

ANNEX 1. STAKEHOLDER CONSULTATION REPORT (Revised)

Theme 7 of the CRP-RTB aims to enhance program impact through its partnerships. To fully exploit this potential, the process of partnership building and management needs to be an integral part of the programmatic planning. In the context of this theme and as a part of program design and proposal development, a stakeholder consultation was commissioned by the four participating CG Centers: Bioversity International, CIAT, and IITA.

To facilitate this involvement of stakeholders, an inter-center taskforce for the stakeholder consultation was set up. The taskforce, supported by a consultant, led the design and implementation of a series of on-site regional workshops, interviews, and a Web-based survey, as well as the management of their associated data. These initiatives took place from 9 to 15 August 2010, during which the proposed CRP-RTB was presented, discussed, and enriched with a wide range of stakeholders, partners, donors, next- and end-users, and target groups. Participants had the opportunity to discuss and contribute to different thematic and programmatic features of the CRP-RTB—its goals, principles, objectives, and potential bottlenecks.

Through their participation, stakeholders provided invaluable input into the design of this CRP, presenting their ideas, concerns, needs, and priorities. This information, synthesized in the following report by the consultant, helped guide us in the development and refinement of the proposal. These efforts and feedback reflect one of this CRP core commitments to engaging RTB stakeholders in order to shape an R4D framework that is truly collaborative, dynamic, and responsive to all the actors who will play a part in its research, programming, and impact.

Stakeholder consultation on CRP-RTB: Roots tubers and bananas for food security and income

1. TYPES AND BREADTH OF CONSULTATION

The stakeholder consultation used four different sources of information:

- Seven regional stakeholder workshops attended by a total of 100 participants from 27 different countries
- An on-line “regional” survey for national and regional partners (prepared in English, Spanish and French) that was answered by 181 people, of whom 79 had attended a workshop.
- A shorter on-line survey for “global partners” from advanced research institutions, policy makers, donors, industry, farmer associations, NGOs and other international players that was answered by 47 respondents
- A total of six one-on-one interviews focused in Indonesia, China and PNG.

The information presented here is thus synthesized from a total of 255 stakeholders representing approximately 200 different institutions¹. The response to the consultation was outstanding considering the short time scale. Stakeholders’ enthusiasm to contribute to the proposal and the CRP itself was shown by attendance at workshops, the survey response rate and the quality of information offered. Open questions received replies from as many as 150 out of 228 survey respondents, many of them extremely detailed, novel and thoughtful; all these enriched the proposal. Such information stretches to more than 100 pages that were supplied to the proposal writers. Of necessity what is presented here is only be a synthesis that highlights the most important ideas and recommendations about the proposal.

The number of participants in these consultations is summarized in the two tables below by region of action and by type of institution. Twenty percent of survey respondents (46 out of 228) were women; ages of all respondents ranged from less than 30 years old, to more than 70, with a median of 40-49.

Main geographical area of action	Regional workshop* (countries represented)	Regional survey (attended workshop)**	Regional survey (did not attend workshop)	Global partner survey	Interview	Total
West Africa	13 (4)	13	26	1	0	40
East and Central Africa	11 (3)	7	12	0	0	23
Southern Africa	14 (5)	0	2	0	0	16
Total (Africa)	38 (11)	20	40	1	0	79
Total (Latin America & Caribbean)	19 (10)	19	26	2	0	47
South, West & Central Asia	29 (3)	26	3	0	0	32
Southeast & East Asia & Pacific	14 (3)	14	19	1	6	40
Total (Asia)	43 (6)	40	22	1	6	72
Total (SH with global action)	0	0	14	43	0	57
Total stakeholders consulted	100 (27)	79	102	47	6	255

Notes to table: * Counts of workshop attendance do not include staff of the four CGIAR centers that initiated the CRP-RTB. One country, Uganda was present at workshops in two different regions.

** Not double-counted in total stakeholders consulted

¹ An exact count of institutions, since there was more than one respondent from some institutions, and countries represented among all consultation methods will be possible once a consolidated of all stakeholders has been prepared.

Type of institution to which respondent belongs	Regional workshop	Regional survey (did not attend workshop)	Global survey partner	Interview	Total
NARES (developing country)	65	32	3	6	106
University (developing country)	4	23	1	0	28
Advanced research institution	0	0	24*	0	24
Donor	4	7	8	0	19
Policy/development institution	3	11	3	0	17
Farmer organization	5	9	1	0	15
Commercial input supply, product processing or marketing	6	5	3	0	14
NGO	5	6	2	0	13
Regional research organization	6	3	0	0	9
Other international public organization	1	6	1	0	8
Other CGIAR Centre	1	0	1	0	2
Total	100	102	47	6	255

Note to table: * 12 are universities in the North; 12 are other research institutions in the North

The objectives of the consultation were to inform stakeholders about CG reform (if they didn't already know) and about the CRP-RTB and to obtain their "buy-in". More importantly, to capture their perspectives on the design and implementation of the CRP, including (a) evidence that they support the proposal in general and wish to be a part of it; (b) fresh ideas on how the proposal might be made more convincing, especially in the area of achieving impact; (c) suggestions on how partnerships, gender/youth strategy, communications/information and capacity strengthening can best function in practice and (d) specific indications on how their institution, and others, should be involved. All of these were achieved.

In workshops, all of which had a similar design, brief initial presentations familiarized the participants with the CGIAR reform and with the outline plans for CRP on RTB. They then discussed whether all themes were relevant, whether others were needed and the principal outputs they expected from each theme. They discussed how to achieve impact and in particular whether and how the four cross-cutting topics (enabling partnerships, gender and youth, communications and information sharing and capacity strengthening) would be useful in that.

Results from all the consultation methods are presented here using the outline of the "regional" on-line survey. The global survey was simpler, in recognition of the time limitations of those answering.

2. THEMES AND FUTURE AGENDA

Participants considered all themes important. They pointed out that climate change, although recognized in its own separate CRP, was an important part of all themes, especially 1, 2 and 4. RTB crops are adapted to a wide range of agro-ecologies and this is important in the face of climate change. The West African workshop proposed two additional themes to give more emphasis on added value (Theme 6) for small enterprises, including business development, credit and finance, insurance, trend analysis, market information and specialized capacity building. The East African workshop suggested a specific additional theme on capacity building and communication and another on data management and sharing across all themes.

The themes – and all other concepts in the surveys - were each scored on a 0 to 5 scale (where 0 meant "not important" and 5 meant "very important") by respondents in the regional survey (n = 175 to 180) and the global partners survey (n = 39 to 42). All themes ranked as important, but the order of priority was informative. It is possible that in the smaller group of global partners, strong opinions by some respondents, particularly specialists from ARIs, may be reflected in the means.

	Regional survey	Global survey
Theme 2: Accelerating the development, delivery and adoption of varieties with stable yields, stress resistance and high nutritional value	4.60	4.55
Theme 6: Enhancing post-harvest technologies and adding value in markets	4.58	4.22
Theme 4: Promoting sustainable systems for clean planting material for farmers	4.51	4.38
Theme 1: Conserving and accessing genetic resources	4.42	3.81
Theme 3: Managing priority pests and diseases and beneficial microbial communities	4.29	4.24
Theme 7: Enhancing impact through partnerships	4.33	4.00
Theme 5: Developing tools for more productive, ecologically robust crops	4.12	4.05

The distribution of scores for all survey respondents - that is, combining data from the regional and global surveys - shows the large differences in number of respondents that lie behind these relatively small differences in mean score. Despite that, the themes are clearly all supported by the vast majority of stakeholders since in every theme 78 to 91% award 4 or 5 on a scale where 2.5 is the mean. Even for this type of survey where low scores are unusual, this is a very positive result².

	No. of respondents awarding						Mean score
	0	1	2	3	4	5	
Theme 2: Accelerating the development, delivery and adoption of varieties with stable yields, stress resistance and high nutritional value (n=220)	0	0	2	18	48	152	4.59
Theme 6: Enhancing post-harvest technologies and adding value in markets (n=219)	0	0	3	18	62	136	4.51
Theme 4: Promoting sustainable systems for clean planting material for farmers (n=219)	0	1	6	18	54	140	4.49
Theme 1: Conserving and accessing genetic resources (n=217)	0	2	11	28	55	121	4.30
Theme 3: Managing priority pests and diseases and beneficial microbial communities (n=220)	0	0	8	26	83	103	4.28
Theme 7: Enhancing impact through partnerships (n=215)	0	0	6	32	74	103	4.27
Theme 5: Developing tools for more productive, ecologically robust crops (n=219)	0	2	9	36	88	84	4.11

Several comments reflected that the connection between research and livelihoods was not clear in the theme agenda. Many respondents suggested a stronger production- or livelihood-systems approach, including participatory action research. This is a dilemma for proposal drafting because of the division of labor among CRPs. Other comments showed that respondents had not clearly perceived from the theme titles the inclusion of natural resources management, storage and processing.

There were also diverse, detailed suggestions on each theme that focused on sharpening the research agenda and methodologies (see box below), and on a question about innovative, futuristic research. These have been taken into account during redrafting.

Examples of suggestions for strengthening specific themes

Theme 1: Gene banks in active interaction with R&D and not as “museums”; reward/fund small farmers for in-situ conservation of genetic diversity

² According to the Kruskal-Wallis test, mean scores fall into three groups: Themes 2, 6 and 4; Themes 1, 3 and 7; Theme 5. Mean scores of members of the same group are not significantly different from each other at the 5% level; but are significantly different from those of all members of other groups. In all data in this report, total counts of responses (n) do not include those who gave no opinion.

Theme 2: Some support for consideration of GMOs in bio-fortification, pest and disease resistance and other desirable traits; develop information on tagged genes; other methods of molecular science; incorporate banana genes from wild species through cisgenics.

Theme 3: Should be broadened to include other abiotic factors, not just pests and diseases; develop forecasting and decision support systems – maybe web-based where connectivity permits this; partners are very worried about emerging pests and diseases.

Theme 4: Develop protocols for rapid high-volume production of quality planting materials (linking formal and informal systems); primary focus of strengthening farmer-based seed systems; make visible the connection between seed production and climate challenges.

Theme 5: Use of agro-industry residue of RTB crops for soil improvement; consider organic production of RT crops; inter-cropping with legumes for soil fertility improvement; small-scale mechanization for some regions, including Africa; extract best practices and lessons on sustainable/resilient farming systems from previous projects.

Theme 6: Explore wide range of potential products not just from cassava; explore zero-waste post-harvest and processing systems; transformation of RTB crops to drivers of economic development; emphasizing high-quality carbohydrate content of root crops..

Several stakeholders suggested ways to increase RTB impact:

- Accepting “the need for a more holistic program beyond technology development, where other non-traditional (sometimes neglected) partners have a role in its definition.” (Staff member, international public organization)
- Ensuring that “the program is a single entity not an unconnected group of scientists working on vastly different crops.” (Government research scientist, North America)
- With a “mechanism to allow donor money to fund CGIAR-NARS-Private Sector partnerships, i.e., some funds must flow through CGIAR to the other partners to create coordinated umbrella programs. Currentlywe are concerned that CGIAR will use its 'international public good' rhetoric to shy away from engaging fully with partners for development and deployment of new varieties.” (Representative of a donor organization)
- “Focus on the things which work and can be delivered and adopted now. Each crop will need a champion to drive the development of these crops in many parts of the world. ...If you do not know where you are going you will not get there.” (Leader, Australian University Research)

Another question asked how to develop a joint agenda and raise the profile of RTB crops. Answers mentioned needs assessment; strengthening researcher capacities to diagnose and analyze problems; identifying gaps and setting objectives; regular consultation workshops; advocacy at high level policy fora; linking to global platforms; and better highlighting of successful case studies. Representatives of agro-industry asked whether the only targets were poor producers and consumers, or whether new consumer markets and new producers in strategic alliances were also part.

3. CROSS-CUTTING TOPICS

Respondents were asked to score cross-cutting topics. Capacity strengthening and communication/information attracted higher priority than partnering and comprehensive gender strategies; regional and global respondents agreed on the relative importance of the four topics. Analysis of women’s responses showed that they too tend to place less emphasis on “comprehensive gender strategies” than the other cross-cutting topics. Comments suggest that the lower scores are partly because of concern about creating an isolated gender topic, whereas most stakeholders would like to see mainstreaming of gender concerns.

	Regional: All (n=170-179)	Global: All (n=38-42)	Regional: Women (n=34-37)	Global: Women (n=8-9)
Strengthening people’s capacities in research for development	4.64	4.32	4.70	4.50
Promoting communication & information sharing	4.46	4.15	4.56	4.63
Exploring new ways of partnering	4.13	3.89	4.27	4.22
Comprehensive gender strategies	3.86	3.50	4.08	4.38

The following data for regional and global surveys combined show the number of respondents awarding each score. Depending on the topic from 62 to 92% awarded a score of 4 or 5.³

	No. of respondents awarding						Mean score	n
	0	1	2	3	4	5		
Strengthening people’s capacities in research for development	0	0	3	12	56	140	4.58	211
Promoting communication & information sharing	0	0	4	22	75	117	4.40	218
Exploring new ways of partnering	0	4	5	40	86	81	4.09	216
Comprehensive gender strategies	0	4	12	68	79	58	3.79	221

Respondents emphasized the importance of capacity building and the need for a clear research- policy connection, including pressure to upgrade government investment in RTB crops as important food sources and opportunities for small-scale value addition; one respondent stated that biophysical issues need to be translated into political ones for policy makers to take them seriously.

4. PARTNERSHIP APPROACH

“The quality of the relationships between partners has to be improved, define rights and responsibilities, improve communication. Partners need to meet, not only rely on internet” (RTB regional workshop, Cali, August 2010)

All nine actions included in the proposal for developing effective partnerships were considered important by respondents according to the regional survey and the global survey.⁴ Two of the other topics, closely related to partnership building were ranked highest, followed by translating research results into policy advice, development of public-private partnerships (which were rated slightly higher than public-civil society partnerships) and identification of poverty hotspots.

³ The four mean scores are all significantly different from each other at the 5% level according to the Kruskal-Wallis test.

⁴ Strictly a test of statistical significance would be needed in order to make statements about stakeholders in general rating characteristics in the survey “similarly”, “lower” or “higher”. This was not possible for all data in the time available for this study. The results from those tests that were conducted on themes, topics and statements about gender allow an estimate that differences in mean score greater than 0.5 are likely to be significant at the 5% level for the sample sizes of approximately 160 in the regional survey and that mean score differences greater than 0.9 are likely to be significant for the global survey.

	Regional survey (n=166-178)	Global survey (n=36-41)
Communication and information sharing	4.52	4.20
Capacity strengthening in research-for-development	4.50	4.39
Learning to translate research results into policy advice	4.46	3.94
Develop public-private partnerships	4.46*	3.88
Identification of poverty hotspots where RTB target crops can help with poverty alleviation and income generation	4.45	4.12
Strengthening networks for prioritizing research needs	4.35	4.03
Develop partnerships between public sector and civil society	4.34	3.74
Outcome and impact assessment	4.32	4.10
Building learning alliances using Participatory Impact Pathway Analysis	4.14	3.72

*By error, this question was only asked in French and Spanish translations (n=54)

Other suggestions and comments about building strong partnerships for the CRP included:

- Linking North and South expertise to develop strong partnerships (European university professor)
- Eliminating duplication and competition between centers (a donor representative)
- Treating partners as equals, and not as secondary players, especially in delivery of results to poor farmers, where the CGIAR system does not have comparative advantage. (International NGO leader, Africa)
- Using regional research centers based on NARS for developing locally adapted technology. Less "on station" work, more networking, more participatory research
- Following the CLAYUCA consortium model to create networks of users, producers, industry players with research centers, closely linked to value chains and public policy. (Latin American policy maker)
- Developing mechanisms to get commitment from local government (Latin American researcher)
- Inter-regional and inter-continental exchange of technology (European university researcher)

One respondent cautioned: "Once the Program is approved, it needs a single organigram of all people involved across all involved CG centers to effectively execute the work, i.e. a new virtual centre, so to facilitate communication. It does not work if we keep on copying all documents to everybody"

Respondents in the regional survey also assessed the importance of several methods for building effective partnerships among people and institutions with the following results (n = 164 to 175)

<i>More important</i>	
Involve the right people and organizations	4.68
Transparent decision making and communication	4.64
Agree clear, shared, flexible objectives that reflect stakeholders' diverse interests and needs	4.54
Share recognition and responsibility for outcomes	4.37
Agree supervision responsibilities across institutional boundaries	4.31
Agree guidelines about how responsibilities are assigned	4.29
Make impact pathways explicit	4.20
<i>Slightly less important</i>	
Agree team standards for response time, sharing credit and time investment in discussion	4.03
Agree conflict resolution processes	3.98
Allow time for development of trust and a common language	3.97
Give leadership responsibilities to non-CGIAR partners	3.84
Clarify expectations about time investment in decision making	3.88

5. GENDER AND YOUTH STRATEGY

To gauge the situation of women and young people, regional survey participants were asked their degree of agreement or disagreement with a series of statements. Respondents saw stronger opportunities for women than for young people in RTB crops. They considered that networking was more likely to help women's livelihoods in post-harvest technology and market opportunities than in seeds and cropping systems. They did not necessarily agree that women were likely to lose if value chains were developed commercially.

	strongly disagree (0)	disagree somewhat (1)	neither agree nor disagree (2)	agree somewhat (3)	strongly agree (4)	Mean score and interpretation
1. Rural women in my region have livelihood opportunities in RTB	7	4	8	59	86	3.30 (agree more than somewhat)
2. Young people in my region have livelihood opportunities in RTB	7	12	19	69	54	2.94 (agree somewhat)
3. Strengthening networks for women to share knowledge on seeds will improve livelihoods in my region	3	7	16	55	86	3.28 (agree more than somewhat)
4. Strengthening networks for women to share knowledge on cropping systems will improve livelihoods in my region	2	4	12	67	84	3.34 (agree more than somewhat)
5. Strengthening networks for women to share knowledge on post-harvest technologies will improve livelihoods in my region	4	2	6	52	104	3.49 (agree quite strongly)
6. Strengthening networks for women to share knowledge on market opportunities will improve livelihoods in my region	2	1	10	49	108	3.53 (agree quite strongly)
7. Women's roles in livelihoods, household and community are at risk of displacement in my region when RTB value chains are developed	44	35	28	32	18	1.65 (disagree a little)
8. In my region, when RTB crops are grown commercially, men dominate decision-making and control of income	16	25	28	49	39	2.45 (agree a little)

Methodologically, the wide range of answers, depending on the statement, indicated that respondents' high scores on other questions in the survey did not represent lack of discrimination among the alternatives, but genuine support.⁵

In order to strengthen gender and targeting in the proposal, several open questions were asked about the situation of the poor, and of women and young people, and about using RTB crops to improve that. One donor emphasized focus: "[We need to] create clear criteria for prioritization based on ex-ante assessment of potential benefits to the poor, then apply those criteria to prioritize ruthlessly, concentrating funding and efforts on a smaller number of important projects, resourced to succeed." The leader of an international NGO in Africa said: "I believe the most urgent action is to develop the seed and agricultural extension systems (through public, civil society and/or private sector approaches) that will effectively deliver technologies to women farmers."

