for the West African savanna and the DD in Tanzania is responsible for Cameroon).

Because of the large number of dimensions (regional research presence, regional administration, research focus, Project research management and recent shifts in the relative importance of

particular sites; e.g. Tanzania versus Cameroun) the Panel could not discern a transparent strategy that defines the changes that are in train. IITA has had a long presence in Uganda (originally established in response to the threat provided by cassava mosaic virus, CMV) and it is currently the largest location outside Ibadan. However, cassava expertise had been reduced and so, in response to the appearance of brown streak virus in cassava (which originally appeared on the East African coast, but is now recognized to be much more widespread) IITA has chosen to build up expertise at the Tanzania office. It is not clear why the work on BSV could not have been coordinated from Uganda so that office could serve the region as formerly.

The Panel strongly suggests that the Institute consider several points:

- A clear set of guidelines is required for the establishment of regional support hubs. Response to emergencies such as a disease outbreak or to the establishment of a large development project is unlikely to foster the type of long-term institutional development at national level contemplated by R4D.
- Deputy Directors' responsibilities should be defined by geographical rather than agroecological boundaries which match with their expertise and their oversight should be confined to management issues and relations with partners. The new DD for Project Development position under recruitment can provide additional support to relations with partners and MTP Project supervisory posts (see Chapter 5) can complement the DDG-R in managing the conduct and assessment of research.
- The IITA office in Cotonou faces particular challenges because of the arrival of WARDA (see Chapter 5) and because the recent reorganization of research at IITA has reduced the independence of the plant health specialists who have traditionally been based at Cotonou. Deploying plant health specialists more widely in Africa surely makes sense, and it is almost certainly a good thing that the new MTP Project organization integrates these scientists into broader research objectives, where their particular skills can contribute to, but also be measured against, other crop management innovations. Nevertheless, there may be some danger in overlooking the need for some critical mass (as long as IITA continues to invest in biocontrol and related activities). Other factors include the strong relations that have developed in Benin that allow the efficient movement of the highly regulated and perishable biological materials needed for the work, and it remains an important link with -Francophone Africa.

2.5.4 Planning the MTP Projects

As explained in Chapter 1, the current MTP Projects were established relatively recently, in 2006, partly in response to the Science Council's overall concerns about the previous round of medium-term planning. It is therefore understandable that they are, to a certain extent, "works in progress". They represent a logical and defensible ordering of IITA research and interests, although each one of them deserves more attention. Observations on individual MTP Projects are found in Chapter 3; this section is confined to a few general observations on the Projects and the way in which they are planned.

The MTP Projects are described in IITA's 2007-2009 Medium Term Plan. The individual Project descriptions follow Science Council guidelines for presentation and feature rationale, objectives, impact pathways, identification of IPGs, partner roles, and logframe. Although the presentation may fulfill the requirements that allow summary and comparison across Centers they do not provide enough detail on actual research or evidence of strategic

planning for the individual Projects. Such evidence does not necessarily have to be presented in the overall MTP, but the Panel finds that there is currently insufficient information or documentation about past or contemplated planning processes for the MTP Projects.

It would appear that some work is still required to transform the MTP Projects from an adequate way of summarizing and describing the totality of the Institute's work to an important tool for strategic planning and research management. Further work on refining the components of the Projects (such as limiting the extent to which individual restricted core projects are divided among several different MTP Projects) is required. It is also necessary to define more carefully the Project objectives so that the rationale for inclusion of a particular activity is clear; for instance, it is important that Project objectives begin to drive the design of restricted core projects, rather than the other way around. Perhaps most importantly, although DDs have been assigned administrative duties related to the MTP Projects, these major building blocks of IITA research require more management and oversight specifically related to their research content, a point that is made in Chapter 5.

At the time of the Review, two of the Projects (Banana and Plantain and Roots and Tubers) had gone through a strategic planning process, but the Panel is not aware of formal documentation. It is important that further elaboration of the Projects distinguishes between planning and brainstorming. At this point, the MTP Projects require more precise delineation and articulation of their activities, their strategies to measure progress, and where specific products fall in the planning-impact assessment cycle. The language of a logframe is not adequate for such a task.

Regional Planning with Partners

An issue related to IITA's regional deployment and planning is the Center's participation in regional planning exercises with other IARCs, in particular related to the Regional MTPs taken by the Centers through the Alliance (previously the Center Directors' Committee or CDC). IITA has joined in the collaborative CGIAR Center, SRO and NARS planning process to develop a regional MTP for West and Central Africa. Formally, WARDA is the Lead Agency appointed by the Alliance Executive to convene this planning process, but IITA estimates it has spent very substantial staff time in contributing to the planning since the undertaking was agreed in mid 2004. The first regional MTP (delivered in mid 2006) identifies seven areas for research and collaboration, but the drawn out process has dampened enthusiasm at IITA for further efforts which are not project-led.

IITA has also provided strategic inputs into other regional and African planning processes. IITA utilized its GIS capacity, regional farming systems knowledge and experience of benchmark site research to support the inception phase of the Challenge Program (CP) for Sub-Saharan Africa and to assist in the identification of the pilot learning sites (PLS) for the first research phase of the CP. Research is planned at the KKM PLS (in northern Nigeria and southern Niger) where IITA has had a long-term presence, and more work is being planned in the ZMM PLS in southern Africa. However, the research process has not been initiated because of a protracted administrative negotiation amongst partners. The Panel is assured that the impasse has recently been overcome, but progress towards initiation of work at this site should be kept under review.

2.5.5 *Managing growth*

The budget of IITA has grown substantially over the review period (the proposed figure of USD 50.6 million for 2007 is 40% higher than it was in 2001). It is important to ask if this new donor investment has enhanced or detracted from the accomplishment of IITA's research outputs. What have been the long term effects of this growth in budgetary resources in relation to the sustainability of IITA's undertakings and the Center's impact?

In an era of generally declining support to agricultural research, IITA's success in reversing its previous budgetary decline and generating new sources of support is to be applauded. The precise value of the additional income to IITA is difficult to judge, because a significant proportion of the funds, while managed by IITA, flow to partner organizations. This is often an effective use of the funds; for instance, an ARI partner provides advanced technology to complement IITA's research, or an NGO facilitates the delivery of IITA's technologies. In addition, the overheads allow some stability for essential research, or the availability of project funding may allow the Institute to continue employing a scientist in an administrative position until more research funds are identified. And of course access to development projects provides IITA with needed experience in R4D in order to generate the information and principles that will lead to broader impact.

However, there are dangers in pursuing development projects simply as a source of funding. Scientists who work as project managers will find their capabilities and access to their discipline declining (and may look for opportunities elsewhere). If a significant proportion of the Institute's funds are derived from development projects, there may be a relative decline in the support services (publications, biometrics) offered to the remaining researchers. Most importantly, the Institute may find itself a victim of its own success. Donors and governments will increasingly come to it for the management of development projects and its reputation will change. It will be less able to attract or retain researchers or even to muster the resources required to monitor, evaluate and synthesize the projects in which it is working in order to derive the principles that would allow donors and governments to gradually abandon the project mode in favor of more sustainable policies and institutions that serve as engines for agricultural development.

In Summary: the Panel encourages IITA proceed to complete its Future Strategy document considering some of the suggestions provided in this report. **The Panel recommends that the Center should seek greater congruence between the overall Center strategy, MTP Project planning and the restricted project grants in order to articulate the high priority research and line up the direction of growth with the intentions of R4D. The Panel further recommends that the relationships should be clearly documented as a nested set.** The Panel notes that the drawing together of experiences (the synthesis of results in different areas, and evaluation of long- and short-term science) is an important input into the continuing evolution of effective strategic planning.

2.6 COMPONENTS OF IITA's APPROACH

IITA's approach to its strategy and priority setting has implications for a number of areas of research management. Four elements are examined in the following discussion: the benchmark area approach (which was a key feature of IITA's earlier research design); biotechnology (which is assuming growing importance in the institute); product delivery (which is relevant to IITA's

focus on market development); and diversification (a key element in the Institute's market-led strategy).

2.6.1 The Benchmark Area Approach: History and Current Situation in 2007

The Benchmark Area approach was developed as the conceptual framework of the Ecoregional Program for the Humid and sub-Humid Tropics of sub-Saharan Africa (EPHTA). It was envisaged that interdisciplinary teams would be located at each benchmark site, backstopped from headquarters in each of their disciplines. The concept depended on the identification of research sites representative of large agroecological zones with fairly uniform socioeconomic features. Strategic research on those sites thus would maximize the extrapolation of research information. Two locations were initially identified, one in Cameroon in the Yaounde-Ebolowa area in the humid forest margins, and a second in Nigeria in the Kano-Zaria area of the northern Guinea savanna. A project proposal supporting the establishment of six benchmark areas was submitted to EU but not funded. Five benchmark sites were partially or completely characterized, but only the Kano and Cameroonian locations have continued to serve as research sites over the past 12 years.

Strengths of the approach: Identification of production constraints that are region-wide generates strategic research addressing important issues of variety, farming systems and soil fertility. This in turn leads to creation of IPGs addressing major production constraints that are widely transferable, giving maximum return to research dollars. Links with local partners ensure that relevant technologies are delivered to farming communities who would scale these out to the diverse communities across the benchmark area.

Assessment of progress: The Guinea savanna and humid forest margin sites have delivered a number of useful methodologies around selection of sites and representative study villages, and the diagnosis and description of local farming systems. The basic rationale behind the development and operation of benchmark areas is sound. To a fair degree IITA has achieved its initial goals in the two fully developed areas. Each is recognized as generating an array of research technologies applicable to farmers operating over a broad east-west belt from Guinea to northern Nigeria. However, characterization, development and maintenance of these sites has proved resource intensive at a time when the core funding needed to underpin long term development has been diminishing. When donors terminated support for a benchmark area the national programs had neither the resources nor the interest to maintain ecoregion-wide research. Some sites simply became irrelevant and were closed. Communication with partners and NARS, if ignored, rendered sites islands rather than nuclei for research. And where BAs were located in relatively remote areas, stable IR staffing became a problem. Sites succeeded where staff completed characterization and identified key constraints promptly, then moved quickly to establish a collaborative research agenda with partners and stakeholders. Staff needed to scale out as quickly as possible. Trim and nimble steering committees, and an appreciation of local culture and the evolving nature of cropping systems were also elements determining success.

The value of the benchmark concept was questioned by the 5th EPMR because of its tendency to compartmentalize resources. IITA has therefore de-emphasized this approach in recent years. A more flexible research investment strategy was needed in the face of major disease threats (e.g. brown streak virus of cassava) - something not possible if a large proportion of core research resources was committed to benchmark area-based research.

Current status: IITA now favors a commodity chain approach as a more efficient means of organizing good science. Factors determining the location of research programs are more heavily weighted towards population concentration and country size (e.g. Nigeria, parts of DRC, Kenya, Uganda, Ghana) or where specific challenges must be met (e.g. cassava brown streak virus in eastern Africa). The benchmark area approach has now become one of several factors determining location of research sites, some others being the regional nature and scope of problems, expertise, strength of NARS partners, availability of funding, and ease of staffing.

Panel assessment: The Panel recognizes the logic and the limitations of the benchmark area approach, and endorses the intelligent and selective use of this approach by IITA. However, the placement of research centers in East Africa, at first blush, does not appear to be very systematic. For example, long term commitments to research centers in Uganda and Tanzania appear difficult to justify on an agroecological zone or a genotype x environment basis. While the concept in ESA of "research stations without walls" provides flexibility in research and fast response to emerging crises, the Panel notes that short term staff deployments are hard on staff and families, and are not conducive to good strategic research. It is noted, however, that when IITA establishes a research location it is committed to providing full institutional support to that location no matter how short the funding horizon. Nonetheless, long-term natural resource issues that seriously threaten African agriculture must not be ignored. These include a decline in the base level of soil fertility, and the build up of problem weeds such as *Striga* and *Imperata*. If these are not addressed by IARCs (either individually or as part of cross-cutting programs) it is difficult to see who will tackle them at a regional level. There appears to be the need to establish at least one additional long-term benchmark area located in the mid-elevation ecology of ESA. The Panel would welcome a greater level of core support for such a step as costs elsewhere are brought under control.

2.6.2 Biotechnology at IITA

IITA has made a major commitment to establish biotechnology facilities at two major centers (hubs) and a network of smaller facilities (nodes) at several locations. Considering that several of the staple crop commodities of Africa under the IITA mandate, namely cassava, yam, cooking banana, plantain, and cowpeas, receive little attention from the larger global biotechnology community, these investments at IITA seem well justified. The Center has clear and deliberate strategy for using its biotechnology facilities for building regional capacity and to serve as a bridge by linking its NARS partners with advanced research institutions around the world to apply emerging biotechnological tools to African crops.

The IITA biotechnology facilities are placed at several locations spreading scarce resources rather thinly. The oldest of these facilities, and still the largest, is the one located at the Ibadan headquarters. This facility undertakes biotechnology R&D in the areas of tissue culture, plant transformation, and the development of molecular markers for diagnostics, diversity analysis, and potential use in breeding. It is supported by good support facilities such as greenhouses and managed by active, hands-on scientists.

The second IITA biotechnology hub is located in Nairobi and is somewhat integrated into an existing ILRI laboratory platform as a joint IITA and ICRISAT sub-platform. This facility is also envisaged to serve as part of a network of bioscience research for eastern and southern Africa (BECA) under the New Partnership for Africa's Development (NEPAD). The government of Canada (CIDA) provided much of the funding for construction and refurbishment of laboratory facilities, equipment for both genotyping and bioinformatics. The IITA-BECA facility specializes

in high throughput marker technology and in serving collaborative research efforts with IITA and NARS partners in eastern and southern Africa. No tissue culture or transformation activities are undertaken at this facility. A Facility Manager is assigned to each of these hubs with total oversight responsibilities.

In addition to the two major hubs, IITA also conducts biotechnology activities at Benin, Cameroon, Kano, Uganda, and Tanzania. Plans seem underway to expand these activities to Malawi and Mozambique. Biotechnology activities at these research locations are conducted in facilities put together primarily by IITA or in joint effort with partner NARS. Some like the excellent facility in Uganda for both transformation and marker work are primarily run as a national facility that receives minimal support and oversight from IITA. In Uganda, IITA's biotechnology research appears fully integrated with those of NARO.

The following observations have been made about the strategic plans, management, and overall conduct and vision of biotechnology research at IITA:

1. While there appears a good division of labor and fully complementary programs between the larger hubs at Ibadan and Nairobi, relations appear cold. A strategy paper presented to the team stated:

   > *"There is currently limited interaction and information flow between Nairobi based scientists and IITA scientists based in western Africa (particularly Ibadan) and IITA's Administrative center in Ibadan. There is a tendency for scientists from eastern Africa to be seen as competitive to those in western Africa, and vice-versa, a culture that is counterproductive to teamwork and IITA's research agenda".*

   The Panel agrees, and it is wise to intervene quickly and delineate the proper division of labor and accentuate the complementary nature of the efforts at these two facilities. Both facilities can easily be enriched by the other excellent R&D efforts that IITA and partner scientists conduct in each of these two regions. We suggest that IITA assess whether the DDG for Research or a designated IITA Biotechnology Officer be designated for this and similar Center-wide coordination of biotechnology research at IITA.
2. There is currently no ASARECA-commissioned regional biotechnology project conducted as a *bona fide* BECA project. Nevertheless, the laboratory is well utilized with projects funded through grants that IITA scientists and partners have developed. We are, therefore, cautiously optimistic, that when current construction efforts are completed, there is likely to be sufficient bench space to accommodate the research needs of IITA and ICRISAT "core" projects as well as the expected NARS demands through the NEPAD/ ASARECA initiative.
3. Research in biotechnology is expensive; there are significant overhead costs and the consumables for wet-laboratories are very costly. We suggest that IITA not continue to expand biotechnology facilities at several centers but focus on strengthening the two hubs for truly regional capacity building, research service, and backstopping.
4. In connection with the above, and where the NARS offer modest facilities, IITA should not invest to equip and run a separate and parallel program but instead strengthen NARS efforts by linkage to IITA's regional biotechnology (hubs) facilities. Placing biotechnology equipment and personnel at several facilities may deny IITA the focus and concentration that its biotechnology program will need to have the needed impact.

The Panel recommends that IITA does not expand biotechnology facilities further into other locations, but instead strengthen the facilities at the two existing hubs to serve the needs of NARS as well as the IITA scientists more adequately.

The Panel further recommends that in order to improve coordination and communication between its biotechnology hubs at Ibadan and Nairobi, IITA should consider appointing a biotechnology coordinator to facilitate the functions of these hubs and enhance effectiveness of the Center's biotechnology thrust.

2.6.3 Product Delivery

IITA develops a number of different types of research products. This discussion focuses on the delivery of tangible products (including crop germplasm, varieties, biocontrol agents and biological pesticides) and does not include the delivery of information products such as crop management recommendations or policy advice.

Germplasm: IITA has managed germplasm development and testing networks for many years. IITA is the host for WECAMAN, a network for maize breeding research in West and Central Africa and coordinates or participates in networks for its other mandate commodities. NARS report that they are able to request trials from IITA although recent funding problems have meant that the number of regional trails sent to NARS for some crops such as cassava has diminished. There are two brief IITA Impact Studies published in 2000 on cassava and maize, showing the significant (and growing) contribution of IITA germplasm to varieties released by national programs. An on-going study in West Africa aims to update information on maize varieties and the use of IITA germplasm. IITA believes that it has contributed to the release of 23 varieties of cowpea, 57 of cassava, 8 of yams, and 17 of soybean", although the retirement of the soybean breeder has been responsible for a lapse in the capacity to track this crop. Maintaining networks for germplasm testing is therefore important, so that IITA can place high priority in the more strategic research of developing new traits and new source populations that NARS partners can exploit at their specific environments. This makes for a proper division of labor.

Crop varieties: NARS are responsible for the final development and release of crop varieties based on IITA germplasm, although in cases where NARS do not have plant breeding capacity these are direct selections from IITA lines. In most countries variety release procedures for grain and legume varieties are fairly well established (although not necessarily efficient), but less so for root and tuber crops and bananas. It is not clear if IITA invests enough effort to help make these variety release processes more agile. It may be worth IITA reviewing national variety release procedures for its crops, especially in the context of renewed interest in the reform and harmonization of seed regulations in all regions of Africa.

The release of crop varieties must be accompanied by a strategy for seed production and provision, and this is an important deficiency for most of IITA's crops. In Nigeria, the private seed industry interacts with IITA to identify suitable maize hybrids and the companies then collaborate with IAR to secure release of the variety. Although Nigeria is West Africa's leading producer of commercial seed, its total production is pitifully small. There are almost no other examples of private seed enterprises for food grains and legumes in West Africa. A donor funded project established a West Africa Seed Network (WASNET); when the project terminated, IITA agreed to run the network, but has recently turned the operation over to its members. The membership is based on national government organizations such as certification agencies, although some national seed producer organizations are also members. The network activities

largely concentrate on issues such as harmonization, variety lists, and interactions with NGO or community seed projects. These are useful activities, but the network does not appear to be an appropriate mechanism to promote commercial seed development in the region. IITA is currently reviewing the status of seed provision for maize in West Africa and soybean in southern Africa. IITA should ensure that it is able to take advantage of, and make contributions to, the several large donor-led initiatives that support seed enterprise development in Africa.

Because of the lack of a seed industry in West Africa, there are a number of instances where IITA projects feature community (or other local-level) seed multiplication schemes. Although such schemes may be useful for diffusing new varieties, there is no evidence from IITA that they lead to any sustainable seed production capacity. In addition, the investment in such schemes may undermine any incentive for the development of private seed production capacity. It would be appropriate for IITA to address this dilemma in a more organized way, as it seriously affects the capacities for diffusion of its products. A review and synthesis of its experiences in this field would be in order.

The challenge is even greater for vegetatively propagated crops. IITA has considerable technical experience in this area. Virtually all of the diffusion of new varieties of these crops is done through special projects that organize multiplication and (often free) distribution. These may be in the context of emergency programs to combat the spread of crop disease or as part of general agricultural development projects. IITA has been involved in so many of these efforts that the Institute should be able to synthesize this experience and work towards promoting more sustainable strategies for the diffusion of these crops. The analysis would also consider where conventional multiplication is the most appropriate route and where innovations such as mini-setts (for yams) or tissue culture techniques are to be promoted.

