

CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH
SCIENCE COUNCIL

**Revised Summary Report on
Developing CGIAR System Priorities for Research
(Including an Appendix describing Draft System Priorities)**

The rapid rates of change in the interlocking fields of science, Agriculture, global trade and development require that a research organisation like the CGIAR System frequently reviews the global context in which it works, in order to adjust its research priorities to continue to meet its goals in the most effective manner. This Summary Report describes the approach and collaborative process adopted by the Science Council to help develop a cohesive research programme with well-defined priorities for the CGIAR, as well as an outline of the process to date.

The priority areas for research respond to the continuing challenge of maintaining sustainable food production systems, and the new agricultural paradigms encouraging competitiveness, and addressing the situation of the poor in marginal lands. The Science Council considers that the reviews undertaken of the current emphases in CGIAR research, the establishment of the future context and the widely participatory process followed for establishing potential new areas for research, provide the basis for the next steps – the establishment of overall CGIAR System Priorities for the period to 2010.

The Summary Report further defines the subsequent activities to be undertaken, and a proposed schedule, through which new CGIAR System Priorities for research may be developed. The Science Council's intention is to link the establishment of priorities (and future priority setting) to the monitoring and evaluation functions, vital for the efficient conduct of agricultural science and to meet the goals of the CGIAR and its global partners.

1. DEFINING SYSTEM PRIORITIES

The rapid rates of change in the interlocking fields of science, Agriculture, global trade and development require that a research organisation like the CGIAR System frequently reviews the global context in which it works, in order to adjust its research priorities to continue to meet its goals in the most effective manner. This summary report describes the approach and collaborative process adopted by the Science Council to help define new priority areas for research for the CGIAR.

The Need for System Priorities: There has been a tendency for dispersion and atomization of CGIAR research initiatives (currently into around 200 Projects of different sizes). This has been due in particular to the decline in core funding and selective funding of specific projects negotiated with donors. Donors tend to seek answers to particular development problems using the CGIAR's research capacity, and the Centres compete for these funds, leading to overlaps in their research portfolios.

Projects addressing difficult issues for sustainable poverty reduction (e.g., smallholder productivity gains in Africa) need sharply focused, multi-pronged approaches involving research on different commodities, themes, and disciplines. The CGIAR as a system has unique comparative advantage in mobilizing research capacity across Centres to organize such complex coordinated projects.

Centers have shown increased willingness and capacity to coordinate and cooperate (through the roles of CDC, CBC, System Office, and proposals for a Future Harvest Alliance etc.). Institutional mechanisms already exist to implement System-level projects through ad-hoc coalitions of centers, Systemwide programmes, Task Force initiatives, and Challenge Programmes, and the Science Council's role in priority setting allows it to define, and to oversee the implementation of, ambitious Systemwide initiatives.

Well-defined System Priorities will help to develop more effective partnerships with NARS and advanced research centers, increase participation by stakeholders to priority setting, and assist donors in allocating their resources to the CGIAR to projects with potentially large impacts.

System Priorities, broadly accepted by donors and stakeholders, and internalized into Center MTPs, will help put into place a performance measurement system to translate logframes and milestones into objective indicators of performance.

How were system priorities established? The Future Harvest Centres and the CGIAR were created to apply science to the solution of problems related to poverty, agriculture, natural resources, food and nutrition. Priorities for conducting this sort of research were set by decisions on relative priorities and resource allocation among commodities, facilitated by congruence analysis based on the value of production. The former means of priority setting is now considered of limited value because of: (i) the *complexity of goals*, (ii) *the value of production criterion* does not work for non-market values (e.g. involved in prioritising germplasm conservation, or assistance to NARS), (iii) *inability to*

encompass new issues and opportunities, (iv) change in funding modalities - the World Bank's decision to abandon its role of donor of last resort reduced considerably the System's capacity to implement the planning and resource allocation implications of congruence analysis.

A New Approach to Priority Setting: As requested by ExCo and the interim Science Council, the Science Council took the leadership in initiating a process of System-level priority setting. This consisted of a multi-pronged approach that had the distinguishing character of being both analytical and broadly consultative with stakeholders (including grassroots and non-governmental organizations), donors, and scientists both in the CGIAR system and in other research institutions (NARS and advanced research centers). The development of a preliminary list of System Priorities (and their associated sub-priorities) derived from a process of information gathering and consultations that can be classified into three major approaches as follows (see Figure 1):

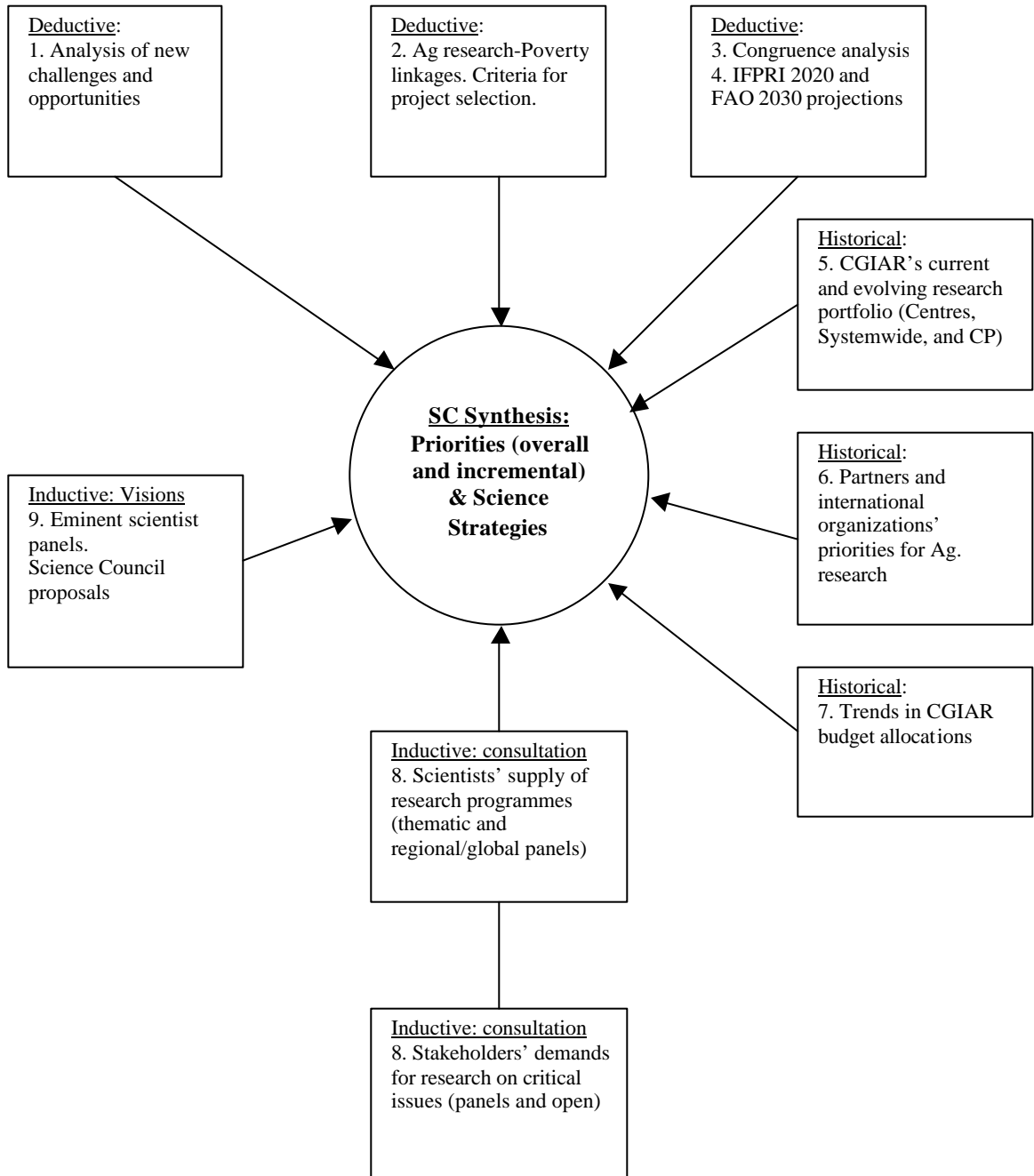
Deductive approaches (boxes 1-4) including a broad analysis of new challenges and opportunities; the development of a set of criteria to achieve poverty reduction through agricultural research that can be used to screen future proposals; an updated congruence analysis to establish the future relative importance to be given in the overall budget to commodities (15 crops) and sectors (crops, livestock, forestry, and fish) by regions, and the use of global and regional projections of future supply and demand for commodities in agriculture.

Historical approaches (boxes 5-7) have included review of the current and evolving research portfolios for a) Centres and the CGIAR, b) the research portfolios for other selected research institutions and international organizations indicative of the "other 96%" contributing to agricultural research and development globally; and analysis of long run trends in the CGIAR's budget allocation across outputs, crops, sectors, undertakings, regions, and Centres.

Inductive approaches (boxes 8&9) have centred on a broadly consultative approach inviting the formulation of demand for incremental research by stakeholders and of potential supply of research by scientists; with a consultative approach with eminent scientists and members of the Science Council, also on incremental research¹. Results from these consultations are given in Section 4.

¹ A more complete description of the approaches and analyses supporting the Consultative process, and the outcomes of this process, can be found in the "Report on CGIAR Priorities and Strategies for the Period 2005-2010: Outcomes of the Consultative Process" (Revised, August 2004, SC, Rome, Italy, 240p).

**Figure 1. Science Council’s Approach to Setting CGIAR Priorities and Strategies:
Outline of the Report**



2. THE EMERGING CONTEXT: RESULTS FROM DEDUCTIVE APPROACHES

Approach 1 identified New Key Challenges and Opportunities in Agriculture: Within the last half a century the world has changed rapidly and so has the food security challenge. Urbanization and globalization are becoming pervasive, private sector involvement in agricultural research has been increasing at a very rapid pace around the world, and global concerns about the sustainable management of resources have been rising. Population pressure and poor land and water use practices are at the heart of these declines. These effects are noticeable in the (i) degradation of natural systems such as forests and fisheries, (ii) degradation of intensively cultivated lands, (iii) exploitation and erosion of marginal lands, (iv) water resource depletion, and, (v) depletion of genetic diversity. At the farm and landscape levels it is necessary to target research and development specifically towards technologies that both enhance productivity while at the same time conserve resources. Improving opportunities for protecting and increasing incomes of the poorest of the poor may be as important to their food security as providing them with new productivity-enhancing technologies. Since the Green Revolution crop staples have been a key component of nutrition and food security. But there are many other commodities and resources, utilized in farming or taken from nature, which ensure nutrition, productivity, incomes, and better livelihoods of farmers, fishers, forest dwellers and pastoralists in developing countries. The global food security challenge has over time become increasingly multi-dimensional. Climate change and instability are projected to become increasingly apparent through the next decades. Developing nations will require assistance to orient agriculture and agricultural practices into less vulnerable choices and pathways.

New Scientific Opportunities: Recent years have witnessed an unprecedented increase in the power and range of biotechnologies, particularly genetic technologies, available to amplify and extend investigations across plant and animal species and to address the organisms, disease agents and abiotic stresses of most concern to developing country agriculture. A parallel explosion in computing and informatics has augmented data acquisition and storage, synthesis and transfer. Modelling, and the ability to combine data from different sources, can not only inform germplasm studies and the search for new genes and functions, but also promise to revolutionise understandings of processes affecting the management of natural resources. The strategic accumulation of data, tools and modeling resources in the coming decade can be expected to develop a more predictive approach to agriculture, the evolution of land and seascapes and the effects of climate, so providing insights for the development of long term agricultural and environmental policy.

Responding to the Globalization of Markets: The impacts of globalization will be seen principally in three major areas: 1) Impacts on agrarian and resource-dependent societies – particularly the poor who, without means to take advantage of new opportunities, require public sector support; 2) Impacts on growth and income distribution; 3) Conflict between *economic efficiency* versus *multiple use* approaches for natural resources.

Reducing transactions costs associated with market access could also help enhance the competitiveness of small farmers.