In many root crops, especially in Africa (where yams are the exception as a "men's crop"), women play a major role in production and commercialization. In general young people do not see opportunities in agriculture; one respondent suggested arranging for both women and young people to receive certification of their abilities and knowledge so as to add status to that. Several respondents in Africa commented that women are more ready to try out new methods, but may be limited in their access to land. In many regions in all continents, women are already the main rural workforce because men and young people have migrated to find work.

⁵ A Kruskal-Wallis test showed that the mean answers for the following groups of statements were not significantly different from each other at the 5% level within each group, but that all other pairs of mean scores were different: statements 6 and 5; statements 5 and 1; statements 1, 4 and 3.

A common idea in comments is that developing RTB crops in value chains can strengthen livelihood opportunities for the whole family – women, men, older people and possibly young people, reducing migration to cities. This is also seen by some as a way to ensure that well-intentioned but misguided help to some groups, to the exclusion of others, does not result in jealousy and increased domestic violence. Improved post-harvest handling and storage of fresh produce is a way to increase family food security. It should be seen as separate from, although often complementary to, processing; the two need to be viewed and evaluated separately in research for development.

Developing opportunities for families requires (to quote one respondent) “work on all levels at the same time - policy, research, capacity building, education, training, extension, etc. Listen to advice from local stakeholder groups and involve local stakeholder groups from the beginning. Develop generic methods and tools that can work across crop systems.”

Reflecting the wide range of opinion of the last two questions in the table above, the comments on small-scale enterprises for value-addition show an interesting debate between the majority who consider them an important opportunity for women and a minority who are concerned that if these crops become more commercial it will displace women farmers. A North American university professor commented: “I think there is just a need to raise the awareness of development issues in general. From one perspective we are better off not having RTB too high on the radar of the developed world. If they do more to commoditize these crops those who are not powerful in the commodity markets will suffer.”

Women and rural youth can be motivated if an agricultural micro-enterprise, preferably owned by them and for which they can receive micro-credit, is economically viable and intellectually satisfying including not just agro-processing but production of quality planting material; production of biocontrol agents and growth-promoting bacteria; vermicomposting; and developing new food products and recipes.

Examples where women and young people already take leadership would be worth mentioning in the proposal: In Costa Rica, support to women and young entrepreneurs begins at schools, colleges and universities. Women are recognized as potential leaders; there are National Rural Youth programs that, among their initiatives, produce RTB crops. In the Andean Region, women and young people are leaders in the production of lesser-known Andean root crops (*rubas, nabos, ibias* and native potato varieties).

Other ways suggested to develop the roles include hiring women in management roles for civil society; and offering management responsibilities to young scientists from the South.

Women respondents’ priorities, when re-analyzed separately, agreed quite closely with those of the whole on most issues, but they gave more emphasis to separate monitoring of early adoption; staffing strategies to encourage gender-responsive research; research awards for women; and establishment of gender focal points. They gave lower priority, however, to reducing drudgery than men did.

One male NGO leader commented: “I have scored several of these lower, not so much because they are bad ideas, but because they can become camouflage for covering gender issues, whereas the objective should be mainstreaming gender issues.”

Participants also scored the importance of a number of actions as part of the gender strategy of the future CRP:

	Regional: All (n=146-162)	Global: All (n=28- 33)	Regional: Women (n=31-36)
<i>More favoured actions as part of gender strategy</i>			
Incorporation of female farmer needs into research priorities	4.28	4.28	4.53
Research grants for addressing the gender dimension of RTB production and post-production	4.15	3.48	4.41
Reduction of drudgery in RTB crop production and processing	4.12	3.67	4.09
Capacity strengthening in gender-responsive research for partner organizations	4.10	3.51	4.31
Understanding gender differences in growing, consumption, preference and use of RTB crops	4.00	4.06	4.43
<i>Less favoured actions as part of gender strategy</i>			
Development of a staffing strategy to enable partners to conduct gender-responsive research and development activities	3.97	3.36	4.32
Gender audit (i.e. during design and major project milestones, review which interventions are effective in achieving gender equity and which are failing)	3.83	3.46	4.09
Research awards for women researchers in RTB	3.93	3.46	4.31
Support establishment of gender focal points in partner organizations	3.80	2.96	4.18
Separate monitoring of early adoption by women and men	3.73	3.55	4.23
Gender review panel composed of specialists	3.71	2.76	4.00
Separate focus group discussions in project areas with women, men and young people	3.58	3.21	3.88

6. COMMUNICATION AND INFORMATION SHARING

Detailed open and closed questions on communication and information sharing covered content, audiences and methods. With three exceptions in the global partner group, respondents rated all types of information content as very important to the Program.

	Regional (n=158-163)	Global (n=35-37)
Research findings	4.67	4.39
Best practices, promising strategies	4.65	4.32
Industry situation in RTB, including trade, value chains, industry players	4.58	3.94
Enhancing capacity development	4.53	4.16
Informing policy makers, development practitioners and farmers	4.46	3.94
Specific program information	4.45	4.05
Scientific content on specific crops	4.43	4.16
Information about partners	4.22	3.56

Several respondents noted that it is difficult to generalize about content; what is needed varies hugely by audience, and the specific objectives of the communication. Other comments emphasized the need to communicate research findings to end users and to communicate clearly the objectives, opportunities for participation and expected benefits to end-users of this new CRP.

Suggestions of opportunities for filling gaps included (from a university professor in Nigeria) retrieving “lost” information that is scattered in journals that are not accessible to many workers; and (from a university professor in Bolivia) setting up a virtual library that would, among other opportunities, give incentives for publications relevant to families, women and children – stories, legends and recipes connected to RTB crops.

The preferred modes of information exchange (asked only in the regional survey, n=151 to 164) were Email (mean score 4.60 out of a maximum of 5), a website (4.47), face-to-face meetings and training (4.43) and site visits (4.27). Slightly less preferred were regular newsletters and updates (4.17), pamphlets, brochures and written materials (4.13) and low literacy materials (4.06). Blogs and other social media (3.51) and telephone or conference calls (3.38) were much less preferred, especially because of problems of connectivity and cost of services in many countries. Farmer organizations and the private sector rarely see CGIAR websites; if they are to be used, more publicity and linking is needed. Radio was suggested as a medium by many, with a need to take care to simplify technical language and support efforts in local languages. Here as in capacity strengthening (see below) a question arises about how a focused CGIAR program should link to others who work with broader audiences.

There was a very wide range of practical suggestions in response to a question about existing communication networks/platforms, audiences, resources, venues or opportunities with which this mega-program should be connected.

7. CAPACITY STRENGTHENING IN RESEARCH FOR DEVELOPMENT

Respondents in the two surveys agreed very closely about the types of institution that most need formal capacity strengthening for their staff in this RTB mega-program.

	Regional (n=152-161)	Global (n=33-35)
National research institutions (including universities)	4.65	4.20
Farmer organizations and/or individual farmers	4.37	4.29
National extension institutions	4.32	4.11
Seed growers, product traders and processors	4.29	3.94
National development institutions (including NGOs)	4.07	3.83
International institutions	3.74	3.40

The high ranking of need for capacity building of farmers and extensionists presents a dilemma about how far the responsibilities of this CRP should extend. Several comments highlighted the need for the whole range of partners to be strengthened, but realized the limitations of research investment. As one asked, “is the issue capacity strengthening in implementing the research or in using the outcomes of research efforts?” Other comments on this issue:

- Developing national capacities seems the most important. Extension services are an absolute “must”, but they are probably too far down the chain to support them strongly through the CGIAR. They certainly need support, but not exactly by funding lines for research. (A donor representative)
- This largely depends where the program wants to situate itself. The weaker the national research institution, the more linkage to other institutions is required. At the same time, I am not sure that it is possible to emphasize so much the capacity training of farmers, for example, without sacrificing the program's own research capacity. This in turn might lead to capacity strengthening using outdated technology, for example” (North American government researcher)
- "National extension institutions" can too easily be interpreted as just the public sector. It is important to start with an analysis of what institutions can effectively provide services to poor women farmers, and then make decisions about which institutions to support. (African NGO leader)
- Our focus is on mass production, so the more people who get training the better. (Researcher, Philippines)

Suggestions about capacity building of researchers included attracting scientists from the South, who are presently in the North, to key positions in research centers located in developing countries; giving more opportunities for NARI scientists to work in advanced laboratories; and tutoring university professors in RTB issues so that they do a better job of training their students. The Earth University (Costa Rica) entrepreneurial development model was suggested as useful; it is not exclusive to RTB.

Asked more specifically the areas of expertise in which capacity strengthening is most needed for this RTB mega-program to be effective, regional respondents rated all the following as important; global partners rated some less highly, possibly reflecting the interests of ARIs who form half the group.

	Regional (n=154-162)	Global (n=34-35)
Postharvest technology and adding value in markets	4.66	4.26
Sustainable systems for clean planting material for farmers	4.55	4.39
Accelerating the development, delivery and adoption of varieties with stable yields, stress resistance, and high nutritional value	4.54	4.52
Linking RTB research with nutrition programs for delivery	4.48	3.71
Strengthening agriculture extension and seed systems for impact on women farmers	4.46	4.03
Ecologically sound crop management, including response to climate change	4.40	4.18
Managing priority pests and diseases and beneficial microbial communities	4.31	4.34
Conserving and accessing genetic resources	4.27	3.74
Enhancing impact through partnerships	4.25	3.79

Asked about capacity strengthening methods for this CRP, respondents from the two surveys agreed quite closely on the order of priorities, with stronger differences visible among global partners.

	Regional survey (n=151-158)	Global survey (n=27-35)
<i>Preferred methods</i>		
Design and Delivery of Training programs or courses	4.45	4.00
Fellowships for students and professionals	4.44	4.14
A research and learning network (virtual dialogues, conferences, etc)	4.31	3.61
Development or better utilization of learning tools and resources	4.26	4.11
<i>Less preferred methods</i>		
In-person network conferences	4.16	3.69
Shared M&E system applied to capacity strengthening	4.10	3.23
Capacities and Needs Assessment Platforms (tools for capacity strengthening professionals)	4.08	3.77
<i>Non-preferred methods (especially by global institutions)</i>		
Publications in capacity strengthening	4.03	2.97
Digital Learning Resources Knowledge Bank	3.88	2.90
Online Training Courses	3.58	2.60

8. KEY QUOTATIONS

Alongside many expression of support for the program in general, a number of comments provided challenges which we share here.

There is a need to go back to the future and rediscover the importance of diversity in production systems to secure their resilience, and to work on management practices which meet livelihood and social aspirations. The innovation will come in social and economic sustainability in the system alongside sustainable production practices. (Staff member of an international public organization)

Based on the documentation given for this program, it is difficult to see how those themes and the outputs coming from the different themes link to the different livelihood options of the farmers and farming communities it is targeting. Why improve productivity and why should farmers adopt those technologies? (A NARES coordinator, Asia-Pacific region)

I am of the view that to make impact on poor producers, the challenge now is making available several already-developed improved varieties to them through a more aggressive technology delivery and extension

system as well as market outlet, including upgrading extension and micro-credit and risk mitigation schemes (Leader of a West African NARES).

It is not possible to construct competitiveness without innovation and technology. Information management is indispensable and must be accompanied by an innovative communication system. (President of a Latin American farmer association)

RTBs are not usually well positioned within agricultural extension, as decision makers do not have a full appreciation of their true importance. Quality data on true level of production, perhaps through remote-sensing methodologies, is an essential starting point (Leader of an International NGO, Africa)

National institutions are very neglected because budgets are low, which is why they often have no capability. (Female researcher in an Andean country)

Stimulating and strengthening farming systems seems to be a good approach, especially for Africa, where RTBs are of very important. If "known" good varieties/crops could be made available to the farmer, if post-harvest losses could be reduced and "best practices" used, poverty could be reduced substantially. (A donor representative)

In principle this is a good idea. However the execution of such a program is challenging and takes real leadership to make it happen and close the enormous yield gap which currently exists in these crops. A focused approach is needed, not trying to do too many things in too many parts of the world without making any real difference. A long term strategy is needed: 10-50 years instead of the usual 5 years or so. (University research leader, Australia)

ANNEX 3. ESTIMATION OF THE NUMBER OF FARMING HOUSEHOLDS AS BENEFICIARIES (Revised)

The estimation of the number of poor beneficiaries of the CRP-RTB is based on publicly available information (mostly FAOSTAT data or Centers' reports) on area under crops per country. Taking FAOSTAT area data (Centers' estimates if available to correct information), the proportion of area grown by poor farmers was estimated for each crop. This parameter was estimated based on expert opinion (leading scientist and economists in each Center) assuming a \$2 per day poverty line, although precise data for all countries was not available and some generalizations had to be made. On the basis of average cropped area per poor farmer per country, we estimated the number of poor farmers growing each crop in each country. Then, using average poor family size from different available statistics we arrived to the total number of poor beneficiaries per crop and per country. Regional figures are an aggregation of the country estimates.

Estimating the number of beneficiaries from crop area data is not straightforward because often farmers are growing two or more RTB. This is principally the case in lowland tropical areas. Hence it was assumed that cassava, sweetpotatoes, bananas, plantains, and yams have a 90% overlap. Potatoes tend to be grown in different cropping systems with less overlap. We also assumed a \$2 per day poverty line although no exact figures were available for all regions and countries. With these assumptions, the estimated number of poor beneficiaries is at least 180 million people, and most likely between this figure and 220 million.

There are no estimates for yams in Asia and Latin America and the Caribbean (LAC), but the area is not significant at all relatively to Africa (although it could be increasing in some countries). We have discussed quite fairly the assumptions for all crops and we are confident that we are on the conservative side with the lowest figure.

Individually, cassava appears in the estimation as the crop with the highest number of potential beneficiaries, with more than 100 million, followed by banana and plantain and sweetpotato (84 million each). The number of potential beneficiaries for potato and yam is similar for each of the both crops at 55 million.

The distribution of the number of beneficiaries for each crop within the regions shows that for Africa, production systems including cassava, sweetpotato, banana, plantain, and yam are predominant and include at least 55 million of poor beneficiaries (with a 75% overlap of the crops) to more than 110 million (under the assumption of 50% overlap), making up 85–90% of the total number of beneficiaries of RTB for this region.

In Asia, potatoes alone are the single most important crop and include 40 million of poor beneficiaries, followed by cassava with 34 million. Roughly, the distribution of the number of beneficiaries in this region is 50–50% between potatoes and the system including the rest of the crops, under the 50% overlap assumption.

Regarding the distribution across regions, Africa is the region with the largest number of poor growing RTB, with nearly 125 million under the 50% overlap assumption, followed by Asia with 84 million. The number of potential poor beneficiaries in LAC is at least 16 million people.

Below is an estimation of the returns on investment (ROIs) and net present value (NPV) of benefits for CRP-RTB. Using conventional ex ante economic analysis (Alston et al. 1995), the changes in economic surplus and the distribution between consumers and producers is estimated based on a

set of seven technologies to be developed as a result of the implementation of the CRP. The values of the technology parameters were assembled through expert opinion elicitation from each of the leading centers and from previous studies where available.

The following is a set of generic assumptions and explanatory notes relating to the ex-ante analysis:

- Project duration is 25 years since beginning of investment, marked as year 1.
- Source of benefit is a yield increase that varies across crops and technologies (Table 1). A cost increase is also included to represent the additional costs of adopting the technology (e.g., increased costs to purchase clean seed of improved varieties, improved management practices which require additional labor and input costs). Annual estimated benefits from each technology were summed up and compared to total research investments.
- Probability of success of the proposed research and release of the technology is included as a proxy of the research risk.
- Prices are nominal producer prices in US dollars based on 2006–2008 FAOSTAT average or on more recent references if available.
- Production data are averages for years 2006–2008 (accessed from FAOSTAT 2010).
- Research investments by the CGIAR Consortium Fund are estimated at US \$50 million per year over the next six years. Additional research investments for US \$50 million a year over the same period are included and represent half of the remainder of the total budget for the four centers (based on 2008 figures). These additional research investments are assumed to be a continuation of bilateral funding from donors.
- Technology dissemination costs are included as centers' investment of US \$14 million a year during the first six years. Additional annual investments of US \$10 million by national and regional partners are assumed as necessary expenditures on research, seed production, technology dissemination, and extension during the duration of the project.
- Logistic patterns of diffusion are developed for each of the seven technologies. The parameter elicitation for the adoption patterns implied that all technologies will be fully adopted to the maximum expected adoption rates before the project ends (in 25 years). See Figure 1 below for detailed diffusion pattern for each of the crops and technologies assessed.
- NPV of benefits estimated at two different discount rates (5% and 10%). Corresponding annuities were also computed.
- Other assumptions include: since all crops are mostly grown for consumption in domestic markets, a closed economy model is assumed; supply and demand elasticities are set at 0.8 and 0.5 for all crops.