Transgenic crops: IITA is developing transgenic cowpea and banana varieties. The African Agricultural Technology Foundation (AATF) is assisting with the cowpea work (*Maruca*-resistant Bt cowpea) and the banana work on transgenes for resistance to bacterial wilt. AATF promotes the concept of developing business plans for its projects but IITA's role in the business planning is not clear, although IITA has recently been commissioned to do a study on demand for Bt cowpea in West Africa. IITA has also been contracted by AATF to do baseline studies related to the development of *Striga*-resistant (imidazolinone-tolerant) maize varieties in several countries, although the actual technology is being developed by CIMMYT and others. It would be useful if IITA played a more active role in business planning for its transgenic crops (whether or not their development is facilitated by AATF).

The development and deployment of transgenic crops depends on the establishment of national biosafety regulations, a process that is proceeding very slowly in much of SSA. IITA has taken the lead on a donor project related to biosafety in Nigeria. Although the establishment of biosafety frameworks is an essential prerequisite for the delivery of any of IITA's transgenic crops, it is difficult to see what IITA's comparative advantage in this area might be, and there are a number of other players in this field. IITA can play a useful supporting role in this area, particularly in collaboration with SROs, but it should not be seen as an institution that would take the lead on the development of national biosafety frameworks.

Bio-pesticides and biological control products: IITA has had considerable success in several biological control innovations (e.g. for cassava mealy bug and green mite control); the deployment of these natural enemies depended on agreements from national governments and publicly funded

dispersal efforts. A more recent example is experience with the development of the bio-pesticide "Green Muscle" for the control of locusts. Although this product is now produced commercially, its deployment is also handled through publicly funded application over fairly wide areas of a country. An on-going effort to identify and produce benign species of fungus to compete with those responsible for aflatoxin in grain may also lead to products that will be deployed by public efforts, at least initially, but if successful would be expected to be available through commercial channels. IITA hopes to develop and deploy other bio-pesticides that will be used by individual farmers and will certainly require commercial production and distribution. The nurturing of local enterprises to produce and market such products is a significant challenge; IITA needs to devote more effort to identifying how such enterprises can be developed and what its role, in collaboration with other partners, should be in this development. There has been much talk in IITA and other CGIAR Centers about "innovation systems", but there is little practical experience for ensuring that the appropriate entrepreneurs and end-users interact with scientists during product development. In addition, national regulatory systems currently make the commercial release of such bio-pesticides difficult or impossible. IITA can achieve a certain "demonstration effect" by limited field experiences (as is apparently the case for *Beauveria bassiana* fungus for the control of the diamondback moth in vegetables in Benin employed by an NGO), but it will not have significant impact until the regulatory issues are addressed. This is not a task for IITA alone, but it needs to formulate a clear strategy to contribute to efforts at regulatory reform.

IITA is entirely correct in emphasizing the important role of markets in agricultural development in Africa but the Panel recommends the institute to pay more attention to building and strengthening national agri-business capacities for marketing the inputs (such as seed, clonally propagated materials and biocontrol agents) that embody the institute's own technologies, and draw lessons from this experience.

2.6.4 Role of IITA in Diversification and High Value Crops

A focus on diversification and high value crops is consistent with the CGIAR System Priority 3. There are various roles for IITA in this area. First, it is important to emphasize that IITA research that allows greater productivity for traditional food staples can contribute to providing farmers with greater food security and thereby open opportunities for diversifying into other crops. Second, the development of a wider range of demand for traditional staples, with new industrial uses and higher grades and standards, can also provide additional income through participation in agricultural markets, and IITA is pursuing several such opportunities. Third, crop research can enhance the productivity of livestock systems (as recent work on dual-purpose cowpea has illustrated). Fourth, this priority offers IITA the possibility of establishing research expertise in new crops and cropping systems.

It is this fourth area that is most challenging. IITA has always had an agro-ecological mandate and has conducted research on quite a wide range of crop staples. The possibility of taking on research responsibilities for additional, non-staple crops is thus a logical option. However, it is important that IITA carefully define its particular areas of expertise and its strategy for collaboration with other partners.

The current support for the various tree crop projects and the application of IITA's experience in IPM to horticultural crops provides an opportunity for building up a reputation and set of expertise over the next several years that could allow IITA to offer a well-defined set of skills, contacts and priorities for contributing to agricultural development through high-value products.

The first priority should be to clearly identify IITA's specific technical contributions. For tree crops, IITA has long experience in crop management and socioeconomic analysis in forest (and forest margin) systems. For vegetables, IITA's biological pest management experience is the principal entry point. However, there are many areas where IITA must rely on the technical expertise of other institutions; the design of the farmer field schools for cocoa, for instance, necessarily relies on the experience of institutions such as CABI and national cocoa research organizations. Similarly, IITA has limited experience in crop management for vegetables, its pest control expertise is limited to biological options, and the potential range of horticultural crops demands some prioritization and focus. IITA has little to offer in terms of germplasm for any high-value crop and thus must identify and collaborate with appropriate partners; even its research on molecular mapping of cocoa must be turned over to someone else in order to make use of it.

Because much of what IITA is being asked to do in terms of technology development for high value crops involves crop management (rather than plant breeding), there are particularly acute challenges for designing adequate delivery systems. The crop management changes recommended for cocoa (e.g. for disease control) require significant farmer learning. The current strategy of investing in the extension technique of farmer field schools (FFS) is logical, but the variable track record of FFS for various crops around the world, and the concern about the technique's cost effectiveness, implies that much investment will be needed in monitoring progress and in searching for the most efficient means of delivering crop management advice. The challenge is exacerbated by the moribund state of most national extension systems; there is considerable hope that civil society organizations can fill much of this gap, but that is so far based on faith rather than accomplishment. The concern about FFS is equally applicable to interests in pest control for vegetables, and the paucity of successful examples of the introduction of IPM to resource-poor farmers argues for careful monitoring and evaluation. These are areas where a combination of IITA expertise and the synthesis of wider experience could make a significant contribution to the policy arena, consistent with IITA's mandate. IITA should move away from concentration on developing particular extension strategies or designing specific configurations for farmer organizations and instead provide objective syntheses of experience to guide others in these areas of technology delivery.

An important crop management option for high value products for which IITA is particularly well placed is that of bio-pesticides. (Bio-pesticides can of course be used on a wide range of crops, but their costs, specificity and management requirements indicate that they are likely to make their first impact on commercial crops.) These currently have little use in Africa (besides the delivery of "Green Muscle" for locust control by public programs and a few examples in export horticulture). Two major impediments are business development and regulatory frameworks. Bio-pesticides have a short shelf-life and lend themselves to small enterprise models but there is little such development in SSA. In addition, there is significant potential for improving national pesticide policies to make them more consistent with safer and more effective pest control strategies, and in particular to make regulatory frameworks accommodate bio-pesticides. Current national regulations and costs essentially preclude the introduction of most bio-pesticides. Until enterprise development and regulatory reform are addressed, there is little hope that any IITA innovation in this area will find its way into farmers' fields on a significant scale. It is essential that IITA identify organizations that can push forward on these two issues and define its own contributions.

It may be argued that some of the problems of encouraging crop management improvement will be resolved when more efficient output markets provide better incentives for investments from farmers. This is a position that is explicit in the conception of the various cocoa projects. For many high value products final demand is well established but intermediate points in the marketing chain are deficient. The argument is undoubtedly valid, but who should take responsibility for improving these output markets? In the current cocoa projects, donors rely on IITA to coordinate much of this work, although they call in other organizations (such as the Canadian cooperative organization, SOCODEVI) to improve marketing efficiency. While temporarily accepting responsibility for helping coordinate others in the development of producer cooperatives, farmer groups and certification systems and organizing market information systems, IITA should not seek to enter directly in these activities. These have been the features of many donor projects (in various crops, in Africa and elsewhere) for several decades, with variable success. Building the local institutions that can support an industry such as cocoa production is a very difficult challenge. IITA should concentrate on identifying the most competent organizations that perform this role and confine its input in this area to synthesizing experiences in those areas where it has competence. One example might be the area of farmer organizations and their interactions with the marketing process (especially where there are interactions with production options and technology use), but even here IITA needs to demonstrate that it has the expertise (and a critical mass of research and analysis) to allow it to make a useful contribution to a field of research where many others are already involved.

Similar arguments can be made about IITA involvement in sectoral policy for high value crops. The CCER for Project C has recommended that IITA limit its contributions in sectoral policy analysis and this advice should be considered for high value crops. IITA socio-economists are capable of describing and modeling commodity sectors, but the significant investment of time in such work would only be justified if they address clear policy outcomes that contribute to practical interventions related to technology generation and provision. Such possibilities should be clearly articulated before engaging in such work.

The growing realization that high-value crops can make a significant contribution to agricultural growth for many resource-poor farmers, the current commitment of donors to fund IITA work in this area, and IITA's relevant technical experience offer the hope that this is an area where IITA can make an important contribution. But the Panel urges IITA to use the next few years to better define its comparative advantage so as to be able to act with more authority in its negotiations with donors and their widely varied interests and objectives in agricultural diversification.

*Summary Assessment***.** The Panel's major concerns about the Center's planning and priority setting relate to the basis for, and process by which MTP projects seem to be conceived. Some of the current uncertainty in this process is related to the changing guidelines and short deadlines for the written plans required by the Science Council, but it is also related to the unclear connections between the Center's strategic plans and its annual planning process. It also appears to the Panel that the Center needs to make a clearer distinction between the research leadership expected of senior managers (especially DDs) and the proposed project management responsibilities of other scientists (Chapter 5). The RDC should be seen as a think tank, while the Deputy Directors should devote themselves to planning, priority setting, and monitoring performance.

3 QUALITY, RELEVANCE AND IMPACTS OF SCIENCE

3.1 Quality of science at IITA

The heart of IITA's mission is to conduct research that addresses key issues of agricultural development in sub-Saharan Africa. The quality of that research affects the impact of the Center, both in the short and long terms. In seeking to address this issue the Panel recognizes that although its mandate is to review the previous 5 years research, a great deal of IITA's strategic research on germplasm improvement and natural resource management may take 10-15 years before its efficacy and impact can be properly assessed. It is today's research that determines IITA's capacity to respond to the needs that arise in a few years. The Panel is also aware that IITA has enthusiastically embarked on a program of R4D, and this has the potential to move research activities downstream on the discovery to delivery scale. As well, a significant proportion of the development research tends to be nationally focused and may generate results that are by nature country-specific, rather than being international public goods applicable to a whole region. These and other issues, therefore, were considered by the Panel.

3.1.1 Steps taken by IITA to address quality of science issues

IITA conducts strategic, applied and adaptive research, as well as engaging in advocacy and capacity building. IITA interprets support from the donor community and the SSA-CP as an expression of confidence in their R4D research strategy and an endorsement of the quality of its science, and in general the Panel concurs. Quality of science has been widely discussed by the RDC. As a result IITA research managers have focused on science quality assurance through leadership, mentoring, the effective use of core funds to support and protect core science competencies needed to ensure gains in long-term research endeavors (such as breeding), and support for new science. The RDC has also outlined a strategy for technology acquisition through stronger links with ARIs. Some examples would be the close relationships that have been forged with the University of Copenhagen during the development of acyanogenic cassava and a cassava-specific DNA micro-array; and strong collaboration with the John Innes Center in UK during the development of genetic linkage maps in yam that has resulted in significant technology transfer to IITA.

Several mechanisms are used by IITA management to ensure and enhance the quality of science:

- Appointment of link persons from the Program Committee of the Board to specific projects, to increase their input to the strategic research agenda of the Center, and assist the Deputy Directors who lead these projects.
- CCERs conducted on five of the major projects described in the 2003-5 MTP, and recently a CCER of the SP-IPM program. There has been a donor commissioned review of Project A. These have produced useful recommendations on the direction and conduct of science. Future CCERs are planned at the rate of one per year.
- The annual work and strategic planning meeting where project outputs are set and quarterly milestones agreed upon.
- Individual scientists set workplans with Deputy Directors (DDs) to help ensure adequate research standards. The DDs monitor the quality of work as it progresses. Annual performance appraisal of scientists awards at least 15% of the overall assessment to quality of science, judged by publications, presentations, paper reviews, proposals prepared and funded, and quality of research outputs.
- Field monitoring tours at Project level are held at all IITA locations to observe field execution, and staff seminars are open to all.

- Competitive grant opportunities for travel to conferences, and training courses that may incubate new science.
- Review of research contribution of staff, who must present a research seminar every three years as part of the contract renewal process.
- In-service training in topics such as statistical analysis, writing skills etc.
- Internal review of manuscripts before submission for publication, managed through the office of the DDG-R4D.

3.1.2 Assessment of science quality at IITA by the EPMR

Quality of science at IITA is not easily defined, since it must always be tempered with relevance of research goals in the R4D continuum and expected return on research investment, as well as the more traditional measures of quality. In assessing the quality of science the Panel relied on the following sources.

1. Reports, articles, presentations and planning documents supplied by IITA, and supported by personal observations during field visits and discussion with research managers at the Center.
2. 20 research publications selected by IITA at the request of the EPMR to represent the breadth and depth of science over the past 5 years.
3. The Reports of the five previous CCERs and one donor commissioned review.
4. Science quality assessment carried out for the IITA EPMR (April/May 2007), which includes an analysis of publication records.
5. Results from the CGIAR Performance Measurement System: IITA results for 2006.
6. Results of a Stakeholder survey carried out for the EPMR (April/May 2007). There were 37 responses from institutes in 15 countries. Institutes from 12 countries in SSA responded (including institutes in the host country, Nigeria)
7. The CGIAR's 2006 Stakeholder survey: The IITA stakeholders (N=52) were a mixture of knowledgeable partners and CGIAR Members, with about 50% from ARIs and 33% from national or regional organizations.

The following indicators have been considered by the Panel (criteria are expanded further in Annex 6.)

A: Relevance of science to SSA:

IITA's stakeholders provide an important source of opinion on IITA's research programs and their relevance. In the 2007 survey all respondents were familiar with IITA, and 56% of respondents rated IITA as excellent in roots and tubers research, while 35% of respondents rated IITA excellent in plant health research. More than 50% of respondents rated IITA as either excellent or good in all research categories except in natural resources management research, where 50% of respondents categorized IITA's research as poor. The attitudes of respondents to IITA's work on high value products and agro-industrial initiatives was more evenly spread over response categories, suggesting that IITA has not yet established a reputation for its research and related activities in these fields. Around 50% were familiar with IITA's R4D approach and felt that this had had a positive effect on the Center's achievement. Half of the respondents (nine of these are institutions from countries in which IITA has sites or projects) indicated they could not contribute at all to priority setting. These results were broadly consistent with those from the 2006 survey, when IITA scored better than average on perceptions relating to its research attributes, e.g. research addressing most current and relevant agricultural challenges, or innovative research.

Research papers submitted to the Panel ranged in relevance to Center research goals from highly relevant (sustainable cropping systems in the savanna; a major review of the severe CMD epidemic) through to irrelevant (sulphur dynamics on temperate soil under ryegrass in pots). And while papers that identify molecular markers associated with major diseases of mandate crops make for good science, their relevance to IITA's mission is reduced when there is little evidence that marker assisted selection has not been routinely applied for the traits in question. The Panel notes that current molecular marker research on diversity analysis tends to be somewhat repetitive. The Panel was informed that staff with the necessary expertise in MAS has recently been hired, and the Panel would welcome a sustained and carefully planned initiative in MAS on one or more of IITA's mandate crops.

The Panel considers that the relevance of the MTP projects to meet Africa's needs is generally high. It is also tempered by the responsibilities the CGIAR itself places on the Center, both in terms of mandated crops and of system wide goals. The projects that focus around crop improvement goals and management systems for those crops are well focused and remain highly relevant to IITA's mandate. Agrobiodiversity is responsible for conserving the genetic variability that drives genetic gains in the commodity programs into the foreseeable future. Opportunities and Threats, inasmuch as it enhances and protects those gains through biotic, abiotic and socioeconomic elements also is close to the heart of the Center's mission in science. IITA's mandate in Agriculture and Health is a departure from traditional concerns but is congruent with new CGIAR goals; whether the production and delivery of cryptic traits whose identity is difficult to preserve is an effective means of addressing these problems remains to be demonstrated. High Value Crops, with its focus on crops such as cocoa and peri-urban vegetable production represents a departure from the Center's historic focus on mandated staples, but there is little doubt that these types of crop represent important income sources for many African farm families. The protection of gains in staples through biocontrol measures provides a direct link to African small-holder needs. The Panel finds however that there are relevant areas that have a long-term horizon, similar to that for crop improvement, that do not appear to be adequately addressed during the period under review. An obvious example would be the sustainable management of the natural resource base of SSA.

B: Rigor of science:

In general the Panel finds that the rigor of science at the core of each of the MTP Projects to be acceptable. This is especially true for those crop improvement projects that represent mature science and that have been in existence for several decades. However, for new areas, such as the High Value Crops Project little traditional research is being conducted. The rigor of the disciplinary science that supports crop improvement is generally adequate, but there is some variability. One concern is in the area of soil fertility where the panel feels the appropriate questions are not being asked. For example, what are the nutrient requirements and the nutrient balances of the major cropping systems in key food producing areas of SSA, and are these sustainable? Are trials being conducted at enough locations to generate confidence in region-wide recommendations? Are indirect indicators of nutrient deficiency such as DRIS being followed up with appropriate field trials to confirm nutrient responses in appropriately adapted germplasm? In the area of socioeconomics, research focus (and perhaps rigor) appears to be threatened by overload and lack of critical mass in addressing priority themes. Management at IITA asserts that all projects proposed and accepted by IITA contain a significant science component. Are line scientists engaged in developing these research components? The Panel strongly encourages IITA to be more assertive in developing researchable hypotheses and

research strategies in each of its major restricted core projects so that technology generation becomes a clearly identified component of the development effort.

The Panel has already noted the tension that exists between the need to conduct relevant research to support development and the need to meet scientific standards of major journals. This is particularly challenging in SSA, where scientific staff are expected to fulfill many roles "to get the job done". Nevertheless, publications are an important measure of scientific quality and provide assurance of that standard to staff and managers alike. A good publication record also helps ensure that researchers will move between IITA and peer research institutions with little difficulty. In the following discussion we make a distinction between "ISI journal" and "All peer reviewed journals" (the latter category is more encompassing, since it includes ISI journal articles as well as many types of articles subject to different forms of peer review).

The publication record of IITA's scientific staff is generally good. It is however uneven, in that 22% of IRS staff published no ISI journal peer-reviewed articles over the past five years, and 16 % published no peer review articles of any sort. The average rate of publication was 0.9 publications per year in ISI journals, and the average for only the staff who published was 1.5 publications per year. Two scientists published 6 ISI journal papers each in 2006. Almost half of the papers published were co-authored with national program partners. Comparisons with other CGIAR Centers are always difficult, but the mean publication rate in ISI journals in six other Centers is 1.7 per year (range 0.8 – 3.0), and the percent staff who failed to publish any articles over a 5 year period was 17% (range 8 - 22%). Clearly the proportion of IRS who did not publish at all in the past 5 years should be of some concern. Forty-seven percent of all IRS joined the Center in the period under review and some may still be establishing their scientific programs. Nonetheless the numbers of students supervised per staff member over the past 5 years (6.4) is high by CGIAR standards, and this usually results in journal publications. IITA staff are, however, widely recognized for their contributions, with 42% being asked to review journal papers in that same period.

Research papers submitted to the Panel ranged considerably in the rigor of the scientific approach employed. For example, the Panel hoped to find in the evaluation of farming systems for the savannas some long term estimates of treatment effects (from modeling or experimentation) on nutrient balances and yields that support assertions of sustainability, but were disappointed. This is an example of where rigor and depth can be added to the R4D approach to provide a quantitative underpinning to its research. Other highlighted research contained in overviews was excellent but sometimes old. The journals chosen for publication varied from average to excellent.

C: Enabling high quality science:

IITA's internationally recruited staff (IRS) is reasonably balanced for gender (22% female), well qualified (>80% with PhDs), and represents a wide array of disciplines. In terms of primary disciplinary expertise the largest group are those trained in crop improvement (approximately 25%), followed by staff trained in plant health, entomology and pest management research (23%) and socioeconomics (23%). Agronomy and soils professionals comprise 21% of staff, and nutrition and food safety professionals 8%. There are a number of specialized skills represented among staff such as GIS, nematology and insect taxonomy. In general it is a well balanced research team, but with some obvious gaps. For example, there is no IRS-level biometrician, and the Center's weed control specialist and its only senior yam breeder have both recently been appointed to positions with more than 75% time allocation to administration. As well, IITA's staff

is aging. The age distribution of the total IRS complement shows 65% in the range 45 to 59, with only 3% of IRS in the "young scientist" age bracket of 30-34. The Panel understands that there has been a concerted attempt to hire Post Doctoral staff to support core competencies burdened by administrative responsibilities. The Panel urges IITA to accelerate that program and augment it by an aggressive hiring of competent scientists in the 30-40 year age bracket.