Potential and challenges of the “new agriculture”: There are opportunities for developing countries to embark on additional opportunities to take advantage of the new scenario for the future of agriculture. This will include moves away from the production of traditional staples, to high value products (including, for example, fruits, vegetables, fish, livestock products, horticulture etc). There will be greater focus on post-harvest improvements to increase cost efficiencies, or to increase the value added to products. Such market-oriented adjustments and increased competitiveness require greater consideration of product quality, and emphasis on production to market food chains, labelling (for product and human health, and environmental safety), and on managing and paying for environmental services. Organization of small farmers will be required to ensure their access to these supply chains and markets.

Regional emphasis: Meeting the Millennium Development Goals, and the vision of the CGIAR, will be most difficult in Africa. Sub-Saharan Africa is characterized by widespread poverty, the high relative dependence of populations upon agriculture or the extraction of natural resources, the low performance of agriculture at the aggregate level, poor infrastructure, and additional challenges from human disease, climatic instability and civil unrest which serve to increase the vulnerability of large numbers of people. There is the opportunity to join in consolidated partnership approaches for the enhancement of African agriculture laid out by regional priority setting and the New Economic Programme for African Development (NEPAD).

Approach 2 considered World Poverty Concerns: In the last 50 years the world has changed fundamentally from one that was predominantly a rural based world to one where almost half the population is living in urban areas. Using agricultural research to reduce urban poverty through the resulting economic growth, employment creation, cheaper foods, and improved quality diets will consequently be increasingly important in the future for the CGIAR in meeting its poverty reduction objective.

The very poor tend to be associated with marginal production environments in rural areas. New technologies fit for these marginal and risky environments are still largely missing, and constitute an evident priority for the CGIAR. Identifying small farmer constraints to technology adoption and use continues to be a priority issue for consideration and planning.

It is anticipated that Agriculture’s contribution to GDP will be no more than 10%. Except perhaps in Latin America and sub-Saharan Africa, Agriculture’s contribution to exports will also not be more than 10%. However, whilst the overall contribution of agriculture declines with development, sustainable productivity through agricultural research remains a key means through which to assist the poor and marginalised within wider development strategies. The indirect effects of agricultural productivity gains in poverty reduction must thus remain a priority for the CGIAR, particularly in reaching the landless and urban poor.

To help the CGIAR develop research priorities, TAC commissioned a study to develop priority areas for a pro-poor agricultural research agenda. The priorities the authors propose provide the criteria to screen future proposals effective for poverty reduction (see Annex I and reference 1).

Approaches 3 and 4 detailed World Food Concerns: Projections made by IFPRI for the predicted values of production in 2020 suggest that many of the CGIAR's major commodities remain critical for developing countries' access to food. Rising food deficits (more than 10% of the value of domestic production) in SS-Africa and WANA are important in rice, maize, soybeans, and low value fish. Wheat deficits (in all regions except LAC) are largely associated with rising urban consumption, and alternative sources of supply exist in the international market. Deficits in beef in WANA, Southeast Asia, and East Asia are predicted to be important. The implication is that maintenance research on productivity of the identified staples, and new emphasis on non-traditional exports as sources of foreign exchange earnings (especially for LAC when there are no other sources of research) would be appropriate. World market prices for wheat, maize and rice, adjusted for inflation, are the lowest they have been in the last century. Commodity prices for pulses have also dropped - to about half of what they were in 1989/90.

Towards 2030 (according to the FAO) the developing countries will become increasingly dependent upon cereal imports. The most serious imbalances for cereals will be experienced in wheat and coarse grains, in WANA, East Asia, and sub-Saharan Africa respectively. The primary means through which increased yields will be met is through increased intensification and technological efficiency in reducing yield gaps. New science has an important role to play in meeting these needs. Changes in the commodity composition of food are expected to occur in developing countries with a relative stabilization of per capita consumption of cereals, roots and tubers, and pulses (the latter somewhat in decline), and marked increases in vegetable oils, meat and milk and dairy products. There will need to be relatively large increases in the production of meat (beef and veal, mutton and lamb, pig meat and poultry meat) in developing countries. The trade imbalance in milk and dairy (including demand for these in feeds) for developing countries will be 39 million tons annually by 2030. Fish consumption is likely to increase but there are uncertainties about the final level of production that can be attained. More modest projections of demand at 150-160 million tons per annum will still mean that fish consumption may stagnate or even decline in sub-Saharan Africa and WANA.

These projections thus stress the dual challenge of increasing demands for staple foods (that can only partially be met through trade) and for diversification to enhance the routes out of poverty through high value crops, animal products, and fish.

3. RESULTS FROM HISTORICAL ANALYSES

Approach 5 examined The Current and Evolving CGIAR Research Portfolio: The current research priorities of the CGIAR are represented *de facto* by the portfolio of projects being undertaken by the Centres. A review of the 196 projects presented in the Centre MTPs for 2004-2006 provided general indications about the System's focus (see Annex II and reference 1).

Approach 6 considered the Priorities of Partners and International Organisations: The Science Council analysis considered the comparative advantage and priority portfolios of a number of other players including: (i) National Agricultural Research Systems (NARS) account for over 95% of agricultural R&D investments in the developing world, contributing for a substantial share of the unprecedented rate of agricultural productivity growth seen over the past three decades. NARS are very diverse in size and capacity but they act and react with increasing numbers of partners and stakeholders. NARS are now being viewed within a wider innovation system (including farmers and foreign suppliers). (ii) *Apex NARS bodies* such as GFAR, have recently developed authoritative regional priorities and programmes which represent the demand side of priority setting. (iii) The Development Banks and other research providers have strategies which are aligned with the Millennium Development goals and/or have expertise that can be deployed in partnership to augment research progress. (iv) The private and civil society sectors: relationships amongst stakeholders in agriculture have changed dramatically; there has been a marked rise in the contribution of the private sector in some aspects of research; and of the civil society sector in defining relevance of research and partnerships, and for delivering research results. There are strong possibilities for augmenting public-private partnerships between the CGIAR and commercial companies, principally in biotechnical applications on behalf of the poor. Similar and complementary linkages can be formed with many of "other 96 per cent" of organizations that undertake and fund aspects of agricultural research in its widest sense.

Confronted by the same changing externalities as the CGIAR, the NARS too are facing new priorities. NARS are being challenged to strengthen their policy and regulatory frameworks for IPRs, biosafety, trade in genetically modified products, food safety, and strategies for accessing the new technologies. The strengthening of NARS to meet these emerging needs is central to the success of the CGIAR. There will be increased demands for knowledge management to enhance the workings of these communities of practice and research consortia, and there are major opportunities to capitalize on the new ICTs in carrying out this collaborative mission. New priorities for agricultural research must be planned and delivered within these contexts in order to be relevant and to achieve objectives.

Approach 7 considered the Historical Budget Allocation: Historical analysis of the CGIAR resource allocation to commodities and sectors shows a steady reduction in allocations to cereal crops research, In 2002/2003 forestry (14%) and fisheries (5%) shares of research budget research had grown to anticipated levels, and research on fish,

forestry and livestock show increasing trends in resource allocations extrapolated to 2010.

In terms of CGIAR undertakings, productivity research has shown a steady decline (although it still remains the largest category, at 36% of expenditures in 2000), with increasing allocations to the Environment (18%), Policy (13%) and the Conservation of biodiversity (which received a 10% share of all resources by the year 2000). Provision of capacity building assistance to NARS remained at around 22% of total expenditures.

Since the beginning of the CGIAR, the two regions of sub-Saharan Africa and Asia have received the main streams of resource flows in the CGIAR. Most recently, there has been again an increase in funds allocated to SSA, which received about 46% - or nearly half of all expenditures - for the period 2002-2003. Asia's levels of resource allocation have been 'stable' at around one-third of CGIAR funding, while the LAC region now receives 13% of funds, down 4 percentage points from the 17% level in the 1990s. For WANA, there has also been a gradual decline in funding for the region that is now at 9% of resources allocated, down 4 percentage points from a maximum level of funding of 13% achieved in the late 80s and early 90s.

4. RESULTS FROM THE CONSULTATIONS FOR INCREMENTAL RESEARCH BUDGETS

Approaches 8 and 9 followed a highly Consultative Approach for CGIAR Priority Setting in 2003: Firstly, a set of some 20 position papers were written by experts on the key issues in agricultural development and research and were shared with the other participants to the priority setting exercise and the public at large².

Constraints were then further identified and elaborated through the discussions of a series of regional panels and a global panel constituted virtually, each made up of some 20 experts with different disciplinary and organizational background.

To broaden the consultation, and seek majority opinions, the list of activities was offered to stakeholders through an open electronic forum. More than 800 participated, included significant numbers of NGOs and GROs.

On the "supply" side, thematic panels of scientists were asked to translate priorities into researchable activities. These panels proposed researchable themes (sub-activities) within each of the categories of activities identified by the earlier steps.

Priorities were then established by regions. To do this, regional panels of scientists were asked to allocate given incremental resources to the researchable sub-activities identified by the thematic panels.

² see the Priorities and Strategies Consultation webpage where these are collected, at <http://www.rimisp.org/cgi-ar-ps2>

Finally, the SC met to take stock of the results of consultations and reconcile conflicting information gathered from different sources (including the regional priorities, outcomes of the consultation, the current CGIAR research portfolio, compatibility with effort determined by congruence, earlier concepts and proposals etc.) into a consistent set of priorities.

The SC process aimed to identify *additional* areas for research or new opportunities for addressing the CGIAR goals with incremental budgets. The Consultation also developed a major focus on the need to provide assistance to NARS in key public policy areas. (These were considered as strategic rather than research priorities and are marked with # in Table 1.) The means for development and implementation of such a “Systemwide” effort in capacity building and institutional strengthening is a strategic issue to be addressed.

Table 1. Results of the Consultation-priority areas for additional new CGIAR research
1. Water management
2. Extended germplasm conservation for wild relatives, orphan crops*
3. Drought and salinity resistance*
4. Agricultural systems and INRM for unfavourable and risky environments*
5. High value added crops and systems, including animals and fish*
6. Indigenous livestock genetics*
7. Artisanal fisheries management and coastal margins
8. Animal health and human food/health safety*
9. Increase production of staple foods, incl. maintenance research
10. Sustainable use of rangelands (CWANA)
11. IPR, IPG, and CGIAR research
12. Increase access to assets for the rural poor, esp. by gender*
13. Biosafety and gene flows*
14. Agroforestry for food, fuel, and fodder
15. Community forest management for marginal environments
16. Food/water safety and more nutritious foods
17. Vegetables and fruits production systems*
18. Adaptation to climate change
19. Forest genetic resources
20. Policies for sustainable NRM
21. Global trade policies and opportunities for smallholders in globalized markets
22. Policies and institutions to enhance adoption of new technologies
23. Participatory farmer-breeder management of crop gene pools*
24. Integrated weed (IWM) and pest (IPM) management*
25. Empowering agricultural research with gender focus
26. Reduce post-harvest toxicity
27. Smallholder provision of environmental services
28. Marketing innovations to link farmers to national and international markets
29. Labour-intensive agricultural (indirect effects) and rural development strategies
30. Post-harvest value added, commodity chains, new agriculture*
31. Enhancing public and private roles in research
32. Germplasm distribution systems
Strengthening producers organizations (strategy)*
Strengthening NARS (strategy)

There are *twelve major recommendations* (marked with an asterisk) that go beyond current Challenge Programmes and Systemwide or ecoregional programmes, that derived from the consultation, and which have been considered by the SC as components of potential new research areas.

The consultative process of priority setting has therefore led to the identification of a number of new potential topics for CGIAR research. Each responds to important issues in the new agricultural paradigm emerging with the globalization of agriculture. These need to be assessed through the further crystallisation of research approaches under these headings. Potential impacts from new undertakings should be determined, and balanced against current undertakings of the System as a whole. As part of this consideration the SC examined the means through which the priority areas for research would enhance the existing portfolio of CGIAR research. The SC: firstly, developed a conceptual framework examining the entry points for public goods research into poverty alleviation through agricultural research; secondly, considered the types of science and programme requirements to tackle the priority areas; and, thirdly, grouped the recommended research areas to enhance focus.

5. NEXT STEPS: DEVELOPING “SYSTEM PRIORITIES” FOR CGIAR RESEARCH

The adoption of some of the new areas for research, identified through the consultative process, would potentially increase the number of projects and scope of the CGIAR portfolio still further, unless some are adopted at the expense of existing activities. The concern is that, without focus, the breadth of the portfolio and distribution of funding could limit the effectiveness for the CGIAR in key areas. In addition, the range of activities in a broad portfolio is hard to capture at the System level, and to explain succinctly to the wider agriculture and development audiences (including potential partners and supporters). There are also unfinished debates about the possibilities of efficiencies arising in the System from structural adjustment. However, these cannot be addressed until greater clarity is developed in the description of the CGIAR System’s priority areas for research.