Table 1. Returns on Research Investments on The Development of RTB Technologies

Theme	Product Line	Crop/Technology	NPV of Total Surplus Change (Million US\$)		Annuity (Million US\$)	
			Discount Rate			
			5%	10%	5%	10%
2, 3	2.2.3, 3.4	Cassava: productivity improvement in Africa	2,987	1,263	194	134
4	4.1	Banana & Plantain: BBTV clean planting material in Burundi, Malawi, and DRC (4.1)	1,268	553	82	59
5	5.2	Plantain: improved resource use efficiency in Ivory Coast, Ghana, and Nigeria (5.2)	1,947	994	127	105
2, 3	2.2.3, 3.4	Banana & Plantain: productivity improvement in the rest of Africa	5,782	2,182	376	231
2	2.2.3	Potato: Late blight-resistant varieties (world)	1,757	814	114	86
2, 3	2.2.3, 3.4	Yam: productivity improvement in Africa	1,079	443	70	47
2	2.2.3	Sweetpotato: virus and weevil resistant varieties in Africa	676	279	44	30
TOTAL—all crops			15,495	6,529	1,008	693

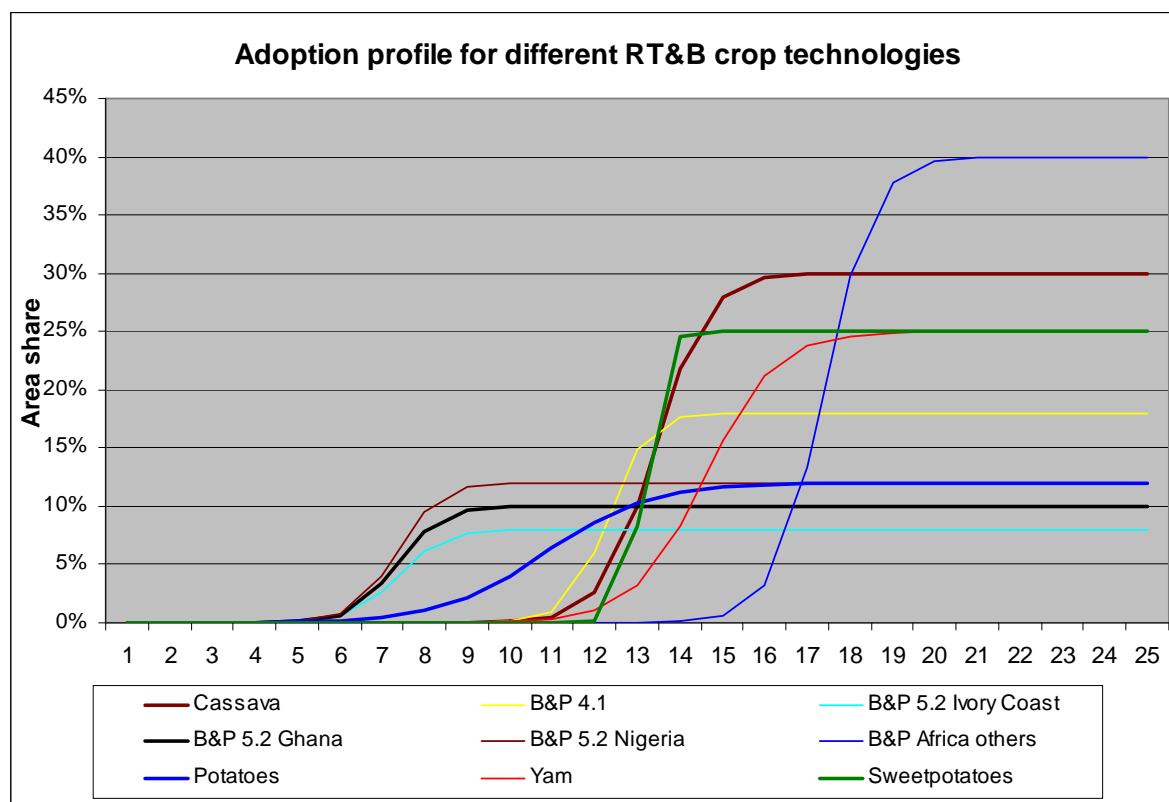


Figure 1. Diffusion patterns of technologies for the estimation of return to research investments.

The proposed technologies used in the ex-ante impact analysis cover most of the relevant RT&B crops and are described in detail in Table 2.

Table 2. Description of Selected Technologies Used for Ex-Ante Assessment

Theme & Product Line	Crop	Technology	Region	References*
2.2.3 & 3.4	Cassava	General productivity improvement based on technology packages involving modern varieties and improved management practices.	Africa	Alene et al. 2009
4.1 & 4.4	Banana & Plantain	Clean planting material access strategies for zones with different levels of Banana Bunchy Top Virus (BBTV) infestation (product line 4.1), and farmer decision tools for selection of clean planting material to reduce the risk of spreading BBTV (product line 4.4). Research outputs are prevention tools.	Burundi, Malawi, and DRC	J. Espinosa and H. Garming, pers. comm.
5.2	Plantain	Improving resource (light, water, nutrients) use efficiency: intensification of plantain production timed to be harvested during off-season through high density planting with clean planting material and irrigation, leading to dramatic yield increases. Adoption is calculated as area required for reaching 25% of production volume increase, which has been estimated as the supply gap for plantain in the domestic markets of the target countries.	Ivory Coast, Ghana, and Nigeria	J. Espinosa and H. Garming, pers. comm.
2.2.3 & 3.4	Banana & Plantain	General productivity improvements based on technology packages involving modern varieties and improved management practices in the rest of Africa (excluding above mentioned countries)	Rest of Africa	Kalyebara et al. 2007
2.2.3	Potatoes	Development and release of late blight (LB) resistant varieties worldwide. LB resistance is the focus of breeding research in potatoes as the most important crop disease affecting potato production in developing countries. The technology also involves improved management strategies are adopted and better access to clean improved seed is developed.	World	Fuglie 2007, Thiele et al. 2008, Walker et al. 2003
2.2.3 & 3.4	Yam	General productivity improvements based on technology packages involving modern varieties and improved management practices.	Africa	Kalyebara et al. 2007
2.2.3 & 3.4	Sweet-potatoes	Development of sweetpotato weevil and sweetpotato virus disease-resistant varieties and improved management practices.	Africa	M. Ghislain, pers. comm.

Note: References include sources for data on expected yield gains, costs changes, and potential adoption.

Table 3 shows in detail the value of some of the basic parameters for each of the technologies. Cost changes may arise due to changes in seed costs, pesticide use, labor costs, and so on. A cost reduction is expressed as a negative figure, a cost increase as positive. Maximum adoption is represented as a proportion of the total crop area in the country or region where the technology is adopted. Since this is an uncertain parameter in ex ante assessments of technology adoption, the sensitivity of the results to changes in the maximum expected adoption rate is conducted at the end.

Table 3. Selected Parameters' Values for RTB Technologies

Crop/Technology	Source of Benefit		Maximum Adoption (%)	Probability of Research Success (%)
	Yield Increase (%)	Cost Change (%)		
Cassava: productivity improvement in Africa	40	15	30	90
Banana & Plantain: BBTV clean planting material in Burundi, Malawi and DR Congo (4.1, 4.4)	100	20	18	90
Plantain: improved resource use efficiency in Ivory Coast, Ghana and Nigeria (5.2)	100	100	8–12	90
Banana & Plantain: productivity improvement in the rest of Africa	45	15	40	60
Potatoes: Late blight-resistant varieties (world)	20	20	12	90
Sweetpotatoes: weevil and SPVD resistant varieties	20–54	5	20–25	80
Yam: productivity improvement in Africa	30	20	25	60

The results presented in Table 1 (above) show that the NPV of the economic benefits produced by the technologies for the 25-year period considered as the project duration is near 15.4 billion dollars (at 5% discount rate). This amount is equivalent to an annual aggregated payoff (annuity) from all technologies of \$1 billion dollars. Since the technologies that will be developed are mainly tackling production constraints that affect poor farmers, adoption by poor farmers is expected to take a large portion of the area and therefore most of these benefits will accrue to poor farmers and their family members.

Doubling the discount rate to 10% reduces the NPV of benefits to \$6.5 billion and the corresponding annuity to \$0.7 billion. Comparing the stream of benefits to the projected research and technology dissemination costs yields a return on all investment of 32.3%, which is comparable and within the range of returns to other investments in agricultural research (Alston et al. 2000). Although the benefits are high relative to the projected investments, the long period until the technologies are released and the maximum adoption rates are reached reduces their present value.

The relatively high benefits are not only due to the expected productivity improvements and their area coverage, but they are also driven by the high value of some of the crops under analysis. This is particularly the case for banana and plantains, whose domestic prices go from \$300/ton as an average in Burundi, Malawi, and DRC to a high of \$850/ton of plantains in Nigeria. As such, the expected benefits for the banana and plantain technologies included in this assessment make up for a large portion (57.8%) of the total benefits. A combination of large productivity increases on high-value crops produces expected large economic benefits of technological improvements. Cassava, potatoes, yams, and sweetpotatoes, on the other hand, are lower value crops, but the analysis is based on larger increases in the production volumes. Their respective share of benefits is 19.4%, 11.4%, 7.0%, and 4.4%.

Since these crops are mostly for domestic consumption (and the analysis assumed a closed economy model), the benefits are shared between consumers and producers. Given the assumed elasticities of supply and demand, consumers share a larger portion of the benefits (61.5%) than producers (38.5%). Besides the fact that many of the consumers are the rural households

themselves and their members, this is also an indication that consumers in rural and urban areas beyond the farms may benefit from reduced prices of critical staple foods and increase real incomes. This situation is mostly beneficial for the poor as major consumers of the staple foods which are the mandate crops of the proposed research.

Given that many of the results of this ex ante analysis are based on assumptions about potential adoption rates, sensitivity analysis is conducted by halving the expected maximum adoption rates (from the ones in table 1 and figure 2) although leaving unchanged the adoption profiles (time for delivery and years until maximum adoption). These changes lead to a reduction in the NPV of benefits to 7.7 billion dollars (with the 5% discount rate) or 3.2 billion dollars (discount rate 10%). The corresponding annuities are reduced to 0.5 and 0.34 billion dollars, respectively. The rate of return on the same investments is reduced to 24.8%, which is still under accepted ranges for agricultural research. The sensitivity analysis shows that projected research benefits based on assumed productivity improvements are relatively high and robust to changes in the expected adoption. Additional estimations when halving assumed yield changes and maximum adoption rates simultaneously result in a NPV of benefits of \$2.6 billion (at 5% discount rate) or \$1.1 billion (at 10% discount rate) and an ROI of 14.8%. The corresponding annuities are reduced to \$0.17 billion and \$0.12 billion, respectively.

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**ANNEX 4. ROOTS, TUBERS AND BANANAS – RESEARCH AND
COLLABORATION PRIORITIES OF PARTNERS AND STAKEHOLDERS (Revised)**

**Roots, Tubers and Bananas – research and collaboration
priorities of partners and stakeholders**

**Chris Wheatley
August 2010**

ACRONYMS

ASARECA	Association for Strengthening Agricultural Research in East and Central Africa
BAPNET	Banana Asia-Pacific Network
BARNESA	Banana Research Network for Eastern and Southern Africa
BECA	Biosciences Eastern and Central Africa
BSTD	Banana Bunchy Top Disease
BXW	Banana <i>Xanthomonas</i> Wilt
CARBAP	African Center for Research on Bananas and Plantains
CAPSA	Center for Alleviation of Poverty through Secondary Crops in Asia-Pacific (UN)
CATIE	Center for Research and Education on Tropical Agriculture (Central America)
CBB	Cassava Bacterial Blight
CIAT	International Center for Tropical Agriculture
CIP	International Potato Center
CLAYUCA	Latin American- Caribbean Consortium for Cassava Research and Development
CTCRI	Central Tuber Crops research Institute (India)
DS	Decision Support
EMPRABA	Brazilian Agricultural Research Corporation
FONTAGRO	Regional Fund for Agricultural Technology (Latin America)
ICT	Information and Communications Technology
IITA	International Institute for Tropical Agriculture
IDIAF	Dominican Institute for Agricultural and Forestry Research (Dominican Rep.)
IMTP	International <i>Musa</i> Testing Program
IPM	Integrated Pest Management
INCOPA	Promotion of Competitive production of Potato in Peru (CIP Project)
INIA	National Agricultural Research Institute (Peru)
INIAP	National Agricultural and Livestock Research Institute (Ecuador)
M&E	Monitoring and Evaluation
MGIS	<i>Musa</i> Genetic Information System
MUSALAC	Plantain & Banana Research and Development Network for Latin America-Caribbean
NARO	National Agricultural Research Organization (Uganda)
NGO	Non Governmental Organization
OFSP	Orange Fleshed Sweetpotato
PCARRD	Philippine Council for Agriculture, Forestry and Natural Resources R &D
PLRV	Potato leaf Roll Virus
PNG	Papua New Guinea
PROINPA	Foundation for the Promotion and Investigation of Andean Produce
PVY	Potato Virus Y
RTB	Roots, Tubers and Bananas
SPCSV	Sweetpotato Chlorotic Stunt Virus
SPFMV	Sweetpotato Feathery Mottle Virus
WCA	West and Central Africa

1. INTRODUCTION AND METHODOLOGY

This desk study aims to provide an overview of the current research priorities for roots, tubers and bananas/plantains in the Asia-Pacific, Africa and Latin American-Caribbean regions of partners and stakeholders of the CRP-RTB. This study will serve as one input to the development of the CRP-RTB. The study does not attempt to cover the R&D priorities of the CGIAR centers themselves. Rather, it indicates the relative areas of emphasis of the different actors engaging in research in these regions, at national and regional level.

This report is organized by crop/commodity, and then by research themes, with a discussion of differences in regional priorities under each research theme. The seven research themes are those used in the CRP-RTB project. In some cases, especially for regional initiatives in Africa, research is organized under commodity groupings such as “roots and tubers” or “staples”, and these are presented in a separate section of the report, to avoid repetition across each commodity separately.

In addition to this report, two other products are available:

- An excel spreadsheet that summarizes the research priorities by organization, crop and research theme.
- A bibliography in endnote linked to the reports and other documents cited in the text of this report.

The study has been conducted based on the following sources:

- Documents provided by CGIAR centers (RTB task force members).
- Partner/Stakeholder strategic and priority setting documents and reports, accessed via CG staff or from internet searches. This includes reports of regional and national level processes. The focus has been on research organizations and regional networks/platforms, rather than on development-oriented actors such as NGOs.
- Information obtained from institutional websites themselves.

Special note is made of two papers by Fuglie (2007a and 2007b) that present the results of a research priority setting exercise for potato and sweetpotato respectively, which involved surveys of potato and sweetpotato scientists across Asia, Africa and Latin America. These provide a rich source of information for the two crops covered in this analysis. In addition, a scoping study of root and tuber crops in Asia was recently completed (Wheatley, June 2010) and this provides a useful summary of research priorities for cassava, potato and sweetpotato in this region.

The short time available for this study limited the degree of interaction with task force members, and there was no time for direct consultations with national and regional RTB scientists or other stakeholders—the study focused on information readily available through task force members and via internet searches. The result is a less than comprehensive survey of the current situation, given that:

- The level of detail readily available on research priorities varies greatly across organizations. While some have detailed priority setting and strategic plans that provide high quality information, others report on general priorities (often not crop specific) on their websites with no further information directly available.
- Reports and websites may not be current – some websites provide research priorities for past years, with little indication of future priorities.

The priorities reported here thus reflect those of the national and regional research organizations/networks for which information could be readily obtained. There is less information on

the priorities of other stakeholders such as NGOs or the private sector, except for the inputs that they have had to regional networks/platforms in some cases (e.g. for cassava and potato in Latin America).

2. RESEARCH PRIORITIES

2.1. Cassava

Cassava is undergoing a transformation from a traditional subsistence crop used directly – or after small-scale processing – for local food and feed uses, to a raw material and feedstock used by a large number of food, feed and non-food industries, including products aimed at regional and global export markets. This transformation is largely complete in many Asian (Thailand, China, Vietnam) and Latin American countries (Brazil), and is in progress in Africa (Ghana, Nigeria etc). However it still retains a vital food security role across Africa and in many other areas (the Pacific, Indonesia, parts of India). Research priorities thus encompass both those related to food security (including nutritional value) and market-driven industrialization (dry matter and starch yields. etc.). The latter has also involved a diversification of stakeholders to include private sector actors involved in the different value chains that cassava now operates in.

Genetic resources and diversity

The CIAT Cassava germplasm collection is the main global genetic resource for this crop. Other Latin American national programs maintain smaller and mainly national collections: Brazil's EMBRAPA Cassava research center in NE Brazil has a cassava germplasm collection derived mainly from that region of the country, for example. Both Brazil and CIAT maintain collections of wild *Manihot* species, however. Other major germplasm collections include IITA in Africa, CTCRI in India and the Rayong Field crop Research Center (Department of Agriculture) in Thailand. Additional collection of local cassava cultivars is now largely sporadic, but does occur outside cassava's center of origin, e.g. Uganda.

Maintaining and characterizing existing collections is a major task. While past emphasis was placed on basic root morphological characteristics, recently more attention has been placed on specific attributes related to end use, disease and pest resistance and nutritional value. Examples of this are:

- The HarvestPlus initiative, with a systematic and massive screening of landraces from CIAT germplasm collection and key improved clones for pro-vitamin A carotenoids
- Post harvest physiological deterioration
- Dry matter and starch content
- Enzymes related to starch breakdown to sugars (useful for bio-ethanol processing).

Thai researchers suggest greater collaboration among research institutes for evaluation of germplasm for a wide range of characteristics, with specialized laboratories undertaking analyses of specific attributes related to industrial end uses.

Improved varieties

Increasingly, breeding, selection and adoption of new, high yielding cassava varieties has been driven by market opportunities created for the crop in recent years, and these varieties have, in turn, made possible further expansion of cassava utilization by enhancing its competitive position as a source of starch and carbohydrate vs. other crops (e.g., maize).

Several priorities for varietal improvement are common across countries and regions, including:

- Fresh root and dry matter/starch yield per hectare (related to production costs and competitiveness) (Nigeria, Ivory Coast, Thailand, Philippines)

- Resistance to major pests and diseases (Nigeria, Ivory Coast, Uganda, Philippines)
 - cassava mosaic disease (India)
- Resistance/tolerance to abiotic stresses (e.g. drought, waterlogging) (Nigeria, Ivory Coast)
- Varieties for specific end uses (Malawi)
- Starch quality (India, Thailand)
- Low cyanogen content (Nigeria, India)
- Micronutrient enrichment (Nigeria)
 - High beta carotenoid content (India)
- Early maturity (Nigeria, India)
- Culinary quality (India)
- Protein content of roots (human nutrition) and leaves (animal feed use) (India).

For bio-ethanol production, breeding for roots and tubers with higher free sugar content or with starches that are easier to convert into ethanol (e.g., amylose-free starch), and thus a focus more on energy production per hectare rather than on dry matter content, for industrially-oriented varieties (Ceballos et al. 2009).

For some of these priorities, application of biotechnological techniques is required, with incorporation of genes from wild *Manihot* species and grain amaranth for improving protein content an example from India.

Related priorities include research to understand basic physiological and biochemical mechanisms for important root characteristics such as physiological deterioration, leading to genetic manipulation to produce resistant varieties in due course.

Pests and diseases

Pests and diseases are major issues in Africa, where cassava mosaic virus, mealy bugs etc have been the focus of considerable R&D effort in recent decades. This also relates to seed systems, since clean (vegetative) seed is a critical component of disease and pest control. This pest and disease situation is, however, quite volatile. For example, while pests and diseases have not been major issues in E and SE Asia for cassava, this situation appears to have changed recently (CIAT, 2010) with the sudden appearance of mealy bugs, brown leaf spot, cassava bacterial blight (CBB) in Thailand and Vietnam. A *phytoplasma* disease appears to be especially severe in Vietnam, and mealy bugs are causing major losses in Thailand. The widespread movement of infected vegetative planting material into the region seems to be the immediate cause of these problems. Short-term solutions based on quarantine, selection and treatment of planting material, and biological control of pests and diseases, is required. Resistant varieties may be needed in the longer term (see above).

Research priorities include:

- Ecologically sustainable biocontrol methods for major pests and diseases (Uganda)
- Biopesticide development (India)
- Field and storage pest management (India)
- Crop management for virus control - e.g. mosaic, brown streak (Nigeria, India)
- Epidemiological studies of main pests and diseases (Ivory Coast).