There have been shifts in the balance of skills in IITA since 2002, with the strengthening of the socioeconomics group. Stakeholders surveyed in 2007 encouraged IITA to continue to provide research activities in all relevant areas, rather than further increasing the emphasis on development, socioeconomics or policy advocacy. In other words, they felt the changes in balance over the past 5 years had gone far enough. On the other hand, more than half of the respondents rated IITA's training and capacity building programs as average, and several noted the decline in these activities in recent years.

Research papers submitted to the Panel painted a mixed picture of staff strength. In a number of cases the senior author was not an IITA employee, and several papers described research that was done prior to the author joining IITA. Most illustrated a healthy research team work ethic, and there was a lot of evidence of good research partnerships among co-authors in ARIs. However, in a few cases IITA scientists' input appeared to be limited to the supply of the genetic materials.

The Panel wishes to compliment IITA on the strength and dedication of its research team. It has however noted some areas of weakness in disciplinary balance of that team. The most obvious is the absence of an IRS-level statistician. Soil fertility is another apparent area of weakness, and needs leadership at the senior scientist level. At a less important level, the absence of simulation capability in the crop and soil areas impedes the capacity of the Center to address long term research issues, especially those associated with time trends.

The Panel has also noted that IITA has been slow to fill senior scientific positions and still may not have the appropriate arrangement for research planning and management (and supporting services like procurement which affect the rate of science). The Panel suggests that IITA has paid a price in the fashioning and refashioning of new projects (a process still in train) without overall direction to reorient its research towards the Research for Development approach.

D: Maintaining science quality:

The successful hiring and retention of high quality staff is a critical component of continuity to long term research programs. Plant breeding frequently depends on a deep familiarity with germplasm, genetic variation and environments and their idiosyncrasies. In agronomy and socioeconomics it is an in-depth understanding and appreciation of the environment – whether it is crop, soil, cropping system, household or policy – in which agriculture operates. However, the 2006 stakeholders survey asked respondents to rate the Centers' abilities to hire and retain high quality staff. IITA scored 11 points below the average Center score for this attribute.

The Panel recognizes the special features if IITA's situation, especially the challenges of attracting staff to Ibadan. IITA has done a remarkable job of providing a safe and comfortable working environment on campus, and reliable access to internet and cell phone services has greatly improved communications with the outside world. However, the Center may have to consider a more deliberate approach to enhancement of family and professional life at headquarters, and the deliberate strengthening of research locations outside Ibadan so they become viable and

recognized hubs of research excellence. The Panel also commends and encourages the steps taken by research management to monitor and mentor research by individual scientists, and to maintain their research skills.

E: Output and impacts of science:
Historically there have been very large returns to IITA's research in areas such as biocontrol and breeding for resistance or tolerance to plant viral diseases. In the assessment of the Medium Term Outputs, as part of the CGIAR's Performance Measurement system, 95% of IITA's 75 declared Outputs were considered met in 2006 - a high rate of accomplishment. IITA identified five outcomes from their work which varied in character: determination and use of cassava standards in Nigeria, Uganda and elsewhere; reduction of child labor in cocoa plantations; adoption of nutrient management systems in northern Nigeria; selection of improved cassava genotypes in Sierra Leone, Benin and Nigeria; and dissemination of improved cassava planting materials in Southern Sudan. It is noteworthy that these 3 out of 5 of these outcomes are in cassava production and utilization.

Stakeholders also have perceptions of IITA's major impacts. The 2007 survey for the EPMR revealed that more than 50% of respondents considered IITA's major contributions to research were in cereal legume systems and in root and tuber systems, and the majority of respondents found IITA's germplasm conservation program highly relevant to their own programs.

Several of the 20 research papers submitted to the Panel showed convincing effects of impact, though as formal studies of impact *per se*, they were rather variable in quality. IITA's role in managing the EACMV epidemic in east and central Africa, the impacts of biocontrol, and the positive benefits of legume-cereal cropping systems in the savannas paint an impressive picture of the impacts of research. Others, such as the mapping of key traits, are expected to provide impact in the future.

Through its Performance Measurement (PM) system the CGIAR has assessed the Centers' impact by two indicators:- a review of 12 papers providing some measure of impact of IITA technologies and published in 2006, plus an evaluation of current 'impact culture' (influenced by the recent increase in socioeconomics staff). The *studies* of impact that IITA submitted and which were evaluated by the CGIAR's PM assessment in 2005 (such impacts are assessed triennially) were found to be of relatively poor quality. However, this does not mean that IITA is without impact (as assumed by one IITA investor who may have misinterpreted this indicator), but rather that the quality of the technical approach of the submitted studies was deficient.

In preparation for the Review IITA prepared a document bringing together methods and experience in the conduct of ex-ante and ex-post impact assessment and farm-level adoption studies since the time of the last review. The review clearly shows a considerable body of research on these topics, reflecting increasing investment by IITA in this area. However, there is much more that IITA needs to do to foster an effective impact culture and to focus impact research on relevant objectives rather than just submitting studies to meet the PM criteria. The Panel notes the somewhat dubious value of CGIAR indicators of performance which can become ends in themselves. Publications may be developed simply to meet performance measures. The opportunity cost to the conduct of research by this type of activity can be high. It is unfortunate that CGIAR stakeholders may misinterpret the real value of indicators and the Panel urges the CGIAR to ensure that information (and investor education if necessary) is made available to

ensure that Centers are not penalized inappropriately nor diverted from practical, comprehensive studies of adoption and impact.

The 5th EPMR suggested that IITA should seek to improve the quality of its science. This Panel is happy to report that the Center has indeed started down the road towards that goal and is making good progress. An effective and sustainable R4D program will work towards ensuring that development is truly driven by science.

Summary: IITA deserves praise for the quality of its scientific team and the core science activities in which it engages. The Panel does not consider that the quality of science is a serious constraint to achieving the mission of the Center at this time, though it also recognizes that good science begins by asking the right questions and building appropriate research skill sets to address those research issues. However good quality science will only lead to practical outcomes if research programs allow the opportunity for a comprehensive and long-term effort, a goal that may be threatened by reliance on multiple projects with varying mandates. The Center's policy of protecting its core competencies appears to be working effectively in the crop improvement programs, but has faltered somewhat in natural resource management. It is important also that IITA maintain its core biotechnology capability, so that it seizes the opportunity to use molecular breeding techniques whenever their cost effectiveness can be demonstrated in an African context.

3.2 Current Research Agenda and Scope

Research lies at the heart of the mission and mandate of IITA, and is the anchor of the Center's R4D strategy. IITA has an ecoregional mandate for sub-Saharan Africa, and a set of mandated crops with which it works. These are staples that nourish Africa – yams, cassava, bananas and plantain, cowpea, maize and soybean, while other sister CGIAR Centers have responsibility for complementary species such as sorghum and groundnut. In the 1980s and 90s the Center's responsibility was to engage in genetic improvement of mandated crops, and develop crop management practices that would exploit these improvements to provide increased production, while conserving the natural resource base. Under those priorities, IITA conducted long term research that had significant impacts on food production in SSA. In 2005 the Science Council adopted an expanded set of priorities for CGIAR Centers that includes enhanced nutritional quality and safety, the genetic enhancement of selected high value species, and the goals of increasing income from fruit and vegetables and from forests and trees. These have been embraced by IITA and together with the more traditional priorities form the basis of the 2007-2009 Medium Term Plan.

3.3 Assessment of the MTP Projects

IITA's research agenda described in the MTP includes seven projects plus the System-Wide IPM Program. These differ considerably in size and scope. When ranked by the proportion of Center budget, the largest is Roots and Tuber Systems (30%), followed by Cereal and Legume Systems (21%), High Value Products (19%), Banana and Plantain Systems (12%), Agrobiodiversity (7%), Agriculture and Health (5%), Opportunities and Threats (5%) and the System Wide IPM Program (2%). Each of these is considered in turn.

3.3.1 Agrobiodiversity

IITA has as one of its major responsibilities the collection and conservation of genetic resources in a form that will be useful to crop improvement programs in IITA, in national programs, and by researchers throughout the world. IITA's Genebank collection represents a unique insurance strategy against future biotic and abiotic challenges on the continent. Collections are of the mandated crops, though some species of regional importance (mainly bambara groundnut and African yam bean) are also conserved. A small microbial collection is maintained in IITA-Cotonou. The Genebank also houses temporarily the African Rice Center collection. A multipurpose tree collection (118 *spps*) is maintained in the IITA arboretum for observation.

Table 3.1 Germplasm collections held in IITA's Genebank (March, 2007)

Common name	Latin name	Total	Seed bank	Field bank	*In vitro* bank	Designated
Cassava	*Manihot esculenta*	3,144	0	3,144	1,547	2078
	Manihot spps (12)	125	33	92		
Yam	*Dioscorea* spps (10)	3,333	133	3,200	1,286	3200
Banana/plantain	*Musa* spps	293			293	293
Cowpea	*Vigna unguiculata*	15,001	15,001			15,001
Bambara groundnut	*Vigna subterranean*	2,030	2,030			2,030
	Vigna spps (56)	1,632	1,632			1,632
Soybean	*Glycine max*	1,909	1,909			1,909
African yam bean	*Sphenostylis stenocarpa*	139	139			
Misc. legumes	(12 spps)	430	430			
Maize	*Zea mays*	767	767			
Total		**28,803**	22,074	6,436	3,126	26,143

Of the genotypes under storage, 77% are stored as seed and 22% vegetatively propagated in the field. Of those vegetatively propagated, 49% are duplicated in the *in vitro* bank. Of the total collection, 91 are designated (distribution to other programs takes place on request, but intellectual property on these varieties cannot be claimed by them or IITA). Long-term seed storage is held at -20^{o}C, while the working collection is maintained at +5^{o}C. Seed stored at -20^{o}C is expected to store in good condition for 50+ years, while at +5^{o}C expected life is ~10 yrs.

The Genebank has been in existence since the inception of the Center, and collections have been steadily accumulated over time. At present it is managed by a Germplasm Scientist supported by a committee of scientists with a direct interest in its utilization and function. From 2002-2006 the Genebank and biodiversity functions were part of Project A, and in 2006 the present stand-alone project was formed. It contributes to CGIAR System Priorities 1A, 1B and 5A.

The Agrobiodiversity Project

There are four project outputs. The first two are the collection, preservation, documentation and distribution of accessions of 1) clonally propagated species (35%) and 2) seed crop species (30%); 3) Description of the genetic diversity of conserved germplasm (25%); and 4) Breeding populations targeting transfer of traits from wild species/unadapted germplasm (10%). The Panel agrees with the nature of these outputs and the balance of effort among them.

Staffing consists of eight scientist years from 23 scientists representing appropriately diverse disciplines. In 2007 the budget for the project was US$3.35 m, a 56% increase over 2006, and comprised of 58% restricted core and 42% unrestricted core. It makes up 7% of Center research expenditure in 2007, up from 4.6 % in 2006.

Collections include cassava landraces from West Africa (the majority), DR Congo, Malawi, Tanzania and Zambia. Some cassava introductions from Latin America are included (most Latin American introductions came as crosses on IITA germplasm since they had no CMD resistance); and cultivated materials from Asia and Africa; a yam (*D. rotundata*) collection from WCA; a collection of *D. alata* from Asia; a collection of yellow fleshed yam (*D. cayenensis*) originating in West Africa. Modest collections of wild relatives of most mandated crops are also housed in the bank, including a *Vigna* collection from Africa. No wild relatives are held for banana. As improved cultivars are released, they also become accessions in the Genebank for later evaluation of genetic gain, though is no clear policy on this. There is a small program of *in situ* conservation on yams at Ibadan in which several sites in the IITA forest are monitored for native populations. There seems little reason to expand this activity at this time.

Seed collections are regenerated every 15-20 years, based on protocols developed at IITA. Between 2001 and 2006 1442 of 1700 bambara groundnut accessions stored for the past 20 years at +5^{o}C and -20^{o}C were successfully regenerated, documented and stored in the long-term vault at -20^{o}C. Germplasm of vegetatively propagated crops is maintained as living collections in the field or as tubers, roots, cuttings or bulbils. For these, field planting each year (yam) or alternate years (cassava) is the main method or regeneration - a costly procedure. IITA has therefore taken a leading role in *in vitro* reduced crop cycle storage. After several rounds of tissue culture, plantlets may lose vigor and exhibit morphological changes because of somaclonally-induced lesions. This merits further study to understand and minimize changes in the genetic integrity of accessions.

Core collections are in the process of being identified. They consist of approximately 10% of the accessions, chosen to represent ~95% of the genetic variation in the collection, and identified by clustering morphological or molecular characteristics. In the past 5 years core collections of yam (380 accessions) and cowpea (2078 accessions) have been identified. A smaller core collection of cowpea (N=374) has been identified using molecular markers. Identification of a core collection based on morphological traits has recently been completed in cassava.

Conservation without characterization and evaluation limits the usefulness of any collection. Various subsets of the cassava collection have been characterized for starch type, CBSD, anthracnose and root knot nematode. The whole collection is scored during growouts and has provided sources of resistance to CMD$_{Ug}$ and cassava bacterial blight. All cowpea accessions have been screened in Kano for *Maruca*, *Striga* and mosaic resistance. The yam collection has been evaluated for resistance to yam mosaic virus, anthracnose and leaf spot, and subsets for nematode infestation. Soybean accessions have been screened against rust, and all are susceptible. Under the HarvestPlus Challenge Program subsets of cassava and yams have been characterized for micronutrients (Zn, Fe, beta carotene).

A number of diversity studies have been conducted in mandated species. SSR markers were used to estimate genetic diversity in 209 collections of cassava from Africa and Latin America, and showed a high level of within-region diversity, being greatest in Brazilian and Colombian collections. A total of 2575 cassava accessions were evaluated for diversity with 14 SSR markers

in 2004 under the Generation Challenge Program. In a study of West African cocoa relatively little genetic diversity was observed, suggesting vulnerability to future challenges from diseases and global climate change.

Physosanitary issues are especially important. Seed and clonally propagated materials are indexed for viruses, and seed shipped from the Genebank outside Nigeria must be accompanied by a Germplasm Health Statement issued by the semi-autonomous Germplasm Health Unit in IITA, as well as a phytosanitary certificate issued by the Nigerian Plant Quarantine Service that is under the Nigerian Ministry of Agriculture. The Panel is satisfied the due care is being taken to avoid the dissemination of diseases through shipments originating in Ibadan. However, since these facilities do not exist at other locations, it urges IITA to establish a similar standard of security at other research locations.

Within IITA linkages are strongest with the crop improvement programs. Externally the Project partners with a wide range of institutions ranging from national genebanks, research Centers and plant protection agencies, and the genetic resources Centers of the sub-regional organizations. The Inter-African Phytosanitary Council works with IITA to provide a framework for safe movement of germplasm within Africa. The University of Nottingham has phenotyped bambara groundnut collections, and CIRAD continues to provide SSR markers for yam. Within the CGIAR, IITA is a partner in the SGRP (System-wide Genetic Resource Program) and SINGER. These ensure standard crop preservation protocols, descriptors and information exchange, and consistent operation under the International Treaty on Plant Genetic Resources for Food and Agriculture (in force since 2004). IITA also collaborates with genebanks in CIAT, CIMMYT, and Bioversity (for *Musa*).

Management of risk is an important consideration. Regeneration of vegetatively propagated material occurs at two separate locations to avoid losses from weather, and duplicate copies of tissue cultured accessions are kept in IITA-Benin. In the future seed will be periodically sent to the International Seed Vault. The Genebank has its own backup generator capable of maintaining essential functions. The panel is satisfied that all reasonable steps are being taken to avoid the loss of genetic materials from accident and misadventure.

Achievements for the project over the past 5 years, in addition to those noted, include the successful maintenance of > 6000 clonally propagated materials in the field; the generation of 2900 field-based accessions in the *in vitro*-genebank with a duplicate copy of 87% of these in Benin for security; the certification of 53 accessions of *Dioscorea*, 1790 of cowpea and 287 of cassava as virus free; and regeneration of 7000 cowpea collections. A total of 3019 accessions in the genebank were distributed to 10 countries during 2003; 3886 accessions in 2004; 3534 in 2005; and 2388 accessions during 2006. The economic value of Genebank activities is currently being assessed.

Assessment: This is a unified and cohesive project that is a protected core IITA activity. The Genebank is functioning securely and efficiently, is well-respected, works with an appropriate range of partners, and is used as source of useful agrobiodiversity throughout SSA. IITA is commended for maintaining these activities in a difficult working environment, and IITA staff have easy access to Genebank data. It is less clear if molecular characterization follows a well defined plan, or how priorities are set among competing activities such as diversity studies in cocoa vs. cowpea and the conservation and regeneration of "orphan" vs. mandated crops.

The future: Cryopreservation of tissue has the potential to eliminate effects of somaclonal variation and the need for regular field and tissue regeneration of conserved, clonally-propagated germplasm. ***The Panel recommends that IITA seek support for collaboration with an appropriate ARI to establish dependable cryopreservation protocols.***

As breeding populations improve, the difference in performance between them and landraces will widen, and a greater investment in prebreeding within core collections will become justified. Prebreeding activities should be broadened and extended to crops other than maize. A plan for the systematic evaluation of the structure of genetic diversity in core collections is needed, using SSR or SNP markers. The Panel suggests that prebreeding activities based on such studies be extended to cowpea, cassava and yam, with a focus on abiotic stress tolerance. Such activities should be jointly designed and managed by scientists from this project and from the major crop improvement programs.

Security and integrity of the collection is of continuing concern. The panel suggests that IITA review the adequacy and distribution of its duplicate storage sites in case of civil unrest, and ensure that a fail-safe bar-coding system for identification of samples throughout the regeneration process is implemented.

Additional collections appear justified. The panel suggests that in light of the challenges to landraces posed by global climate change, additional funds be sought to complete the collection of *Dioscorea* species. The successful crossing of cassava and castor suggests that the maintenance of a collection of *Ricinus* spps. in the genebank is now justified.

Designated germplasm: Under the terms of the International Treaty on Plant Genetic Resources, IITA supplies designated germplasm under the Standard Material Transfer Agreement (SMTA), a lengthy document that accompanies each seed shipment. IITA admits some confusion and concern over the use of the SMTA for distribution of material under development. The panel shares IITA's concern and encourages the Center to continue to share its experiences in the implementation of the SMTA with Bioversity and other Centers of the CGIAR.

Although IITA considers its insect collection formally under the Opportunities and Threats Project, the Agrobiodiversity title might be expected to represent the Center's collections more broadly. Certainly, the Panel notes an absence of any cross-reference to the insect biodiversity collection held at IITA-Cotonou. Its collection of 6,000 African insect species and 250,000 specimens is unique, and information and taxonomic skills embedded in this collection should be utilized more widely in IITA. At the same time, there is the need for long-term and stable financial support for this unique African asset. We encourage IITA to address these two issues in the near future, while maintaining the utility of the collection to the biocontrol program in Cotonou.

3.3.2 Roots and Tuber systems

Roots and tubers have a major role in the nutrition and well-being of Africans living in the humid and sub-humid ecologies of the continent. Cassava provides good famine insurance, is quite drought tolerant, ranks 6th among major staples globally and is second only to maize in Africa. It provides over 50% of calories for over 200 million people in SSA. Yam is estimated to provide 60 million people in SSA with 200 kcal/day in West Africa. Both are vegetatively propagated crops, so transmission of viruses and bacteria in planting materials is a challenging problem. Data on current production, area and yield of cassava and yams, and trends from 2000-2005 (Table 3.2) indicate that both crops are predominantly found in WCA.

Table 3.2 Production, area planted, and yield of cassava and yams in Eastern and Southern Africa and in West and Central Africa (Source: FAOSTAT, 2007).

	Eastern and Southern Africa			Western and Central Africa		
	Production m ton	Area m ha	Yield t/ha	Production M ton	Area m ha	Yield t/ha
Cassava						
Current[a]	22.2	2.57	8.62	83.9	8.61	9.75
2000-05: Slope	-0.066ns	0.011ns	-0.070ns	3.37**	0.195**	0.183**
2000-05: %/yr	-0.29	0.43	-0.79	4.28	2.34	1.94
Yams						
Current[a]	0.23	0.03	7.14	44.58	4.60	9.72
2000-05: Slope	-0.023*	-0.0114*	0.74*	1.954**	0.233**	-0.071ns
2000-05: %/yr	-8.54	-21.04	13.16	4.70	5.48	-0.72

[a] Current level is the mean of 2003, 2004 and 2005 data. Zambia data not included.