The Science Council therefore wishes to build on the consultative stage of the priority setting process described above, and review the total research outlook of the CGIAR projected to 2010. Seeking to meet key needs and capitalise on new science, the intention is to focus the CGIAR research agenda on a smaller number of System Priority areas for research. The System Priorities will have goals commensurate with the mission of the CGIAR, and should encapsulate major areas of science within the CGIAR’s comparative advantage in its assistance to developing country agriculture. System Priorities will be set so as to have measurable outcomes - so that specific links can be made between priority setting and future monitoring and review functions. The development and refinement of System Priorities will be carried out by the Science Council in close consultation with the Centres and CGIAR members.

6. A PRELIMINARY SET OF SYSTEM PRIORITIES

The Science Council proposes that the Future Harvest Centres and the CGIAR members agree to allocate 80-90 percent of the total CGIAR budget to the following ten System Priorities:

1. Conserve and characterize genetic resources
2. Genetic improvement of specific traits
3. Improve water management and use in agriculture
4. Better management and use of forests and forest landscapes
5. Better soil and land management and use
6. Improve production and processing systems for high-value commodities
7. Enhance resource-efficient and equitable forms of livestock sector growth
8. Improve management and use of aquatic resources
9. Policy and institutional innovation to reduce poverty and hunger and to enhance competitiveness of smallholders
10. Strengthen national and regional capacities for agricultural research

7. AN AGENDA FOR DEVELOPING NEW SYSTEM PRIORITIES

Each of these System Priorities, presently considered as drafts, is presented in more detail in the attached Appendix. They, and particularly the more specifically detailed sub-priorities (listed in Annex 3), will be subject to refinement based on the further, planned consultations, and priority setting between sub-priorities. The Science Council (SC) proposes the following schedule for such consultations and revisions:

- September 1-October 22nd, 2004: - SC Members will seek feedback from donors and other stakeholders.
- September 30-October 1st, 2004: - SC Chair discusses first formulation of priority areas at a meeting of European donors.
- October 2004: - SC Secretariat revises draft System Priorities on the basis of accumulated inputs (arising from SC, Ex Co, observer and donor responses), and provides revised draft to Centres to aid preparation for later discussions.
- October 2004: - Centres are invited to comment on the revised draft list of System Priorities and sub-priorities.
- October 22-29th, 2004: - SC Chair holds discussions with CDC and CBC at their meetings in Mexico; and with CGIAR members and other stakeholders at the CGIAR stakeholder and business meetings in Mexico.
- November-December 2004: - SC conducts an initial gap-filling analysis to identify differences between current CGIAR portfolio and the proposed System Priorities for research.
- Between January 10-28th February, 2005: - A meeting is held for each priority area to refine the content.
- April 4-9th, 2005: - SC discusses and gives final approval to the System Priorities on the basis of the individual meeting inputs and further gap-filling analysis.

- May, 2005: - A meeting is held to discuss and agree on implementation, governance, and management of the priority areas.
- 2005-2008: - Gradual programme alignment with the System Priorities is undertaken by Centres through MTP planning and SC review of individual Centre and Systemwide programme MTPs.

Annex 1: Criteria for a pro-poor agenda

1. Increasing the production of staple foods in countries where food price effects are still important and/or that have a comparative advantage in growing these crops.
2. Increasing agricultural productivity in many less-favoured lands, especially heavily populated low-potential areas.
3. Reducing risks in agriculture, in particular in high-value market-oriented production, and the vulnerability of rural households to shocks of both idiosyncratic and covariate nature.
4. Helping smallholder farms across the board diversify into higher value products, including livestock products, especially in countries with rapidly growing markets for such products and/or access to suitable export markets.
5. Increasing employment and income-earning opportunities for landless and near-landless workers in surplus labour regions.
6. Developing more nutritious and safer foods to enhance the diets of poor people.
7. Undertaking agricultural research in ways that are more empowering of the poor, in particular by helping them acquire the capacity to tailor technology to their specific livelihood strategies, with particular attention to women farmers and excluded groups.

Annex II: Summary of the CGIAR research portfolio as presented in the Centre MTPs for 2004-2006³

The Centres continue to conduct needed commodity improvement research (23 projects) in their mandated commodities.

Improvement is carried out through genetic enhancement research (8) which encompasses breeding approaches and new genetic biotechnology approaches, and farming systems research (25) which is undertaken in a commodity-specific fashion, or more often in general improvement approaches to the key agro-ecosystems of developing countries where the commodities are grown or raised.

Whilst farming systems research encompasses aspects of resource management, there is a large body of Centre research on integrated natural resource management (INRM) (39) directed principally at water, soils, watersheds, fisheries, forestry, forages and pastures aimed at augmenting the sustainability of agricultural and natural production systems. Commodity, INRM and farming systems research are integrated in some ecoregional programmes (6) run by centres as research networks or as system-wide programmes.

The conservation and use of biodiversity (26) supporting agricultural productivity is carried out through the programmes of IPGRI, the operation of gene banks by the plant commodity centres, the system-wide genetic resources programme and in conjunction with INRM research in natural ecosystems (forestry, fisheries) or agricultural systems.

There are smaller but emerging bodies of research on climate change (2), the links between agriculture and human health (1), and the system-wide programme on gender and diversity (1).

There is a large body of policy research (24) conducted by the CGIAR Centres. This is focused on the programme of IFPRI, and aspects of food security and nutrition, but is wide ranging across centres addressing markets, trade and globalization (11); poverty research (3) and sectoral or regional assessments (e.g. for livestock, or the semi-arid tropics), individual high priority issues (like genetic resources policy); and governance issues, particularly for common pool natural resources (such as forestry and fisheries).

Approaches adopted by the centres to enhance performance are participatory approaches (4) to assist design, dissemination and adoption of interventions; impact assessment procedures (8) aimed both at centre impacts and the effects of external factors on sectors or commodities; and the conversion of publication systems into true knowledge management systems (8) for centre efficiency and for the benefit of partners and stakeholders.

There is similarly a major component of the portfolio directed towards NARS capacity building (7), implicit in conducting research through partnership, but also as a specific goal in some regions, commodities and sectors, and subject to analysis through research on institutions and processes of development change.

This rule of thumb characterisation of the current composite portfolio is of use in considering new or additional priorities and in determining the future evolution of the System's agenda.

³ The number of projects of any particular type is given in brackets. This should be considered as indicative and not definitive since the categorisation is of a general nature based on assumed major undertakings, when in fact Centre projects are tending towards greater integration, and multi-disciplinarity

New priorities are also being developed by the Centres on the basis of the emerging issues. Amongst these it is possible to note three major areas: (i) a heightened concern for knowledge management, (ii) a focus on systems of innovation amongst farming or resource management communities and NARS, (iii) more explicit examination of the linkages between agriculture, health and trade.

Annex III: List of draft System Priorities and sub-Priorities
(As of October 4th 2004)

System Priority 1

Conserve and Characterize Genetic Resources

- Sub-priority 1a: Traditional commodities and their wild relatives
- Sub-priority 1b: High value crops, (including fruits and vegetables)
- Sub-priority 1c: Orphan crops and wild relatives
- Sub-priority 1d: Indigenous livestock breeds
- Sub-priority 1e: Fish

System Priority 2

Genetic Improvement of Specific Traits

- Sub-priority 2a: Yield and quality improvement of staple commodities
- Sub-priority 2b: Drought and salinity tolerance
- Sub-priority 2c: Biofortification
- Sub-priority 2d: Resistance to selected diseases, insect pests and weeds.
- Sub-priority 2e: Adaptation to climatic change
- Sub-priority 2f: Labour productivity and flexibility traits
- Sub-Priority 2g: Science and technology policy toward intellectual property rights and biosafety

System Priority 3

Improved Water Management and Use in Agriculture

- Sub-priority 3a: Improved water productivity at the crop and field level
- Sub-priority 3b: Enhanced efficiency in the use of water resources across multiple users of water at the basin level
- Sub-priority 3c: Increased efficiency of water use in agriculture through developing improved water harvesting practices, supplemental and micro-irrigation
- Sub-priority 3d: Re-use of water in agriculture, including peri-urban settings
- Sub-priority 3e: Policy and institutional aspects of water management

System Priority 4

Better Management and Use of Forests and Forest Landscapes

- Sub-priority 4a: Sustainable management of forest resources
- Sub-priority 4b: Sustainable management of forest margins

System Priority 5

Better Soil and Land Management and Use

- Sub-priority 5a: Agro-ecological approaches at the farm level
- Sub-priority 5b: Land-use management at the landscape level

System Priority 6

Improved Production and Processing Systems for High Value Commodities

- Sub-priority 6a: Fruits and vegetables and selected cash crops
- Sub-priority 6b: Post harvest treatment and processing

Sub-priority 6c: Markets and trade: food safety and the environment.

Sub-priority 6d: Livestock and aquatic product health to meet domestic and international trade requirements

Sub-priority 6e: The “new agriculture”: policies to promote opportunity for smallholders

System Priority 7

Enhancing Resource-efficient and Equitable forms of Livestock Sector Growth

Sub-priority 7a: Protecting rural livelihoods

Sub-priority 7b: Creating the conditions for growth

Sub-priority 7c: Coping with growth

System Priority 8

Improved Management and Use of Aquatic resources

Sub-priority 8a: Sustainable production systems in the coastal zone

Sub-priority 8b: Sustainable inland fisheries

Sub-Priority 8c: Sustainable Aquaculture

System Priority 9

Policy and Institutional Innovation to Reduce Poverty and Hunger and to Enhance Competitiveness of Smallholders

Sub-priority 9a: Globalization and farm policies

Sub-priority 9b: Rural development strategies to offer pathways from poverty

Sub-Priority 9c: Policies and institutions for nutritional improvement and food/water safety enhancement.

Sub-priority 9d: Environmental regulations, payments for environmental services, and sustainability

Sub-Priority 9e: Property rights and sustainable management of natural resources

Sub-priority 9f: Reducing risk and vulnerability of the poor

System Priority 10

Strengthened National and Regional Capacities for Agricultural Research and Rural Institutions

Sub-Priority 10a: Strengthening NARS

Sub-Priority 10b: Strengthening Producer Organisations

Sub-Priority 10c: Institutional arrangements for private-public-NGO partnerships

Appendix

DRAFT SYSTEM PRIORITIES FOR CGIAR RESEARCH

A DISCUSSION DOCUMENT

SCIENCE COUNCIL

4 OCTOBER 2004

System Priority 1

Conserve and Characterize Genetic Resources

- Sub-priority 1a: Traditional commodities and their wild relatives
- Sub-priority 1b: High value crops, (including fruits and vegetables)
- Sub-priority 1c: Orphan crops and wild relatives
- Sub-priority 1d: Indigenous livestock breeds
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System Priority 2

Genetic Improvement of Specific Traits

- Sub-priority 2a: Yield and quality improvement of staple commodities
- Sub-priority 2b: Drought and salinity tolerance
- Sub-priority 2c: Biofortification
- Sub-priority 2d: Resistance to selected diseases, insect pests and weeds.
- Sub-priority 2e: Adaptation to climatic change
- Sub-priority 2f: Labour productivity and flexibility traits
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System Priority 3

Improved Water Management and Use in Agriculture

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- Sub-priority 3b: Enhanced efficiency in the use of water resources across multiple users of water at the basin level
- Sub-priority 3c: Increased efficiency of water use in agriculture through developing improved water harvesting practices, supplemental and micro-irrigation
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- Sub-priority 3e: Policy and institutional aspects of water management

System Priority 4

Better Management and Use of Forests and Forest Landscapes

- Sub-priority 4a: Sustainable management of forest resources
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System Priority 5

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- Sub-priority 5a: Agro-ecological approaches at the farm level
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System Priority 6

Improved Production and Processing Systems for High Value Commodities

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Sub-priority 6b: Post harvest treatment and processing

Sub-priority 6c: Markets and trade: food safety and the environment.