Climate change will be an additional factor affecting the geographic patterns of pest and disease incidence, and can be expected to produce new threats to cassava production – the recent case of Thailand and Vietnam is a case in point.

Sustainable systems for planting material

The importance of systems that deliver clean planting material are highlighted above in the recent case of SE Asia. Several countries report that the lack of quality planting material is a major constraint for industrial development of the crop (e.g. Philippines, Thailand, and Vietnam). From this situation, priorities for research are:

- Mass propagation techniques e.g. tissue culture (Philippines)
- Sustainable production and distribution systems for healthy, mosaic resistant planting material (India)
- Planting material preservation
- Mechanization (Nigeria, CLAYUCA).

Tools for productive cropping systems

Cassava's reputation for soil fertility exhaustion and erosion has been addressed through long-term research in Asia that demonstrates that successful soil and erosion management can sustain crop yields over time (Howeler et al.). Participatory research methods were key to adoption of these practices.

Given the pressures for production intensification, research priorities in all regions reflect the need to produce more food with fewer inputs (increase efficiency of resource use), including

- Early maturing varieties (India)
- Reduced fallow systems (Nigeria)
- Legume and other intercrops (India).
- Low input, low cost technologies- reduced levels of fertilizers, use of biofertilizers, manures and industrial waste (India, Uganda)
- Weed control (Nigeria)
- Development of integrated soil nutrient management strategies and long term fertility management for sustainable production (India, Nigeria, CLAYUCA).

Jarvis et al. (2009) identify non-traditional production areas where cassava production may be favored by increasing temperatures and rainfall patterns as climate changes occur, but equally highlight other areas where cassava is produced currently, but where drought and flood tolerance will be needed if production is to be maintained.

Postharvest, value chains and markets

For cassava, the key factor is whether small farmers, usually in more remote areas with poor market access, growing cassava on sloping land susceptible to erosion and with low soil fertility, can benefit from the transformation of the crop into a raw material for a range of modern, large-scale industrial processes for food, feed and other industries. In many more traditional markets – India, Africa - inefficient market chains with many middlemen and high margins result in a very low producer share in the final price, and producers have little negotiating power. Market information is patchy. Postharvest research priorities therefore cover technological, market and organizational issues, including:

- Postharvest storage of fresh roots (including physiological deterioration) (Zambia, Caribbean, India)
- Processed product development (all areas), including
 - High quality cassava flour (Ghana)
 - Modified starches (Brazil, Asia)
 - Bioethanol production (Latin America, Asia, Uganda)
 - Animal feed rations (Latin America)

- Quality certification and standardization (India, for sago starch)
- Market information systems (India, Africa)
- Value chain and sub-sector operation, governance, equity (India, Philippines, Ghana).

Enhancing impact through partnerships

See 2.5 Staple crops

2.2. Potato

Since 2005, potato production in the developing world has exceeded that in developed countries. Expansion of markets for processed products (chips, French fries etc) has been one component of this, but also the growth of production in non-traditional regions in the lowland sub-tropics. National potato research priorities were investigated in a study by Fuglie (2007a), and this information forms the basis for the priorities presented here, supplemented by additional information provided by various national research organizations. A recent strategic visioning exercise carried out in the Andean region in 2008 (Devaux et al. 2009) provides useful insight into priorities in this area.

Genetic resources and diversity

Fuglie (2007a) found that improved characterization and ex situ conservation of potato genetic resources were ranked as an important need in every region. Strengthening the capacity to manage Intellectual Property Rights to national potato genetic resources was important, especially in Latin America, the origin of the potato, as was in situ conservation. In situ conservation was also mentioned as important by respondents from northern China but was ranked low by respondents from other areas.

Potato genetic resource priorities cited by other organizations include

- Prospecting, conserving and characterizing native varieties in the Andean region (INIAP, CONPAPA)
- Characterise and evaluate for adaptability, processing quality, biotic and abiotic stresses (early planting, late blight, bacterial wilt, potato tuber moth, hopper burn and mites, cyst nematodes, stem necrosis, viruses) in India
- Cryopreservation, in vitro conservation (India).

Improved varieties

Fuglie (2007a) reported priorities for crop improvement in a number of areas, as follows (and in order of priority by area):

- Yield and quality
 - Stable and high yielding varieties for fresh consumption
 - Pre-breeding of parent material for use by national programs
 - Improved processing varieties with high dry matter content and low reducing sugar contents (especially in Latin America and East & South East Asia)
 - High starch varieties (low priority)
 - Improved TPS progenies (low priority)
- Biotic stresses
 - Late blight (*Phytophthora infestans*) ranked as the highest biotic stress limiting potato productivity throughout the developing world
 - Viruses (especially in Asia, lower priority in Latin America). The main viruses were PVY and PLRV:

- Bacterial diseases were more important in Africa and East & South East Asia than in South Asia or Latin America. Wilt (*Ralstonia solanacearum*) and *Erwinia* soft rots were the two main constraints
- Insect pests –especially important in South America, but with considerable variation in pest species.
 - Tuber moth was common across all regions (species varies).
 - The potato weevil *Premnotrypes* spp was important in the Andean countries,
 - leaf miner in SE Asia and Brazil
 - aphids in Africa and Central Asia
 - Colorado potato beetle (*Leptinotarsa decemlineata*) in Central Asia and the Caucasus
 - Nematodes were given a low priority in all regions except Latin America
- Abiotic stresses – in general these were (in 2006) assigned a lower priority than biotic stresses and yield/quality, despite the growing concerns about climate change.
 - Drought stress was given the highest priority in most areas, especially China
 - Heat stress was prioritized in South Asia, due to concerns for production vulnerability in the low-lying Indo-Gangetic plains area
 - Cold stress was important in some Andean countries
 - Relatively low priority was given to varieties with tolerance to marginal soils
 - Earliness was prioritized to allow for increases in cropping intensity, reduce exposure to biotic stresses, and give a better fit with cropping cycles
 - Seed dormancy to fit cropping cycles
 - Long day adapted varieties was important only for southern areas of South America and North Asia/Caucasus.

Since the survey of Fuglie (2007a) there has been an increased emphasis on improving micronutrient content of potato tubers, with heritable variability for vitamin, iron and zinc concentrations found for potato (Bonierbale et al. 2009) Breeding for nutrient-dense varieties could contribute to food-based approaches to nutrition improvement for vulnerable populations.

In Asia, the single cropping area of northern China the main research priorities are: seasonal high aphid pressure, potato viruses (PLRV and PVY), drought, and sometimes devastating late blight (*Phytophthora infestans*) epidemics. The double cropping system, with a short potato growing season (the potato is first cultivated as a mono-crop and then as an intercrop with maize) faces constraints of viruses and bacterial wilt (*Ralstonia solanacearum*), and late blight is important if potatoes are grown in the fall (Ezeta 2008).

In Central Asia, the main traits desired by local breeders are earliness for lowlands and medium-late maturing cycle for the highlands (up to 120-130 days from planting), red skin color, resistance to viruses and main abiotic stresses (heat, drought), storability and marketability (Carli et al.,2009). In Bangladesh, late blight, leaf blight Black scurf, Common scab, Bacterial wilt, viruses, IPM aphids, cutworms, while Pakistan prioritizes late blight resistance and processing quality traits.

In the lowland Asian sub-tropics early maturing, high-yielding potato cultivars resistant to late blight (the main disease threat), viruses and bacterial wilt are a high priority (Pandey 2008). A diagnostic survey of farmers in Gujarat, India found that heat tolerance was the top priority trait required in new potato varieties, followed by high yield, resistance to late blight and then resistance to potato-tuber-moth (Rana et al. 2009) Principal tolerance traits that could diminish the vulnerability of potato yields to drought stress include improved transpiration efficiency, which is associated with optimized stomatal control under drought to reduce water loss but at the same time allow for continuous CO₂ access for photosynthesis, enhanced detoxification of reactive oxygen

species produced during stress, and mechanisms to protect proteins and membranes from damage by water stress. Candidate genes underlying these traits as well as genotypes that express them are available and, after appropriate validation, could be used in breeding. Future efforts could address improving photosynthetic efficiency and reducing photorespiration under drought.

In the highland tropics of Asia, heat and drought tolerant potato cultivars with the ability to initiate tuberization at higher temperatures (climate change adaptation) are a high priority (Pandey 2008, CIP 2009).

In Africa, Kenya gives high priority to late blight and bacterial wilt resistance breeding. Nigeria has prioritized late blight resistance and yield breeding. In Andean Latin America, Peru (INIA) has prioritized drought and frost tolerance, late blight resistance, yield and quality improvement for native and processing varieties.

Pests and diseases

In the survey of Fuglie (2007a) the main disease management priorities were:

- Late blight was ranked as the greatest need in potato crop management for all regions (bar West and Central Asia), not only for the high losses it causes, but also for the health and environmental effects of high level of pesticide applications (Pandey 2008)
- Potato viruses (and their aphid vectors) were important for West and Central Asia, Sub-Saharan Africa and Asia but not Latin America
- Control of bacterial wilt, primarily in and East & South East Asia
- Early blight (*Alternaria* sp.) especially in Sub-Saharan Africa,
- Bacterial soft rot (*Erwinia*) in Southeast Asia and Latin America,
- Fusarium, primarily in Sub-Saharan Africa and Latin America.

In developing countries, aphids are primarily a vector for spreading viruses like PLRV but do not cause much crop damage directly. Virus control may be sought through varietal resistance, crop management and/or clean seed systems. Apart from aphids the main pest priorities were:

- The potato tuber moth (*P. operculella*), important in all regions
- Nematodes (*Nacobbus aberrans*, *Globodera* sp, and *Meloidogyne*) were important in Latin America, as was the Andean potato weevil in Andean mountain countries
- The leaf miner fly (*Liriomyza huidobrensi*) was highly ranked in Indonesia, the Philippines and Brazil
- The Colorado potato beetle was only important in the Caucasus and Central Asia; there is a risk that it may migrate into north eastern Asia.

Specific priorities mentioned by national research organizations are:

- Tuber moth control (Nigeria)
- Clean production, rational use of pesticides, IPM, biocontrol (Ecuador, Peru, Bolivia)
- Pathogen diagnostics (India)
- Potato cyst nematode (Indonesia).

Development of new techniques for pathogen detection, farmer participatory pest and disease control/management supported by pest and disease forecasting and risk assessment models are all relevant here, particularly because of the emergence of new pests and the re-emergence of others that could become threats due to climate change or pesticide abuse (e.g. the case of leaf miner fly (*Liriomyza hidrobrensis*)).

For potatoes, the use and misuse of pesticides is an issue in some areas (e.g. Andes, highland Asia). Research to provide effective alternatives to chemical pest and disease control, including through crop management, are important for these areas.

Sustainable systems for planting material

In developed countries, effective certified seed systems have been developed to eliminate the virus problem from potato production, but for institutional and climatic reasons such systems have proven difficult to establish in developing countries (Crissman 1990). Seed accounts for 40-50% of production costs, and degenerates after only a few multiplications when varieties susceptible to virus are used (especially in the tropics). By the time seed potato (even from improved varieties) reaches the farmer, it is often already seriously contaminated by viruses and tuber-borne diseases. Some countries import certified seed at high prices, while others (e.g., China) severely restrict imports of potato tubers due to phytosanitary concerns. Formal seed systems have frequently been established with external financial and technical support, but their track record after the end of project support is poor.

Thus Fuglie's survey found that the need for improved seed production methods was important or very important need by all respondents, with maximum scores given by all of those from Sub-Saharan Africa. It was also the highest-ranked need in the survey in the East and South East Asia region. Improving potato seed quality and quantity concerns management practices, policies and regulations as well as the specific technical issues related to propagation and virus elimination. The lack of seed storage methods suitable for small-scale farmers was indicated as an important constraint in Sub-Saharan Africa and Asia. The need for better TPS propagation methods ranked lowest among the seed questions, although it scored relatively high in the West and Central Asia countries. Improving farmers own seed system through practices such as positive and negative seed selection and use of TPS gave positive results in India and Nepal. (Girish et al. 2009, Campilan 2008). In Central Asia, the potato seed system is a particular concern since the potato research and development system has been neglected since 1990, resulting in the loss of valuable local varieties, a limited supply of quality seed tubers, decreased productivity and increased post-harvest losses. Farmers are now largely dependent on expensive, imported seed potatoes from Europe that lack needed resistance and adaptive traits. (Carli 2008).

In line with these priorities, countries have expressed research needs in this area:

- Clean material via meristem culture (Nigeria, India, Bangladesh)
- Improved seed systems, seed quality and certification (Andean region, India)
- Farm level clean seed production systems (Bangladesh)
- Production of breeder seed (Bangladesh)
- TPS evaluation (Pakistan).

Tools for productive cropping systems

In the Fuglie (2007a) survey, the main priorities were:

- Improved management of soil fertility to optimize potato production, high priority for all regions.
- Improved management of potato cropping systems was ranked relatively high in all regions except Central Asia and the Caucasus. The importance of cropping system management may be related to the increasing cropping intensity in some areas (e.g. potato production between rice or wheat crops). In China, for example, there is good potential for a new potato production system in southern provinces that takes advantage of the rice fallow period.

- Soil erosion control, especially critical for highland potato-growing areas such as in the Andes region and Southeast Asia
- Improved water management was important to the LAC Region, where potato is usually grown without irrigation
- Better harvesting methods and management of problem soils (high acidity and salinity) were of low priority.

Pandey (2008) summarizes that the main research issues are centered on development of cropping systems and cultural practices (including plant protection regimes and fertilizer application rates) that maximize crop intensity while increasing land conservation efficiency i.e. finding the best option considering trade-offs between input use, crop productivity and environmental sustainability (Pandey 2008).

Recent experiences (e.g., in Nepal) indicate that landscape scale approaches to crop management for disease control (bacterial wilt) can be successful through integrated management strategies that combine technical with social and economic interventions and full community participation.

Some other priorities recently cited are:

- Fertilizer effects on tuber quality (Nigeria)
- Reducing production costs (Peru)
- Soil management, ecological production systems (Bolivia)
- Efficient use of water resources (irrigation) (Bolivia)
- Sustainable cropping systems for efficient resource use; expert system development; low input technology development; integrated water and nutrient management; heat tolerance, mechanization (India, China)
- Standardization of production practices (Bangladesh).

In China, managing the tensions between production intensification and resource limitations (water, soil fertility, etc.) is exacerbated by the continual loss of cropland to urban and industrial development.

Expert systems, mentioned as important by India, relates to decision support tools that could be developed for improved crop management that offers potential for improving efficiency of resource use, for production systems intensification, etc.

Postharvest, value chains and markets

In the Fuglie (2007a) survey, the main priorities in this area were:

- Improvement in potato marketing systems and value chains (for efficiency and equity) including market information issues. These were especially important concerns in Latin America
- Developing new potato products, important in Latin America
- Improved methods for ware storage (storage structures, pest and disease control, grading and pre-conditioning, (Illangantileke 2008)
- Policy reform.

Note that the value chain constraints identified by can be addressed through innovations that may be (Campilan 2008):

- Technological e.g. production and post-harvest practices to improve quality and reduce losses, new varieties

- Commercial e.g. adjusting seasonality and volume of supply) and
- Institutional e.g. marketing agreements that provide more equitable distribution of profits/benefits among chain partners, support services to provide marketing information.

Potato processing – for chips, French fries and starch – is expanding greatly in the developing world. Raw material for fast food must meet high standards of quality, uniformity and regular supply to keep the processing units operating all year round. Value chain development that includes the private sector linking to small-scale producers (e.g., in India, Pandey 2008) opens new research areas with private sector stakeholders, such as:

- Determination of an optimum harvesting period for processing cultivars, and of linkage mechanisms at the regional level for year-round supply of raw material to major potato processing industries of a given region
- Development of energy-efficient storage conditions that do not compromise processing attributes
- Development of new processes that have minimal effect on the environment, and products that have lower fat content and fewer additives but maintain product quality.

The strategic vision process for the Andean region identified many postharvest/market related challenges and priorities including:

- Postharvest loss reduction
- Strengthening of producer organizations
- Promotion of consumption, market studies, product positioning, including of native varieties
- Improved linkages to fast food value chains and other internal markets
- Development of processed products.

Other research priorities more recently articulated are:

- Value added process and product development (Bangladesh, India)
- Value chain strengthening, market studies (India, Kenya, China)
- Storage behaviour (Bangladesh).

Enhancing impact through partnerships

Regarding socio-economic research, Fuglie (2007a) identified a need for more evidence for:

- Impact of potato technology adoption on poverty alleviation
- Health and environmental risks of pesticide use on potatoes.

There was also a need expressed for capacity building in the area of information and communication technology (ICT), especially for R&D organizations from Sub-Saharan Africa.

Partnerships with CGIAR centers (CIP specifically) are seen as important, for example:

- China – recent establishment of the China CIP potato research center
- Peru – close partnership with the national research program of INIA.

Areas where partnerships at regional or global level are seen as useful include:

- Development of decision support and expert systems, (see above)
- Developing scenarios/models for the effects of climate change on national potato production strategies, including consideration of adaptation mechanisms (changes in geographic production areas, cropping patterns etc), changes in pest and disease ranges, and development of new varieties tolerant of different production conditions

- Developing methods and tools and systematizing experiences on value chains that deliver fair returns to small-scale producers for added value products/produce
- Improving nutritional value of the crop where it has an important food security role
- Participatory research methods (including participatory M&E)
- Methods for impact/evaluation studies.

Finally a strategic planning process has recently been completed for the Andean region (Devaux et al., 2009) in cooperation with PROINPA Foundation (Bolivia), the National Potato Program of the INIAP (Ecuador) and the INCOPA Project (Peru), and in coordination with public and private actors of the sector in each country. Several priority areas requiring action through collaboration at national and regional level were identified. This type of analysis is relevant to other regions and commodities as well:

- Organizing the potato sector, promoting local consortiums that could converge in a national potato council playing a coordination role among the actors of the market chain and organizations supporting the potato sector,
- Developing lobbying abilities at producers, entrepreneurs and businessmen levels for policy influence in favor of the potato sector,
- Defining policies, programs and actions that would contribute to managing the risks generated by significant price fluctuations;
- Developing technologies adapted to the situation of each actor in the market chain to improve the efficiency of the potato production system in both the economic and environmental contexts.

Conclusions

Fuglie's (2007a) study concluded by identifying the five highest-ranked research needs for low-income potato farmers in developing countries (as described by the respondents) across all regions and research themes:

1. Control of late blight fungal disease (through varietal resistance and crop management);
2. Improved genetic material, suitable for consumption, with high and stable yield potential (new cultivars and prebreeding);
3. Improved supply of quality potato seed (seed systems management and seed production);
4. Control of viruses and their vectors (through varietal resistance, seed production and crop management);
5. Control of bacterial wilt (through varietal resistance and crop management).

Regional exceptions included:

- Bacterial wilt control, important in Sub-Saharan Africa and East and Southeast Asia, and
- Virus control, which was of low importance in Latin America.