*, **, ns: slope significantly different from zero at P<0.05, P<0.01, and P>0.05.

M=million

Only 21% of SSA's cassava production comes from ESA. In WCA, cassava production is dominated by Nigeria (46%). From 2000-2005 production has grown at a faster annual rate in WCA (4.3%) than in ESA (no change). In both regions, growth in area during this period has been greater than growth in yield. More than 99% of SSA's yam production occurs in WCA, where the main producers are Nigeria (71%), Cote d'Ivoire (11%), Ghana (9%), and Benin (5%). From 2000-2005 the 4.7%/yr increase in production was entirely due to an increase in planted area. Industrialization of cassava is occurring across the continent, following the pattern of development of the crop in Thailand and Brazil where it serves as an important source of industrial starch and animal feed. It is likely that the new opportunity of bio-fuels production from cassava will have an impact on cassava production and utilization dynamics. IITA has the sole mandate for conservation and improvement of yams, while the mandate for cassava is shared with CIAT.

History: Yam and cassava breeding at IITA dates from the early 1970s. Prior to 2002 cassava and yam were part of at least four projects (numbers 5, 6, 13 and 14). In the reorganization of research in 2002, roots and tuber research activities were distributed mainly in three of six projects (B; D; E). In 2006, a further reorganization formed the present Roots and Tuber Systems Project. The Panel welcomes the uniting of these two major crops under one project and one head.

Roots and Tuber Systems Project: Crops include cassava (*Manihot esculenta*), yams (*Dioscorea* spps, mainly *D. rotundata* and *D. alata*), with sporadic research on taro (*Colocasia* spps.) and cocoyam (*Colocasia* and *Xanthosoma* spps). Both cassava and yams flower, and can be relatively easily crossed. From F1 onwards each is clonally propagated, and takes about 5 years from initial crossing to the first replicated yield test, and a further 4-5 years to release and large scale multiplication. Cassava has multiple uses (fresh roots, gari, chips for animal feed, leaves as vegetable or forage; starch, glue, ethanol, etc) while yams are considered a luxury staple used for human consumption. Nigeria has legislated that 10% of all bread shall be non-wheat flour, and this component is often cassava.

The project has six major outputs: 1) Prioritization of policy, input/output markets, post harvest and production constraints (17%); 2) Description of biotic and abiotic processes and interactions (24%): 3) Improved root and tuber germplasm (22%); 4) Integration of improved component technologies (18%); 5) Assessment of the commercial viability of agro-enterprises (7%); 6) Strategies for enhancing technology adoption potential (12%): Impact is expected to be through increased productivity and informed agroenterprise investment.

Root and Tuber Systems is the largest of IITA's projects, utilizing 28 scientist years (56 scientists in total), of which 74% are located in WCA. The budget (2007) is US$14.3M (68% restricted core, 32% unrestricted core), and represents 30% of IITA's research budget, down from 37% in 2006. Major donors are USAID and Government of Nigeria for cassava, and IFAD for yams.

Variety development: A major goal of the central breeding program in both crops is to create a reservoir of useful genetic variation in an improved genetic background. Genetic variation is first collected and preserved in the Genebank. Sources of resistance are identified and delivered when a biotic challenge to the crop arises on the continent. This population is improved through recurrent selection. Breeding objectives in cassava reflect its diverse uses as food, feed (cassava leaves; chips) and industrial applications (mainly starch). Germplasm divides by adaptation into lowland and mid altitude. Four satellite breeding populations have been formed for biofortification, mealiness (cyanogenic glucoside levels are low), industrial requirements, and ploidy manipulation. Extending shelf life after harvest is desirable, though not as important as stable pest resistance. Selection in yams includes yield, pest resistance, upright unsupported top morphology to reduce labor, and tuber shape. There is no active selection for fertility responsiveness, though increasingly cassava progeny trials are being evaluated under low and high fertility. The main breeding program is at Ibadan, but breeding is also conducted in Uganda, Tanzania (east Africa) and Malawi (southern Africa). The crop is widely adapted as it is grown under a wide range of environmental conditions. The genotype x environment structure of the cassava germplasm within Africa does not appear well defined. Potential for breeding cassava appears prospective as African and Latin American germplasm pools are considered heterotic. Yam breeding populations are divided by species (*rotundata* and *alata*) and across end uses (e.g. fresh or for flour) and earliness to bulk.

For both crops the main immediate challenges are diseases. The most urgent of these are viruses, namely severe CMD (cassava mosaic disease), formed from a viral hybrid and showing aggressive resurgence in Uganda ($EACMV_{Ug}$), and cassava brown streak disease (CBSD), found on the East African coast, and spreading. By screening accessions from the Genebank in disease "hotspots", sources of resistance have been identified. Some of these are linked closely with an SSR marker, and robust ELISA tests have been developed for use by NARS to type variants of both diseases. IITA scientists have introduced resistance against CBSD into farmer-grown

cassava varieties and have optimized plant regeneration protocols for farmer-grown cassava varieties to prevent virus transmission in seed materials. Genetic transformation experiments using a reporter gene construct are in progress for CMD resistance, and resistance to cassava bacterial blight has been found by screening ~1200 clones from the Genebank. Yam mosaic virus (YMV) is the most important yam disease. Resistant sources are available, including a QTL identified for resistance in *D. rotundata*. Reliable methods of accurately identifying YMV and its variants by ELISA or PCR-based tests are available for use by NARS. QTL and RAPD markers for yam anthracnose resistance have been found in *D. alata*, which is severely affected by the disease. To be useful these should be converted to a PCR-based marker system.

Insects and nematodes are also a major challenge, though IPM through biocontrol has had a history of remarkable successes in cassava. Cassava green mite is widespread but is being adequately controlled by a predator mite, *T. aripo.* Selection for hairy (vs. glabrous) apices on cassava improves the effectiveness of *T. aripo*, and provides a useful trait during selection. African root and tuber scale is a challenging disease to both crops in specific locations, and little resistance has been identified. Nematodes are a problem in both crops, but treatment of planting materials with nematocides improves performance, and some genetic resistance in cassava has recently been identified. Applications of fertilizer may suppress nematode reproduction in yam tubers.

Testing and distribution of improved germplasm is challenging. Multi-location testing and distribution in ESA has been through the networks EARRNET and SARRNET (though EARRNET may be discontinued by ASARECA). Similar work on yams in WCA has been supported by project funding. In WCA distribution of both crops was sometimes facilitated by WASNET, but this function has been handed back to the NARS. A major effort is needed throughout SSA to provide clean root and tuber propagation materials, either as stalks, tubers or as tissue-cultured plantlets. There are currently project-related activities which allow for the distribution of planting materials and harmonization of rules for seed production. However, no formal seed system is in place for the multiplication/distribution of clean planting material.

In general, breeding programs for both crops appear ready to meet short-term challenges from pests and diseases. The Panel is satisfied that sources of resistance to key threats have been identified, and tools for accurate virus identification are available to scientists and to a lesser extent IITA's partners. However, the programs appear less well prepared to meet the challenges of intensification that will surely occur in the next decade. The Panel commends IITA as the global leader in vegetative propagation of field crops, and strongly suggests that the Center, with appropriate partners, actively encourage large scale efficient tissue culture and field propagation methods, backed by cutting edge virus detection methods, and executed by the private sector wherever possible.

Research in agronomy, nutrition and processing: While cassava yields are increasing in WCA, yields of cassava in ESA and yams in WCA are declining, in part because of declining soil fertility. Specific nutrient requirements for cassava and yam are not well defined, nor indeed is the value of chemical fertilizer to these crops. The role of arbuscular mycorrhizal fungi in yam nutrition is also somewhat obscure, but under investigation. Under the guise of the HarvestPlus Challenge Project variation for beta carotene, iron and zinc have been assayed in African landraces, and genetic gains can be made for these traits. However, the relationship between nutrient content and yield has not been clearly defined. The Panel strongly encourages IITA to

determine the general response of both crops to chemical fertilizer in terms of yield and suitability of roots or tubers for pounding and storage.

Processing and storage research focuses on industrial demand, and on traits like suitability for mechanical peeling of cassava roots; mechanical systems for mechanization; convenience for packed food; starch and glue - all in partnership with NARES, the industrial sector and ARIs. IITA should examine its comparative advantage in pursuing industrial applications of cassava and seek to transfer gradually most of its industrial applications research to suitable partners.

Partners and roles: These reflect an appropriate choice of NARES, regional and subregional organizations, international Centers (ILRI and especially CIAT) and ARIs that can provide an array of industrial and laboratory technologies and information. Several partners are developing molecular tools in both crops and some are experimenting with transgenic events in cassava. The new BiocassavaPlus project links many upstream partners to generate an experimental multi-gene transgenic cassava with high nutritional value and disease resistance. The Panel finds the mix of partners and their roles to be appropriate, but specifically urges IITA to develop stronger links in germplasm exchange with CIAT.

Impacts: The period under review builds on an era of extensive adoption of IITA cassava germplasm. It is estimated that by 1998, 22% of the 9 million ha of cassava grown in 20 SSA countries was IITA derived, giving on average a 49% yield increase. A total of 48 IITA-derived cassava varieties were released in SSA 2002-2006. The cassava green mite biocontrol campaign has resulted in continent-wide success, largely through the distribution of *T. aripo*, which is now established in at least 20 countries in sub-Saharan Africa. A total of 8 yam varieties have been released in Nigeria and Ghana over the past 5 years. The first linkage maps for *D. rotundata* and *D. alata* based on AFLPs have been published, and a large number of ESTs are available for each crop. The group has produced a total of 204 publications as well as a significant number of postgraduate theses. The Panel wishes to congratulate IITA scientists for the remarkable impact on cassava production of IITA's cassava varieties and biocontrol agents, and commend them for communicating these results through a very good publication record.

The future: The strengths of this project are its multi-disciplinary team, partnerships with ARIs and NARS, and its cross links with other projects such as Agrobiodiversity, Agriculture and Health, and Cereal and Legume systems. The project has good internal coherence, and a uniting central theme based around root and tuber crops. Provided it can maintain a product focus, it should serve African farmers and IITA well in the next decade.

Genetic gains will need to be protected by ensuring that ample genetic variation for pest resistance is present in the breeding programs. A continuing program of evaluation of the cassava and yam collections from the Genebank, grown under disease pressure, provides the basis for this. Cassava is easily crossed with its wild relatives, and recently has been crossed with castor bean (*Ricinus communis*). For yams, the ideotype developed after the 5th EPMR provides a useful breeding guideline that should result in high yield and lower labor costs during production. Crosses between *D. alata* and *D. rotundata* have not been successful thus far, but the Panel agrees that this is an important crossing barrier to be overcome because of the wide adaptation of *D. alata* and generally better tuber quality and anthracnose resistance of *D. rotundata*. The panel strongly encourages IITA to continue research on carefully selected wide crosses in both crops, and to retain its focus on reducing labor costs associated with growing both crops.

New breeding methods may also improve the chances of using seed rather than vegetative materials when exchanging germplasm. There are several possibilities. The most interesting is hybrid production in cassava, using male sterility, doubled haploids, and followed by pedigree breeding approaches. The identification of heterotic groups and the development of inbred materials that set seed reliably would allow germplasm exchange through sexually produced seed, with little/no virus transfer. Backcrossing would be facilitated, something presently quite difficult in cassava. A second, already underway, is ploidy manipulation to facilitate wide crosses. The Panel strongly suggests that an experimental breeding program in cassava, oriented mainly towards hybrid production, be started as a special output within Root and Tuber Systems.

The panel strongly suggests that breeding procedures be modified to ensure that fertilizer responsiveness is determined at the progeny level during selection by routine evaluation under at least two diverse fertility regimes, following an assessment of historic data for the presence of genotype x fertility level interactions. This will permit the identification of genotypes that do well under both, and prepare the program for intensification that will inevitably occur in these crops. The Panel notes that there is a need for a senior root and tuber agronomist based at Ibadan to work closely with breeders. Leads on improved management practices for cassava will likely come from Thailand and Brazil.

Molecular breeding is largely an untapped resource in this project. A recent donor review found little or no evidence of use of molecular information in breeding programs at IITA. The overarching strategy in molecular breeding of roots and tubers is not clear to the Panel. It strongly encourages the development of such a strategy. IITA has been active in hiring staff with skills in this field. The Panel encourages IITA to undertake a proof of concept marker-assisted selection experiment using PCR-based markers or SNPs identified in partnership with ARIs, refined as needed by the experiences at CIAT in this area.

While the new Project structure should work well for varietal improvement, it is less clear if this grouping will result in integrated sustainable farming systems in which both crops play important parts. This research is allocated to Output 4: integration of improved component technologies, where it attracts one activity. To the Panel this appears to be an inadequate attempt to exploit the characteristics of new improved germplasm through better crop management, and strongly encourages further agronomic research in these two crops. Furthermore, innovative yam-based systems may be required to build interest in the crop in 1-2 countries in ESA. If this proves insurmountable, IITA should consider abandoning plans for improving yam production in this sub-region.

The Panel endorses the thrust towards increased involvement of the private sector particularly leading to the commercialization of post-harvest product processing in a number of project activities. These initiatives will trigger primary needs for systems that provide clean seed, diagnostic kits for disease detection at the farm level, and industry that absorbs additional production through processing plants. IITA has done an exemplary job in fostering private sector involvement in processing. The Center can step back from cassava processing, storage issues and food technology options, promote them with the private sector, and thus release resources to develop a program on "seed" systems for clonally propagated species. It is strongly suggested that IITA consider establishing a commercialization group advised by successful businessmen to provide guidance and linkages in the business community across a wide array of technologies with potential for commercialization.

3.3.3 Banana and Plantain Systems

Bananas and plantains are perennial crops that grow quickly and can be harvested all year round. In 2000, there were some 9 million hectares of bananas and plantain globally, with world production estimated at 99 million tonnes in 2001. Figures are approximate because around 85% of banana production comes from small plots and backyard gardens, and most is consumed locally. Around 10% of production comes from large plantations and enters world trade.

Banana and plantain, however, are staple food crops for millions of people in developing countries[18]. In parts of sub-Saharan Africa, Latin America and the Caribbean, average per capita consumption is 0.15-0.30 kg per day. In Uganda, Rwanda, Gabon and Cameroon, bananas account for between 12 percent and 27 percent of daily calorie intake of their populations. In export, it ranks fourth among all agricultural commodities, and is the most significant traded fruit, with world trade totaling over US$ 4.7 billion annually[19] (and see Annex 7.)

Diseases are among the most important factors in banana production worldwide. They remain the primary focus of all current breeding programs. Recently, diseases have also become principal targets of biotechnological efforts to improve this crop. The main challenges to research include breeding for resistance to Black Sigatoka disease, Fusarium Wilt (Panama disease), Bunchy Top Virus and banana weevil, alongside the development of improved production systems.

The importance of banana and plantain in Africa is underscored by the priority rating these crops have been given by the sub-regional organizations, particularly so in the ECA countries where banana and plantain are in the top four commodity and factor research priorities. The IITA program therefore has a strong justification for its focus on these crops. In the ECA the strongest banana proponent is Uganda, and both IITA and NARO have strong commitments to the program. IITA has been in Uganda for over 14 years where it has definitely contributed to the strengthening of the banana and plantain research profiles of NARO.

IITA strategies for banana research: Tetraploid bananas have been introduced from IITA/Uganda in 2004 and 2006 for establishment of nurseries, experiments and setting up of demonstrations in Mozambique, Malawi, Zambia and Angola.

In the project "Production of transgenic bananas resistant to *Xanthomonas* wilt disease in Eastern Africa", efforts are underway to develop improved varieties of banana resistant to *Xanthomonas* wilt using the *pflp* and *hrap* genes isolated from sweet pepper (*Capsicum annuum)*. These genes are owned by the Academia Sinica, Taiwan, and are accessed by IITA through AATF. The transgenic crops expressing these genes have shown to be resistant to experimental bacterial disease and fungal disease challenge. This project will be implemented by ensuring that farmer preferred banana varieties are transformed and regenerated using the protocol established at IITA. Plants expressing transgene (*pflp* or *hrap*) will be tested in a proof of concept experiment by artificial inoculation (*in vitro* screening) to evaluate for BXW resistance, in controlled laboratory conditions and containment facilities. IITA and other organizations are also involved in researching and promoting crop management interventions for the control of BXW. In this case (and in all instances in which IITA is pursuing genetic transformation) an important part of IITA's business

[18] The world banana economy 1988-2002 FAOSTAT

[19] UNCTAD-INFOCOM , 2004, Market information in the commodities area

planning for technology deployment should include periodic assessment of the costs and benefits of competing or complementary technologies.

Other pest management options, such as the use of clean planting material as a strategy against nematode and weevil attack, have been developed (including hot water treatment to sanitize planting material). Some of these technologies on testing have provided benefits to farmers. Introduction into farmers' fields on a larger scale is needed, together with pre- and post-harvest handling techniques that enhance the suitability of the produce for trade. Efficient partnerships with both national public and private networks of extension agencies, and various segments of the private sector, will be required. In agronomy, research efforts are being made to identify soil-pest interactions, soil degradation effects, and drought stress responses. A number of factors affecting yield have been identified, and technologies are being developed to improve agronomic practices. This is done in close collaboration with research on germplasm improvement, in particular in the fields of IPM and drought stress research.

Dissemination process for bananas and plantains**:** *West Africa:* In West Africa, the "Strategic *Musa* Improvement Project" (SMIP) aims to develop disease resistant plantain and banana hybrids. The IITA hybrids combine disease resistance with high quality fruit and yield up to three times the levels of traditional varieties[20]. New varieties have been distributed to NARS in West Africa, through conventional multi-locational evaluation trials.

In Nigeria, some 15 banana or plantain hybrids have been delivered, with clear geographical x socio-cultural differentiation. In Ghana, where testing has been in effect since 1998, three hybrids (two plantain, one cooking banana) were identified as meeting the requirements of producers and consumers. IITA is currently setting up performance trials requested by the National Variety Release Committee (NVRC) prior to official release. In Cameroon, adaptive work with four hybrids was initiated in 2002. Farmers are better able to control the hybrid delivery process and to promote capacity in seedling production and post harvest processing. Awareness of improved hybrids in Cameroon has also increased with on-farm tests at nodal sites across the country.

East Africa: The overarching challenge has been to develop diploids and tetraploids having both disease and pest resistance and improved agronomic qualities with '*matoke*' characteristics and identify fertile triploids for use as seed parents.
Breeding achievements:

- Eight Sigatoka resistant East Africa Highland Banana (EAHB)-derived secondary diploid hybrids have been developed and are now being used for developing triploid hybrids.
- Forty-eight Sigatoka resistant EAHB-derived secondary triploid hybrids have been developed and are being evaluated. So far, four triploid hybrids have been evaluated by farmers for disease and pest resistance and yield. These rated above the EAHB and are being further evaluated in different parts of Uganda.
- Hybrids with improved resistance to black Sigatoka are being used in varietal mixture trials with farmers' varieties. Such experiments have shown that by reducing the inoculum load of black Sigatoka, the hybrids enable the landraces to perform better.
- Resistance against the most important nematode has been identified and is being used in the breeding program.

[20] In 1994 IITA was awarded the King Baudouin Award for outstanding scientific merit on the basis of this research.

Dissemination of five IITA bred hybrids has been undertaken in Uganda, where IITA collaborates with a private company, AGT, to produce endophyte-enhanced tissue culture material for bananas for dissemination at large scale. Hybrids BITA-2 and BITA-3 were also included in the largest scale hybrid distribution scheme ever undertaken in eastern Africa, culminating in the distribution of nearly 2.5 million seedlings of improved varieties since 1997 in northern Tanzania. New donor support has boosted the dissemination scheme in Mozambique[21]. In the Crop Crisis Control Project (C3P), management practices to contain BXW are disseminated through NARS and NGOs in six countries (Uganda, Rwanda, Burundi, Eastern DRC, Tanzania, and Kenya). Deployment of transformed, adapted and farmer-preferred banana varieties in East African target countries will be commissioned in conformity with biosafety, risk assessment and management, seed registration and release procedures, public perceptions and consumer acceptability.