Sub-priority 6d: Livestock and aquatic product health to meet domestic and international trade requirements

Sub-priority 6e: The “new agriculture”: policies to promote opportunity for smallholders

System Priority 7

Enhancing Resource-efficient and Equitable forms of Livestock Sector Growth

Sub-priority 7a: Protecting rural livelihoods

Sub-priority 7b: Creating the conditions for growth

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System Priority 8

Improved Management and Use of Aquatic resources

Sub-priority 8a: Sustainable production systems in the coastal zone

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System Priority 9

Policy and Institutional Innovation to Reduce Poverty and Hunger and to Enhance Competitiveness of Smallholders

Sub-priority 9a: Globalization and farm policies

Sub-priority 9b: Rural development strategies to offer pathways from poverty

Sub-Priority 9c: Policies and institutions for nutritional improvement and food/water safety enhancement.

Sub-priority 9d: Environmental regulations, payments for environmental services, and sustainability

Sub-Priority 9e: Property rights and sustainable management of natural resources

Sub-priority 9f: Reducing risk and vulnerability of the poor

System Priority 10

Strengthened National and Regional Capacities for Agricultural Research and Rural Institutions

Sub-Priority 10a: Strengthening NARS

Sub-Priority 10b: Strengthening Producer Organisations

Sub-Priority 10c: Institutional arrangements for private-public-NGO partnerships

Each Draft System Priority is described by:

Title, Rationale(s), Sub Priorities, Goals (examples of general and specific goals), Scope of research, and Regions that may preferentially benefit.

The Draft System Priorities are presented as a basis for discussion and future refinement.

Draft of 4 October 2004

System Priority 1

Title: Conservation and Characterization of Genetic Resources

General Rationale: Genetic and functional diversity of plants and animals are the characters that allow the habitation of different agroecosystems and on which increases in agricultural performance and production can be based. Much of the diversity rests in under-studied wild relatives of major and minor crops, livestock and fish indigenous to the countries served by the CGIAR. In some areas of the world, the advent of monocropping, industrialization and habitat degradation threaten to marginalise or extinguish indigenous genetic diversity of plant and animal species useful for agriculture. There is a continuing need to collect, conserve and characterize this diversity in relation to sustaining and augmenting future agricultural production.

Sub-priority 1a: Traditional commodities and their wild relatives

Rationale: The CGIAR has placed major emphasis in the past in the collection, conservation and distribution of staple crops of importance to the poor in developing countries. This is both an international public good and a means of augmenting the CGIAR's improvement programmes (such as the Diversity Challenge Programme and others). The continued success of wide crossing programmes (e.g. the Nerica rice varieties for use in West Africa) suggest that characterisation of hardy varieties of staples will remain important to CGIAR research. The wild relatives of crops provide a reservoir of untapped, potentially important genes for crop improvement. This is particularly so for genes for tolerance or resistance to biotic and abiotic stresses, but also for genes for other important adaptive traits. However, wild relatives are greatly under-represented in most of the CGIAR Centre collections. A concerted effort is needed to study the remaining distribution of such species and ensure that accessions are collected that adequately represent the broad range of genetic diversity within them. There is a need to apply modern and efficient means for the collection, long-term conservation, evaluation and characterization of germplasm. Enhanced ICT technologies provide means for improving the documentation of these processes. Through appropriate wide-cross breeding techniques, the desired traits need to be transferred into breeding populations for further development (The use of wild relatives was also identified as a breeding priority and this is elaborated under SP 2).

General goal: *Maintain and enhance future agricultural productivity and food security.*

Specific goals:

- Identification and collection of representatives of the biodiversity of agricultural crops
- Conservation, evaluation and utilization of genetically diverse staple crops
- Conduct research and related activities to conserve, characterize, and evaluate the collections (the collections are mainly of traditional crops)
- Disseminate appropriately characterized materials for their use by national programmes

Scope of Research: Assemble, conserve and evaluate genetic resources of staple crops to: Complete core collections for a wide range of genetic variation, including wild relatives (in concert with sub-activity 1c). Evaluate for biotic and abiotic stress reactions and for value-added traits (nutrition, processing, new uses). Develop molecular techniques to increase efficiency of screening procedures Explore *in situ* conservation methods for key varieties in areas of low environmental threat. Augment genebank information services to ensure characterisations are available to other global and national efforts to exploit rare types and relatives.

Regions of focus: SSA, C-WANA, Asia, LAC.

Sub-priority 1b: High value crops, (including fruits and vegetables)

Rationale: A major tenet of the new agriculture approach is that it will be necessary for small-holders to diversify the agricultural products they produce to spread risk, and to identify higher value products - compared with staples which may be locally over produced or which are affected by other global factors causing a slump in world prices. The Consultation gave strong support to a new focus of the CGIAR on vegetable and fruit food production systems. As above, genetic diversity provides the raw material with which to adapt and improve individual species of fruit or vegetables. New research foci would entail completion of plant and systems surveys, farm and market analyses, and agro-ecosystem-based assessments to determine the target species appropriate to CGIAR beneficiaries. Collection and conservation may be required to protect diversity (in which case collections should be made in line with International agreements on the subsequent uses for food and research). Commodity focus would be on solanaceous vegetables, legumes, crucifers, cucurbits, tropical and subtropical tree fruits and nuts, citrus, grapes, and indigenous horticultural crops.

General goal: *Maintain and enhance future agricultural productivity and livelihoods.*

Specific goal:

Conservation, evaluation and utilization of genetically diverse horticultural crops

Scope of Research:

To assemble, conserve and evaluate genetic resources of horticultural crops, it would be necessary to:

- Complete core collections for a wide range of genetic variation, including wild relatives
- Evaluate for stress reactions and for value-added traits (nutrition, processing, new uses)
- Develop molecular techniques to increase efficiency of screening procedures

For *in situ* and on-farm conservation of tree and vegetatively propagated crops:

- Identify these increasingly popular, endangered and frequently high value crops
- Protect and promote promising crops for home garden and small-scale production

To promote the *in situ* conservation of horticultural crops with potential high value or high added value, research would be required to:

- Coordinate participatory evaluation of new materials by farmers, traders and consumers
- Promote new materials and demonstrate production of these materials
- Conduct on-site trainings of household members directly involved in food preparation

Regions of focus: Listed in order: Sub-Saharan Africa, South Asia, Central Asia, SE Asia, and Central America.

Sub-priority 1c: Orphan crops and their wild relatives

Rationale:

Just as for the wild relatives of crops, there are many ‘orphan’ crop species that have been neglected by science but which, with appropriate research, offer the potential to contribute to sustainably improving the diets and incomes of poor people, especially those in marginal environments. Foremost in this respect are fruits, vegetables and oil crops, but the list also includes minor cereal crop species. The CGIAR has concentrated mainly on major food staples: wheat, maize and rice, food legumes and roots and tubers, and has essentially neglected many of the species that are important to key groups of poor people and contribute to dietary diversity. These include both traditionally researched and new crops for the CGIAR. A relatively modest, but sustained research and development effort with such species could have a major impact. The research needed would initially aim at identifying those species on which to concentrate, and then, together with partner institutions, efforts should be undertaken to develop representative collections that should be conserved and characterized. Promising subsets of the materials should be widely evaluated in different production systems and made available to genetic improvement programmes.

It is particularly important in all aspects of the work undertaken by the Centres that due regard be given to the legal status of the materials under study and development. Many, but by no means all, of the wild relatives will be included within the multilateral system of the International Treaty on Plant Genetic Resources for Food and Agriculture. In the case of ‘orphan’ crops, only a few will come under the multilateral system. Working in partnership with national institutions will be particularly important, as will due regard for access and benefit-sharing regimes. (This remark applies equally to the other sub-priorities for conservation activities and research.)

General goal: *Maintain and enhance future agricultural productivity and food security*

of the rural poor in developing countries.

Specific goal:

- Identify the distribution and importance of wild relatives of CGIAR mandate commodities and orphan crops (either directly, to increase the current productivity of developing country agriculture, or for future genetic use).

Scope of research: Identify key species of ‘orphan’ crops, survey their eco-geographic distribution and assess the status of existing *ex situ* collection. Develop appropriate sampling strategies and assemble collections that represent the broad range of diversity within the species concerned, both through field collecting and through acquisition from other collections. In the case of orphan’ crops, it will not usually be necessary to maintain highly centralized collections – either at the Centre concerned or partner institution - as dispersed collections maintained collectively among a network of collaborating institutions would, in many cases, be a better approach.

Conserve, characterize, and evaluate the collections. With wild relatives, research may be needed to develop appropriate conservation techniques. Research may also be needed on germplasm health – to ensure that healthy materials are conserved and distributed. The collections should be well documented and the information made available through SINGER.

The materials should be made widely available, subject, of course, to any legal obligations and restrictions. ‘Orphan’ crop germplasm should be made available not only to plant breeders, but also for direct testing and use in different production environments.

Regions that could benefit: This is expected to be a global undertaking. Linkage to specific trait improvement research (SP2) may be focused on crops important to SSA and to dry areas of South Asia and WANA.

Sub-priority 1d: Indigenous livestock breeds

Rationale: Poor livestock keepers depend on the ability of their indigenous, locally adapted livestock breeds and strains, to hedge against the impacts of harsh and highly variable and unpredictable production environments. Given the multifunctional importance of livestock to the rural poor (e.g. small-holder farmers and herders) and the value of livestock products in health and nutrition, especially of vulnerable groups (such as pregnant and lactating women, and children), an emphasis on the role of livestock diversity for the livelihoods of rural communities is justified. The programme will need to address the major problems confronting the use, development and conservation of indigenous breeds, and in particular:

- The increasingly rapid loss of livestock diversity and the implications of such loss on producers and production systems in the longer-term
- Poor knowledge of local breeds and understanding of their value
- Lack of appropriate strategies for maintaining and using the little understood inherent genetic attributes of local breeds

- Technical and economic constraints to livestock conservation (both in-situ and ex-situ)
- Weak human and institutional capacity for supporting the management and use of livestock diversity
- Inappropriate policies hampering livestock conservation, exchange and use.

Over-arching goals of the research agenda will be to help improve livelihoods and reduce poverty, to enhance food security, nutrition and health, and environmental sustainability. The issues addressed require multi-disciplinary research and multi-stakeholder involvement from local to global level. Often the lack of information about local breeds, their values and their attributes, and poor or inexistent programmes for their management, development and use are the root causes of the loss of diversity. Cross-breeding with exotic breeds in often ill-conceived attempts to improve farm productivity, and this in the absence of local breed assessment and development, exacerbates the loss of diversity. Addressing these issues requires the involvement of communities, researchers and policy-makers. Despite the efforts of the CGIAR Centres, FAO and others, overall investments to date in livestock genetic resources are limited.

General goal: *Maintain and enhance livestock productivity and the basis of further production improvements*

Specific goals:

- Breed characterization at molecular and phenotypic levels
- Influence the establishment of policies conducive to the exchange, use and conservation of livestock diversity.
- Investigate *in situ* and *ex situ* conservation options.
- Demonstrate the value of livestock diversity and the benefits of livestock diversity to health, nutrition and livelihoods, and to the productivity and stability of agro-ecosystems.

GOAL 1: *Breed characterization at genotypic and phenotypic levels.*

Scope of research: Information on breeds is a prerequisite for decisions on what to conserve, since the high costs of conservation preclude broad-scale approaches. This area is a major component in the agenda of ILRI which has global activities on assessment and documentation of genetic diversity of ruminant livestock and poultry and ICARDA with activities in small ruminants in the WANA region. FAO is undertaking an inventory of global Animal Genetic Resources and thereby assessing country capacity for breed characterization. FAO and ILRI are developing agreed and coordinated protocols for molecular characterisation to enable studies on overlapping and comparability of diversity. Research protocols for the field need to be developed to investigate adaptive traits of local breeds and their functionality and physiological mechanisms. Also, criteria for decision making for conservation decisions need to be developed (see goal 4). In the face of the accelerating loss of diversity, this work also needs to be accelerated.

GOAL 2: *Influence the establishment of policies conducive to the exchange, use, development and conservation of livestock diversity*

Scope of research: Demonstrating the impact of policy interventions and providing policy options is critical for creating an ‘enabling environment’ for enhancing the use of diversity in strengthening livelihoods and for livestock conservation. Research on legal and regulatory aspects of exchange of genetic material, including access and benefit-sharing arrangements, will be important for informing the development of any international agreements on livestock genetic resources which might possibly be initiated by the FAO Commission on Genetic Resources for Food and Agriculture. This should be done in inter-institutional partnership.