Additional high-ranking needs included improved varieties suitable for processing, improved management of insect pests, cropping systems and soil fertility, and improved marketing systems and ware storage methods. Although insect pest management was ranked high generally, the importance of specific species varied considerably from one region to another. Other top-ranked global priorities included supporting the potato research community through improved characterization of potato genetic resources and better evidence of the impact of potato technology adoption on poverty reduction.

2.3 Sweetpotato

As for potato, the survey by Fuglie (2007b) provides a comprehensive summary of the main research priorities for sweetpotato across the different production regions, as indicated by the research community. This is complemented by more recent information from additional sources. The overall situation of sweetpotato is different from that of cassava and potato, as production is very concentrated in a single country (China) so that global trends are heavily influenced by production and market/utilization situation in that country. Since 2000, the crop has experienced declining production, as the decrease in its traditional role (on-farm consumption and animal feed) has outpaced its inclusion in the expanding food and feed industry (unlike cassava), or in urban diets/fast food (like potatoes). Sweetpotato production and utilization has fared more positively in Africa, with much recent focus on the nutritional (beta carotene) benefits of orange fleshed varieties (OFSP) in a food security role.

Genetic resources and diversity

For sweetpotato genetic resources, improved characterization was ranked in Fuglie's 2007b study as an important need in every region. Ex situ conservation was generally seen as a higher-priority need than in situ conservation. In addition, better capacity to manage intellectual property rights over sweetpotato genetic resources is emerging as an important issue in a number of countries.

In the Philippines attention is now given to in situ germplasm conservation by PCARRD (Philippine Council for Agriculture, Forestry and Natural Resources Research and Development). Germplasm characterization for a range of characteristics is mentioned by national research organizations as follows:

- Screening for root rot nematode resistance (Nigeria)
- Attributes for fresh consumption and value added products (Caribbean).

Improved varieties

The most important need found by Fuglie (2007b) was for new cultivars with stable and high yield acceptable for local fresh consumption. Apart from China there has been little modern genetic improvement in cultivated varieties to date. Even in China, there is still good potential for further improving the productivity of sweetpotato crop production with appropriate investments in research and extension (Huang, et al. 2001). The need for pre-breeding (genetic enhancement of parental breeding lines) was also ranked highly, especially by respondents from Asia.

Specific important traits identified in the survey were:

- Earliness (early bulking)
- Virus resistance
- Drought tolerance
- Improved nutrition (especially higher levels of beta-carotene, a precursor to vitamin A)
- Insect resistance
- Higher dry matter yield (primarily for starch and flour processing).

In Sub-Saharan Africa, where the crop has taken on a major food security role in some countries, the main priorities were for:

- Improved nutritional content (mainly beta-carotene)
- Virus resistance
- Earliness
- Adaptation to marginal soils (acid soils and water-logged soils being the most frequently named soil conditions)

- Insect pests, especially the sweetpotato weevil (*Cylas brunneus* and *Cylas puncticolis*)
- Varieties suitable for use as livestock feed, which implies not only high root yield but also high vine yield for fodder.

In Asia (Wheatley 2010 scoping study) sweetpotato breeding objectives include:

- Increasing both fresh root starch yield and extractable starch contents (improves competitiveness for starch production) and manipulating starch functional properties (for expanding utilization potential in the food and other industries) (China, Philippines)
- Enhancing nutritional value, including concentrations of iron and zinc as well as beta-carotene. This includes evaluation of the adaptability of introduced OFSP accession (India)
- Shorter crop duration, useful for expanding production into grain-based cropping systems in S. Asia. This was also prioritized for high altitude production in PNG (frost avoidance)
- Sweetpotato weevil resistance, via use of transgenic (Bt-based) approaches and based on root latex for resistance breeding (India).
- Control of stem and root knot nematodes through resistance breeding, particularly detection of molecular marker linked to nematode-resistant genes (China)
- Postharvest storage life
- Salt tolerance (important for low lying coastal production regions in Bangladesh and India)
- Drought tolerance
- Development of high value dark-colored (dark-yellow, orange and purple) varieties for β -carotene and anthocyanin content, with processing directed towards added-value nutrient-rich products (Philippines).

In the longer term, biotechnological approaches (Agrobacterium-mediated transformation, regeneration) can be applied to introduce traits for aphid resistance, herbicide resistance (Zhang et al. 2009) and virus resistance (Pido 2010).

Pests and diseases

Fuglie's study (2007b) found that the most important research priorities for pests and diseases were:

- Sweetpotato weevils (*Cylas formicarius* in Asia and Latin America and *C. brunneus* and *C. puncticolis* in Africa), especially highly ranked in Africa and India, where integrated weevil management has proved problematic to date
- Viruses, including sweetpotato chlorotic stunt virus (SPCSV) and sweetpotato feathery mottle virus (SPFMV), especially in sub-Saharan Africa and Latin America.

In China (Zhang et al. 2009) development of virus detection techniques and renewal and storage of virus-free planting materials are research priorities. In addition, whitefly control, both as a pest in its own right, and as a vector for several viruses is prioritized, with current research exploring use of a fungal toxin as a bioprotectant.

In India, where weevil can cause yield reductions of 25-40% (Edison et al. 2009) resistant varieties are not available and pest management research is focused on cultural practices, including biological control measures such as sex pheromone traps.

Sustainable systems for planting material

In developing countries, sweetpotato is propagated vegetative using vine cuttings, roots, and slips (shoots emerging from roots) in which viruses tend to accumulate over time, limiting plant vigor and root yield. The need for improvements in availability, quality, distribution and storage of

planting material was ranked highly by survey respondents (Fuglie 2007b). The importance of propagation constraints was ranked highest by respondents from sub-Saharan Africa relative to the other regions.

The need to improve the availability of sweetpotato planting material increased in importance when responses were weighted by area and poverty rates, joining the need for disease-free planting material as top-ranked priorities.

In addition to the technological aspects of virus elimination from planting material, the organizational and economic aspects of developing sustainable seed systems that deliver quality planting material beyond the life of individual projects and initiatives remains important. For example, in India, development of a support scheme to make available planting materials of OFSPs through community-based systems for multiplication, maintenance and distribution of sweetpotato planting materials is a critical task, in the absence of a functioning formal seed system for sweetpotato (Campilan et al. 2009). Priority is also given to community level seed system development in the Philippines. In the Pacific, the rapid regeneration of planting material by viruses, and the need for clean planting material has been identified (Jackson et al. 2006).

Tools for productive cropping systems

From Fuglie's study (2007), the priority needs for production and resource management included improved:

- Management of soil fertility
- Sweetpotato cropping systems
- Water management, especially in Asia
- Management of soil salinity (South Asia).

Other sources provide additional details for some countries:

- Improving efficiency of fertilizer use, especially in infertile soils, in order to reduce input costs for small-scale production (China).
- Weed control (Nigeria)
- Fertilization effects on carotenoid content (Nigeria)
- Sweetpotato based cropping systems (India, Caribbean)
- Decision support for organic/low input farming, including OFSP varieties (India)
- Development of sweetpotato growth simulation models (India).

Postharvest, value chains and markets

Declining sweetpotato production and utilization (in Asia especially) has occurred despite the availability of a wide range of technologies for producing higher value sweetpotato based products, suggesting that technological innovation by itself is not sufficient to change the dynamic affecting this crop. This fits with the strong need expressed by Fuglie's (2007b) survey respondents to improve the status, postharvest utilization and marketing of the crop for low income farmers through a variety of measures including:

- New food products
- Small enterprise development
- Improvements to marketing systems and value chain operation.

Next in importance were:

- Improved methods of ware storage appropriate for small-scale farmers
- Better ways of using sweetpotato for animal feed

- Policy reform to promote improved utilization and marketing of the crop was seen as important in Sub-Saharan Africa and East and South East Asia.

The low status of the crop that is commonly cited in Asia is susceptible to change (Sister et al. 2009, in the Philippines) if the crop is promoted on the basis of nutritional properties and health benefits of the fresh tuber, especially for orange and purple fleshed varieties. Based on this experience, there is a need for business development services to develop the value chain (including quality requirements) so as to ensure the inclusion of smallholder producers in these potentially lucrative value chains and markets, using a participatory market chain approach. In the Philippines the national sweetpotato program will focus R&D (2010-2020) on value-adding opportunities for health and wealth, as well as food security particularly in disaster-prone areas (PhilRootcrops 2007, Roa et al. 2009).

Finally, the major pests and diseases contributing to sweetpotato post harvest losses – in India - include sweet potato weevil and tuber rots caused by *Lasiodiplodia*, *Rhizopus* and *Fusarium* (Edison, 2002).

Enhancing impact through partnerships

In the Fuglie study (2007b) in the socio-economic research area, the priorities were for:

- More empirical evidence on how improvements in sweetpotato technology affected poverty
- The economic rate of return to public investments in sweetpotato research.

This information is useful for building support for investment in research programs and for strategic planning. PCARRD in the Philippines sees impact evaluation as important for learning from experience as well.

In the communications area, improving access to scientific knowledge and better ability to communicate research results to target audiences were ranked as important ICT needs, especially for Sub-Saharan Africa.

With respect to research partnerships, the development of OFSP for improved nutrition is a prime example, covering:

- Varietal development, especially to contribute to the goal of Vitamin A nutrition improvement
- Cross-sectorial collaboration, with sweetpotato integrated in a strategy for dietary diversification that includes agriculture, health and education

For example, in India, a partnership platform in Orissa includes organizations from the NGO and private commercial sectors across the three sectors. In the Pacific, OFSP can also play an important role in combating lifestyle related health issues (Taylor et al. 2009).

Conclusion

From the Fuglie study (2007) the top five research priorities for sweetpotato across all thematic areas were:

- Control of viruses (through varietal resistance, quality planting material, and crop management)
- Small-enterprise development for sweetpotato processing
- Improvement in availability and quality of sweetpotato planting material
- Improved cultivars exhibiting high and stable yield potential
- Early-bulking cultivars.

In addition, respondents from sub-Saharan Africa also prioritized:

- Improved control of the sweetpotato weevil
- Cultivars with high b-carotene content to address vitamin A deficiency
- Improvements to sweetpotato propagation systems and storage methods (in addition to improvements in availability and quality listed above)
- Cultivars tolerant to drought and marginal soil conditions
- Cultivars providing high yield as animal fodder as well as food
- Improved management of soil fertility and cropping system
- Improved harvesting methods for sweetpotato
- Better evidence on the economic rate of return to sweetpotato research and development.

Respondents from China, the main sweetpotato producing country, had the following additional priorities

- Conservation and characterization of sweetpotato genetic resources
- Pre-breeding
- Cultivars with high starch yield
- New food products from sweetpotato
- Improved capacity in using information and communication technologies.

These priority differences reflect both the different role of the crop in the two locations, and also the different capacity of their respective R&D systems, with China showing greater emphasis on longer term crop improvement, expansion of industrial utilization, and information exchange while Africa is focused more on shorter-term food security (crop management, seed systems) and nutrition.

2.4 Bananas and plantains

Musa includes a wide range of types and cultivars, including cooking bananas, plantains and dessert bananas of which about 85% are produced by small-scale farmers for home consumption or for sale in local and national markets. Cooking banana and plantain provide a staple food for over 400 million people, with great importance in Sub-Saharan Africa. Approximately 15% of world-wide banana production is destined for the export market. For many countries, in Latin America, the Caribbean, Africa and the Asia Pacific, bananas provide an essential source of foreign exchange and rural employment (Bioversity Musa Brief).

The current contribution of *Musaceae* to smallholder food security and income is threatened by spreading disease and virus problems, while growing human population and increasing urban demand call for greater production and intensified production systems. Farmers need strategies for higher quality, disease free planting material, cost-effective, clean pest management practices and more efficient approaches to soil fertility maintenance and improvement. There are few breeding programs for banana and plantain. Most of the commercially important cultivars are highly sterile, making breeding challenging, hence the importance of characterizing and evaluating cultivars for their potential use in breeding schemes and production systems. While the genetic diversity is beginning to be characterized for the main plant characteristics and pest and disease resistance, relatively little is known about fruit pulp qualities (starch properties, mineral concentrations) and the special health and cooking properties that have potential to expand the use of banana and plantain in new products and markets.

A range of platforms or networks for collaboration on bananas and plantains have been developed to share information, leverage resources and strengthen organizational capacity, with support/facilitation from Bioversity and other CG centers. These comprise:

- Researcher networks: ProMusa, Global *Musa* Genomics Consortium
- Genetic resources networks: MusaNet
- Regional research for development networks: BAPNET, BARNESA, MUSALAC, WCA Plantain Innovation Platform.

Many of the R&D priorities for *Musa* detailed below are the result of planning and priority setting processes carried out at the level of these organizations.

Genetic resources and diversity

The International *Musa* Germplasm Collection maintained by Bioversity has over 1200 accessions, but its holdings need to be analysed to identify duplicates and gaps in the wild and cultivated diversity represented in the collection. Taxonomists estimate that there are some 1,000 cultivars and 70 wild *Musa* species, with new species and cultivars still being described. The most important gap is in the representation of wild species and their infra-specific diversity (a survey of 24 collections has shown that 88% of the accessions representing wild species belong to just two species). Poorly known or unexplored areas in Asia, the Pacific and East Africa are likely to harbour wild and cultivated diversity possessing characteristics of agronomic interest.

Bioversity itself aims to make use of diversity – of microorganisms as well as plants - to manage pests and diseases and improve plant health; add value via processing/marketing, and improve human nutrition. It also aims to develop new information and models for sharing and applying biodiversity. The regional and research networks/platforms involved in bananas and plantains also prioritize aspects of genetic resource diversity such as:

- Collection of additional genetic resources, including wild species (BAPNET, BARNESA)
- Development of core collections at regional level (BAPNET, Uganda)
- Biodiversity characterization (descriptors, taxonomy), conservation, maintenance and management, including capacity building (BARNESA, BAPNET, CARBAP, Ivory Coast)
- Germplasm exchange (ASARECA, BAPNET)
 - Development of policies and protocols (BAPNET)
- Biodiversity characterization (BAPNET, WCA Plantain Innovation Platform¹)
 - for micronutrient content, (WCA Plantain Innovation Platform/CARBAP)
 - for pest and disease resistance and yield (BAPNET).

Improved varieties

Varietal improvement is important in all regions, with priorities identified as follows:

- High yield and fruit quality (market acceptability) (BAPNET)
- *Fusarium* and BBTD resistance (BAPNET)
- Tolerance to abiotic stresses e.g. drought, waterlogging (BARNESA, BAPNET)
- Disease resistance (BARNESA, BAPNET)
 - Sigatoka resistance (global relevance, including IDIAF, Dominican republic)
 - BXW (BARNESA)
- New plantain-like cultivars (WCA Plantain Innovation Platform)
- Agroecological adaptation (Ivory Coast)
- Varieties that meet end user needs (CARBAP).

¹ Formerly, the MUSACO network

WCA Plantain Innovation Platform also prioritized methodological topics, for example biodiversity tools for cultivar descriptions and performance available through the Musa Germplasm Information System (MGIS) and cultivar evaluation for micronutrients.

BAPNET gives importance to the exchange and dissemination of improved cultivars, with a need to strengthen disease indexing and quarantine capability, and to develop improved propagation techniques identified.

The International Musa testing programme (IMTP) is a collaborative effort coordinated by Bioversity International to evaluate, in various locations around the world, elite Musa varieties produced by breeding programmes as well as promising germplasm from the International Musa Germplasm Collection (ITC) in Leuven, Belgium. Its aim is to identify banana and plantain hybrids, that, in addition to being resistant to the main pests and diseases that affect banana production, also meet local requirements.

Pests and diseases

There is a high priority across all banana types for control mechanisms for pests and diseases, and technologies for rapid and reliable disease diagnostics. Three diseases appear most important:

- *Fusarium* wilt (especially Tropical race 4)
- Banana *Xanthomonas* wilt (BXW)
- Banana bunchy top disease (BBTD).

BXW and BBTD are currently spreading rapidly in Africa (e.g., Malawi) and are of special concern, both because of the severe losses they cause and because all types of varieties seem to be susceptible. BXW can be confused with *Fusarium* wilt, and the early stages of BBTD are difficult to identify, hence the need for rapid and reliable diagnostics. For Sub-Saharan Africa, eradication or management of BBTD and BXW involves:

- Surveillance (harmonization across countries etc) and quarantine (protocols, policies)
- Ensuring supplies of clean planting materials
- Optimal field practices (information, training, implementation and enforcement issues)
- Further research (genetic resistance, disease epidemiology).

Fusarium wilt is a major problem for Finger bananas and the widespread Kayinja (Pisang awak, ABB) variety, and in particular Tropical race 4 threatening global production of Cavendish varieties. In Latin America, MUSALAC has prioritized surveillance and monitoring in the field as well as varietal improvement (tolerance).

Other priorities mentioned are:

- Banana weevil control (Ivory Coast)
- *M. Fijiensis* control - fungicide resistance (IDIAF, Dominican Republic).

The BAPNET network in Asia sees priorities for:

- Surveys and mapping of pests and diseases in Asia Pacific particularly on various races of *Fusarium oxysporum f sp. cubense*; on viruses and the various *Mycosphaerella* leaf spot diseases; and bacterial wilts.
- IPM technologies for important diseases (*Fusarium* wilt, Sigatoka, viruses, moko),
- Conduct basic research on selected pests (leaf roller, scab, bacterial wilt, *Fusarium* wilt),
- Identify natural defence mechanisms against pests and diseases,

- Epidemiological research on *Fusarium* wilt
- Developing IPM strategies for banana wilts including *Fusarium* wilt (emphasis on TR 4, and bacterial wilts)
- Develop diagnostic tools for banana viruses.

CARBAP in Africa also prioritizes epidemiological studies of main pests and diseases and their control, including varietal evaluation for resistance.

Sustainable systems for planting material

BARNESA has prioritized seed systems to produce disease-free planting material for improved varieties as crucial for East African highland bananas and plantain. Similarly, the WCA Plantain Innovation Platform has identified a need for a review of practices for multiplication of clean planting material and pilot seed production.

Tools for productive cropping systems

For BARNESA, another production priority for all banana types is the ecological durability for intensified farming systems (especially the sustainability of nutrient use efficiency and knowledge of appropriate agronomic methods). Research on farming systems and water management was also identified as a key priority for East African highland and dessert bananas.

WCA Plantain Innovation Platform has prioritized soil health and plant nutrition for mixed cropping systems, and development of high density plantain production systems.

In the integrated farming systems area in Asia, BAPNET has identified:

- Characterization and improvement of the various banana cropping systems (i.e. annual cropping, intercropping, crop rotation), with trials in farmers' fields
- Identify nutrient and water management systems and evaluate crop performance. This includes use of both organic and inorganic fertilizers. Determine ways to improve current systems, and conduct trials in farmers' fields.