Southern Africa: A range of improved hybrids which incorporate genes for resistance to several important pests and diseases (including black Sigatoka), together with other with desirable agronomic characteristics (high yield etc.) have been developed. Some of these varieties have been introduced into NARS research systems in the Tanzania, Mozambique, Malawi and Angola. Plans include wider dissemination in the future in Mozambique and Zambia.

Expected overall impact of banana and plantain research: An earlier ex-ante study[22] on the impact of tissue culture of improved germplasm in Western Kenya (although not done by or for IITA), estimated welfare gains at US$ 60M. An ex-ante assessment by IITA of the impact of BXW on economic welfare estimated the average annual economic losses over a decade from BXW in Uganda at US$200M. A large number of farm and household surveys in Rwanda, Burundi and DRC have been done, which will allow an analysis of the economic viability of "on the shelf" technologies, as well as an impact analysis for the project. IITA intends to make impact assessment system-based instead of commodity based, and to cover economic, social and other aspects such as health and nutrition. A joint project between Bioversity and IITA, on assessing effects of diversified *Musa* genetic resources on poverty reduction, environmental sustainability and gender equality in rural communities began in early 2007.

Future Continental and Regional Needs: The Panel recognizes that banana and plantain are critical crops in the African food equation. Noting the development of emphasis on impact assessment, the Panel encourages IITA to ensure that such assessments are built into individual projects. However, according to available information at the continental level, banana and plantain productivity increases are not dramatic. Compared to other crops, increases in production have generally not kept pace with population growth from 1990-2005. Since 2000 increases in area have been minimal, and yield has increased only by about 2% in that period. The challenge will be to continue the increase in yields given some of the challenging disease issues faced by the crop and the general population increase.

It would appear that one of the main limitations to the improvement of the banana and plantain is the availability, access and affordability of clean and certified planting materials. This matter has attracted the attention of ASARECA in the ECA region. While the key players appreciate the fact that the production of planting materials should be handled by the private sector, the teams also recognize that tissue culture technology still needs support from a partner like IITA in

[21] http://www.agr.kuleuven.ac.be/DTP/TRO/_data/onfarmactivities.htm#Tanzania
[22] Qaim (1999), not by IITA

relation to the development of appropriate protocols, indexing capacity services, provision of transboundary material passports, and to serve as a trusted source of foundation vegetative propagation materials[23]. The panel would therefore encourages IITA to consider taking a lead in partnering with other interested parties like USAID/East Africa, the Tissue Culture Business Network (TCBN), CIAT, ISAAA, AATF, ASARECA and NARIs to launch and invest in a support platform for an African wide tissue culture initiative. Whilst this is important for banana and plantain, the Panel believes that this capacity should be thought of more broadly.

The Panel recommends that IITA enhance capacity to provide intellectual and material support to germplasm health and transfer in Africa. This includes appropriate tissue culture protocols, transboundary material passports and indexing capacity and foundation, vegetative propagation materials. The intention of this recommendation is to further enhance IITA capacity so that this critical expertise can be shared.

3.3.4 Agriculture and Health

IITA's mission oriented approach to agricultural research is designed to produce outputs that meet health as well as "market" needs. This project currently focuses on two particular elements:

- Malnutrition caused by a lack of micronutrients, such as vitamins, zinc, and iron, that affects vulnerable groups such as women and children.
- Poor food quality and safety, caused by mycotoxins, which endanger health and lives of consumers in Africa but also impose barriers to trade between African countries and important export markets such as the EU and USA.

There is also a small part of this project focusing on the impact of diseases, such as HIV/AIDS and malaria, on the availability of labor and agricultural productivity, and the consequent effect this has on food security and livelihoods.

IITA scientists involved in this project include breeders, economists and post harvest scientists, amounting to a total of 3.75 Full Time Equivalents (FTEs) across 12 scientists. Resources are allocated to specific projects in the following manner:

- Characterization of staple crops for vitamins and minerals (28%)
- Biofortification strategies to enhance the diets of nutritionally disadvantaged populations (28%)
- Improved food safety (36%)
- Options to mitigate human disease (HIV/AIDS, malaria) effects on agricultural productivity (8%)

Research highlights include:

- The development of aflatoxin biocontrol agents for maize and methods for inoculum production
- The identification of micronutrient-dense yellow-fleshed cassava clones (iron and zinc, and provitamin-A)
- The development of drought-tolerant and Striga-resistant high protein maize varieties
- Studies on nutrient retention of traditionally processed food products of cassava

[23] Proceedings Of The Asareca/ Ecabio Workshop on Plant Tissue Culture Held at Novotel Hotel, Bujumbura, Burundi from 29 November to 1st December 2006

- Studies on options for aflatoxin management (cropping systems, post harvest and storage) and the impact of aflatoxin on children's' growth.
- The conduct and analysis of a national dietary survey in Nigeria in order to inform priorities for crop-based nutritional improvement.

The nutritional enhancement work is based on the premise that despite the fact that increasing incomes and improving education about the benefits of a balanced diet are effective in dealing with malnutrition in the longer term, improving the nutritional quality of staple foods can play a role in reducing malnutrition in the short and medium term among the chronically poor. Most of this work is supported by restricted funds, including those provided through the CGIAR Harvest Plus Challenge Program. There is good evidence that IITA's plant breeders have made considerable progress in identifying useful sources for micronutrient improvement and have incorporated these in productive breeding programs, particularly in cassava and maize. It is less clear if IITA (or other institutions involved in these efforts) have thought as carefully about the targeting and delivery of nutritionally-enhanced varieties. IITA's involvement in the national nutrition survey in Nigeria provided useful experience on the distribution of micronutrient deficiencies, but there is little experience in providing guidance on what populations (defined by geographical or agroecological zone, rural/urban residence, or economic status) should be priority targets for such varieties, nor how these varieties would be promoted and delivered. For instance, an implicit assumption of much of this work is that these will be crops grown by farmers for home consumption, although rural laborers or the urban poor may often be at risk from malnutrition. The targeting and delivery issues need to be addressed in a wider context than IITA's own research, but an institute such as IITA that is particularly concerned with the role of markets in delivering innovations could provide a lead in this area.

While crop breeding has a role to play in improving nutrition, the assumption that this is a significant way to achieve improved food quality needs to be confirmed by an analysis of the food chain. This includes an evaluation of the nutritional value of current (and potential) varieties as well as an examination of how the nutritional value of the food product is affected by harvest, storage and processing. This type of analysis determines the points at which interventions might be required to increase nutrients or reduce their destruction, and the comparative cost effectiveness of each. IITA has an experienced food technology capacity that is already involved in relevant research. As most of IITA's mandate crops are potential candidates for this type of breeding investment, it is important that clear priorities and areas of intervention are identified. Given that the selection for micronutrient content involves significant opportunity costs (e.g. in foregoing additional yield or yield stability) it is particularly important that the work is carefully monitored.

The work on aflatoxin control involves both the development of atoxigenic strains of *Aspergillus flavus* that can compete with toxigenic strains and research on crop management and post-harvest conditions that can minimize the presence of aflatoxin. The impact on trade is the major economic incentive for adoption of control measures and instances where farmers are penalized economically for the presence of aflatoxin may be the logical place to start promoting technology change. For broader uptake of such technology, considerable farmer education will be necessary, and IITA will have to rely on suitable partners and policy makers. IITA's role should center on assessing the distribution of the toxic organisms and developing suitable technologies, while others will take the lead in making the case for policy intervention. The delivery of the atoxigenic agent shares many challenges with those of biopesticides, and these challenges - particularly in the absence of clear policy support and public health campaigns - should not be underestimated.

Although crop breeding for micronutrient content and the development of management options for aflatoxin control have little in common technically, they share an important reliance on health and nutritional data as a guide for agricultural research priorities and for targeting delivery. It thus makes sense that they fall under the same project so they can share the cost of monitoring the latest thinking and literature in these areas that fall, for the most part, outside of IITA's expertise. They also share the priority of identifying how products (new varieties or crop management options) that have health benefits that consumers will have difficulty recognizing or appreciating, can be delivered. Current plans are for analysis of the implications of HIV/AIDS or malaria for agricultural production, although this seems more appropriate for Opportunities and Threats. IITA should resist the temptation to include work that addresses general food security concerns in this project, unless it relies heavily on nutritional or medical data to provide a rationale for research decision-making.

In summary: A strategic plan for this project will be developed in the near future. The Panel strongly suggests that the planning process pay particular attention to defining those characteristics that qualify a research activity for this project, including the reliance on medical or nutritional criteria (as opposed to broader food security). It further suggests that the project contemplate mechanisms for periodic review of the rationale for pursuing specific health-related goals, including a review of alternative means of addressing these problems and analysis of opportunity costs for pursuing the research. IITA should devote an increasing proportion of its attention in this project to developing strategies for targeting these innovations and delivering them to specific populations in need.

3.3.5 Opportunities and Threats

This is the most dispersed of IITA's seven projects, with a large number of staff contributing, on average, less than 0.3 person-years of time to its activities. The project's major output at present (with 42% of resources utilized) concerns diagnoses of biotic and abiotic stress. Although several of the contributing scientists are currently supported by core funds, and the project is presently relatively small in size, its scope and sustainability are threatened by the fact that more than 90% of the current budget derives from activities that terminate by September 2007. Thus there is a need to rethink the nature of this project.

The project emphasizes broad-based analysis of constraints and priorities; but as recent IITA documents on the "impact culture" have shown, priority setting must be seen as part of a system that includes farm-level monitoring, adoption studies, and impact assessment. It is not the best use of resources to envision a major project focused solely on identification of constraints. An alternative goal of the project would be to provide relevant information and analysis to the other projects (and to the institute as a whole) for the purposes of strategic planning, priority setting and monitoring of research results.

The project is described as taking responsibility for assessments that go beyond commodity-specific projects. There are certainly some important examples of this nature (e.g. climate change, input markets) that the project can address. But much of the work that IITA will do on priority setting and impact assessment is necessarily commodity-based, and confining the project to supra-commodity assignments would considerably limit its activities and its benefits. In addition, IITA must always consider its comparative advantage in devoting its scarce resources to long-term, cross-commodity issues rather than to issues of more direct importance to the institute.

Furthermore, the current list of constituent projects (biotechnology policy, mycotoxin control, livestock markets, knowledge support systems, climate change) is so broad that it is difficult to understand the "glue" that holds the current set of activities together. There is the danger that this project might simply become a repository for any activity that does not have a clear commodity focus. Instead, the project's activities should be defined by their contribution to the ability to identify constraints and priorities for IITA's work.

A reformulated project could contribute more directly to the planning and impact activities of the four cropping system projects (each one of which lists constraint analysis and impact assessment among its own objectives), and could explore contributions to the Agriculture and Health and Agrobiodiversity projects, which would presumably also profit from assessment of constraints and priorities. The project also offers opportunities for sharing data and analysis across commodities, and could assist the institute to develop more robust methods and impact assessments.

A reformed and more focused project could help address the challenge faced by IITA of ensuring that individual adoption and impact studies (often done in response to donor or other external pressure) do not remain as isolated analyses but contribute to the broader monitoring, evaluation and planning of the institute's work. The project could also take the lead on the synthesis of individual, pilot-level experiences (in commercial markets for crops, input delivery, or innovations in technology transfer) that would provide the type of broad guidance expected from a research institute such as IITA.

In addition, the project could promote an approach to market development based on an action research model (or using the innovation systems paradigm that IITA has promoted in the past), involving key stakeholders in information gathering, reflection and planning phases of commodity based projects. This would provide the project more immediate involvement with IITA's active work, rather than being confined to developing future scenarios. Providing a rigorous means of involving relevant stakeholders in the strategic planning process would be particularly relevant for IITA's R4D philosophy.

A minor (but important) issue is the name of the project. The current name is unattractive and fails to convey the services that the project can offer. It is understood that "threats" was adopted to refer to the analysis of biotic and abiotic stresses, which are an important element of IITA's priority setting environment, but a more attractive term that conveys rather clearer meaning should be sought for the project, such as "Strategic Analysis and Planning".

Finally, it appears that if this project is broadened to include planning or impact activities that are linked to other projects but are not separately funded themselves, it would have difficulty in assembling a sufficient critical mass of staff. Many of these activities would be managed by socioeconomists; but the project should not be seen as a way to reconstitute a separate socioeconomics unit. Instead, it should encourage a healthy mix of disciplines that provide a broad perspective on the progress and potential for other projects, as well as provide syntheses and cross-project analysis for IITA.

The panel recommends that the goals of the Opportunities and Threats project should focus on commodity-specific as well as multi- or supra-commodity analyses that are linked to a well-defined priority setting and strategic planning process at the project and institute levels.

3.3.6 Cereals and Legume Systems

The IITA Cereal and Legume Systems project targets the promotion and adoption of improved best-bet cropping practices in collaboration with multiple stakeholders. The project has a goal of enhancing food security, improving livelihood, reducing poverty, and improving human nutrition in the savannas of West and Central Africa. The major constraints to agricultural production in the savannas with intensified cropping systems are: soil erosion, poor soil fertility, low soil organic matter, insect pests and diseases of cereals and legumes and other crops (e.g. cotton), weed infestation such as *Striga hermonthica*, drought, overgrazing and lack of feed resources. These all contribute to low crop and forage yields or poor livestock growth. Ecologically, the savannas of West and Central Africa are characterized by elevations below 800 m, a growing period of sufficient length for cereal and grain legume crops, and a relatively high production potential. Soil erosion and nutrient depletion have gradually increased and have become serious threats to food production. With increasing demand for food and feed catalyzed by steadily rising population, farming systems in the savanna may intensify further. This may lead to a reduction in traditional fallow periods, increased grazing demands, and may exacerbate current problems unless sound interventions are put in place.

Past research at IITA has demonstrated that an integrated crop (cereal and legume) and livestock system that promotes judicious use of fertilizers (organic and non-organic) and management of crop residues is a good prescription for enhancing soil fertility, increasing organic matter content, and reducing pest and disease population. IITA's comparative advantage lies in its capacity to generate and deliver technology options to improve food systems that can be directed to the benefit of the rural poor. While not losing sight of the value of improving the key food crops, IITA should maintain its primary focus on studies of enhancing the efficiency of the total farming systems prevailing in different agro-ecologies, including the role of cash crops. With an increasing focus on poverty alleviation and reduction, IITA should interject supplemental programs on market analysis. These should have a food system approach that promotes responsiveness to changing demands from the rural, urban, and commercial sectors, as well as its more traditional targets in the community. Hence, in addition to the disciplinary research targeting crop improvement, a research agenda should be emphasized that looks into the specific needs of the variety of production and sustainable natural resource management options without disregard for diversification and increased commercialization and profitability of the farming enterprise.

The following list of planned interventions to address key constraints in the production-to-consumption chain of the cereal and legume systems in the savannas are sound, but require disciplined prioritization for implementation:

- More rational use of nutrients (strategic fertilizer use).
- Greater recycling of nutrients, appropriate replenishment of soil organic matter through the use of dual-purpose legumes and manure.
- Better use of biological resources to raise and maintain yields of crops and livestock, such as rotation or relay cropping systems.
- More effective measures for soil and water conservation.
- Integrated pest management through the integration of varieties resistant to insects and diseases with rotation, trap crops, optimum pesticide use, and better agronomic practices.
- Use of high yielding cultivars adapted to the production environment.
- Introduction of labor saving devices for production and post-harvest processing, and reduction of post-harvest losses through appropriate storage technologies.
- Employment of more effective input and output marketing strategies.

- Effective ways of technology transfer.

The research agenda is also properly rationalized both in its planned implementation approach as well as its implications on longer term adoption and use. Agronomy and resource management research is often best conducted locally in the area of intended use to increase chances for adoption of the ensuing technologies. IITA scientists link with their NARS partners to conduct research that evaluate interactions between newly developed crop cultivars with novel traits (best variety) and efficient natural resource management (NRM) practices (agronomic technology) in intensifying food and forage crop-livestock systems. These tests are conducted in consultation with stakeholders to ensure the likelihood of effective delivery and adoption. Also recognized are the value of production to the consumption value chain, and the value of appropriate farming technologies resulting from well designed agronomic research in facilitating adoption and sustainable use of appropriate technological packages. The long term sustainability of science-based new farm practices can only be assured if local institutions and/or agents of change are empowered, and efficient market access and commercialization support is put in place. Access to inputs is often a critical constraint to improved productivity, as is the promotion of value-added processing and storage to improve rural income and investment in crop-livestock production related activities.

The Cereal and Legume Systems project is subdivided into the following six major output groups, each with generalized priority thematic areas and more specific and defined research activities:

Output 1: Researchable issues in response to stakeholders' needs formulated, targeted, and prioritized through identification of key drivers of intensification. This is the social science component of the Cereal and Legume System project. Priority thematic areas in this output are: (1) characterization studies for prioritizing constraints and opportunities, (2) developing and testing methodologies for scaling-up/out technologies, (3) *ex-ante* impact assessment of seed and non-seed technologies, (4) monitoring the spread and impact of improved technologies, and (5) commercialization opportunities for maize, soybean, cowpea, and other important crops in the savanna.

Specific activities in this output include conducting diagnostic surveys to prioritize constraints and opportunities, commodity market surveys, bio-physical characterization of soils, assessing prevalence and severity of pests, diseases, and weeds, monitoring impact and spread of new technologies, economic evaluation of best-bet crop-based livestock systems, and assessment of commercialization opportunities for emerging IITA-derived technologies.

Output 2: Management practices for the optimization and stabilization of intensified production systems developed through enhanced understanding of soil processes weed and crop interactions. This is the Agronomy and Soil Science component with priority thematic areas of research organized as follows: (1) Strategic research on soil processes and crop and weed interactions, (2) Weeds and their interaction with crops, soil, and field management, (3) The benefits of legumes in cereal–legume rotation with regard to BNF, soil microbiota, weed control and others, (4) Understanding and utilizing the beneficial interaction between organic and inorganic fertilizers in crop production systems, (5) Understanding and utilizing interactions between planting patterns, plant densities, and crop combinations to enhance resource-use efficiency, and (6) Identifying appropriate soil conservation technologies to sustain crop and soil productivity.

Research project activities in Output 2 include strategic research on soil processes and crop and weed interactions such as rhizosphere processes that enhance P acquisiton, identification of legume genotypes that utilize P from sparingly soluble sources, P distribution and desorption charcteristics and residue characteristics vs. P availability. Output 2 also includes assessing soil conservation technologies, benefit of cereal-legume rotation on BNF and soil microbes, weed interactions with crops and field management, and assessing effect of planting densities and patterns on crop yield and yield components.

Output 3. System and end-user constraints and opportunities addressed through the development of high yielding maize hybrids and open-pollinated varieties, dual-purpose soybean breeding lines, cowpea breeding lines, and promotion of improved varieties of other important crops in savanna systems. Output 3 is primarily a plant breeding component addressing the crop improvement task for sets of traits and against constraints on cereal and grain legumes deemed important by stakeholders. Priority thematic areas of research in this output are as follows: (1) Developing and testing improved varieties with high and stable yields in different agro ecological zones; (2) Developing and evaluating crop varieties that are resistant/tolerant to biotic and abiotic stresses and with ability to stimulate suicidal germination of *Striga* and *Alectra* seeds; (3) Developing and evaluating crop varieties with higher nutritional value; (4) Developing and evaluating crop varieties with efficient use of nutrients; (5) Tailoring varieties to fit different cropping systems; (6) Developing and evaluating crop varieties with increased crop residue of high feed value.

Major crop improvement activities include developing and testing of new crop varieties and hybrids, genotypic evaluation of crops against biotic and abiotic stresses, breeding for *Striga* resistance, breeding dual-purpose legumes for grain and forage, breeding maize for enhanced nutritional value and micronutrient content, and developing cereal and legume crops for nitrogen use efficiency and for higher N-fixation.

Output 4: Improved post-harvest technologies, production and processing equipment for expanded utilization and commercialization in the food, feed, and industrial sectors developed: Priority thematic areas of research in this output are as follows: (1) Develop and test production, harvesting, and processing machinery to improve labor use efficiency, add value to productivity, and reduce storage and handling losses in major crops; (2) Develop, evaluate, and promote new products and processing methods to diversify utilization of maize, cowpea, and soybean for income generation and improved nutritional status; (3) Improve storage technologies; and (4) Improve nutritional status of vulnerable groups.

Activities in Output 4 include evaluation of post-harvest equipment for field operations, assessing influence of infestation of storage structures on infestation of pests of stored cereals and legumes, and evaluation of new food products for improved nutrition and income.