GOAL 3: *Investigation of in situ and ex situ conservation options*

Scope of research: Advances in cryopreservation technology and reductions in its costs, combined with increasing pressures on diversity (especially culling due to disease), suggest that it is timely to re-assess *ex situ* approaches, alongside the further development of *in situ* conservation methods. SGRP and FAO are joining forces to work on this topic.

GOAL 4: *Demonstrating the value of livestock diversity and the benefits of livestock diversity to health, nutrition and livelihoods, and to the productivity and stability of agro-ecosystems*

Scope of research: Demonstrating the economic, social and environmental benefits of diversity are crucial for justifying and targeting investments and commitments for the conservation and use of indigenous breeds. ILRI has developed various valuation approaches. SGRP is facilitating collaboration among ILRI, IFPRI and IPGRI on advancing this agenda. Promotion of community-based management and use of livestock diversity would bring together the plant and animal genetic resources scientific communities to study the interactions between the biodiversity components. This work would contribute to the development and implementation of integrated biodiversity and natural resources management.

Aspects of the approach are:

- Collaborative approaches between ILRI, IPGRI, ICARDA and through the SGRP
- Working in support of the FAO Global Strategy on Farm Animal Genetic Resources – contributing to its institutional and policy frameworks and priorities
- Assisting in raising awareness of the importance of livestock diversity and leveraging resources and new partnerships
- Mobilizing CGIAR and partners’ expertise to contribute, as feasible and appropriate, including in the areas of policy and institutional arrangements; valuation of diversity; conservation strategies; community-based management of diversity, livelihood and agro-ecosystem approaches; information sharing

Regions and beneficiaries:

A priority focus would be smallholder farmers and livestock keepers in Africa and Asia (including west Asia) where there is a strong role for indigenous livestock diversity under the marginal, variable production environments. These poor, rural livestock keepers are the custodians of important livestock diversity, and recognition of this role should be reflected in the improvement of their livelihoods.

Sub-priority 1e: Fish*Rationale:*

Most of the improved strains of fish are of alien species or stocks with possibility of their use resulting in biodiversity and economic loss. It is recognized that one of the main pathways for entry of alien aquatic species into natural systems is the accidental escape of farmed fish. To ensure that aquaculture is developed sustainably, the problem of alien species and stocks have to be addressed.

Inventory and characterization of the key species stocks used in developing country aquaculture is required for conservation and appropriate management of domesticated strains and wild stocks. The information would be similarly important to genetic enhancement programmes and management of improved strains. With regard to *ex situ* conservation, for finfishes only cryopreservation of milt is feasible, and some developing countries have already started gene banks. However these accessions are not collected systematically nor utilized in genetic improvement programmes. Improved knowledge about building gene banks accessions for aquaculture species would help the developing countries to consolidate their genetic conservation and use programmes. The dissemination of improved strains of tilapia and carps would increase aquaculture production in most poor countries. Conservation of prioritized stocks, protection of centres of diversity, and mitigation of the impact of alien stocks would ensure that the genetic improvement is sustainable.

General goal: *Maintain and enhance the productivity of aquaculture and the basis of further production improvements*

Specific goals:

- Inventory and value important wild and improved stocks of aquaculture species, and develop plans for their better utilization in aquaculture and for *ex situ* conservation of these stocks.
- Develop methods for the safe deployment of improved strains and for mitigating the impact farm fish escapees.

GOAL 1: *To inventory and value important wild and improved stocks of aquaculture species for developing plans for their better utilization in aquaculture and for ex situ conservation of these stocks.*

Scope of research

- Inventory important wild and improved stocks and threats faced by tilapia and carp species cultured widely by poor farmers.
- Based on the inventory, prioritize stocks to be characterized using genetic markers and production parameters.
- Integrate and improve quantitative and molecular techniques for characterization (also to be used in genetic improvement).
- Determine the economic value of prioritized stocks and develop a plan for *ex situ* conservation of these stocks.
- Evaluate the use of cryopreserved milt for conservation and genetic improvement and develop plans for building and sustaining gene banks.

GOAL 2: *Development of improved strains of cultured species, and plan means for the safe deployment of such strains, mitigating the impact of escapees of farmed fish.*

Scope of research:

In conjunction with activities under SP8, enhance capacity of developing countries to undertake genetic improvement programmes. This would involve the continued development of genetic characterization and improvement methods and training of developing country scientists in risk analysis. Develop scientific tools and capacity building for the safe deployment of improved strains and the containment of impact in case of escapees, with a focus on developing country situations.

Regions that could benefit:

South, South-East, and East Asia; West Asia and North Africa; sub-Saharan Africa.

System Priority 2

Title: Genetic Improvements of Specific Traits

General Rationale:

Improving the performance and productivity of crop and animal species used by the farmers of developing countries is one of the most direct means through which agricultural research can meet the goals of the CGIAR. The CGIAR has already had success, particularly in the improvement of crop staples, through traditional breeding methodologies. Genomics will play an increasingly important role in plant and animal improvement and the recent availability of the genomic sequences of rice, Arabidopsis and soon *Medicago* and others will further fuel applications.

The CGIAR has examined the status of biotechnology in breeding in the ‘Systemwide review of plant breeding methodologies’¹. The major recommendations were: 1) that individual Centres should, in house, develop the basic genomics infrastructure necessary for marker assisted selection (MAS) and gene discovery for those orphan crops, including cultivated fish and farm animal species, which still lacked the basic genomics tools: maps, markers, large insert libraries, representative EST collections and transformation technology. (This is, similarly, a priority result of recent consultation on Priorities and Strategies). 2) Individual Centres should pool their different expertise and outsource more between Centres. 3) Centralisation of some common activities, such as DNA analysis in MAS should be pursued as the most cost-effective way forward. Genomics and some of the associated platform technologies must be developed as part of the System’s skill-base to enhance individual Centre research on specific commodities.

CGIAR research utilising genomics and biotechnology should be organised around a defined number of traits in species of most importance to agriculture of the poor. Success in such approaches is contingent upon the formulation of specific scientific targets to be accomplished and partnerships between Centres, ARIs and NARS, to conduct globally relevant research and to ensure delivery of new varieties. This rationale has been rapidly adopted through the implementation of two of the pilot Challenge Programmes (the Generation CP and Harvest Plus). There are also opportunities to link animal (livestock and fish) improvement programmes in the CGIAR to international genomic approaches through the formation of consortia (see SPs 7 and 8). Part of the institutional considerations include the means by which the CGIAR and its partners deal with challenges to the modus operandi provided by Intellectual Property Rights (IPR) and Biosafety issues in agriculture and research.

Overall Goal: *To deliver to breeders gene sequences for water stress tolerance in key crop species, resistance to major pests/pathogens, and metabolic efficiencies leading to higher yields across CGIAR commodities.*

Purpose

1. To reduce poverty, hunger, malnutrition and environmental degradation in semi-arid environments applying currently available promising biotechnologies to enhance the

- livelihoods, incomes and nutritional value generated by agricultural production.
2. To improve the efficiency, effectiveness, speed and precision of plant breeding for drought tolerance, pest and disease resistance; and better agronomic traits, including nutritional quality.
 3. To improve the efficiency, effectiveness, speed and precision of animal breeding (including aquaculture) for improved production and marketability traits including disease resistance.

This will include:

Sub-priority 2a: Yield and quality improvement of staple commodities

Rationale: In some environments, yield ceilings have been reached under the prevailing climatic and farming conditions. There will be a continuing requirement to improve staples for local farming conditions or to enhance their marketability. However, the continuing development of private and public research capacity for breeding and crop improvement, particularly in Asia and LAC, mean that choices of species and traits for CGIAR improvement will need to be made much more selectively. The expectation is that CGIAR will focus therefore on commodities not addressed by others or traits targeted to assist smallholder production in SSA and WANA.

General goal: *Protect productivity gains made through earlier CGIAR research, and continue the improvement of selected commodities for yield and traits relevant to smallholder production systems and markets.*

Specific goals: Enhance the productivity of staple crops and animals through improvement in yield, production, market or other traits for farming systems and developing country regions where there is no other provider of this research.

Scope of research: Centres responsible for particular commodities will undertake breeding, participatory research, and genetic improvement for production and market traits in crops. Livestock and fish genetic improvement are detailed under SPs 7 and 8. This will include the establishment, in collaboration with international consortia, common platform(s) of research to be able to utilize the genetic diversity across commodities (and their wild relatives), to provide genomic and functional information and the development of markers of genes and traits of relevance for CGIAR research. Initially this will be initiated for rice, maize and wheat with extension to wild relatives and orphan crops where synteny makes this advantageous.

Sub-priority 2b: Drought and salinity tolerance

Rationale:

The productivity of many of the current farming systems serving populations of the poor are limited by climatic conditions or abiotic stresses such as periodic water shortage, or soil salinity. A major means of improving productivity per unit of land and population

would be to enhance stress tolerance and hence productivity in some of these currently marginal environments. This work will be undertaken largely through the Generation CP.

General goal: *To enhance the tolerance of crop species to abiotic stresses and so increase agricultural productivity in marginal environments.*

Specific goals: Enhance the productivity of crop farming in marginal environments in developing countries through gene and trait identification and breeding for tolerance to abiotic stresses.

Scope of Research: It will depend upon programmes of biodiversity conservation and characterization (both genetic and functional), and programmes of bioinformatics to correlate large amounts of genetic and phenotypic data. It will conduct work on rice, maize, wheat, cassava and sweet potato in the first phase. It will compare productive phenotypes from areas of abiotic stress such as drought and seek inducible systems and correlates of stress tolerance. Trait capture will be followed by the introduction of target genes into productive phenotypes. Capacity building programmes will allow NARS to access new science and genetic and other data for the improvement of crops important to individual countries.

Sub-priority 2c: Biofortification

Rationale:

Micronutrient malnutrition is an insidious form of malnutrition affecting millions of poor people with inadequate amounts or variety of foodstuffs. As this is most widespread amongst the poor living largely on single sources of staples (such as cereals, roots, tubers or pulses) improving the micronutrient content of such staples is considered to be the most effective way of overcoming nutritional insufficiency and the morbidity and disease to which it predisposes.

General goal: *To enhance the content and availability of micronutrients in staple commodities for enhanced human nutrition.*

Specific goals:

- Increase the content of micronutrients in the edible parts of crop plants through improved biotechnologies and breeding.
- Evaluation of bio-fortification strategies and introduction of the best means to enhance the diets of nutritionally disadvantaged populations in developing countries.

Scope of research: Research will initially focus on the enhancement of the concentrations of micronutrients iron (to combat anaemia), zinc (for immune system function and resistance to disease) and vitamin A (for maintenance of good vision, particularly in childhood, and cellular development). It will include plant breeding and pre-breeding feasibility studies on rice, maize, wheat, cassava, and sweet potato in the first instance to demonstrate the validity of the biofortification strategy. Subsequently

useful varieties will be improved for the best nutritional and agronomic traits in each crop, using adaptive/decentralized breeding methods and seed production where feasible. If successful, research will be extended to additional crops (banana/plantains, barley, cowpeas, groundnuts, lentils, millet, pigeon peas, potatoes, sorghum, and yams) for which the knowledge base for biofortification has yet to be developed. Promising lines will be screened for micronutrient bioavailability using *in vitro* and animal models and subsequent efficacy studies involving human subjects to evaluate nutritional impact of the most promising lines intended for release. This will be augmented by research to understand economic and social factors that determine the dietary quality of the poor and their micronutrient status, and policy advocacy based on that research; and coordinated communication activities supporting dissemination and adoption of micronutrient-enhanced varieties. Dissemination of nutritionally improved varieties will be closely evaluated to determine the effectiveness of the biofortification strategy after adoption.

Sub-priority 2d: Resistance to selected diseases, insect pests and weeds

Rationale:

Improved tolerance or resistance to biotic stresses (diseases, insect pests and weeds) is required to enhance the productivity of CGIAR commodities (principally including crop plants; for livestock and fish see SPs 7 and 8). The focus will be on generic resistance to pests and pathogens of major global or regional importance.

General goal: *Increase agricultural production, food security and livelihoods in the face of biological challenges from diseases, pests or weeds.*

Specific goal:

Enhance key species of plants and animals for resistance to biotic stresses, primarily diseases, insect pests and parasitic weeds, to increase their productivity and contribution to farming systems of small holders.