Optimizing water and nutrient use efficiency/management is also important for Dominican Republic and Ivory Coast, especially in high density systems and for maintaining soil health.

Postharvest, value chains and markets

For East Africa, BARNESA has a clear set of priorities in this area for both bananas and plantains:

- Matching supply and demand, and growers selecting the most suitable market types
- Recognition of consumer preferences, to integrate the needs of consumers in technology development and dissemination
- The need to tailor technologies to scale of industry, and liberalizing trade, are crucial.
- Excessive postharvest losses
- Analyse and strengthen value chains, improve chain linkages, support to develop farmer and marketing organizations and their business orientation, build business capacity and strengthen farmer-orientated local, regional and export marketing arrangements (highland and dessert bananas)
- Post-harvest ripening technologies (dessert bananas) at local and regional market levels
- improved provision of market information, and better communication between actors.

The value chain improvement, organizational strengthening and market information priorities have also been identified by others including BAPNET, CARBAP and the Plantain Innovation Platform.

Technological priorities from other areas include:

- Improved postharvest handling and storage technologies/systems (BAPNET, CARBAP)
- Information sharing on standards, processing and good manufacturing practices (WCA Plantain Innovation Platform)
- Quality evaluation of fresh and processed products (CARBAP)
- Processing technology development (CARBAP)
- Postharvest micronutrient issues, food preparation (WCA Plantain Innovation Platform).

Enhancing impact through partnerships

The various *Musa* platforms or networks are very involved with a range of collaborative initiatives, designed to share information, leverage resources and strengthen organizational of their members. Relevant priorities identified by these networks include:

BARNESA

- Improved information systems for all banana types in order to promote innovation. Growers need access to useful, high-quality information, tools, services and support institutions
- For East African highland bananas and plantain, linkages with agricultural science and technology need to be strengthened to increase innovative capacity and to learn continuously from feedback and impact evaluation
- Develop formal 'knowledge platforms' to share current knowledge and to facilitate multi-site testing, training and education with farmer groups. This should feed into a pan-African 'system' for consultative priority setting that is charged with information exchange, strengthening capacity, forging partnerships and developing policy to support banana production and trade across the continent.

BAPNET

- Strengthen production and information exchange through the Regional Information System for Banana and Plantain (RISBAP).

CARBAP

- Understand processes of technological diffusion

WCA Plantain Innovation Platform

- Learning, sharing knowledge, diagnostic surveys, policy advocacy, participatory approaches.

ProMusa

- Identify specific opportunities for research collaboration and funding
- Deliver research-based knowledge products to various user groups.

MUSALAC

- Develop maps with *Musa* production zones and homologue zones for extrapolation of research results, prioritization of grants etc.
- Inventories of ongoing research, information exchange
- Facilitate collaboration in new areas (bananas in mixed cropping systems with coffee; sub-tropical bananas, pesticide use reduction/clean technologies) including grant proposal development.

2.5 Staple crops

In Africa and Latin America regional and sub-regional platforms have developed strategies for collaboration among their member national R&D organizations, plus partners including the CGIAR centers. Many of these organizations have strategic plans that indicate priorities where collaboration adds value, but this is identified at a rather general (and not commodity) level, with roots, tubers and bananas/plantains often grouped together as "staples" with similar sets of

priorities. The same situation occurs for some national research programs in all regions, where detailed commodity specific priority setting is not documented.

These general research priorities are detailed in this section, in order to avoid repetition of the same information for each individual commodity.

In addition, IITA conducted a priority setting exercise involving a both internal scientists and others from partner organizations (Manyong, undated). This process resulted in a clear prioritization of a number of activities in five objectives (increasing productivity, decreasing risks, adding value/improving markets, policy/advocacy and capacity building). These are also detailed in the spreadsheet.

Genetic resources and diversity

In Africa, ASARECA (East and Central Africa) has developed detailed strategic priorities, including a program areas for “Enhanced Germplasm Information and Technology Exchange, Conservation and Utilization to Catalyse Productivity of Staple Crops”. This covers identification and management of information on, and technology of, regional importance to staple crops, including:

- Establishing mechanisms for the generation and management of communication, information, knowledge and technologies among members and stakeholders
- Utilization and learning from activities implemented in the region
- Supporting germplasm and conservation exchange in the region, including policy development and harmonization
- Enhancing access to technologies/innovations and their utilization in the region
- Developing capacities for quality germplasm management research that has an impact on the production of staple crops in the region (key constraints).

Some individual country priorities for staple crops (across roots, tubers and bananas) are:

- Collection, conservation and use of local germplasm (NARO, Uganda)
- Biodiversity characterization for cassava and banana (CATIE, Central America)
- Germplasm collection, characterization and conservation (CTCRI, India)
- Germplasm enrichment and conservation (Indonesia)
- Germplasm characterization and optimization (FONTAGRO, Latin America)
- Screening for salt tolerance (Bangladesh, potato and sweetpotato)
- Collection,, conservation and management of indigenous resources (PNG, taro, yams).

Improved varieties

The IITA priority setting exercise identified the following priorities related to crop improvement research for roots and tubers in Africa:

- Development and application of biotechnological tools for biotic and abiotic stress resistance
- Breeding for water and nutrient use efficiency
- Breeding for markets and nutrition.

ASARECA the “Enhancing productivity” Program area seeks to enhance the development of regional undertakings and to support the actualization of spillover management of investments from national level crop improvement activities.

Other cross-commodity crop improvement research priorities identified are:

- Breeding more acceptable varieties resistant to diseases and pests (Uganda)

- DNA sequencing and genomics (Beca, Africa)
- Improved productivity (Indonesia)
- Varieties suited to new products (Fontagro).

Pests and diseases

In Africa, a key priority identified by both ASARECA and IITA's exercise is to improve knowledge of pest and disease risks/threats. This includes pest-disease epidemics, of both resurgent and new threats. Climate change is likely to increase the incidence of these threats in the future. The ability to respond to these threats to the productivity and competitiveness of staple crops requires, according to ASARECA:

- The setting up frameworks to respond to the threats
- Implementation of strategic, development oriented research to address these threats.

This will require collective action for resource mobilization, priority setting and establishing linkages.

Sustainable systems for planting material

For ASARECA, the development of competences to enhance the effectiveness and efficiency of informal and formal seed systems (in partnership with the public and private sectors) to produce and deliver quality seeds to the farming community is important. Robust, efficient and effective input and seed supply systems for staple crops will help to improve access to technologies for staple crop production across the region. This will also involve the harmonization of policies to handle seed systems and access to technologies between countries. Regional seed and other inputs delivery models and best practices are also needed. This accords with the IITA exercise, where "reduced seed system risks" was identified as a priority research area.

Other staple crop research priorities mentioned by other organizations are:

- Cell and tissue culture
- Certification systems (review of experiences)

Tools for productive cropping systems

The IITA exercise identified development of sustainable systems – water, soil, pest, crop as a priority for roots and tubers. This is in accord with NARO in Uganda (for resource poor farmers), for FONTAGRO and CATIE in Latin America (including diversification of cropping systems) and PNG, especially for soil fertility management across the range of root and tuber crop important in the Pacific region.

Understanding the interactions of different climate change impacts on smallholder producers requires modelling work based on a thorough understanding of the complexities of specific real-world smallholder systems and empirical research on the circumstances under which current strategies to cope with extreme events foster or constrain longer-term adaptation (Morton, 2007). Root crop responses to climate change need to be better understood, including post-harvest and marketing as well as production issues. As regards adaptation, many of the potential agronomic adaptations (e.g., improved soil and water conservation) are very relevant to smallholder producers, but require careful interdisciplinary and participatory research (Morton, 2007). India has prioritized the development of decision support systems for precision farming for these crops.

Postharvest, value chains and markets

For ASARECA, enhancing value addition and improving access to regional and global markets of staple crops in ECA is another priority program area for staple crops.

This seeks to:

- Enhance the development of regional undertakings
- Support the actualization of spillover management of investments.
- Improve selected regional input and output value chains, including through incentives for public-private partnerships (seed systems, processing and value addition, standards, policies, regulations, certification etc.)
 - Develop approaches to enhance and sustain regional value chains of staple crops
 - Document lessons learned for application to other crops
- Capacity building for key stakeholders to participate in commodity value chains
- Improving access to regional and global markets of staple crops through market analysis, establishment of a market information system to facilitate access to the regional and global markets and other means of information dissemination.
- Evidence based policy development
- Enhancing value addition of staple crops through processing and product diversification.

Similarly, IITA's priority setting exercise identified root and tuber crop product development, reduction of postharvest risks and improved knowledge of consumer risks.

Other staple crop priorities reported are:

- Develop improved post harvest practices acceptable to resource poor farmers (Uganda),
- industrial development, value-added product development (India, Uganda, CATIE Central America)
- Biofuel development (Uganda)etc
- Postharvest standards, certification (CAPSA)
- Processing best practices (Indonesia)
- Market linkages (Malawi)
- Market studies and information systems (India, Malawi)
- Value chain improvement (CATIE, FONTAGRO)
- Enterprise Development (CATIE)
- Fresh root/tuber storage (PNG).

For root and tuber crops produced as raw materials for industrial processing (value chains related to food, feed and non-food uses), Ceballos (2009) identified a number of key requirements for research to have a successful impact, including close interaction between agriculture and industry (and their needs), and recognition that this research is long-term in nature.

The Asia root and tuber scoping study (Wheatley 2010) identified the roles of public sector R&D in the postharvest area, in partnership with other chain actors/stakeholders as:

- To investigate, develop and disseminate practices, models of industrial and chain organization and governance etc that enhance the equitable distribution of added value in these value chains, so that poor producers obtain a fair return on their links to these chains
- To carry out research that enhances the efficient use of inputs/resources, management of wastes and reduces GHG emissions along value chains (product life cycle processes).

Enhancing impact through partnerships

Socio-economic research priorities for staple crops focus on policy development, for poverty reduction/livelihoods, market competitiveness and sustainability, which were identified as important by ITTA, and also for FONTAGRO, Zamorano and CATIE in Latin America and CAPSA in SE Asia.

For ASARECA, several priorities for regional partnerships have been identified, including:

- Strategic technology generation platforms for public goods, covering biotic and abiotic threats, including specialized networks developed and used to generate technologies and products for the wider benefits of the region
- Shared research and training facilities and capacities rationalized for enhanced economies of scope and scale, aiming to address the challenge faced by national systems in achieving their goals with limited resources (infrastructure/facilities, human resources) across common agroecologies. This aims to reduce transaction costs, increase cost-effectiveness, improve solidarity and promote efficiency
- Information management for marketing, learning and policy advocacy between program partners and stakeholders (including value chain actors) that contributes to agricultural policy and development practice
- Enhanced productivity, regional value addition and improved access to regional and global markets of staple crops. This seeks to enhance the development of regional undertakings, especially the development of regional value chains through regional frameworks of platforms for specific crops and trade policy harmonization for regional trade.

Although these regional level partnership areas are articulated by ASARECA, they are common for other regional and national groupings (Latin America, India, and Indonesia). Recent approaches to innovation stress the importance of learning from existing experiences, extracting lessons and promoting the best practices. There are challenges regarding development of the practical methods needed to use an innovation systems approach, and how to promote inter-organizational learning (e.g., research organizations in partnership with public and private stakeholders) (Ortiz 2009). This type of process is important, as interactions among diverse stakeholders and actors (especially in value chains) are frequently characterized by a lack of trust. Multi-stakeholder “platforms” can be developed – and facilitated - that promote interaction, social learning, social capital formation, consensus building and collective action involving these diverse actors (in market chains or geographical regions) in innovation and market coordination processes (Thiele et al. 2009).

Communication of research results is also becoming more important, in order to support policy formation, including use of decision support (DS) approaches and tools, ranging from general discussions and mutual awareness-raising (including formal joint exercises such as scenarios construction and analyses) to simulation modelling, GIS and other tools for conducting quantitative analyses of trade-offs of given policy options (Ingram et al. 2008) and for providing user-friendly means of visualizing the results of different scenarios and policy options.

3. GENERAL CONCLUSIONS - PRIORITIES FOR CGIAR COLLABORATION

The information collated above aims to reflect the research priorities of a range of the main RTB R&D partners/stakeholders across regions and themes relevant to this exercise. However, the articles, reports, strategic plans, websites and other information consulted provide only a limited insight into the research topics that are seen as a priority for collaboration with the CGIAR (as a sub-set of the overall research priorities of each organization). This section therefore attempts to identify some broad areas of collaboration based on sources that were, in general, not designed to

elicit this type of information. For this reason, only broad areas are identified, to serve as a starting point for more direct consultations. These areas of collaboration are presented by research theme (as there is much commonality across crops), but there are some differences across regions based on the relative strength of national and regional research systems.

A recent APAARI report on research priorities in Asia (across agriculture in general) identifies three main challenges for R&D where regional collaboration is required:

- Sustained, increased productivity (staples, diversification, integrated farming systems and biotechnology)
- Improved value chain development (linking farmers to markets, partnerships)
- Enhanced resilience (climate change and economic shocks).

These are useful to integrate the seven research themes developed for the CRP-RTB program, relating to crop production, market/utilization and longer-term processes that need to be addressed. Additionally, in order to integrate socio-economic and biophysical research that enables analysis of different options for root and tuber crops food systems, crop specific R&D needs to be integrated (Thiele et al. 2009) with the wider food system, including diet diversification and food policy in general, and with other sectors such as health (e.g., for nutritional R&D).

Genetic resources and diversity

- Germplasm characterization (including quality traits)
- Germplasm exchange policies and protocols
- IP management.

Improved varieties

- Development and application of biotechnological tools in breeding
- Selection and pre-breeding for resistance/tolerance to key biotic and abiotic stresses
 - Pests/diseases
 - Water stress, drought, floods
 - Temperature (heat and frost tolerance)
 - Soil nutrient use efficiency
- Basic selection and breeding for “fit” into specific cropping systems (e.g., earliness)
- Improved traits for added value markets, industrial uses, human nutrition and quality attributes.

Pests and diseases

- Response to threats – new diseases and pests
- Basic epidemiological research on major pests/diseases (coordination for efficient allocation of resources with regional and national programmes needed) for development of IPM
- Development of diagnostic tools (e.g., viruses).

Sustainable systems for planting material

- Sustainable seed systems that deliver clean, high quality planting material at affordable prices – best practice
- Virus eradication
- Certification.

Tools for productive cropping systems

- Development and application of decision support tools, GIS etc, to optimize efficient use of resources (soils, water, fertilizer)
- Models/scenarios for climate change adaptation (including practices that reduce GHG emissions).

Postharvest, value chains and markets

- Methods, tools, good practice for equitable, sustainable value chain development, improvement and rural enterprise development, working with multiple stakeholders (including through value chain oriented platforms)
- Best practice for equitable public-private partnerships
- Market information system development
- Information sharing (processing technologies, product development, etc.).

Enhancing impact through partnerships

- Knowledge management, information exchange across range of topics (incl. genetic resources, crop production and postharvest/markets)
- Capacity building in ICT (especially for Africa)
- Facilitation of platforms (related to specific commodities, research issues/technologies, value chains etc)
- Innovation platforms
- Policy design, implementation, evaluation and advocacy
- Impact analysis.

Attention is drawn to the challenges of climate change. While roots, tubers and bananas will be impacted by climate change, they also have the potential to contribute positively to the challenges that climate change brings. Genetic improvement, pest, disease and crop management are all relevant here. To achieve the required breakthroughs, research-for-development networks will need to work closely together so that technology and knowledge can flow to allow farmers to face the risks associated with future harvests. Breeding for biotic and abiotic stresses will be critical to future food security. (Rosegrant et al. 2007).

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(These references are additional to the documents, reports and websites identified in the spreadsheet that accompanies this report. They are mainly derived from the Asia root and tuber scoping study (Wheatley 2010) and compensate for the lack of stakeholder priority documents found that region in the spreadsheet summary.)

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ANNEX 5. BUDGET TABLES (Revised)

Annex 5.1 CRP-RTB Investments by Theme (US\$ Million)

Research Theme	UPSIDE GROWTH SCENARIO				
	2011	2012	2013	Total	%
T1 Conserving and accessing genetic resources	6.8	7.5	7.7	22.1	10.7
T2 Accelerating the development and selection of varieties with higher, more stable yield and added value	15.4	18.6	20.1	54.1	26.1
T3 Managing priority pests and diseases	6.6	7.8	8.3	22.8	11.0
T4 Making available low-cost, high-quality planting material for farmers	5.8	6.6	6.9	19.2	9.3
T5 Developing tools for more productive, ecologically robust cropping systems	3.7	4.5	4.9	13.1	6.3
T6 Promoting postharvest technologies, value chains, and market opportunities	4.9	5.6	5.8	16.3	7.9
T7 Enhancing impact through partnerships	5.3	6.2	6.2	17.7	8.5
Sub Total	48.5	56.9	60.0	165.3	79.8
Institutional Overhead	9.4	11.0	11.6	32.1	15.5
Total Budget before CRP Management Cost	57.9	67.9	71.6	197.4	95.2
CRP Management Cost (5%)	2.9	3.4	3.6	9.9	4.8
Total Budget	60.8	71.3	75.2	207.3	100

Annex 5.2 CRP-RTB Theme Investments by Crop (US\$ Million)

Research Themes by Crops	UPSIDE GROWTH SCENARIO						
	2011 -2013						
	Potato	SWP	Banana	Cassava	Yams	Others RTB	Total
T1 Conserving and accessing genetic resources	0.3	0.2	8.1	9.0	2.9	1.6	22.1
T2 Accelerating the development and selection of varieties with higher, more stable yield and added value	15.2	15.0	5.1	12.9	4.0	1.8	54.1
T3 Managing priority pests and diseases	3.9	2.1	7.5	6.8	2.4	0.1	22.8
T4 Making available low-cost, high-quality planting material for farmers	4.0	2.6	4.3	6.1	2.2	0.1	19.2
T5 Developing tools for more productive, ecologically robust cropping systems	1.6	1.3	4.9	4.4	0.9	0.1	13.1
T6 Promoting postharvest technologies, value chains, and market opportunities	2.0	0.6	4.9	5.7	2.0	1.1	16.3
T7 Enhancing impact through partnerships	1.3	4.1	7.4	3.7	1.2	0.1	17.7
Sub Total	28.3	25.9	42.2	48.6	15.5	4.8	165.3
Institutional Overhead	5.7	5.2	8.2	9.0	3.1	1.0	32.1
Total Budget before CRP Management Cost	33.9	31.0	50.4	57.6	18.6	5.8	197.4
CRP Management Cost (5%)	1.7	1.6	2.5	2.9	0.9	0.3	9.9
Total Budget	35.6	32.6	52.9	60.5	19.5	6.1	207.3

Annex 5.3 CRP-RTB Theme Investments by Center (US\$ Million)