Output 5: Integrating farmer acceptable cereal-legume and livestock systems that are developed, validated, and promoted through participatory, income-generating crop, resource management, and IPM based best-bet strategies. This is the integrative component project. In this project IITA and its NARS partners focus on the interaction between new crop germplasm (best variety) and more efficient natural resource management (NRM) system (crop and soil management techniques) in intensifying food and forage crop–livestock systems. Such a combination would consist of the best variety for a given environment grown using improved crop and soil management technologies. Both the technology and the desired outcomes would be appropriate to the farmers to whom they must be delivered effectively.

Priority thematic areas of research in this output are: (1) Develop integrated soil fertility management systems, (2) Develop integrated pest management systems; (3) Develop improved legume–cereal cropping systems suitable for different niches; (4) Develop options for enhanced crop–livestock systems, (5) Develop options for mechanization and post harvest systems; and (6) Integrate best-bet options identified in themes 1–5 into synergistic systems (or systems that address all key constraints).

The major research conducted in this project is the farmer participatory testing of integrated crop-livestock systems. Others are more mundane participatory evaluation of newly improved cereal and legume crop cultivars and participatory seed production, evaluation of cowpea relay cropped into maize plots, and on-farm trials of improved crop livestock system.

Output 6: Enhancement of NARES and other stakeholders' capacity to adopt, generate and transfer technologies: This is the "Technology Transfer" component of the Cereal and Legume Systems project. Priority thematic areas of research in this output are as follows: (1) Participatory technology development and transfer; (2) Sustainable seed systems for major crops in the savanna developed; (3) Networks and partnerships encouraged; and (4) Institutional and human capacity building.

Project activities range from educational components (ranging from farmer field days to degree training), organizing international trials, scaling up mature technologies, organizing community seed multiplication efforts, involvement in organized regional networks, encouraging private sector initiatives, and training workshops for farmers, extension personnel, contract sprayers, and agrochemical companies.

Integrated Nutrient Management in Crop-Livestock Systems in the Savanna
This is the major research effort in Cereal-Legume Systems conducted as a fully integrated activity. In this project IITA and its NARS partners focus on the interaction between new crop germplasm (best variety) and more efficient natural resource management (NRM) system (crop and soil management techniques) in intensifying food and forage crop–livestock systems. Such a combination would consist of the best variety for a given environment grown using improved crop and soil management technologies.

Results from process-level research in Output 2 (Breeding) and Output 3 (Natural Resource Management) led to component technology development. These components were used to design "best-bet" technologies that had potential to improve the productivity of legume-cereal production systems. Promising technologies included a) maize varieties tolerant to low nitrogen, *Striga,* and drought , b) dual purpose soybean and cowpea varieties that fix high quantities of nitrogen and produce biomass under low phosphorous conditions, and with resistance to *Striga gesnerioides* or cause suicidal germination of *Striga hermonthica;* and, c) improved crop and soil management practices such as cereal-legume rotations, appropriate planting dates, and densities, judicious use of organic and inorganic fertilizers, and the application of environmentally-friendly pesticides.

Best-bet technologies and impacts: Various permutations of these technologies were deployed and tested in farmers' fields in collaboration with extension agencies. The participation of farmers provided the opportunity to select technologies that best suited their circumstances and environments. Monitoring and evaluation of on-farm trials was conducted periodically and this

allowed participating farmers to share experiences with non-participating farmers as well as providing feedback to researchers. In addition, policy makers at several levels of government (traditional, local, state or federal) participated in the monitoring and evaluation activities.

One of the best-bets identified is "Balanced Nutrient Management System, BNMS", a practice in which half of the recommended fertilizer quantity is replaced by animal manure or a soybean-maize rotation with reduced fertilizer rate to the maize (BNMS package). The BNMS package was compared to a fertilizer practice recommended by SG2000 (136 kg N, 20kg P, and 37 kg K ha^{-1}) and farmer practice (no or little use of external inputs). Whereas the two improved packages provided higher maize yield than the farmer practice, the BNMS package was more appreciated by farmers for its lower fertilizer N requirement for maize, the higher price of soybean, the high quality crop residue for livestock, and the low input costs.

The development of the BNMS technology also brought together collaboration from IITA and its partners. The Katholieke Universiteit of Leuven provided support in upstream research in isotopes and ICP measurements. National programs in several countries (IAR in Nigeria, INRAB in Benin, and ITRA in Togo) participated in oversight of the on-farm technology testing and validation in different environments. Extension organizations (Sasakawa Global 2000 and Institut de Conseil et d'Appui Technique) promoted technology diffusion through organized extension programs of field days and farmer visits, and provided feedback to researchers.

Summary: This is an exemplary research project in its science quality, its interdisciplinary integrative approaches, and the steady courting and nurturing of policy advocacy via invitations extended to state and local officials to farmer field days and topical workshops. It has been under repeated testing in northern Nigeria for several years. However, this experience has now been shared with collaborators in several states in Nigeria. Similar on-farm tests are planned to be conducted with leadership by national scientists in nine states with limited involvement of IITA. A project is under discussion to extend a similar approach to Mozambique. There is need to have multiple integrative projects designed to address the natural resource management issues that no-doubt will increase with the intensification of the cropping systems. It is also important that tested best-bet options are scaled up and out to larger communities sooner for greater impact, their imperfections notwithstanding.

3.3.7 High Value Products

The current MTP, 2007-2009 indicates that the main objectives of this project are to:

- Develop and facilitate dissemination of natural resource management technologies that increase the productivity of high value cropping systems in a sustainable manner.
- Facilitate the development of post-harvest technologies and market systems that increase the availability of high quality agricultural products.
- Generate knowledge to facilitate effective management of ecosystems.
- Facilitate development of local agroenterprises for cost-effective seed systems and biological plant health management products.
- Explore and develop innovative institutional arrangements to facilitate the dissemination of research processes, methods, and emerging International Public Goods (IPGs) in selected value chains.
- Advise upstream decision-makers on a conducive institutional and policy environment for vibrant high value production systems that are environmentally sound and socially acceptable.

Many of the activities in the High Value Products (HVP) Project can trace their origins to earlier IITA investment in two areas:

(i) Work of the former Resource and Crop Management Division in forest and forest margin environments (and the later "Project D" on Livelihoods in Humid and Semi-Humid Zones) which addressed crop diversity and incentives for intensification. One of the principal reasons for IITA's central role in the STCP is the impact its analysis of cocoa systems in Cameroon made on a workshop on cocoa industry development sponsored by USAID and the cocoa industry in 1998.

(ii) IITA's work on biocontrol and IPM, based in Benin, that has traditionally focused on IITA mandate crops such as cassava but whose experience is now being applied to a wider range of crops.

The HVP Project, as currently constituted, is based in large part (78%) on restricted core funds. The project is dominated by restricted grants that address the rehabilitation and development of the cocoa industry in several West African countries. Most of the rest of the project is concerned with pest control in vegetables, funded in large part by restricted grants. There are a few other activities supported by restricted grants, such as a project on biological control of coconut mite, based on earlier IITA experience with cassava green mite, and interest in cashew in West and southern Africa.

The HVP Project is the most concentrated of IITA's projects; most of the staff in this project work full-time on HVP activities. Such concentration offers a number of advantages. First, there is a geographical focus; virtually all current activities are centered on West Africa and most project staff are based in Ghana and Benin. Second, there is a crop concentration, featuring tree crops (almost exclusively cocoa at this point) and vegetables. Third, there is solid IITA technical expertise in biological pest control that can be applied to vegetable crops and the socioeconomics of forest systems that has informed the early years of the tree crop research.

However, such concentration may present some disadvantages as well. The project depends heavily on current donor interest in the cocoa sector; if that interest wanes it is not clear where IITA would turn. In addition, there is the potential danger that the project might be isolated from the rest of IITA's work, responding mostly to the particular interests of restricted grants, and not contributing as much as it should to IITA's wider mandate. Addressing these potential disadvantages will require a clearer definition of IITA's niche in the area of high value products and attention to project coordination and developing synergisms among the various project activities.

The best-documented experience of this project is the set of activities, funded by several donors (including the cocoa industry), promoting cocoa sector development in West Africa. The Sustainable Tree Crops Project (STCP) was initiated in late 2002 and the first four years of work involved activities in five areas: strengthening community groups; technology dissemination and research; policy change and implementation; market information systems; and labor and social systems. IITA serves as the "host" for the project, which includes a number of partner organizations and activities in Cameroon, Cote d'Ivoire, Ghana, Guinea and Nigeria (with current work expanding into Liberia). IITA provided coordination for this wide range of activities, although much of the work was done by partner organizations.

An external review was conducted in 2005 and this led to a second phase of the project, with the goal of establishing a sustainable multi-institutional forum that would promote cocoa sector

development by passing most responsibilities to local government and civil society organizations. While the review acknowledged that there were problems with national-level commitment, the management of a multi-institutional endeavor, and the role of the project in policy change, it found enough positive outcomes to recommend further investment. It singled out the work on farmer field schools (FFS) for particular praise, which was one of IITA's principal responsibilities in the project. IITA developed curricula for cocoa FFS (drawing on the technical expertise of local and Northern research organizations with experience in cocoa), trained facilitators, and organized the conduct of a large number of FFS in four countries. A manual on the organization of FFS has been produced and IITA has done comprehensive evaluation surveys in each of the countries.

In the next phase of the STCP IITA needs to think carefully about its role and comparative advantage. Many of the expectations for the project clearly fall outside IITA's mandate and will be left to partners. IITA has made an excellent contribution to technology generation and diffusion in the context of the FFS, and there is the expectation that this method will be widely used by partner organizations in the coming years. On the one hand, the IITA studies have shown that FFS participants apparently achieved higher production and often lowered input costs, but the uptake of technical recommendations was variable, and the link between participation and production increases is not always clear. Worldwide experience with FFS indicates that this method can be quite effective on a small scale, but expanding it to cover a greater proportion of farmers involves significant organizational and financial challenges. There is an expectation that IITA will help devise methods for cost sharing for FFS (e.g. involving the combination of public funds and farmer contributions). There may be some scope for investigation in this area, but now that IITA has established a model for FFS organization and monitoring, it should shift its research emphasis to synthesizing results of evaluation studies and to documenting the costs and benefits of a range of technology transfer techniques, so that national partners have guidance on options available outside the context of external project funding. (This type of research would certainly benefit from collaboration with other IITA activities in technology transfer in areas such as IPM so that comprehensive guidance is available.)

The external review of STCP points to the need for more emphasis on soil fertility management, and some participatory research with FFS graduates is underway in this area; it would seem that this is a theme where IITA should be able to make significant contributions. IITA is also organizing participatory research on diversification, featuring the planting of timber species in cocoa farms; IITA's experience in socio-economic analysis can be applied here, although it is an area that requires input from other research organizations as well. The next phase of the STCP project also includes work on marketing and policy issues, and it is less clear what IITA might contribute. There are plans for analyzing the efficiency of different types of producer cooperative (e.g. in Cameroon); the results of such an analysis would be most useful if they provided clear guidance on feasible interventions to help develop producer organizations. Similarly, IITA is developing econometric models of agricultural production for cocoa-growing regions that can be used and modified by national partners; such work will benefit from prior identification of specific, practical choices that can be informed by reference to such models. In all cases, IITA needs to think about how its socioeconomic work in STCP contributes to IITA interests and mandate.

The other major element in the HVP Project is interest in vegetable production, particularly in West Africa (although IITA is also backstopping a value chain analysis for vegetables in southern

Africa). The technical part of this work draws on IITA's long experience with biological pesticides and natural pest control products and principally addresses peri-urban vegetable production. The challenge has been to develop alternative pest control techniques that will help lower dependence on chemical pesticides. Several promising innovations have been tested (and in one case a biopesticide provided by IITA is being used on a small scale by a local NGO that trains farmers) but there is no immediate prospect for the delivery of these products because of a lack of commercial production capacity and by a lack of national regulatory frameworks that would permit the deployment of such products. A second project is examining the prospects (and farmers' willingness to pay) for safer pesticides for vegetable production in four West African countries.

The current vegetable work draws on recognized IITA expertise in the development of biological pest control measures and socioeconomic analysis; these are two important areas, but only a small part of the skills required for vegetable sector development. If IITA hopes to continue working on vegetables it will have to decide how to strengthen these skills with others that may exist in the institute (e.g. crop management) and combine them with those of other organizations that work on germplasm, management, sectoral development to establish a well-defined niche.

The current mix of IITA partnerships for the research and promotion of high value agricultural products is deliberately broad, as it seeks to integrate comparative skills available in various platforms and has a justified emphasis on technical resources. However it should be recognized that the very definition of the high value crops implies that the crops or their products generate income for the target farmers. It is therefore important that the project also makes a deliberate attempt to guide partnerships that will create the possibility of a whole value chain approach. Clearly there is need to link the current programs to other players who can contribute to the considerations of business development profiles, otherwise the project risks falling into the trap of developing technologies that may not find favor with potential adopters. These partnerships can be explored elsewhere in the continent where IITA is already active and where experience in market oriented production research for either tree crops and/or vegetables already exists. The case of Kenya's horticultural development program could provide valuable insights and also provide an avenue for the Kenyan NARS to become a contributor to IITA's high value crops program. There are too few examples where south-south co-operation is truly beneficial, and this is one opportunity awaiting exploitation.

Summary: The HVP Project is a logical way of presenting and managing current restricted grants in two somewhat disparate areas (tree crops and vegetables). The two major activities to date have been well managed and productive. The two areas share some themes in common, and the Project management should seek as many synergies as possible in the coming years (but without forcing collaboration where there is little rationale to do so). The long-term existence of the HVP Project will depend on identifying sufficient synergies (and contributions to IITA's wider work); the identification of a clear set of IITA contributions; and continued donor interest in these commodities. It is not clear that all these conditions will be met, but in the short-term the HVP Project appears to be a reasonable approach to organizing this research.

3.3.8 System-wide IPM Program

Background: The System-wide Program on Integrated Pest Management (SP-IPM) was established in 1995 in response to Agenda 21, the main aim being to encourage system-wide activities to facilitate IPM as an important component of sustainable agricultural development. It has a Steering Committee of 12 made up of representatives of CGIAR Centers, the interim chair is

currently the DDG-R4D of IITA, and it is led by a Coordinator who is an IITA staff member. The goal of SP-IPM is to increase the quality and usefulness of IPM research and capacity strengthening to increase productivity, improve human health, and decrease environmental degradation.

While there has been continuing enthusiasm by many of the staff involved in this program over its 12 year history, in practice, the whitefly collaborative project appears to be the only significant success story, most of the other initiatives having had short term or limited success, or had limited support from participating institutes. Since 2005, the activity of SP-IPM has been at a low level, associated with administrative difficulties and conflicts. However, despite this chequered past, there still appears to be interest from CGIAR Centers and from donors in continuing the SP-IPM. At a meeting in Nairobi in February 2007, a fresh approach to SP-IPM was proposed.[24]

The main proposal of the Nairobi meeting was that … "*SP-IPM should break away from its traditional quest for pest-oriented inter-Center project interests and instead strengthen inter-Center research on understanding and utilizing agrobiodiversity to mitigate food/fibre losses due to pests, and endeavor to design R4D within the context of climate change effects on biodiversity, that is, the bases of agriculture, human and environmental health. Soil health; effect of climate change on key global pathogens, insect pests and weeds; functional agrobiodiversity use and monitoring; food safety (and biosafety); educational tools for capacity building; and vegetative seed production systems were agreed upon as the emerging themes around which the MTP 2008-2010 for SP-IPM will be structured*".

Subsequent to the initial meeting of the EPMR team, a CCER of the SP-IPM was conducted in Ibadan in March, 2007. The main objective of this CCER was to provide recommendations on: the validity of the program; responsibilities and mechanisms for governance, management and implementation of SP-IPM; the role of IITA in this regard; options (with pros/cons); and a sequence of actions.

The report of the CCER (March 2007), notes that the SP-IPM has made a valuable contribution to cross cutting issues associated with removing bottlenecks to IPM implementation. There are two ways in which this has been attempted – through activities focused on collaborative research involving staff from various Centers (and possibly outside the CGIAR system) and activities to communicate knowledge and information to NARES and other agencies involved in IPM implementation. The CCER opted for continuing the SP-IPM based on the MTP 2007-2009, and provided 15 recommendations, all of which have been subsequently agreed to by the IITA Board (for further details see Annex 8.)

The main recommendations include the following:

- A restructured administration of SP-IPM with a smaller Steering Committee, an independent Chair and a transparent procedure for funding SP-IPM activities
- The focus of SP-IPM projects to be on no more than three priority themes
- An internal monitoring and evaluation system to be developed and impact assessments made on pilot sites
- A facilitated workshop to be held in 2007 to plan for future SP-IPM activities

While the Panel generally agrees with the analysis and recommendations of the CCER, the future of SP-IPM clearly needs to be carefully considered, given the problems previously encountered

[24] See minutes of the Steering Committee Meeting, Nairobi, Kenya 25 – 27, February 2007

by this system-wide program. In the past, the SP-IPM has been top heavy with administration. What is now required is a lighter, more streamlined administrative structure – which will provide the encouragement, resources and flexibility to enable interested parties within and outside the CGIAR to collaborate on specific IPM projects. A smaller steering group and the appointment of a full-time Chair and Coordinator of SP-IPM are certainly steps in the right direction.

The shift in emphasis recommended by the CCER to focus on just two or three IPM themes is also to be commended. It is suggested that resources previously allocated to overall SP-IPM administration would be better used to free up champions in these two or three focus areas.

Collaborative SP-IPM research on pests common across Centers could potentially provide valuable economies of scale - as with the whitefly program. Future possibilities include stem borers, certain diseases and weeds but the potential for adding value is not clear. Perhaps it would be better to focus on common pest management issues – such as improved pesticide use in the context of IPM, including improved pesticide application techniques for chemical pesticides as well as bio-pesticides. IPM related policy is another topic that has been suggested in the past but one which has not been taken up.

This raises the important issue of the involvement of other, non-CGIAR agencies in SP-IPM. The effectiveness and impact of SP-IPM activities are likely to be much greater if key IPM expertise outside the CGIAR is included. For instance, input from external partners is likely to be required on improved pesticide use, such as pesticide application techniques, mentioned above.

The extent to which SP-IPM research and development activities should include practical IPM implementation is another issue that needs to be discussed. Since best practice in IPM is generally site specific, successful IPM strategies need to be designed and adapted to local agro-ecological systems, current cropping practices, and socioeconomic, marketing and political situations. Therefore, local NARES have a crucial role to play to support the design, implementation and sustainability of IPM on farms in their locality. However, approaches and techniques for facilitating NARES and other stakeholder involvement in specific SP-IPM projects is certainly a topic that would be appropriate for SP-IPM involvement.

In its report, the CCER team suggested that SP-IPM can add value by addressing constraints to IPM implementation, such as facilitating the development of regulatory processes for bio-pesticide registration, promoting skills and documenting evidence that demonstrates the benefits of IPM research. Approaches and methods for determining these constraints, focusing on common issues and devising means of reducing them is another possible generic activity the SP-IPM could perform, involving the participation of socioeconomic expertise from such programs as IITA's "Opportunities and Threats" program.

SP-IPM Communication activities have been viewed favorably in the past. Feedback from some of the original participants in SP-IPM indicated that the networking and information dissemination functions of the project were seen as very valuable – with SP-IPM playing the role of an objective, honest broker. In this context, the SP-IPM web site could play a much more important role – in terms of internal and external communication. However, as well as providing information about the different programs, publications and meetings of the SP-IPM, consideration should be given to developing a portal on the site designed for CGIAR and other visitors who wish to find out about specific IPM topics. The current section on educational tools is a case in point, although

there is currently only one manual (on nematology) in this section. The potential for the SP-IPM to engage in training courses as part of this activity should also be considered. Another aspect of communication that the SP-IPM might consider is to re-explore is the idea of an African PestNet – based on the very successful PestNet model being used in the Asia-Pacific region for linking practitioners and experts via a list server.

In summary: The Panel concurs with the recent CCER and supports the continuation of the SP-IPM focused on one or a small number of themes. The Panel offers some suggestions but is not prescriptive, urging the partners to address areas that, firstly, clearly add value to individual Center programs (including the proper meshing with IITA plant/health and commodity approaches) and, secondly, which share information to advance approaches and the enabling environment across the wider community of practice in IPM.