Scope of research: Research will be undertaken on key diseases (viral, bacterial, fungal), insect pests or weeds of major global or regional importance constraining productivity of crops used by smallholders and where there is no alternative supplier. Infections or blights leading to post harvest losses (e.g. through aflatoxins) may also be included.

Striga is an example of a parasitic weed causing major losses of revenue to small farmers in Africa and Asia for which it may be possible to exploit the comparative genetics of host plant resistance.

Sub-priority 2e: Adaptation to climate change

Rationale:

The world is experiencing global warming and increased frequencies of climatic instability. Recent indications from historical trend data suggest that with current, improved varieties, rice yields may drop by as much as 15% when mean day time temperatures rise by one degree (although the relatively greater increase in night time

temperatures is apparently key to the size of the effect). Temperatures are projected to rise globally by 1.5-4.5°C in the coming century - or 3 to 9 times more than in the past century. Global warming thus threatens to erase the hard-won productivity gains that have kept the rice harvest in step with population growth.

General goal: *Develop capacity to maintain or augment agricultural production and related benefits in the face of climate change.*

Specific goal:

Enhance target CGIAR crop species for tolerance to temperature stress and other traits to remain productive in agroecologies subject to climate change.

Scope of research: As with other work under this priority, the approach will be to make use of the platform genomic approaches and phenotyping of varieties of rice and other crops for differential productivity with growth temperature. Research will also develop strategies for shortening harvest period etc.

Sub-priority 2f: Labour productivity and flexibility traits

Rationale: Diversification of enterprises makes additional demands on farm labour. Additionally, in some farming communities the incidence of human disease, particularly HIV/AIDS, reduces the available family labour. Labour saving farming technologies would assist such communities continue to gain cash and nutrition from the farming enterprise which otherwise might be abandoned as too difficult.

General goal: *Maintain agricultural productivity, nutritional benefits and livelihoods in the face of human disease or other constraints which reduce labour availability.*

Specific goals:

To enhance crop species for a range of traits reducing labour requirements, particularly for farming systems in areas of reduced labour availability due to HIV/AIDS.

Scope of research:

The programme will explore the development of productive varieties of the major staple crops in southern Africa which require less tillage, weeding, changed harvest intervals etc. to determine whether technology packages can be developed which can reduce agricultural labour requirements. This will be undertaken in concert with the biofortification programme to increase the nutritive quality of grains of the same commodities.

Sub-Priority 2g: Science and technology policy toward intellectual property rights and biosafety.

Rationale: Research and trade are increasingly affected by the needs to take into account intellectual property rights and biosafety regimes. Both the CGIAR and partner NARS require to develop appropriate policies to continue to advance agricultural research to

provide international public goods on behalf of the needs of the poor, in spite of privatization of innovations on living organisms. Many innovations that could have significant impact on world poverty are held back by lack of sufficient information on nutritional and environmental risks. For the poor to eventually derive benefits from this research, important advances need to be made in the understanding of their biosafety implications. Regulatory systems need to be devised and put into place, requiring policy and institutional research.

General goal: *Enhance the delivery of international public goods from agricultural research for the sustainable benefit of the poor in a context of increased privatization of research and of intellectual property rights on scientific and technological discoveries*

Specific goals:

- Parity principle: The rate of delivery by the CGIAR and its partners of technological innovations for smallholders, and their effectiveness in enhancing profits, must be sufficient to secure the competitiveness of smallholders in a context of declining prices due to technological change in commercial agriculture, and in competing with more developed countries.
- Define operational rules that allow the maintenance of access for (1) CGIAR scientists to proprietary research methods and materials, and (2) the rural poor to the proprietary products of research under fair and remunerative conditions.
- Put into place effective biosafety systems to protect consumers and the environment while enabling the CGIAR and public/private/civil society organizations to invest in gene research (breeding and biotechnology) and derive high economic and social rates of returns from these investments.

General scope of the research: Research studies will seek to identify optimal means for the CGIAR and its partners to enter into research and research partnerships, and to meet international demands and public concerns for intellectual property and biosafety. The intention is to ensure that the CGIAR meets its goals for poverty alleviation through agriculture in an expeditious and appropriate manner. It is necessary to ensure that products and improved materials developed by CGIAR research are not hindered from entering trade.

Regional Focus: The scope of potential species, traits and applications covered by this SP is broad. It is expected that further focus and selection of species and traits having global or regional significance will be elaborated through discussion, and will be subject to priority setting.

System Priority 3

Title: Improved Water Management and Use in Agriculture

General Rationale:

As populations rise, incomes rise, and countries industrialize. This trend will create significant demands for water in urban areas of developing countries in the coming decades. Fuelled by concern over the food supply, previous expansion in water use has been to meet agricultural needs: as the human population tripled in the twentieth century, water use multiplied six-fold. Part of the productivity increases can be traced to major investments in water resources infrastructure and massive subsidies on energy for pumping groundwater. These investments and subsidies are not likely to be repeated in coming decades. There is now a need to divert water from irrigated food production to other users and to protect the resource and the ecosystem. The majority of environmental goods and services are provided by lakes/streams, wetlands and marine waters, and depend on the integrity of resident aquatic ecosystems. These include water regulation, water supply, erosion control, nutrient cycling, waste treatment, habitat/refuge, food production, recreation and cultural value. Groundwater levels are falling in key aquifers that have contributed substantially to food security in recent years. Large-scale development of river and groundwater resources is less acceptable and less cost effective now than it was in the 1960-1990 period, when most of the world's 45,000 large dams were built. All these diversions of water have been made with little regard to the impacts on fisheries and wildlife and those who depend on them.

Agriculture is the largest user of water. To maintain and improve agricultural productivity, the requirement is to improve the productivity of water use, for example by getting more "crop per drop" in agriculture. This is a useful framework at the field or farm scale, but at the river basin scale, water productivity needs to be better understood in the widest possible sense – including crop, livestock and fishery yields, wider ecosystem services and social impacts such as health, together with the systems of resource governance that ensure equitable distribution of these benefits. There are requirements to ensure that advances in increased water productivity are directed at foodstuffs and agriculture, livestock and fisheries systems that are relevant for the poor. And that they contribute to reducing malnourishment and rural poverty, increase levels of human health and maintain or improve environmental quality and biodiversity.

The stated intermediate objective of the Water and Food CP is: To maintain the level of global diversions of water to agriculture at the level of the year 2000, while increasing food production, to achieve internationally adopted targets for decreasing malnourishment and rural poverty by the year 2015, particularly in rural and peri-urban areas in river basins with low average incomes and high physical, economic or environmental water scarcity or water stress, with a specific focus on low-income groups within these areas. Research on policy for water allocation and use is integral to such an objective.

Sub-priority 3a: To improve water productivity at the crop and field level

Rationale:

The increased food production associated with the Green Revolution has come hand-in-hand with sharply increased water use in irrigated agriculture that has benefited farmers and the poor variously, as well as damaged the environment. Alternatives and efficiencies in water use must be sought. However, water management practices in rainfed agriculture have equally important implications for food and environmental security. Increases in the productivity of rainfed agriculture lessen the need for more irrigation. But rainfed agriculture is not necessarily an environmentally neutral activity.

General goal: *To increase the efficiency of food production in agriculture through sustaining water supplies, and improving the management of water in rain-fed and irrigated systems.*

Specific goal: Improve water productivity of agricultural systems at the crop and field levels

Scope of research: Research will encompass development of tools to optimize water productivity in the system, taking into account the underlying process of interaction among the hierarchical scales within the system (e.g. return flows). Strategies will be developed to match management of irrigation systems to cropping patterns and field water requirements, making more effective use of unevenly distributed rainfall and water storages (groundwater, small reservoirs, drainage canals....) contributing to the irrigation system. Methods to improve production and water productivity in land that is degraded due to water logging and salinization will be developed and tested. Tools and methodologies will be developed to assess the impact of interventions on crop performance, water productivity, water balance components, soil and water quality. Socio-economic and institutional research will augment incentives for farmers to cooperate in water productivity enhancing technologies.

Sub-priority 3b: Enhanced efficiency in the use of water resources across multiple users of water at the basin level.

Rationale:

Various hydrological and engineering approaches have been developed to improve water productivity by reducing water losses. However, strategies for increasing output have so far been limited to crop cultivation. Major opportunities exist to increase water productivity by integrating fish and other living aquatic resources into farming systems at field level, as well as in larger irrigation systems and flood-prone areas.

General goal: *Increase livelihood opportunities for the poor and small holders through enhancing the productivity of aquatic resources in multiple use systems.*

Specific goals:

- Increase the productive use of water in upper catchments

- Enhance the sustainability of agriculture in the wetlands and methods to maximise the productive use of water

GOAL 1: Increase the productive use of water in upper catchments

Scope of research: Research will examine aspects of the multiple use of water in upper catchments - water and livelihoods; catchment hydrology; and social organization. Aquatic ecosystems and fisheries will be evaluated for their contributions to enhance food security and livelihoods through the productive use of water and provision of environmental services. Means to foster the effective governance of the aquatic ecosystems and their resources within water use in basins will be examined. Models and methods to manage trade-offs in water use, and policy research will be carried out to enhance the overall productivity in relation to competing uses.

GOAL 2: Towards sustainable agriculture in the wetlands and methods to maximise the productive use of water

Scope of research: Research will focus on the means by which livelihoods can be improved by integrating fish production and harvest of other aquatic animals and plants into farming and irrigation/flood-prone systems. This will be coupled with estimates of cost benefit analyses of additional water use options in general.

Regions that could benefit

All regions will benefit through the selection of major water basins in each region, and the conduct of research at relevant benchmark sites and through generic thematic research.

Sub-priority 3c: Increased efficiency of water use in agriculture through developing improved water harvesting practices, supplemental and micro-irrigation

Rationale:

Water harvesting and supplemental irrigation show promise to increase production, to improve livelihoods and household food security for many of the world's rural poor. The land required for agriculture replaces other - often natural - uses and mismanagement of intensified farming leads to pollution and to land and water degradation. The spectrum of water use for agriculture must consider options from fully irrigated, to rainfed, and choices in between, such as supplemental irrigation and the use of small rainwater harvesting structures. There is the possibility to augment efficiencies through the development of more water efficient plants (in conjunction with SP2).

General goal: *Maximise water harvesting and the productivity of water in agriculture*

Specific goals:

- Increasing the efficiency of water use in agriculture through developing improved water-harvesting practices.
- Improve agro-ecological systems and methods to maximise the productive use of

water and environmental sustainability.

GOAL 1: *Increasing the efficiency of water use in agriculture through developing improved water harvesting practices.*

Scope of research: For rainfed and water scarce environments research will focus on how yield can be maintained for crops growing under extended periods of mild water deficit or brief periods of severe water deficit e.g. focusing on increased harvest index and reduced crop duration where appropriate; breeding for temperate and tropical aerobic rice that give high yield and are responsive inputs when grown in non-flooded conditions; breeding for drought escape (short duration) drought avoidance (deep root) and drought tolerance at the reproductive stage; breeding for increased submergence tolerance, salt stress tolerance (in conjunction with SP2). Research will develop, adapt and apply technologies and management strategies for the use of rainwater, surface water, and groundwater, and the reuse of urban wastewater.

GOAL 2: *Improve agro-ecological systems and methods to maximise the productive use of water and environmental sustainability.*

Scope of research: New agro-ecological methods (see SP 5) will be tested for their ability to augment retention of soil moisture or mitigate seasonal decreases in water availability. Special effort will be devoted to developing technologies and management strategies that exploit synergies between different uses to enhance water productivity, whilst maintaining or improving environmental sustainability.

Regions that could benefit: All, but particularly areas subject to low or single annual rainfall patterns and areas or regions facing intermittent water supply.

Sub-priority 3d: Re-use of water in agriculture, including peri-urban settings

Rationale:

As water use intensifies, water quality becomes more of a concern for aquatic ecosystems and agricultural and non-agricultural uses. The health and environment factors of water use are not well known, yet essential in any strategy for sustainable water use in peri-urban settings. It will be necessary to develop practical measures to minimize negative and maximize positive health and environmental impacts for the most productive use of water in agriculture.