Research Theme	UPSIDE GROWTH SCENARIO				
	2011 -2013				
	Bioversity	CIAT	CIP	IITA	Total
T1 Conserving and accessing genetic resources	5.5	3.5	2.0	11.1	22.1
T2 Accelerating the development and selection of varieties with higher, more stable yield and added value	1.6	5.3	31.7	15.5	54.1
T3 Managing priority pests and diseases	5.3	2.5	6.0	9.0	22.8
T4 Making available low-cost, high-quality planting material for farmers	2.3	2.1	6.5	8.3	19.2
T5 Developing tools for more productive, ecologically robust cropping systems	4.0	2.8	3.0	3.3	13.1
T6 Promoting postharvest technologies, value chains, and market opportunities	3.1	2.1	3.6	7.6	16.3
T7 Enhancing impact through partnerships	6.3	1.5	5.4	4.5	17.7
Sub Total	28.1	19.7	58.1	59.4	165.3
Institutional Overhead	5.3	3.3	11.6	11.9	32.1
Total Budget before CRP Management Cost	33.4	23.0	69.7	71.3	197.4
CRP Management Cost (5%)	1.7	1.2	3.5	3.6	9.9
Total Budget	35.1	24.2	73.2	74.9	207.3

Annex 5.4 CRP-RTB Center Investments by Region (US\$ Million)

Regional Distribution by Center	UPSIDE GROWTH SCENARIO				
	2011 -2013				
	SSA	ASIA	LAC	GLOBAL	TOTAL
BIOVERSITY	10.8	2.2	3.2	11.9	28.1
CIAT	2.7	2.7	6.2	8.1	19.7
CIP	23.5	11.0	5.6	18.0	58.1
IITA	59.4	-	-	-	59.4
Sub Total	96.4	15.9	15.0	38.0	165.3
Institutional Overhead	19.1	3.1	2.8	7.2	32.1
Total Budget before CRP Management Cost	115.5	19.0	17.7	45.2	197.4
CRP Management Cost (5%)	5.8	0.9	0.9	2.3	9.9
Total Budget	121.2	19.9	18.6	47.5	207.3
%	58%	10%	9%	23%	100%

Annex 5.5 CRP-RTB Expenditures by Cost Categories (US\$ Million)

Cost Category	UPSIDE GROWTH SCENARIO				
	2011	2012	2013	Total	%
Personnel Cost	18.7	21.6	22.8	63.2	30.5
Travel	2.9	3.4	3.6	9.9	4.8
Operating expenses (Supplies & Services)	12.4	15.3	16.4	44.2	21.3
Traning / Workshop	0.8	0.9	1.0	2.7	1.3
Partners / Collaborator Contracts	11.1	12.8	13.4	37.3	18.0
Capital and other equipment for project	2.5	2.7	2.8	8.0	3.9
Sub Total	48.5	56.8	60.0	165.3	79.7
Institutional Overhead	9.4	11.0	11.6	32.1	15.5
Total Budget before CRP Management Cost	57.9	67.9	71.6	197.4	95.2
CRP Management Cost (5%)	2.9	3.4	3.6	9.9	4.8
Total Budget	60.8	71.3	75.2	207.3	100

Annex 5.6 CRP-RTB Funding (US\$ Million)

Funding	UPSIDE GROWTH SCENARIO				
	2011	2012	2013	Total	%
Projected Unrestricted Funds	20.9	22.9	24.0	67.8	32.7
Current Restricted Donor projects (assured)	19.4	14.9	12.4	46.7	22.5
Other Income:	1.0	0.7	0.6	2.3	1.1
CGIAR Fund -Funding Gap (Research)	16.5	29.4	34.6	80.5	38.9
CGIAR Fund -Funding Gap (CRP Management Cost)	2.9	3.4	3.6	9.9	4.8
Total	60.8	71.3	75.2	207.3	100

Annex 5.7 CRP-RTB Investments by Theme and Product Line (US\$ Million)

Research Theme	BASE SCENARIO			
	2011	2012	2013	Total
Theme 1: Conserving and accessing genetic resources	6.4	6.5	6.7	19.6
PL 1: Ex-situ and in-situ conservation methodologies optimized	1.3	1.4	1.4	4.2
PL 2: Increased coverage of gene pools in global genebanks	0.7	0.7	0.7	2.2
PL 3: Collections of RTB evaluated, phenotyped and genotyped for important traits	2.3	2.4	2.4	7.1
PL 4: Collections of RTB documented and information freely accessible to users	0.9	1.0	1.0	2.9
PL 5 : Safe exchange of RTB genetic resources	1.1	1.1	1.1	3.3
Theme 2: Accelerating the development and selection of varieties with higher, more stable yield and added value	14.8	15.7	16.7	47.3
PL 1: Breeding tools, strategies and approaches	2.5	2.6	2.8	7.9
PL 2: Trait capture and gene discovery	2.1	2.3	2.5	7.0
PL 3: Population development and pre-breeding	5.5	5.7	6.0	17.2
PL 4: Variety development	2.9	3.1	3.4	9.4
PL 5: Aligning research with farmers and end-users priorities	1.8	1.9	2.1	5.8
Theme 3: Managing priority pests and diseases	6.3	6.7	7.0	20.0
PL 1: Detection, surveillance and mapping	1.8	1.9	2.0	5.8
PL 2: Ecology, biology and epidemiology of pests and diseases	1.4	1.5	1.6	4.6
PL 3: Ecology and management of beneficial organisms	1.1	1.1	1.2	3.3
PL 4: Specific management strategies	2.0	2.1	2.2	6.3
Theme 4: Making available low-cost, high-quality planting material for farmers	5.5	5.7	5.9	17.1
PL 1: Policies, strategies and decision support tools to improve effectiveness of seed systems	1.5	1.5	1.6	4.6
PL 2: Lower cost, more effective mass propagation methods	1.9	2.0	2.1	6.1
PL 3: Farmer-based quality seed production and management methods	2.1	2.1	2.2	6.4
Theme 5: Developing tools for more productive, ecologically robust cropping systems	3.6	3.8	4.0	11.5
PL 1: Ecological and physiological understanding of RTB crops and cropping systems	0.8	0.9	0.9	2.7
PL 2: Increasing productivity in RTB cropping systems through nutrient/water/light management practices	1.2	1.3	1.4	3.9
PL 3: Integrated decision and management tools for RTB crops developed and validated	1.5	1.6	1.7	4.9
Theme 6: Promoting postharvest technologies, value chains, and market opportunities	4.7	4.8	5.0	14.5
PL 1: Postharvest approaches to improve food security	1.4	1.5	1.5	4.5
PL 2: Improving linkages to markets for environmentally friendly income generation activities	2.0	2.1	2.1	6.2
PL 3: Marketing strategies and policies to promote RTB consumption	1.3	1.3	1.3	3.9
Theme 7: Enhancing impact through partnerships	5.1	5.3	5.5	15.9
PL 1: Targeting and setting priorities	1.2	1.3	1.2	3.7
PL 2: Building effective partnerships	0.7	0.7	0.7	2.1
PL 3: Communication and knowledge sharing	1.3	1.4	1.5	4.3
PL 4: Capacity strengthening	0.7	0.7	0.8	2.2
PL 5: Outcome and impact evaluation	1.1	1.1	1.3	3.6
Sub Total	46.4	48.5	50.9	145.9
Institutional Overhead	9.1	9.5	9.9	28.4
Total Budget before CRP Management Cost	55.5	58.0	60.9	174.3
CRP Management Cost (5%)	2.8	2.9	3.0	8.7
Total Budget	58.3	60.9	63.9	183.0

Annex 5.8 CRP-RTB Theme–Product Line Investments by Center (US\$ Million)

Research Theme	BASE SCENARIO				
	2011 - 2013				
	BIOVERSITY	CIAT	CIP	ITA	Total
Theme 1: Conserving and accessing genetic resources	4.8	3.1	1.8	9.9	19.6
PL 1: Ex-situ and in-situ conservation methodologies optimized	0.7	1.1	0.4	2.0	4.2
PL 2: Increased coverage of gene pools in global genebanks	0.4	0.6	0.2	1.0	2.2
PL 3: Collections of RTB evaluated, phenotyped and genotyped for important traits	1.7	0.7	0.7	3.9	7.1
PL 4: Collections of RTB documented and information freely accessible to users	1.3	0.4	0.2	1.0	2.9
PL 5: Safe exchange of RTB genetic resources	0.6	0.3	0.4	2.0	3.2
Theme 2: Accelerating the development and selection of varieties with higher, more stable yield and added value	1.4	4.6	27.5	13.8	47.3
PL 1: Breeding tools, strategies and approaches	0.2	0.8	4.1	2.8	7.9
PL 2: Trait capture and gene discovery	0.5	1.2	3.9	1.4	7.0
PL 3: Population development and pre-breeding	0.3	1.3	12.1	3.4	17.2
PL 4: Variety development	0.2	1.2	3.9	4.1	9.4
PL 5: Aligning research with farmers and end-users priorities	0.2	0.2	3.3	2.1	5.8
Theme 3: Managing priority pests and diseases	4.7	2.2	5.1	8.0	20.0
PL 1: Detection, surveillance and mapping	1.2	0.5	2.1	2.0	5.8
PL 2: Ecology, biology and epidemiology of pests and diseases	1.3	0.5	0.8	2.0	4.6
PL 3: Ecology and management of beneficial organisms	0.4	0.5	0.8	1.6	3.3
PL 4: Specific management strategies	1.9	0.7	1.3	2.4	6.3
Theme 4: Making available low-cost, high-quality planting material for farmers	2.0	1.8	5.9	7.4	17.1
PL 1: Policies, strategies and decision support tools to improve effectiveness of seed systems	0.7	0.6	1.2	2.2	4.6
PL 2: Lower cost, more effective mass propagation methods	0.0	0.6	2.1	3.3	6.1
PL 3: Farmer-based quality seed production and management methods	1.4	0.6	2.6	1.8	6.4
Theme 5: Developing tools for more productive, ecologically robust cropping systems	3.5	2.5	2.5	3.0	11.5
PL 1: Ecological and physiological understanding of RTB crops and cropping systems	0.4	0.6	0.8	0.9	2.7
PL 2: Increasing productivity in RTB cropping systems through nutrient/water/light management practices	0.5	1.1	1.0	1.3	3.9
PL 3: Integrated decision and management tools for RTB crops developed and validated	2.6	0.8	0.8	0.7	4.9
Theme 6: Promoting postharvest technologies, value chains, and market opportunities	2.7	1.8	3.2	6.8	14.6
PL 1: Postharvest approaches to improve food security	0.4	0.9	0.8	2.4	4.5
PL 2: Improving linkages to markets for environmentally friendly income generation activities	2.0	0.7	1.5	2.0	6.2
PL 3: Marketing strategies and policies to promote RTB consumption	0.3	0.3	0.9	2.4	3.9
Theme 7: Enhancing impact through partnerships	5.5	1.3	5.0	4.0	15.8
PL 1: Targeting and setting priorities	1.0	0.1	1.4	1.2	3.7
PL 2: Building effective partnerships	0.7	0.3	0.5	0.6	2.1
PL 3: Communication and knowledge sharing	2.9	0.2	0.8	0.4	4.2
PL 4: Capacity strengthening	0.5	0.4	0.8	0.6	2.2
PL 5: Outcome and impact evaluation	0.5	0.2	1.6	1.2	3.6
Sub Total	24.7	17.3	51.1	52.8	145.9
Institutional Overhead	4.7	3.0	10.2	10.6	28.4
Total Budget before CRP Management Cost	29.4	20.3	61.3	63.3	174.3
CRP Management Cost (5%)	1.5	1.0	3.1	3.2	8.7
Total Budget	30.9	21.3	64.3	66.5	183.0

Annex 5.9 CRP-RTB Theme–Product Line Investments by Crop (US\$ Million)

Research Themes by Crops	BASE SCENARIO						
	2011 - 2013						
	Potato	SWP	Banana	Cassava	Yams	Others RTB	Total
Theme 1: Conserving and accessing genetic resources	0.3	0.2	7.0	7.3	2.6	2.1	19.6
PL 1: Ex-situ and in-situ conservation methodologies optimized	0.1	0.0	1.2	1.9	0.5	0.4	4.2
PL 2: Increased coverage of gene pools in global genebanks	0.0	0.0	0.7	1.0	0.3	0.2	2.1
PL 3: Collections of RTB evaluated, phenotyped and genotyped for important traits	0.1	0.1	2.6	2.4	1.0	0.8	7.1
PL 4: Collections of RTB documented and information freely accessible to users	0.0	0.0	1.6	0.8	0.3	0.2	2.9
PL 5: Safe exchange of RTB genetic resources	0.1	0.0	1.0	1.2	0.5	0.4	3.2
Theme 2: Accelerating the development and selection of varieties with higher, more stable yield and added value	12.0	14.0	4.6	11.6	3.6	1.4	47.3
PL 1: Breeding tools, strategies and approaches	1.8	2.1	0.8	2.2	0.7	0.2	7.9
PL 2: Trait capture and gene discovery	2.4	1.4	0.8	1.9	0.4	0.1	7.0
PL 3: Population development and pre-breeding	3.6	7.7	1.1	3.1	0.9	0.8	17.2
PL 4: Variety development	2.4	1.4	1.1	3.3	1.1	0.1	9.4
PL 5: Aligning research with farmers and end-users priorities	1.8	1.4	0.7	1.2	0.5	0.1	5.8
Theme 3: Managing priority pests and diseases	3.2	1.9	6.6	6.2	2.1	-	20.0
PL 1: Detection, surveillance and mapping	0.9	1.2	1.7	1.5	0.5	-	5.8
PL 2: Ecology, biology and epidemiology of pests and diseases	0.6	0.2	1.7	1.5	0.5	-	4.6
PL 3: Ecology and management of beneficial organisms	0.6	0.2	0.8	1.3	0.4	-	3.3
PL 4: Specific management strategies	0.9	0.4	2.4	1.9	0.6	-	6.3
Theme 4: Making available low-cost, high-quality planting material for farmers	3.5	2.4	3.8	5.5	1.9	-	17.1
PL 1: Policies, strategies and decision support tools to improve effectiveness of seed systems	0.7	0.5	1.2	1.7	0.6	-	4.6
PL 2: Lower cost, more effective mass propagation methods	1.4	0.7	0.8	2.3	0.9	-	6.1
PL 3: Farmer-based quality seed production and management methods	1.4	1.2	1.8	1.5	0.5	-	6.4
Theme 5: Developing tools for more productive, ecologically robust cropping systems	1.3	1.2	4.3	3.9	0.8	0.0	11.5
PL 1: Ecological and physiological understanding of RTB crops and cropping systems	0.4	0.4	0.7	1.0	0.2	0.0	2.7
PL 2: Increasing productivity in RTB cropping systems through nutrient/water/light management practices	0.5	0.5	0.8	1.7	0.3	0.0	3.9
PL 3: Integrated decision and management tools for RTB crops developed and validated	0.4	0.4	2.8	1.2	0.2	0.0	4.9
Theme 6: Promoting postharvest technologies, value chains, and market opportunities	1.8	0.5	4.4	5.2	1.8	0.9	14.5
PL 1: Postharvest approaches to improve food security	0.5	0.1	1.0	2.1	0.6	0.2	4.5
PL 2: Improving linkages to markets for environmentally friendly income generation activities	0.9	0.2	2.5	1.7	0.5	0.4	6.1
PL 3: Marketing strategies and policies to promote RTB consumption	0.4	0.2	0.9	1.4	0.6	0.4	3.9
Theme 7: Enhancing impact through partnerships	1.2	3.9	6.5	3.4	1.0	-	15.9
PL 1: Targeting and setting priorities	0.3	1.0	1.3	0.7	0.3	-	3.7
PL 2: Building effective partnerships	0.1	0.4	0.8	0.6	0.2	-	2.1
PL 3: Communication and knowledge sharing	0.2	0.6	3.0	0.4	0.1	-	4.3
PL 4: Capacity strengthening	0.2	0.6	0.6	0.7	0.2	-	2.2
PL 5: Outcome and impact evaluation	0.3	1.3	0.8	0.8	0.3	-	3.6
Sub Total	23.2	24.2	37.1	43.0	13.8	4.5	145.9
Institutional Overhead	4.6	4.8	7.3	8.0	2.7	0.9	28.4
Total Budget before CRP Management Cost	27.8	29.0	44.4	51.0	16.5	5.4	174.3
CRP Management Cost (5%)	1.4	1.4	2.2	2.6	0.8	0.3	8.7
Total Budget	29.2	30.4	46.7	53.6	17.3	5.7	183.0

Annex 5.10 CRP-RTB Theme–Product Line Investments by Region (US\$ Million)

Research Themes by Crops	BASE SCENARIO				
	2011 - 2013				
	SSA	ASIA	LAC	GLOBAL	Total
Theme 1: Conserving and accessing genetic resources	11.1	0.5	1.1	6.7	19.6
PL 1: Ex-situ and in-situ conservation methodologies optimized	2.3	0.1	0.3	1.4	4.1
PL 2: Increased coverage of gene pools in global genebanks	1.3	0.1	0.3	0.6	2.3
PL 3: Collections of RTB evaluated, phenotyped and genotyped for important traits	4.5	0.3	0.5	2.0	7.3
PL 4: Collections of RTB documented and information freely accessible to users	1.1	0.0	0.0	1.6	2.8
PL 5 : Safe exchange of RTB genetic resources	2.0	-	0.0	1.1	3.1
Theme 2: Accelerating the development and selection of varieties with higher, more stable yield and added value	25.1	5.5	3.4	13.3	47.3
PL 1: Breeding tools, strategies and approaches	4.4	0.7	0.3	2.6	8.0
PL 2: Trait capture and gene discovery	3.1	0.8	0.8	2.3	6.9
PL 3: Population development and pre-breeding	8.3	2.4	1.3	5.5	17.5
PL 4: Variety development	5.8	0.9	0.8	1.5	9.1
PL 5: Aligning research with farmers and end-users priorities	3.5	0.6	0.3	1.3	5.7
Theme 3: Managing priority pests and diseases	11.5	2.1	2.8	3.6	20.0
PL 1: Detection, surveillance and mapping	3.1	0.7	0.8	1.2	5.8
PL 2: Ecology, biology and epidemiology of pests and diseases	2.8	0.5	0.6	0.6	4.6
PL 3: Ecology and management of beneficial organisms	1.9	0.2	0.6	0.6	3.3
PL 4: Specific management strategies	3.7	0.8	0.7	1.1	6.3
Theme 4: Making available low-cost, high-quality planting material for farmers	13.0	1.0	1.3	1.9	17.1
PL 1: Policies, strategies and decision support tools to improve effectiveness of seed systems	3.4	0.3	0.4	0.6	4.6
PL 2: Lower cost, more effective mass propagation methods	4.9	0.3	0.3	0.5	6.1
PL 3: Farmer-based quality seed production and management methods	4.7	0.4	0.6	0.7	6.4
Theme 5: Developing tools for more productive, ecologically robust cropping systems	6.3	1.2	1.5	2.4	11.5
PL 1: Ecological and physiological understanding of RTB crops and cropping systems	1.4	0.2	0.3	0.7	2.7
PL 2: Increasing productivity in RTB cropping systems through nutrient/water/light management practices	2.1	0.4	0.8	0.6	3.9
PL 3: Integrated decision and management tools for RTB crops developed and validated	2.8	0.6	0.4	1.1	4.9
Theme 6: Promoting postharvest technologies, value chains, and market opportunities	11.3	0.4	1.4	1.4	14.5
PL 1: Postharvest approaches to improve food security	3.3	0.2	0.4	0.7	4.5
PL 2: Improving linkages to markets for environmentally friendly income generation activities	4.6	0.2	0.8	0.6	6.2
PL 3: Marketing strategies and policies to promote RTB consumption	3.4	0.1	0.2	0.1	3.9
Theme 7: Enhancing impact through partnerships	8.6	0.5	1.6	5.1	15.9
PL 1: Targeting and setting priorities	2.5	0.2	0.4	0.7	3.8
PL 2: Building effective partnerships	1.2	0.1	0.2	0.7	2.2
PL 3: Communication and knowledge sharing	1.3	0.1	0.4	2.5	4.3
PL 4: Capacity strengthening	1.3	0.1	0.2	0.6	2.2
PL 5: Outcome and impact evaluation	2.3	0.1	0.4	0.6	3.4
Sub Total	86.9	11.4	13.2	34.5	145.9
Institutional Overhead	17.2	2.2	2.4	6.6	28.4
Total Budget before CRP Management Cost	104.1	13.6	15.6	41.0	174.3
CRP Management Cost (5%)	5.2	0.7	0.8	2.1	8.7
Total Budget	109.3	14.3	16.4	43.1	183.0