3.4 Cross Cutting Issues

3.4.1 Plant Breeding

Introduction: IITA conducts crop breeding in each of its mandate crops, i.e. banana and plantains, cassava, yam, cowpeas, soybeans and maize. Crop breeding efforts at IITA fall into two major groups based on the mode of propagation of the crops, namely seed or clonal material. Several of the crop breeding programs at IITA have enjoyed sustained long term support and have developed into seasoned crop improvement programs. Today, they are able to respond to emerging disease crises as well as new commercial opportunities for growth. The cassava program at IITA has been particularly notable in successfully responding to the outbreak in cassava mosaic disease in eastern Africa in the late 1990s. More recently, it has responded to the Nigerian Presidential Initiative, a pilot project that is currently under deployment to promote cassava as a commercial food, feed, and industrial crop in Nigeria. Continuity and sustained support are crucial for any plant breeding program, but are more critical for some of the IITA mandate crops such as cassava, banana and plantains, that take several years to establish as crop plants. These crops are vegetatively propagated, and opportunities for continual exploitation of segregating populations are limited. On the other hand, crops such as cowpea have almost no input from other major breeding programs outside of IITA. As a result, IITA has been a primary source of knowledge and germplasm for cowpea breeding internationally. IITA has also been the sole source of tropical Africa's soybean germplasm, although its breeding program has been interrupted. Maize breeding at the Center is mandated to improve the crop for the lowlands of sub-Saharan Africa focusing on the major traits of drought tolerance, resistance to major diseases (maize streak virus, ear rots, and leaf blight) and the parasitic weed, *Striga.* Each of these breeding programs has shown a good record of accomplishments as measured by germplasm developed and distributed, cultivars released and/or registered, and more recently with an increased emphasis and effort in generating journal publications (see Annex 9).

Program Focus: Perhaps not by design, but through demands generated over time, the IITA crop improvement programs have had to respond to germplasm needs of institutions all over Africa. The geographical foci of the breeding programs in the mandated IITA crops are shown in Annex 10. Crop breeding at IITA focuses on improvement for productivity, resistance to biotic and abiotic stresses, nutritional quality, as well as new traits needed for industrial processing. But the most important challenges for clonal crops are diseases; fungal, bacterial and particularly viruses. Significant progress had been made in several diseases, but currently cassava mosaic virus (CMV) and cassava brown streak viruses (CBSV), yam mosaic virus (YMV), and banana

wilt (BXW) are the major diseases that threaten these crops. Insects and nematodes are also major problems in these crops. Response to moisture stress, parasitic weeds, and productivity under marginal environment with limited inputs are the primary targets of improvement for these crops.

Breeding Approaches: The breeding methods used vary, naturally, from crop to crop based on mode of propagation (asexual or sexual), and pollination (allogamous, autogamous). The complexities of the breeding scheme employed also range among the diverse species included in the mandate crops. The simplest methods are used in the clonally propagated species as a result of restrictions imposed in undertaking more elaborate crossing and evaluation of these species. The self pollinated legume species, cowpeas and soybeans, generally employ "pedigree breeding, back-cross breeding" and these are generally sufficient to generate the range of variation needed, to introgress desired traits, and to allow successive manipulation and exploitation of the variation generated. In maize, a cross pollinating species, IITA maize breeders have adopted efficient means for use of these approaches without encumbering the flow of genetic material and getting into costly and elaborate testing schemes. Methods such as intra- and inter-population improvement schemes, pedigree breeding, backcross breeding and use of selection indices have been practiced to improve the more complex agronomic traits of grain yield, agronomic fitness and adaptation, drought tolerance, nitrogen use efficiency.

Generally, the breeding methods currently employed by IITA breeders across all crops do not impose restrictions to success. The list of crop cultivars released and distributed by IITA during the last five years is shown in Annex 10. The plant breeders at IITA have also been open to exploring new approaches to move beyond the "natural" restrictions of the species. Even in the clonal species, certain innovations such as searching for genes for male sterility, pushing the limits and integrity of the genome via ploidy manipulation and interspecific hybridizations, as well as induced mutagenesis have been carried out. IITA breeders have also wisely linked with ARIs to undertake basic studies in crop biology or complex traits.

The Panel applauds the response capacity to emergencies and new initiatives demonstrated by the crop improvement programs at IITA, such as the cassava program (primarily) and the banana and plantain team as well. However while these responses were readily met at this time where the current productivity levels are low and variants were readily available, future competition will be much greater as new releases compete with improved clones and varieties from previous releases. Past releases have benefited from access to "abundant" genetic variation and the broad adaptation inherently associated with clonally propagated heterozygous species. Future responses may continue to rely on these built-in benefits, but will also require more deliberate creation of genetic variation and selection beyond that found in nature. The Panel judges that the programs should evaluate the potential heterosis across and within species towards a more systematic exploitation of hybrid vigor. At the time of the Review there is evidence that IITA is developing new staffing to address MAS. In general effort should be given to the more cutting-edge sciences of genetic transformation (cowpea, banana, and cassava) and molecular diagnostics, as well as expanding the molecular marker development and genomics work in a more organized fashion. This should be done in collaboration with appropriate ARIs and other partners. Current DNA marker efforts aimed at genomic diversity studies appear scattered and unfocused, but still provide a service for capacity building among IITA staff and the students training under them.

Testing Environments: The field crop team has sets of testing environments managed by IITA staff as well as a network of locations available for their use through their collaborators. Data collected from these sites are summarized annually to determine selection and advancement, as well as accumulating performance data for use in cultivar release. The facilities visited by the Panel at Ibadan, as well as in the field stations in other countries, were excellent or adequate for the conduct of reliable experiments, the only limitation perhaps being inadequate irrigation facilities in several of the other locations. Laboratory and support facilities for plant pathology and disease diagnostics, food chemistry, and entomological services for plant breeding are generally good, and staff support seems very adequate. The tissue culture facilities at Ibadan and Kawanda, Uganda, are excellent, and both can conduct genetic transformation on site. Facilities needed to conduct molecular breeding and MAS are available at Ibadan and Nairobi (BECA) facilities.

Relations with NARS: IITA breeding teams have developed a network of collaborators in selected countries to whom breeding materials are sent for testing on a regular basis. The field crop breeding effort, particularly maize breeding, also services regional networks such as WECAMAN and uses these for getting breeding germplasm tested regionally. Funding for conducting such a coordinated effort is paid for by the regional network.

Seed Dissemination: The field crop breeding teams use existing setups for seed dissemination. Many of these are semi-organized and ad-hoc facilities put up mostly by a local plant breeder. Even in Nigeria, most true seed multiplication of improved IITA-derived cultivars is handled by community-based seed multiplication programs. These programs may serve to promote the diffusion of crop varieties, but are never good substitutes for an organized and reliable seed delivery mechanism such as through the private seed industry. The IITA maize breeding team has initiated some activity with local small and medium enterprises (SMEs) to encourage seed industry development.

Private Sector Involvement: IITA scientists work with the private sector particularly to promote end product utilization and encourage commercialization of IITA-derived technology (or products derived from these technologies). However, there is much less effort directed towards developing in-house capacity to deal with the development of a private sector seed industry for both seed based crops as well as clonally propagated commercial crops. We encourage the modest efforts of the maize team working with private SMEs and hope that this effort is expanded. The Panel also suggests that greater attention is paid by IITA management to establishing an in-house expertise in "seed" issues both for sexually and asexually propagated species. This represents a good opportunity for IITA and would provide an essential service to the stakeholders in promoting commercialization of newly derived genetic technologies.

Capacity Building Efforts: Each of the crop breeding programs lists capacity building as a major function of their efforts. The teams work directly with breeders at collaborating NARS, and enter into a mentoring role and share resources via regional networks. IITA scientists are increasingly engaged in graduate education of young African scientists through supervisory roles for MSc and PhD research dissertations. They are commended for this function which takes a significant portion of their time, but is an extremely valuable and satisfying function both for both parties. Capacity building at any level is a long lasting contribution, but graduate education in support of struggling Universities in Africa is a very worthwhile service to render. This also allows IITA scientists to undertake research that requires extensive data collection and analysis, and provides answers to critical research questions as well as publications.

3.4.2 Plant health

The Plant Health scientists at IITA have a strong record of accomplishment through the activities of the biocontrol group in Cotonou, and in the diagnosis of major diseases and the management of insect pests. Although not a formal group, they have played a full part in crop improvement teams that have successfully developed host-plant resistance, and continue to participate in the development of nematode resistance in yams. Plant Health scientists include entomologists, plant pathologists, virologists and a nematologist. Despite changes in the reporting structure within which they have operated in the last several years (Plant Health Division, Agro-ecological zones, the current project structure), the specialists still operate as a plant health group.

The demand for plant health specialists within IITA exceeds supply. This shortfall is sometimes resolved by involving available and appropriate NARS expertise in specific projects. Collaborative links exist with other centers of expertise – for example on fruit flies and stem borers with ICIPE. Although small projects may be seen as detracting from the "mega-project" strategy, the specialists feel they serve a valuable purpose. For example, IITA plant health specialists provide a range of back-stopping services for NARS and other regional groups. These make important contributions to research, provide valuable feedback from different locations, and help develop capacity in NARS. Training courses for the region are provided by plant health specialists (e.g. two training courses in The Gambia in 2007 for quarantine officers). In some cases, project proposals are developed by NARS scientists who then bring the projects into IITA.

A number of management issues were raised in relation to Plant Health. While deliverables are set on an annual basis, progress is monitored on a 3-monthly basis. This is felt to be too short a reporting period and an inefficient use of staff and management's time. Mentoring within disciplines can be achieved in various ways. For instance, a young plant pathologist has been placed at Ibadan rather than at some other site (at least initially) so he can benefit from working closely with an experienced pathologist. In the past, the plant health specialists organized an annual seminar series, where they would make presentations on their projects. Continuation of this practice would help the mentoring and quality control process within the disciplines.

The need for a number of additional appointments in plant health disciplines (or at least access to these disciplines) was expressed – including weed science, pesticide residue research (this would require analytical equipment), and pesticide application techniques (for chemical as well as bio-pesticides).

Cotonou has served the entomologists well as a location for their research. The site is close to an international airport, and the quarantine services of Benin have been very cooperative in allowing the import and export of biocontrol agents. Access to the Insect Biodiversity collection held at the station is an additional benefit. There is also an excellent cadre of trained NRS serving as support staff in Benin. The Panel notes that this unit has had a strong record of successes at this site, and suggests that provided they can be fully integrated into crop improvements programs in Ibadan, they may maintain their current advantages and have better transportation access to research programs in ESA than if they were located in Ibadan. Recognizing the critical role the Plant Health group has played in the past, the Panel strongly suggests that IITA continue to maintain its relative strength, given the history of major insect and disease outbreaks on staple crops that have threatened food security of the entire region.

3.4.3 Natural Resources Management[25]

The agricultural environment in sub-Saharan Africa is characterized by declining soil fertility status, under-exploited water resources and aggressive weeds that are difficult to manage. Population increase is averaging 2.2% annually, but annual yield increases of IITA's mandated crops are almost all less than this. Because the 5th EPMR had felt this area was weak, the Panel undertook to consider the nature and impact of IITA's research on natural resources over the last decade.

A brief history of NRM research at IITA: NRM research has been focused around benchmark sites that were reference areas characteristic of major target areas. Ten years ago scientists in NRM and Agronomy were part of the RCMD and were divided into two groups (humid forest and savanna systems) with several disciplines represented in each. The forest group studied primarily soil acidity and nutrient response, while the focus of the savanna group was animal-plant interactions, biological N fixation, P interactions, and Striga. There was little or no emphasis on fertilizers. Agroforestry (maize-Leucaena) systems were developed, but were generally not adopted, and were followed by development of herbaceous legume systems (N fixation and forage). A CCER conducted in 2001 recommended that external inputs again be considered, so fertilizers and pesticides were combined with the best technologies of the previous years. The Humid Forest NRM team has since been disbanded, and the system-wide program, Alternatives to Slash and Burn has lost momentum in Africa. The Savanna NRM team, based in Kano, is now an integral part of the Cereals and Legumes System Project.

The 5th EPMR noted (p50) that "continued investment by IITA on leguminous cover crop trials, animal manures and crop residues would appear to be a case of diminishing returns", and suggested a shift in emphasis from experimentation to collation of "best bet" technologies based on existing data. The Panel therefore is interested in assessing if this suggestion has resulted in change.

A: NRM issues in the savannas, derived savannas and forest transition zone

In the next decade it seems likely that much of the savannas of WCA will be largely under continuous cultivation, so managing erosion, problem weeds, declines in soil organic matter (SOM) and nutrients, insect pests and diseases of cereals and legumes are keys to sustained and increased production. Opportunities for expanding crop area will be fewer.

Soil fertility and fertilizers: The striking feature of SSA is the lack of fertilizer usage on the continent, where average annual application rates over the cropped area are 8 kg/ha. This compares with 96 kg/ha in E & SE Asia, 101 kg/ha in south Asia, and 78 kg/ha in Latin America. In 2000 average cereal yields in SSA, E & SE Asia, S Asia and Latin America were 1.0, 3.4, 2.4 and 2.9 t/ha with a negative growth rate in yield in SSA 1980-2000. Nutrient mining exceeds 30 kg nutrients/ha/yr, for a net loss of at least 4 million tons of nutrients annually in SSA. The 5th EPMR noted that low input systems without fertilizer have failed to provide adequate productivity gains in much of SSA.

Key factors affecting low usage of fertilizer in SSA are its high farm gate price, untimely supply, and risk of uneconomic returns, but <u>not</u> a low biological response by cereals[26]. Other traditional

[25] A more complete discussion of this section on Natural Resource Management is contained in Annex 10I

[26] Morris, M., V.A. Kelly, R.J. Kopicki and D. Byerlee. 2007. Fertilizer Use in African Agriculture: Lessons Learned and Good Practice Guidelines. World Bank, 144pp.

crops such as cassava, yams, and banana do not have a long selection history at high fertility levels, and show only modest responses to applied N. IITA's research on soil fertility over the past 10 years has been well documented in peer reviewed journals, and can be classified as a mature research area. Over 20 journal articles have been published on factors governing N and P availability over the past 5 years, with a larger emphasis on the role of P. The limitation of low organic matter levels (perhaps the major source of soil nutrients) has been recognized. Important and useful research has been conducted on improvements to biological N fixation, through identification of improved strains of *Bradyrhizobium*. However, the use of NPK fertilizers such as 20-20-20 or 15-15-15 continues in SSA, despite limited responses to K. Zinc and sulfur deficiencies have been reported in the Guinea savanna, but not systematically evaluated across large areas. Cover crops such as *Mucuna* and *Puereria* that boost cereal yield have been identified, but offer no edible by-product in return for the land and water they use during growth. Research data from the first 25 years of research were summarized as scholarly publications in a special issue of the Soil Science Society of America in 2001,[27] but the Panel notes that this is not in a form that the fertilizer industry or policy makers could easily use, nor is the summary by nutrient and crop.

The Panel is concerned that IITA-led strategies for promoting an upward trend in yields, fertilizer use, and soil fertility in the savannas will not adequately meet future food demands. ***The Panel recommends that IITA prepares a comprehensive summary of its past soil fertility research; that it monitor nutrient flows in its farming systems research and exploit possible genotype x fertility level interactions in its germplasm; and that it enhances advocacy for efficient fertilizer use and supply systems.***

Soil water: Global climate change will likely increase variability of rainfall events, and perhaps reduce crop available water. The Panel endorses and encourages research on improved drought tolerance by IITA's crop breeders in collaboration with CIMMYT for maize. However, the panel sees little reference to research on strategies that increase water use efficiency on target crops under rainfed or irrigated conditions. Modest research investments on irrigation management and water use efficiency by crop within common cropping systems appear justified.

Weed management: During the last decade IITA scientists have made significant progress in non-herbicide control options for major weeds, though herbicide options remain the most effective for *Imperata*, and are generally favored by farmers. IITA research has shown that integrating tillage, herbicide, optimum plant density, intercropping and cover cropping has given good control of *Imperata*. The Panel notes that in the majority of weed control studies undertaken by IITA scientists the target crop has been maize, and occasionally cassava. Little or no mention was made of research targeting weed control in cowpea, soybean, yam and *Musa*. Weed control in these crops adds greatly to the labor burden, and merits further efforts. The Panel is also concerned that the leading weed scientist in IITA has moved to a largely administrative position, further weakening this important area.

Cropping Systems: Despite (or perhaps because of) the wide diversity of cropping systems, a commodity chain approach is now widely used by IITA. Alley cropping, a major research theme and cropping system developed by IITA in the 80s, has largely been abandoned because of poor adoption. Current research emphasis has been on cereal-legume systems in the natural and

[27] Sustaining Soil Fertility in West Africa. 2001. G. Tian, F. Ishida, D. Keatinge (eds). Soil Science Society of America Special Publication #58, Wisconsin.

derived savanna zones. Much of IITA's recent research has focused on the control of *Striga*, since about two thirds of fields in the savanna zone are infested.

In the last decade *Striga* research at IITA has focused on developing tolerant varieties, improving soil fertility and utilizing trap crops in rotation. Key "best-bet" methods are rotations of maize and promiscuous soybean, and millet-dual purpose cowpea intercropping, both of which result in a reduction in *Striga* plant density and in the *Striga* seed bank. Both have been responsible for a 50-70% increase in gross incomes of adopting farmers and have fuelled a major increase in soybean area. Research is currently refining these systems. The Panel congratulates IITA on the excellent work done in *Striga*. It notes however that it focuses heavily on the savannas of West Africa. It urges IITA to evaluate the effectiveness of these technologies in ESA also, and to assess the suitability of imazapyr resistance in germplasm adapted to the SSA lowlands. The Panel also encourages the rapid field evaluation of *Striga* resistance in IITA's own selections from *Zea diploperennis*.

B: Humid and sub-humid forest zones

This is a mature research area for IITA. Because farmers in the humid forest have shown an unwillingness to invest in soil fertility directly, emphasis has changed to nutrient use efficiency by crops *per se* where germplasm is being screened under farmers' field conditions. IITA's research has shown that an early planted, vigorously growing crop is the best intervention to capture nutrients by reducing leaching and runoff. Choice of species planted during fallows (where these are still practiced) has been shown to have a large effect on the natural resource base. For crops such as plantain, the use of small amounts of fertilizer plus control of nematodes significantly increases yields, thereby reducing the need to clear further forest. Green manure crops have been shown to be twice as effective as a natural fallow in restoring soil properties, and can reduce the labor costs of clearing forest after a fallow. The Panel notes that little reference has been made to perennial issues such as soil acidity, soil organic matter and general nutrient status, and their long term trends in the humid tropical zone. These require monitoring and modeling over time

Gaps and future needs in NRM: IITA has indicated that high priority areas for future research in NRM will be: the role of P in biological N fixation; the extent and severity of micronutrient deficiencies; sustainability of best bet technologies that include improved varieties, fertilizers, pesticides and cropping systems; and the role of conservation tillage. The Panel endorses these priorities provided they are focused on a broader range of crops, and encourages IITA to invest in fertility management and weed control research in ESA. We strongly suggest that IITA hire a roots and tubers agronomist who will work closely with NARS partners to address management and sustainability issues in these crops. The Panel also expresses concern that soil fertility research and fertilizer advocacy seems to have gone on the back burner, despite a steady decline in soil nutrients status with time. There is a need for a network in the savannas, perhaps similar to the SoilFertNet established in southern Africa, where "best bet" technologies for stabilizing and increasing fertility status of soils under constraints faced by small-scale farmers are developed, promoted and documented. The panel also urges IITA to evaluate the case for herbicide use and conservation tillage as viable resource-conserving systems in areas where *Imperata* and *Striga* predominate, and to lead research on ways to improve the efficiency of African fertilizer markets. The Panel see little mention of livestock and their use of crop residues in the savannas, yet they are an important component of the farming system. It is clear that in the past IITA has worked closely with ILRI in developing best-bet practices for integrating and optimizing crop and livestock output, especially through dual purpose cowpeas. However, the

Panel notes that the absence of an active ILRI presence at key savanna research sites currently jeopardizes further developments of this sort. The Panel strongly suggests the development of a policy on the maintenance, use and continued relevance of long-term NRM sites at Ibadan and Zaria since these are a major research asset. Finally, we note the need for access to state of the art laboratory facilities in soil fertility, and a strategy for training national program partners in NRM.

3.4.4 Socioeconomics

The 2001 EPMR and the 2003 CCER of Project C recommended that more attention be devoted to socioeconomics. They both pointed to the importance of priority setting and impact assessment, and recommended that the project contribute to understanding processes of agricultural intensification and strengthen collaboration with biophysical science in technology generation. IITA has taken these recommendations seriously, and has strengthened its capacity in socioeconomic analysis in recent years.