General goal: *Enhance the productivity and safety of water for peri-urban agriculture for small-scale farmers and users of aquatic ecosystems*

Specific goal: Ensure the safe re-use of water in peri-urban agriculture

Scope of research:

Water quality and health monitoring in varied examples of peri-urban uses of water for agriculture. Development of recommendations for water management to avoid major

risks to agriculture and human health. Participatory research and capacity building as important means to both generate knowledge and achieve impact, through the acceptance and implementation of recommendations.

Regions that could benefit: Sub-Saharan Africa, Asia.

Sub-priority 3e: Policy and institutional aspects of water management

Rationale:

Research on water policy and institutions is a critical area requiring enhanced research related to water in the social sciences. The CGIAR has the potential to make significant contributions in this area for two reasons; it can freely exchange information and compare features of institutions in the various areas, and it can act as a more objective advisor when policy and management research is carried out on institutional development and change. In general, very little is known about the reasons for the adoption gaps that are so common in agricultural water management. The assumption that new technologies will be picked up spontaneously by farmers is incorrect, and insufficient attention has been paid to the dissemination of appropriate technologies. New knowledge on the different user-organized water institutions must be developed to remove a critical constraint in many areas where innovative water institutions could make the most important contribution to improved water management.

There are water policy and governance issues in all major water basins. In East Africa, for example, there is strong evidence that increased water abstraction in the hillside areas leaves less water available for downstream users – who include pastoralists, agro-pastoralists, and wildlife. Increased water scarcity leads to frequent conflicts, loss of life, and generally to the marginalizing of the poor and powerless in terms of access to fresh water.

General goal: *To improve the productivity of water use in agriculture and contribute to higher productivity and livelihoods for the poor, as well as environmental sustainability, through improved policies and institutions for water management.*

Specific goal: To enhance the understanding of the factors influencing optimal policy and institutional development in relation to the efficient, reliable and equitable use of water

Scope of research: Research will integrate biophysical and socio-economic issues and approaches to identify key omissions or challenges to producing water policy. In the specific area of water and forests, policy decisions are often based on insufficient scientific evidence on the interactions between forests and water issues. Thus, there is a need for further characterization of the causal relationships that form the basis for the policy interventions that will ensure the delivery of expected water services by forests. In the specific area of water institutions, the research agenda will address:

- Innovative institutions that would deal effectively with emerging problems such as equitable groundwater and wastewater management.

- The roles of prices, markets and regulations in improving water management
- New methods for enhancing stakeholder participation in institutions and in defining water policies.

Regions that could benefit:

SSA, Asia, LAC, WANA.

System Priority 4

Title: Better Management and Use of Forests and Forest Landscapes

General Rationale: The core business of the CGIAR is to help increase the benefits for the poor that flow from the variety of agricultural and mixed crop-livestock-forest landscapes that provide livelihoods for poor rural people. Across the rural landscape in most developing countries, the CGIAR is dealing with a continuum of livelihood sources: from the intensive, purely crop-based, peri-urban farming systems on through mixed agricultural landscapes with significant presence of trees and/or livestock, to the forest margins, and on into the dry and wet tropical and sub tropical forests where bushmeat, NTFPs and other outputs provide part of the livelihoods strategies of the rural poor. Management of all of these landscapes for production increases which also avoids deterioration of the environment and the natural resources on which the poor depend is, and has to remain, one of the main priorities of the CGIAR System in terms of its research agenda.

To complement the a) traditional breeding and b) biotechnology approaches to agricultural improvement, the CGIAR requires to enhance the sustainability of production through c) agriculturally-focused land use systems research that takes an agroecology, integrated natural resources management, and sustainable livelihood perspectives. The first two are well represented in the CGIAR's research portfolio and remain as CGIAR system priorities. The third is also a priority and requires continued evolution within the CGIAR to achieve its full potential.

The sustainable management of agricultural landscapes for high productivity includes improved management of forests and forest margins, selection of crop and animal species appropriate to the environment, changing resource base and markets. It always includes appropriate management of soil for sustainability and optimal nutrient levels and flows. It requires effective water and watershed management, and the provision of ecosystem services (amenities) for household and community well being.

Sub-priority 4a: Sustainable management and use of forest resources

Rationale: Hundreds of millions of poor people live on or near the forest margins in Asia, Africa and Latin America. Not intentionally, these people are the sources of major forest biodiversity loss. There has been an annual net loss of 9.4 million hectares (0.22 per cent annually) since 1990. Most was natural forest in both the wet and the dry tropics. The main causes are conversion of forest to agricultural or grazing land, , shifting cultivation, unsustainable forest management, introduction of invasive alien plant and animal species, infrastructure development (road building, hydro-electrical development urban sprawl), mining and oil exploitation, forest fires caused by humans, pollution and climate change. The fact is, however, that most of the degradation and deterioration occurs at the forest margins as many millions of poor slash and burn farmers move further into the forest.

As well as the products of the forest for the poor, like timber, pulpwood, firewood, fodder, meat, cash crops, fish and medicinal plants, forests provide critical environmental services including cycling of essential nutrients such as nitrogen and phosphorus, absorbing carbon dioxide from the atmosphere, regulating micro climates, protecting watersheds, and providing living environments for pollinators for agricultural crops. Forest biodiversity also has important economic, social and cultural roles in the lives of many indigenous and local communities.

Both traditional and modern management approaches to forests have been based on the principle of sustainable use. A major challenge to sustainable forest use is to maintain the level of biological diversity in the ecosystem. Seeds of some of the most economically important trees are being conserved in seed centres and genebanks as a way of protecting their genetic diversity. However, there are a relatively large number of forest species, many of economic importance, whose seed cannot be stored *ex situ*.

The Convention on Biological Diversity has created a new framework that requires the negotiation of formal agreements with a range of stakeholders. Biodiversity is most likely to be maintained if local values are fully captured and local costs are minimised. Optimising the balance between all the goods and services in various sorts of multiple-use forests are likely to be the best option in many situations where poor people live in proximity to forests rich in biodiversity. Institutional arrangements that reconcile local and global values in this way are required. There are few fundamental technical obstacles to meeting biodiversity objectives in forest managed for timber. However, the diversity of the forests and the people who depend upon them is so great that it is neither desirable nor possible to develop broadly generalised prescriptions for management. Both the objectives of biodiversity conservation, and the technologies and trade-offs needed to achieve them, will need to be developed in response to local social and biophysical conditions.

General goal: *Expand the opportunities for poor forest dwellers to enhance their livelihoods and reduce the pressures on remaining natural forests*

Specific goals:

- Improve management of dry and wet tropical forests with a focus on benefiting the poor forest dwellers.
- Improve systems of production, harvest, processing, trade and use of non-timber forest products (NTFPs) as well as environmental services.
- Improve capability of forest managers to assess biodiversity and develop new insights into relationships between human interventions, biodiversity and ecosystem processes in order to safeguard and increase the benefits from the sustainable conservation and use of forest biological diversity at the landscape scale;
- Support and strengthen the international efforts to conserve biological diversity and reduce climate change.

Scope of research: (to be developed).

Main Regional Beneficiaries: Of global importance to dry and humid tropical forests with particular emphasis on SE Asia as well as the wider Asia and the Pacific region, SSA, LAC. The entire world benefits from research that increases global environmental services from forests.

Sub-priority 4b: Sustainable management and use of forest margins

Rationale:

Millions of poor live on the forest margins in the tropics. Most of these people are part time farmers who also rely on the forest for food and for incomes. Many of them are slash and burn farmers or shifting cultivators who every few years have to move on to clear other forest areas while their previous lands go into fallow to rebuild the nutrient base. Forests and forest margins provide fuel-wood, forest foods for subsistence and as sources of income, and act as water magazines, controlling the hydrological condition in watersheds. The links between forests, trees, food security and deforestation therefore involves a two-way relationship between agriculture and forest margins. On the one hand, the major source of deforestation is agriculture (particularly slash and burn agriculture and large scale cattle ranching). On the other hand, agroforestry systems and forest management contribute to increased food security, income generation and poverty alleviation.

Sustaining productivity and enhancing poverty alleviation in forest margins requires diversification of land use activities. Whilst improvement and expansion of forest and tree related activity by the poor is only one small part of the diversification needed, in some areas it can be an important entry point in contributing to poverty alleviation. However, diversifying land use more broadly in the forest margins involves taking the appropriate opportunities for use of improved plant and animal species together with a new generation of ideas, technologies, and institutional arrangements for sustainable land management (what the FAO has called the Second Agricultural Paradigm). Examples of approaches under this second paradigm also include: breeding of crop varieties that are tolerant to adverse soil conditions (SP2), soil nutrient cycling, integrated pest management (SP 5), improved water management (SP3) and increased production from appropriate livestock systems (SP7).

General goal: *Expand the opportunities for poor forest margin dwellers to enhance their livelihoods without exerting additional pressure on natural forests*

Specific goals:

Develop new and improved agroforestry and other technologies that increase the sustainability of forest margin agriculture and enhance the contributions of forests to the livelihood opportunities of forest margin dwellers.

Scope of research:

- Introduction or improvement of agroforestry systems that provide various products both for home consumption and for markets, and that improve soil and agricultural productivity where possible;
- Increased integration of forest-based activities into overall farming systems development and into poverty alleviation programmes for the landless;
- Increased use of niche opportunities - using exotic and indigenous, often underutilized, plants and animals; and taking advantage of small areas of good land, or other unique attributes, to produce high value crops such as flowers, herbs, spices, small stock etc;
- Increased blending of off-farm employment and income generating activities with farm system management and increased vertical integration of farm activities from field to consumer using new developments in postharvest technologies;
- Increased integration and appropriate intensification of livestock and/or aquaculture into mixed farming systems.

Main Regional Beneficiaries: Sub-Saharan Africa, Asia, LAC.

System Priority 5

Title: Better Soil and Land Management and Use

Rationale:

Sustaining agricultural productivity depends upon a thorough understanding of farm and landscape level processes and the development of affordable means of farming given local physical and social endowments. Science-based optimisation of the use of natural resources such as soils, soil micro-organisms, plants (including weeds), and animals (including natural pollinators, insect pests and their competitors) can increase production efficiencies as well as maintain the sustainability of farming systems. Research on farming systems therefore encompasses soil nutrient cycling; reliance on genetic pest and disease resistance to replace, either partially or fully, chemical and mechanical pest control; the active use of functional biodiversity, where predators and other natural control agents of pests and diseases are actively encouraged through the maintenance of complex ecosystems within and adjacent to farming activities. However, demonstrated local successes in applying agro-ecological or IPM methods require to be scaled-up to larger areas, and means found to meet labour and other input requirements to encourage adoption more widely.

Natural resource services used in farming are linked at landscape levels, requiring community or cooperative planning and management. The efficiency of resource use to sustain production also depends therefore on understanding of resource, social, policy and market interactions at various levels. Each of these sciences collects and manages information in different ways and integrating solutions to resource management must be found, as well as effective means to extend new sustainable production technologies over large areas.

The sub-priorities listed represent a progression of international public goods science, beginning with the basic fundamental science of agroecology as applied to agronomic and horticulturally-dominated landscapes, to landscape-level integration at larger scale.

Sub-priority 5a: Agro-ecological approaches at the farm level

Rationale: The implementation of an agricultural systems approach in the field has considerable local and household specificity, particularly as it is extended in the INRM and sustainable livelihoods dimensions. System-level research on agricultural systems therefore needs to be oriented towards the generation of international public goods. This means focusing on methods, processes, best practices for implementation, measurement techniques and scaling-up methods.

Agroecology is the science and understanding of key processes (biological, physical, social and economic) that determine resource use in production systems for productivity and environmental impact. Those processes (such as organic matter status and flows, soil, crop and tree nutrient status and flows, crop balance with populations of pests and pathogens, and their interactions with management, social and economic factors) all

operate across environmental gradients. They provide the understanding for managing change in production systems. They are variables that can be modeled, understood and extrapolated across time and space. They thus provide the international public goods of production science, just as the genetics component does at the plant or animal level. They operate fully at any level of cash or management inputs. At both the high and low input ends of the economic spectrum they are important for efficiency of resource use and environmental impact. At the low input availability end they can be managed to enhance ecosystem services (as with biological nitrogen fixation and biological control of pests and pathogens.) They highly influence water use efficiency.