Annex 5.11 CRP-RTB Investments by Theme and Product Line (US\$ Million)

Research Theme	UPSIDE GROWTH SCENARIO			
	2011	2012	2013	Total
Theme 1: Conserving and accessing genetic resources	6.8	7.5	7.7	22.1
PL 1: Ex-situ and in-situ conservation methodologies optimized	1.4	1.6	1.7	4.7
PL 2: Increased coverage of gene pools in global genebanks	0.7	0.8	0.9	2.4
PL 3: Collections of RTB evaluated, phenotyped and genotyped for important traits	2.5	2.7	2.8	8.0
PL 4: Collections of RTB documented and information freely accessible to users	1.0	1.1	1.2	3.3
PL 5 : Safe exchange of RTB genetic resources	1.1	1.2	1.3	3.6
Theme 2: Accelerating the development and selection of varieties with higher, more stable yield and added value	15.4	18.6	20.1	54.1
PL 1: Breeding tools, strategies and approaches	2.6	3.1	3.3	9.0
PL 2: Trait capture and gene discovery	2.2	2.8	3.0	8.0
PL 3: Population development and pre-breeding	5.6	6.8	7.3	19.7
PL 4: Variety development	3.1	3.7	4.0	10.7
PL 5: Aligning research with farmers and end-users priorities	1.9	2.3	2.5	6.7
Theme 3: Managing priority pests and diseases	6.6	7.8	8.3	22.8
PL 1: Detection, surveillance and mapping	1.9	2.3	2.4	6.6
PL 2: Ecology, biology and epidemiology of pests and diseases	1.5	1.8	1.9	5.2
PL 3: Ecology and management of beneficial organisms	1.1	1.3	1.4	3.8
PL 4: Specific management strategies	2.1	2.5	2.6	7.2
Theme 4: Making available low-cost, high-quality planting material for farmers	5.8	6.6	6.9	19.2
PL 1: Policies, strategies and decision support tools to improve effectiveness of seed systems	1.6	1.8	1.9	5.2
PL 2: Lower cost, more effective mass propagation methods	2.1	2.3	2.4	6.8
PL 3: Farmer-based quality seed production and management methods	2.1	2.5	2.6	7.2
Theme 5: Developing tools for more productive, ecologically robust cropping systems	3.7	4.5	4.9	13.1
PL 1: Ecological and physiological understanding of RTB crops and cropping systems	0.9	1.1	1.1	3.1
PL 2: Increasing productivity in RTB cropping systems through nutrient/water/light management practices	1.3	1.5	1.6	4.4
PL 3: Integrated decision and management tools for RTB crops developed and validated	1.6	1.9	2.1	5.6
Theme 6: Promoting postharvest technologies, value chains, and market opportunities	4.9	5.6	5.8	16.3
PL 1: Postharvest approaches to improve food security	1.5	1.7	1.8	5.0
PL 2: Improving linkages to markets for environmentally friendly income generation activities	2.1	2.4	2.5	6.9
PL 3: Marketing strategies and policies to promote RTB consumption	1.3	1.5	1.5	4.4
Theme 7: Enhancing impact through partnerships	5.3	6.2	6.2	17.7
PL 1: Targeting and setting priorities	1.3	1.5	1.3	4.1
PL 2: Building effective partnerships	0.7	0.8	0.8	2.4
PL 3: Communication and knowledge sharing	1.3	1.7	1.7	4.8
PL 4: Capacity strengthening	0.8	0.9	0.9	2.5
PL 5: Outcome and impact evaluation	1.2	1.3	1.4	3.9
Sub Total	48.5	56.8	60.0	165.3
Institutional Overhead	9.4	11.0	11.6	32.1
Total Budget before CRP Management Cost	57.9	67.9	71.6	197.4
CRP Management Cost (5%)	2.9	3.4	3.6	9.9
Total Budget	60.8	71.3	75.2	207.3

Annex 5.12 CRP-RTB Theme-Product Line Investments by Center (US\$ Million)

Research Theme	UPSIDE GROWTH SCENARIO 2011 - 2013				
	BIO DIVERSITY	CIAT	CIP	ITA	Total
Theme 1: Conserving and accessing genetic resources	5.4	3.5	2.0	11.1	22.1
PL 1: Ex-situ and in-situ conservation methodologies optimized	0.8	1.2	0.4	2.2	4.7
PL 2: Increased coverage of gene pools in global genebanks	0.5	0.6	0.2	1.1	2.4
PL 3: Collections of RTB evaluated, phenotyped and genotyped for important traits	1.9	0.8	0.8	4.4	8.0
PL 4: Collections of RTB documented and information freely accessible to users	1.5	0.4	0.2	1.1	3.3
PL 5: Safe exchange of RTB genetic resources	0.6	0.4	0.4	2.2	3.6
Theme 2: Accelerating the development and selection of varieties with higher, more stable yield and added value	1.6	5.3	31.7	15.5	54.1
PL 1: Breeding tools, strategies and approaches	0.2	0.9	4.8	3.1	9.0
PL 2: Trait capture and gene discovery	0.6	1.3	4.6	1.6	8.0
PL 3: Population development and pre-breeding	0.3	1.5	14.0	3.9	19.7
PL 4: Variety development	0.2	1.3	4.6	4.7	10.7
PL 5: Aligning research with farmers and end-users priorities	0.2	0.2	3.9	2.3	6.7
Theme 3: Managing priority pests and diseases	5.3	2.5	6.0	9.0	22.8
PL 1: Detection, surveillance and mapping	1.3	0.5	2.5	2.3	6.6
PL 2: Ecology, biology and epidemiology of pests and diseases	1.4	0.5	1.0	2.3	5.2
PL 3: Ecology and management of beneficial organisms	0.5	0.5	1.0	1.8	3.8
PL 4: Specific management strategies	2.1	0.8	1.6	2.7	7.2
Theme 4: Making available low-cost, high-quality planting material for farmers	2.3	2.1	6.5	8.3	19.2
PL 1: Policies, strategies and decision support tools to improve effectiveness of seed systems	0.7	0.7	1.3	2.5	5.2
PL 2: Lower cost, more effective mass propagation methods	0.0	0.7	2.3	3.7	6.8
PL 3: Farmer-based quality seed production and management methods	1.6	0.7	2.9	2.1	7.2
Theme 5: Developing tools for more productive, ecologically robust cropping systems	4.0	2.8	3.0	3.3	13.1
PL 1: Ecological and physiological understanding of RTB crops and cropping systems	0.5	0.7	0.9	1.0	3.1
PL 2: Increasing productivity in RTB cropping systems through nutrient/water/light management practices	0.6	1.2	1.2	1.5	4.4
PL 3: Integrated decision and management tools for RTB crops developed and validated	3.0	0.9	0.9	0.8	5.6
Theme 6: Promoting postharvest technologies, value chains, and market opportunities	3.1	2.1	3.6	7.6	16.3
PL 1: Postharvest approaches to improve food security	0.4	1.0	0.9	2.7	5.0
PL 2: Improving linkages to markets for environmentally friendly income generation activities	2.3	0.7	1.6	2.3	6.9
PL 3: Marketing strategies and policies to promote RTB consumption	0.4	0.3	1.0	2.7	4.4
Theme 7: Enhancing impact through partnerships	6.4	1.5	5.4	4.5	17.7
PL 1: Targeting and setting priorities	1.1	0.1	1.5	1.4	4.1
PL 2: Building effective partnerships	0.8	0.4	0.5	0.7	2.4
PL 3: Communication and knowledge sharing	3.3	0.3	0.8	0.5	4.8
PL 4: Capacity strengthening	0.5	0.5	0.8	0.7	2.5
PL 5: Outcome and impact evaluation	0.6	0.3	1.7	1.4	4.0
Sub Total	28.1	19.7	58.1	59.5	165.3
Institutional Overhead	5.3	3.3	11.6	11.9	32.1
Total Budget before CRP Management Cost	33.4	23.0	69.7	71.3	197.4
CRP Management Cost (5%)	1.7	1.2	3.5	3.6	9.9
Total Budget	35.1	24.2	73.2	74.9	207.3

Annex 5.13 CRP-RTB Theme–Product Line Investments by Crop (US\$ Million)

Research Themes by Crops	UPSIDE GROWTH SCENARIO						
	2011 - 2013						
	Potato	SWP	Banana	Cassava	Yams	Others RTB	Total
Theme 1: Conserving and accessing genetic resources	0.3	0.2	8.0	8.3	2.9	2.3	22.1
PL 1: Ex-situ and in-situ conservation methodologies optimized	0.1	0.0	1.3	2.2	0.6	0.5	4.7
PL 2: Increased coverage of gene pools in global genebanks	0.0	0.0	0.7	1.1	0.3	0.2	2.4
PL 3: Collections of RTB evaluated, phenotyped and genotyped for important traits	0.1	0.1	2.9	2.7	1.2	0.9	8.0
PL 4: Collections of RTB documented and information freely accessible to users	0.0	0.0	1.8	0.9	0.3	0.2	3.3
PL 5 : Safe exchange of RTB genetic resources	0.1	0.0	1.1	1.3	0.6	0.5	3.7
Theme 2: Accelerating the development and selection of varieties with higher, more stable yield and added value	14.0	16.1	5.1	13.2	4.0	1.6	54.1
PL 1: Breeding tools, strategies and approaches	2.1	2.4	0.9	2.5	0.8	0.2	9.0
PL 2: Trait capture and gene discovery	2.8	1.6	0.9	2.1	0.4	0.2	8.0
PL 3: Population development and pre-breeding	4.2	8.9	1.2	3.5	1.0	0.9	19.7
PL 4: Variety development	2.8	1.6	1.3	3.7	1.2	0.2	10.7
PL 5: Aligning research with farmers and end-users priorities	2.1	1.6	0.8	1.4	0.6	0.2	6.7
Theme 3: Managing priority pests and diseases	3.7	2.3	7.5	7.0	2.4	-	22.8
PL 1: Detection, surveillance and mapping	1.1	1.4	1.9	1.7	0.6	-	6.6
PL 2: Ecology, biology and epidemiology of pests and diseases	0.7	0.2	2.0	1.7	0.6	-	5.2
PL 3: Ecology and management of beneficial organisms	0.7	0.2	0.9	1.4	0.5	-	3.8
PL 4: Specific management strategies	1.1	0.5	2.8	2.2	0.7	-	7.2
Theme 4: Making available low-cost, high-quality planting material for farmers	3.9	2.7	4.3	6.2	2.2	-	19.2
PL 1: Policies, strategies and decision support tools to improve effectiveness of seed systems	0.8	0.5	1.3	1.9	0.7	-	5.2
PL 2: Lower cost, more effective mass propagation methods	1.5	0.8	0.9	2.6	1.0	-	6.8
PL 3: Farmer-based quality seed production and management methods	1.5	1.3	2.1	1.7	0.5	-	7.2
Theme 5: Developing tools for more productive, ecologically robust cropping systems	1.5	1.4	4.9	4.4	0.9	0.0	13.1
PL 1: Ecological and physiological understanding of RTB crops and cropping systems	0.5	0.4	0.7	1.2	0.3	0.0	3.1
PL 2: Increasing productivity in RTB cropping systems through nutrient/water/light management practices	0.6	0.6	1.0	1.9	0.4	0.0	4.4
PL 3: Integrated decision and management tools for RTB crops developed and validated	0.5	0.4	3.2	1.3	0.2	0.0	5.6
Theme 6: Promoting postharvest technologies, value chains, and market opportunities	2.0	0.5	4.9	5.8	2.0	1.0	16.3
PL 1: Postharvest approaches to improve food security	0.6	0.1	1.1	2.3	0.7	0.2	5.1
PL 2: Improving linkages to markets for environmentally friendly income generation activities	1.0	0.2	2.8	1.9	0.6	0.4	6.9
PL 3: Marketing strategies and policies to promote RTB consumption	0.4	0.2	1.0	1.6	0.7	0.4	4.4
Theme 7: Enhancing impact through partnerships	1.2	4.1	7.3	3.8	1.2	-	17.7
PL 1: Targeting and setting priorities	0.4	1.1	1.5	0.8	0.4	-	4.1
PL 2: Building effective partnerships	0.1	0.4	1.0	0.7	0.2	-	2.4
PL 3: Communication and knowledge sharing	0.2	0.6	3.4	0.5	0.1	-	4.8
PL 4: Capacity strengthening	0.2	0.6	0.7	0.8	0.2	-	2.5
PL 5: Outcome and impact evaluation	0.4	1.4	0.9	0.9	0.4	-	3.9
Sub Total	26.7	27.4	42.2	48.6	15.5	5.0	165.3
Institutional Overhead	5.7	5.2	8.2	9.0	3.1	1.0	32.1
Total Budget before CRP Management Cost	32.3	32.5	50.4	57.6	18.6	6.0	197.4
CRP Management Cost (5%)	1.6	1.6	2.5	2.9	0.9	0.3	9.9
Total Budget	33.9	34.2	52.9	60.5	19.6	6.2	207.3

Annex 5.14 CRP-RTB Theme-Product Line Investments by Region (US\$ Million)

Research Themes by Crops	UPSIDE GROWTH SCENARIO				
	2011 - 2013				
	SSA	ASIA	LAC	GLOBAL	Total
Theme 1: Conserving and accessing genetic resources	12.6	0.6	1.3	7.5	22.1
PL 1: Ex-situ and in-situ conservation methodologies optimized	2.6	0.1	0.4	1.5	4.6
PL 2: Increased coverage of gene pools in global genebanks	1.4	0.1	0.3	0.7	2.6
PL 3: Collections of RTB evaluated, phenotyped and genotyped for important traits	5.0	0.4	0.5	2.2	8.2
PL 4: Collections of RTB documented and information freely accessible to users	1.3	0.0	0.0	1.8	3.2
PL 5 : Safe exchange of RTB genetic resources	2.3	-	0.0	1.2	3.6
Theme 2: Accelerating the development and selection of varieties with higher, more stable yield and added value	27.6	8.3	3.9	14.4	54.1
PL 1: Breeding tools, strategies and approaches	4.8	1.1	0.3	2.9	9.2
PL 2: Trait capture and gene discovery	3.4	1.2	0.9	2.5	7.9
PL 3: Population development and pre-breeding	9.1	3.7	1.4	5.9	20.1
PL 4: Variety development	6.5	1.3	0.9	1.6	10.3
PL 5: Aligning research with farmers and end-users priorities	3.8	1.0	0.3	1.4	6.5
Theme 3: Managing priority pests and diseases	12.9	2.8	3.1	4.0	22.8
PL 1: Detection, surveillance and mapping	3.4	0.9	1.0	1.3	6.7
PL 2: Ecology, biology and epidemiology of pests and diseases	3.2	0.6	0.7	0.7	5.2
PL 3: Ecology and management of beneficial organisms	2.2	0.3	0.6	0.7	3.8
PL 4: Specific management strategies	4.1	1.0	0.8	1.2	7.2
Theme 4: Making available low-cost, high-quality planting material for farmers	14.4	1.3	1.4	2.1	19.2
PL 1: Policies, strategies and decision support tools to improve effectiveness of seed systems	3.8	0.3	0.4	0.7	5.2
PL 2: Lower cost, more effective mass propagation methods	5.5	0.4	0.4	0.6	6.8
PL 3: Farmer-based quality seed production and management methods	5.2	0.6	0.6	0.8	7.2
Theme 5: Developing tools for more productive, ecologically robust cropping systems	7.0	1.6	1.7	2.7	13.1
PL 1: Ecological and physiological understanding of RTB crops and cropping systems	1.5	0.3	0.4	0.8	3.0
PL 2: Increasing productivity in RTB cropping systems through nutrient/water/light management practices	2.3	0.6	0.9	0.6	4.4
PL 3: Integrated decision and management tools for RTB crops developed and validated	3.2	0.7	0.5	1.3	5.6
Theme 6: Promoting postharvest technologies, value chains, and market opportunities	12.5	0.6	1.6	1.6	16.3
PL 1: Postharvest approaches to improve food security	3.7	0.2	0.4	0.8	5.1
PL 2: Improving linkages to markets for environmentally friendly income generation activities	5.1	0.2	0.9	0.7	6.9
PL 3: Marketing strategies and policies to promote RTB consumption	3.8	0.1	0.3	0.2	4.3
Theme 7: Enhancing impact through partnerships	9.5	0.6	1.9	5.8	17.7
PL 1: Targeting and setting priorities	2.7	0.2	0.5	0.8	4.2
PL 2: Building effective partnerships	1.3	0.1	0.2	0.8	2.4
PL 3: Communication and knowledge sharing	1.4	0.1	0.4	2.9	4.8
PL 4: Capacity strengthening	1.4	0.1	0.3	0.7	2.5
PL 5: Outcome and impact evaluation	2.6	0.1	0.5	0.6	3.7
Sub Total	96.4	15.9	15.0	38.0	165.3
Institutional Overhead	19.1	3.1	2.8	7.2	32.1
Total Budget before CRP Management Cost	115.5	19.0	17.7	45.2	197.4
CRP Management Cost (5%)	5.8	0.9	0.9	2.3	9.9
Total Budget	121.2	19.9	18.6	47.5	207.3