There are currently 11 socioeconomists at IITA, six of whom joined since the last EPMR. These staff are no longer housed in a single unit or project but are dispersed across a range of projects. This has some advantages, but there is a risk of insufficient disciplinary leadership and coherence. The Institute's socioeconomists indicate that they have adequate opportunity to interact with each other (and the number of co-authored publications is a positive sign), but attention should be given to ensuring that this interaction is structured and directed. The 2001 EPMR recommended the appointment of a senior economist to a disciplinary leadership/coordination role. The Panel suggests that IITA consider this suggestion seriously.

Impact assessment is of course a high priority throughout the CGIAR, and in the past few years IITA has devoted increasing resources to this subject. A recent document (*A framework for conceptualizing impact assessment and promoting impact culture in agricultural research*) outlines how the concept of an impact culture should inform all of IITA's activities. This culture comprises a broad platform that includes ex-ante assessment, on-farm evaluation, adoption studies and impact assessment. IITA economists have a good grasp of the literature and methods in this field and have made contributions in each of the areas.

Two of the staff are currently designated as "impact economists". IITA publishes an Impact Series (launched in 1999), which currently includes 11 studies, and a number of other institute publications document adoption and/or impact. Two documents in particular outline a framework for impact assessment and summarize the recent IITA work in this area. To some extent IITA must structure its impact analysis to suit the tastes of its donors, but it should ensure that any analysis provides as much useful information as possible to feed back into the planning cycle. In addition, priorities for impact assessment need to be carefully identified; there are many cases where competent and successful technology generation can lead to useful changes in production practices without necessarily providing sufficient evidence of statistically measurable "impact", especially as defined in some of the more ambitious impact assessment schemes.

A review document (*Achievements in Impact Assessment of Agricultural research: IITA experience, 2001-2006*) demonstrates a very wide range of relevant studies done by IITA socio-economists in the past six years, but the variety of products is in large part a function of the many different projects in which IITA has been involved and the shifts in research strategies it has employed. There is a need to ensure that IITA moves toward a more coherent set of objectives in which planning and assessment play a clearer role in establishing research priorities and attracting research funds. The four elements of the impact cycle/framework need to be linked to IITA's

management procedures rather than being a series of isolated analyses of different endeavors at various stages of the research process.

For ex-ante impact assessment, it is important that analyses are conducted at a level and scope that offer fairly immediate guidance to IITA's technical research agenda. (For instance, a criticism of the previous FOODNET project was that its market analyses had little immediate relevance for IITA research.) Current work includes the use of models for commodity sectors, production systems and research priority setting. For this work to be useful, other IITA scientists or partners should be able to interrogate such models to obtain relevant information for practical decision-making.

Adoption studies are an important element in the impact framework. These studies are important for demonstrating progress, providing feedback to biophysical scientists, and indicating where changes in strategy may be required. IITA socioeconomists have conducted a considerable number of adoption studies, although they have not always been structured and analyzed in a way that provides the optimum amount of feedback and guidance for research decision makers. Many are confined to the immediate areas of a development project's activity and often treat adoption as a yes/no variable rather than examining the detail of farmer adaptation. The unfortunate reality is that the requirements of journal publications are often inimical to practical adoption analysis as part of an on-going program of research.

In addition to the contributions of the socio-economists in planning, impact assessment and policy discussed above, there are several other areas of socioeconomic research that also deserve attention.

One potential contribution of the socioeconomists is in synthesizing the experiences of IITA's "pilot" projects. IITA needs to demonstrate that these projects provide robust and broadly applicable guidance for research organization or policy that would qualify as IPGs. A potential candidate for this kind of synthesis is the experience in promoting cassava and its industrial utilization. There seems to be a significantly broad set of examples, where (for instance) industrial promotion led to production increases (Malawi), ran into production constraints (Uganda), or did not elicit adequate commercialization strategies (Ghana). There is a constellation of issues that could be examined, including: appropriate varietal and crop management technology, marketing mechanisms, the balance between local and large-scale processing, and the degree to which subsistence and cash-crop production are synergistic or deserve separate treatment. A comprehensive synthesis could draw principles that development projects or national governments could use to better plan their activities for cassava promotion.

A second candidate for more socio-economics attention includes crop management issues, particularly fertilizer use. IITA was a key player in the recent Fertilizer Summit in Nigeria; and it should take advantage of this momentum and experience to synthesize the implications of IITA's considerable knowledge of soil fertility and fertilizer response in its mandate crops to provide clear guidance on fertilizer requirements, constraints and policies. The best place to start would be Nigeria itself, where IITA's involvement in several national crop production efforts provides an entry point for discussion of appropriate fertilizer policy; this might be done in collaboration with IFDC.

A third possible contribution of the socioeconomists would be to push forward IITA's interests in market development for its own products. It is somewhat paradoxical that IITA's interest in

market development seems to be focused more on output markets rather than input supply. The delivery of IITA products (seed, planting material, biocontrol products) has more direct links with the technical interests and expertise of the institute, and yet the involvement of IITA in these business areas seems to be minimal. There are current plans to examine the status of maize seed production and delivery in West Africa (including IITA's considerable experience with local-level seed production initiatives) and this is encouraging. Similar work is planned on soybean and cowpea seed in SSA. IITA has an immense amount of experience on the production and delivery of planting material of vegetatively-propagated crops, yet most development projects for these crops seem to develop their own ad-hoc schemes without reference to past experience. IITA could synthesize its observations and help move forward current debates on the relative importance of state, civil society and private sector roles in providing sustainable planting material supply for these crops.

A fourth possible area for socioeconomic analysis is the analysis of the delivery of crop management advice. The High Value Products project in particular is investing considerable resources in methods such as farmer field schools (FFS) and it may be an appropriate time for IITA to synthesize its experience with these crops to provide useful information on costs, benefits and alternatives for the efficient delivery of crop management information.

In summary: the Panel commends the recent increase in the number of socioeconomists at IITA, and welcomes their distribution among research sites. The socioeconomists have been involved in a wide range of tasks and are producing an increasing number of publications. But it is sometimes difficult to see how these analyses are contributing to substantive priority setting at IITA or helping synthesize IITA's recent experiences in technology generation. Part of the problem is a lack of research leadership, and a better mechanism for coordinating and prioritizing the activities of the socioeconomists. The re-establishment of the working paper series would contribute to disciplinary communication and help define priorities. IITA's economists need to develop a clear set of priority themes on which to build a reputation; and they need to contribute to the institute's planning and assessment of major investments in technology generation.

3.4.5 Other research-related cross-cutting groups

Biotechnology
Issues relating to this unit are addressed in Chapter 2.

Germplasm Health Unit
This unit has a very heavy responsibility – that of checking all seed and clonally propagated material coming and going from IITA, and sometimes for other institutions. It has service, research and compliance functions. Diagnosis and treatment (if necessary) of seed samples and viral indexing for clonally propagated materials are carried out. The Unit issues a Germplasm Health Statement, and ensures that germplasm consignments for export from, or imported to IITA are not infested or infected by pests, particularly of quarantine importance. The Unit can grow material under containment in Nigeria but is costly. The Panel was impressed by the purpose, enthusiasm and discipline of staff engaged in this Unit, and by its leader.

Geographical information systems (GIS)
IITA has a Geospatial Laboratory staffed by one core-supported IRS and national staff. The appointment of an APO to lead GIS activities in Tanzania is expected, but a second IRS position

remains unfilled and contingent on project funding. Most current GIS activities are covered under the Opportunities and Threats Project, and address issues such as mapping CMV or banana wilt incidence and spread, or the predicted effects of climate change. The unit has played an important part in helping identify representative pilot sites for the SSA Challenge Project using soils and climate information, and socioeconomic data such as population and distance from markets and roads. In WCA GIS services have been used to map socioeconomic data under the SAKSS project, and the distribution of geo-referenced collections of cowpea so similar environments can be investigated in order to fill gaps in collections. Remote sensing data accurate to 30-50 million resolution (Landsat 7) and biophysical data are readily available. Partners include GIS units in other CGIAR Centers, and data are freely shared among IARCs. Current limiting factors to output and application are not equipment but the time of the manager, who gets little time to initiate research. GIS capacity is provided also by NRS at headquarters and several outreach locations. Capacity building among IITA staff and NARS staff is largely in the use of GPS units to geo-reference experimental data. The Panel commends IITA on strengthening its geospatial capacity and its efforts to further augment IRS-level staffing under project financing.

Biometrics and statistics

Biometrics advisory services comprised of qualified NRS staff are available to scientists at headquarters and at several outreach locations. Common software packages (SAS; GENSTAT; SPSS) are available to scientists for data analysis by HQ and outreach staff. The Panel notes that the IRS vacancy resulting from the departure of the senior statistician has not been filled, and is concerned that the Center is not gaining the full benefit of newer techniques in spatial adjustment of data, in genotype x environment interaction analysis, and in the analysis of molecular information. This concern has also been voiced by several scientists during discussions. ***The Panel recommends that the position of senior statistician be filled as soon as possible.***

Research data management

Geo-referenced data from experiments and breeding plots are routinely entered into the IITA Data Management System (DMS), a server-based database maintained at Ibadan. Historical data from mandated crops for the past ~20 years is available on the DMS, which is fully compatible with the ICIS platform that has been widely adopted by other CGIAR centers. At present data from IITA's laboratory information management system is not a part of the DMS. The internet provides access to the DMS database from outreach locations, though access is restricted by password and areas of interest. Data enter the database through Excel files submitted by scientists to the Ibadan NRS database manager who is responsible for maintaining consistent definitions of variables and database integrity.

Crop and soil modeling

This is often used to test hypotheses, synthesize understanding about crop responses, and to predict effects of weather variability, climate change, or long term soil fertility trends on crop performance. It appears that IITA currently has no capability in crop and soil modeling. The Panel suggests that IITA place emphasis on developing this capacity in at least one key crop or in soils when hiring future APOs or project staff for natural resource management-related projects.

Biosafety

IITA has an institutional biosafety committee (IBC) constituted in line with Nigeria's National Biosafety Guidelines. The committee has five members, two from outside IITA. It is chaired by an IITA Deputy Director and one IITA staff member as secretary and biosafety officer. IITA has

adopted guiding principles for development and deployment of genetically engineered organisms (see Annex 12). IITA has worked closely with the Nigeria's Federal Ministry of Environment, providing inputs into the preparation of the national biosafety bill. IITA is also assisting Uganda, Tanzania and Malawi in the development of their biosafety bills based on this experience in Nigeria. The practical conduct of research at the BECA site is conducted under the aegis of ILRI's biosafety regulations.

3.5 Research Locations

The Team visited IITA offices and/or facilities in Ghana, Benin, Kano (Nigeria) Kenya, Uganda, Mozambique, Tanzania, as well as headquarters at Ibadan.

In general the quality of offices and office support was quite adequate. It exemplified IITA's policy of establishing full corporate support of outreach locations once the decision had been taken to post staff to the location. The quality of field facilities that staff relied upon for research did not limit their abilities to conduct relatively downstream components of R4D. Relatively small investments in laboratory facilities can significantly improve the depth of science and contribute to retention of high quality staff. The Panel was heartened to see excellent field and laboratory facilities at the majority of these locations where R4D is being actively practiced. In some cases IITA could advertise their presence in the country to greater effect. For example, in IITA's Ghana office there was no obvious sign or identifying mark indicating they were linked with IITA (or even STCP) on an office shared with Technoserve. In addition, research staff of Crop Research Institute (a leading NARS) were unfamiliar with IITA's staff or program in Ghana, and were requesting the appointment of a part-time IITA liaison officer from among their ranks. Cotonou as a research location continues to contribute uniquely to IITA's research portfolio, and has a critical mass of scientists working on biocontrol, and excellent physical facilities supporting such research. The loss of an agronomist from this location was noted, and the Panel asks that IITA consider ways in which this location can contribute more broadly to its research agenda in the derived savanna ecology. Mozambique was noted as a challenging working environment, but one where conditions were improving.

The more difficult question, however, is the balance between number of locations, critical mass of scientists at each location, and the possible dilution of research and research management resources at key centers such as Ibadan as further expansion in SSA takes place. Does expansion to ESA threaten strategic research activities of the center? Effective management of staff at outreach locations is easier today than 10 years ago, largely because of vastly improved telecommunications. Where staff are fully integrated with a progressive NARS organization, issues of critical scientific mass become less apparent because NARS partners provide the needed disciplinary mix, and Mozambique may be a good example of this principle. There was some evidence that expansion to ESA has diminished research capacity in WCA, and the Panel is concerned that similar effects may result from moving staff from one country to the next in quick succession. Key scientists have taken roles as Deputy Directors, and the travel to locations for research supervision inevitably is onerous, and has an opportunity cost to their research programs. Staff in other disciplines represented by only one or few IRS are stretched, and the resulting multi-tasking can result in a loss of depth in strategic research. The report has already alluded to strained relationships that can occur over distances, perhaps because of communication issues and competition for resources. On the other hand, representation in areas where major languages are spoken (French and Portuguese) also has some advantages in terms of technology transfer and inclusiveness.

The Panel suggests that research effectiveness and efficiency would be increased by having most scientists in one or two regional centers of excellence outside Ibadan. National research issues would then be handled through partnerships and extended visits. Exceptions to this principle should only be when crises develop that are country-specific but potentially regional in nature.

3.6 Science Support units

3.6.1 Computing services in Ibadan

The IITA computer system has evolved from a mainframe based system 12 years ago to a dispersed system of 16 servers on the Ibadan campus and two servers at most the main outreach location. Inventory is about 450 computers at Ibadan, 900 for IITA as a whole. The main factor causing breakdowns is the stop/start electricity supply. IITA Ibadan imports PCs as components from Taiwan and assembles them according to specific needs of the user. This reduces unit cost to about US$500, and servicing and repairs are done on site. Renting computers sometimes aids in overhead recovery on special projects, but there seems little opportunity for savings by this means at present.

Backbone wiring on campus is fiber optic, and the rest is 12 year-old cabling. At present the group are experimenting with one large central radio transmitter for internet access that will reach most campus locations. Computing services are led by an IRS, supported by trained NRS. The computer group responds to requests from programs for computers; there is no direct charge back to the programs. Operational databases (financial, procurement, assets, project management (ProMIS), and some H/R functions) are all handled on Oracle, but it is slow to access from outreach locations. In order to improve security, IITA is considering contracting backup storage at a location external to Nigeria.

Bandwidth is expensive in Nigeria, and IITA pays US$25,000 per month for its connection. Doubling the bandwidth available would make video conferencing and Netmeetings a real possibility – an important consideration with a geographically dispersed staff. An institutional policy on bandwidth is under development, as are plans for upgrading the computer system.

The Panel commends the computing services group for the standard of computer service offered at the Center, and for the bulk purchase of computers as components. IITA needs to continue to invest in adequate bandwidth. This would improve internal operating efficiency by improving response times, would increase the quality of teleconferencing, and may result in a reduced need for staff to travel.

3.6.2 Communications and Information Services

This unit is headed by one IRS and supported by NRS. In a recent reorganization 14 NRS positions were discontinued and seven new positions created, at a higher level. However, many of these positions, such as web editor, creative designer, and corporate communications manager are yet to be filled. The head of the unit currently spends 80% of his time on strategic issues, concerned primarily with the development of the IITA corporate image and internal communication. The remainder of his time is mainly spent on producing corporate publications.

Staff of the Unit have been involved in the development of software that facilitates internal communication – such as the development of online travel approval systems. Currently, the web

site is focused on providing access to information relevant to staff within IITA and in other CGIAR Centers. The Panel learned that only 4% of the hits on the IITA site were of African origin when IITA staff were excluded. In the future, the strategy is to provide information in response to client demand rather than providing IITA-generated information without regard for what is truly useful. The implementation of this strategy will depend on the appointment of staff to fill vacant positions.

The 5th EPMR proposed the development of a specific strategy for information dissemination and training (also echoed by the CCER of Project B), especially training for mid-career NARS staff. The Panel expresses concern that this Unit appears so strongly focused on IITA's corporate needs while materials needed for supporting training programs for NARS remain on hold. It urges IITA to fill the remaining IRS vacancies so the needs of NARS are more fully met.

3.6.3 Ibadan Research Farm

IITA has a large research farm at Ibadan that provides essential facilities for field experimentation. The efficiency of field experiments is a direct reflection of the within-replicate uniformity and general vigor of plant growth. The Panel was informed that support for the conduct of the field research program (irrigation; application of pesticides; land preparation, etc) was timely and of an acceptable standard. The farm has however been under cultivation for at least 35 years, and a number of fields are depleted. The Panel suggests that management of the farm embark on a program of systematic rehabilitation of these fields, using judicious combinations of green manure, chicken manure and synthetic fertilizers to stabilize and increase soil organic matter, and restore soil uniformity and productivity.

3.6.4 Laboratory facilities and screen houses in Ibadan

IITA has a considerable amount of laboratory space. There are a number of laboratories included in this group. These include biotechnology, soils and fertilizers, food quality, microbiology, pathology, entomology and viral indexing. The physical facility in most cases is now more than 30 years old, and equipment, while adequate for most of the requirements of the research program, is in some cases rather dated. There are some notable exceptions (Biotechnology; Plant Health and Microbiology), but the Panel raises the question of whether these facilities are generally of a standard to attract cutting edge scientists in fields such as soil science and soil chemistry, and urges IITA to consider outsourcing non-strategic laboratory services whenever a supplier can be identified in Nigeria and when quality can be assured.

3.7 Capacity Building

During the discourse with the EPMR Panel it was clear thatIITA recognizes the training needs that accompany its research activities. From its inception, IITA has supported both formal and non-formal training activities from its core budget as part of its strategy to improve food security and reduce poverty in Africa. IITA training activities have been guided by the overall goal to strengthen the capability of scientists and technicians of national agricultural research systems (NARS) to conduct the research and training necessary for agricultural development in their own countries. Further, IITA training activities facilitate research collaboration between IITA and NARS. IITA's comprehensive strategy for training comprises graduate research, individual attachments, and development and distribution of group training course materials.

The present realities of declining research and training budgets calls for the reassessment of the present approach to training. Future training must be service-oriented and must provide the

opportunity for skill-based professional capacity development and enhancement for NARS employees and for graduate students of agriculture to develop their professional skills. Training at IITA has undergone major transformation, moving away from the traditional IITA based training format to a decentralized and more field based training. IITA has adopted three key approaches as a means of ensuring that it continues to contribute to the pool of effective NARS researchers. The new plan will be effected through the Professional Capacity Advancement Program, Graduate Research Program and Short Term Courses.

The Professional Capacity Advancement Program (PCAP): targets professionals from partner national research institutions and universities. A Visiting Fellows (VFs) program will target BSc or MSc degree holders with several years of experience and fresh PhD degree holders who will be assisted to conduct research in areas similar to those of IITA scientists. The VFs will work as part of a team. The Training Unit, together with the IITA host scientist, will ensure quality management of the learning process. Appointments will range from 6 to 18 months, depending on the availability of funds and the type of research project.

Graduate Research Program (GRP): The long-term goal is for the IITA-trained researchers to take up positions in research institutions in their home countries. Areas of study provided by IITA scientists will be an integral part of a continuing IITA projects and will be widely advertised.

Short-term Course (STC): Scientists identifying a critical need for training of research collaborators may propose courses that will be packaged and advertised by the Training Unit.

IITA will continue to explore with relevant institutions (universities, development agencies, NGOs, CBOs, NARS) partnership ventures with donor support for training materials production and adaptation, and development of on-line resources, CD-ROMs, interactive tutorials, and the joint organization of courses, workshops, and conferences. An example is IITA's Social Sciences Laboratory in Cotonou, which provides computer access to trainees who are learning analytical techniques. IITA is in the process of developing a series of 10 5-day training modules on various subjects that can be offered to national scientists; major effort to date has been on the development and delivery of a module on impact assessment.

During the course of this EPMR, Panel members interacted with various NARS at country locations where the issue of training was repeatedly raised by the NARS members. In general there was recognition of the active role that IITA has played in training but at the same time the NARS decried the currently diminished training opportunities. From the perspective of the NARS they linked training to both program and institutional sustainability and the need to avoid erosion in both areas.

Summary: The Panel notes the general reduction in funds which support traditional training. Nevertheless, the Panel would like to encourage IITA to continue the dialogue and engagement with donors and national governments, as well as NARS, in relation to the identification of innovative training support, and to ensure that it considers the type of training activities that will allow NARS to acquire the new skills that are required for the R4D approach.