General goal: *Enhance and expand the benefits to the poor through improved sustainable management along the continuum of priority farming systems from intensive high value crop production and cereals based cropping systems through agroforestry and silvo-pastoral systems.*

Specific goals:

- Introduce more wide scale, generalized application of improved agricultural systems approaches for priority farming systems by:
- Increasing the cost effectiveness of relevant agro-ecological approaches to land management, thus encouraging greater adoption;
- Prioritize methods which can be generalized across mega-domains of application and classes or types of farmers to ensure maximum possible benefits;
- Use CGIAR research to be a catalyst of regional and worldwide coordinated approaches to agro-ecological research in order to generate maximum IPG benefits through information sharing and development of widely applicable soft and hard technologies.

Scope of research: (to be further developed).

Agroecology (production ecology) knowledge is best studied within operating systems in different environmental conditions over time and space. The use of benchmark sites is one way of sampling those gradients of change. The major components of focus include, but are certainly not limited to:

- Soil ecology (including nutrient status, physical quality and the population dynamics of soil plant and animal life) for optimal productivity
- Integrated pest management
- Optimal crop rotations and farm-level diversity to meet farm family needs and goals
- Social and economic dimensions of productivity at the farm family and community levels.

The science of such work is embedded in the CGIAR, with advances in each field being embedded in the integrated natural resource (INRM) concepts and theory. While presented here *for application to intensively managed systems, it applies across all landscape management production systems.*

Sub-priority 5b: Land-use Management at the Landscape Level

Rationale: Farms are embedded in wider agro-ecologies and political contexts by which their capacity to provide livelihoods ultimately is determined. Poor forest dwellers are often associated with forest patches in forest-agriculture mosaics. Watercourses permeate lands in different ways and change opportunities for farming and income across the landscape. The core problem in many parts of the world (but particularly at high population densities such as in East and Southeast Asia) is the demand for more food under increasing competition for scarce natural and socio-economic resources. This leads to conflicts in land use objectives and resource use, and increases in agricultural production have to be achieved with less land, water, labour and other resources. It is clear that to meet the needs of the poor - whether in marginal lands, raising livestock in small holdings or pastures, in forests, in coastal or inland water fisheries - that their socio-economic and resource endowments and the political contexts in which they live will be critical to solutions. The systems require to be sustained and institutions developed for management. The units of analysis are both the local (the immediate household or community) and at the level of landscape or coastal region.

Different approaches are followed (by the CGIAR and others), at different scales, to tackle agricultural problems, which include:

- Technology-oriented, at field/farm scale: examines methods to increase production while increasing resource use efficiency
- Policy-oriented, at regional to national scales (or aimed at markets)
- Participatory, at household to national scale: explicitly takes into consideration the active role of resource managers and planners (at different levels) in the research process.

The requirement is to develop effective tools and approaches to integrate the outputs from these different approaches and to produce resource and production management solutions that are coherent at different scales. Assistance is required by NARS (still mostly organised along disciplinary lines) to understand and integrate the different levels of information required to optimise agricultural and land use planning and poverty alleviation at the landscape level.

General goal: *To safeguard and enhance the livelihoods of the poor by protecting and improving agricultural and natural resource endowments of the poor through improved land use management at the landscape level.*

Specific goal:

Introduce improved land-use planning that increases opportunities for more sustainable agricultural land use and conservation by poor people.

Scope of research: (to be developed).

Main Regional Beneficiaries: SE, South and East Asia, SSA, LAC.

System Priority 6

Title: Improved Production and Processing Systems for High Value Commodities

General Rationale:

With prices for most of the global staple commodities projected to remain flat or fall for the near future, many development specialists feel that increasing the diversity of high value products for market has potential to add significantly to the incomes of small farmers. Such commodities include fruits and vegetables, livestock products, fish, horticulture etc. This would also include some cash crops with the specific intention of improving smallholder competitiveness (e.g. spices, medicinal plants, sugar cane). Some of these commodities have not been considered by the CGIAR previously, or have not been addressed from the point of view of livelihood opportunities for the poor. Additionally, higher value added can be gained by protecting harvests of staple and other commodities more effectively, or developing products which provide higher returns. Production and diversification choices are intimately linked to the development of market opportunities, and the need to maintain access in the face of international and commercial regulation of food and environmental safety. CGIAR research in this area should focus carefully on the provision of international public goods. It is suggested that staple and high value food commodities, such as fruit and vegetables, may be addressed through a range of biotechnical research approaches for their improvement as well as socio-economics and policy research; and that other cash crops, including non-food products, should be the subject principally of socioeconomic research to establish when they clearly contribute to the equitable provision of livelihood opportunities to the CGIAR's target beneficiaries.

Sub-priority 6a: Fruits and vegetables and selected cash crops

Rationale: A major tenet of the new agriculture approach is that it will be necessary for small-holders to diversify the agricultural products they produce to spread risk, and to identify higher value products - compared with staples which may be locally over produced or which are affected by other global factors causing a slump in world prices. The Consultation gave strong support to a new focus of the CGIAR on vegetable and fruit food production systems. These commodities have attraction because they can be seasonally or spatially integrated with existing farming systems in some cases or, when grown on smaller plots, can contribute to agriculture in urban or peri-urban settings. Local availability of fruit and vegetables can enhance nutritional security for producers and consumers.

Vegetables research to date has been focused on the CGIAR-associated AVRDC. The first step in collaboration will be the requirement for a global evaluation and framework to prioritize vegetable research by region and its compatibility with existing farming systems.

While bananas are presently covered in the CGIAR (by IPGRI and IITA), other fruit crops are not systematically covered - although tree crops have been included in some of

ICRAF's cropping systems work, in conservation studies by IPGRI and some research is being done under special project arrangements at CIAT. Fruit in general has a higher income elasticity of demand than vegetables, may have more specialized cultural requirements, be more demanding of improved marketing sector and infrastructure, and production may come in competition with exports from developed nations, etc. An initial survey will therefore be required to identify the fruits that could benefit smallholder production systems. Farm to market analyses will be required for the prioritized commodities, and ex ante assessments of the appropriate means of diversification made for any agro-ecosystem and region of choice, including local competition effects from adopters of similar technologies. Commodity focus will be: solanaceous vegetables, legumes, crucifers, cucurbits, tropical and subtropical tree fruits and nuts, citrus, grapes, and indigenous horticultural crops

General goal: *Improve the health, income and job opportunities for smallholder producers and consumers through research on fruits, vegetables and other high value crops.*

Specific goals:

- Enhance the productivity of fruit and vegetables through genetic and physiological improvements and breeding.
- Improve the introduction and exploitation of fruit, vegetables and other high value agricultural products in the farming systems of small-scale producers
- Develop processing and marketing procedures which meet the requirements of the poor and of markets.

Scope of Research:

- (i) Genomics, breeding, proteomics, metabolomics, and phenomics
 - Determine gene products, metabolic processes, regulation and phenotypic expression
 - Develop lines for enhanced productivity, nutrition, product quality and safety
 - Incorporate new genes from distant relatives by wide crosses and biotech approaches
- (ii) Crop management
 - Develop production systems that reduce seasonality of yields and market supplies
 - Design IPM technologies for greater safety and reduced environmental degradation
 - Improve water use efficiency through drip irrigation, mulches, and drought-resistant lines
- (iii) Post harvest storage, processing and distribution
 - Develop low-cost processing, packaging and storage technologies for domestic markets
 - Conduct compliance training for international phytosanitary, quality and trade regulations
- (iv) Economics and policy
 - Partner with market managers and traders to improve product supply systems
 - Facilitate interaction of horticulture, transportation, urban, and policy planning

- Build capacities of institutions to respond to opportunities of comparative advantage

Regions of focus: Listed in order: Sub-Saharan Africa, South Asia, Central Asia, SE Asia, and Central America.

Sub-priority 6b: Post harvest treatment and processing

Rationale:

The need for greater efficiency in the use of primary products, as well as demographic changes associated with urban expansion, call for changes in international research and development programmes in agriculture, forestry and fisheries. Alleviation of poverty and the sustainable management of natural resources must be seen as being dependent on increasing incomes, not only from primary production, but also from the whole chain of operations leading from primary production to final use. Within this “production to consumption continuum” numerous research issues can be identified that cover technological, sociological, economic and policy issues that call for collaboration among numerous institutions and organizations, including agro-industrial enterprises. Current work in the CGIAR covers a wide range of problems in harvest and post-harvest research, undertaken in relation to the individual mandates of the Centres. The most significant contributions are built around the genetic improvement of quality and storage characteristics of food commodities. At present, however, the emphasis is on productivity research with no coherent strategy for ensuring that priorities are set in the broader context of the production to consumption continuum.

It is assumed that work will be applied to species and commodities important for smallholder systems and where the considered aspects of post-harvest research are not being undertaken by the private sector or other players. Noting that other aspects of food safety and trade issues are considered separately, research should focus on meeting the following goals:

General goal: *Augment livelihoods and returns to investment in agriculture for small holders in developing countries through value added and employment in post-harvest processing.*

Specific goals:

- Improve the harvest, storage and marketing efficiency of key commodities for food security and smallholder production.
- Improve policies that enhance income and nutritional returns for the poor from post harvest activities.

GOAL 1. *Improve the harvest, storage and marketing efficiency of key commodities for food security and smallholder production.*

Scope of research:

Research will include the development of harvest methods or mechanisation and storage facilities for small producers, and the integrated management approaches to combat storage pests and diseases. It can be linked to SP2 through germplasm enhancement for resistance to factors causing storage losses. This will require the characterization of biochemical and physical components affecting either nutritive quality or the industrial processing of primary products. It will be linked to SP 1 and 2 through the identification of genes governing such qualities and subsequent enhancement of germplasm of high-priority CGIAR commodities.

Research will include the identification of opportunities for product diversification; the processing of primary products (e.g. drying, milling) and by-products (e.g. straw, waste water) and the assessment of the demand for product development. The CGIAR anticipates that pilot enterprises will be established by collaborators and not by Centres. Research towards this goal will be undertaken on a commodity basis, more generic approaches to the development of markets are found under SP8.

GOAL 2. *Improve policies that enhance income and nutritional returns for the poor from post harvest activities.*

Scope of research:

In relation to post-harvest improvements, this will include means to enhance the dissemination of technology; the promotion of the application of new technology by small-scale enterprises; the establishment of grading rules and quality standards; and the design of development policies to improve infrastructure and political stability in marginal areas. Research towards this goal will be undertaken on a commodity basis.

Regions that could benefit:

All developing country regions.

Sub-priority 6c: Markets and trade: food safety and the environment

Rationale: The growing globalization of the food system over the last few decades has far-reaching consequences. The world trade in agricultural products is approaching US\$600 billion annually, with developed countries exporting slightly more than developing countries but importing substantially more. Bulk commodities (grains, oilseeds) now make up only one sixth of trade in agricultural products; trade in the many diverse processed and high-value food products now exceeds 80 per cent of global commerce. Food and product safety regulations are governed at the multilateral level (by the WTO), and predominantly by the GATT Agreement on the Application of Sanitary and Phytosanitary Measures (SPS)⁴. The latter is concerned with protecting plant, animal,

⁴ Other relevant agreements bearing on trade and food safety of agricultural products include the standards set through the Codex Alimentarius Commission, the Technical Barriers to Trade Agreement (TBT), the Agreement on Trade-related aspects of Intellectual Property Rights (TRIPS) - through such issues as the adoption of IP or exclusion through for example, geographical indicators, and the Cartagena Protocol on Biosafety.

and human health and life within the territory of the importing country from specified hazards (e.g. including pests, diseases, contaminants and toxins). However, the setting of international norms is challenged by often quite different national regulations and capacities for production, monitoring, risk assessment and certification of food quality. The imposition of new food safety regulations shifts responsibilities, and the economic consequences for meeting regulations, from importing to exporting countries. There is scope therefore for food quality regulations to be interpreted by developing countries as barriers to trade, and for these countries to have their export trade limited by bans or other measures related to food and product safety. The establishment and oversight of food safety regulations are considered as international public goods. For developing countries to ensure their continued access to international markets for food and agricultural products, they require particular assistance with three specific provisions of the SPS agreement, equivalence in meeting and certifying standards, risk assessment, and regionalization.

Of the emerging food regulatory issues in relation to trade, the most contentious relate to process attributes to achieve quality goals. Such processes could also be taken to include the genetic transformation of materials incorporated into foodstuffs. The multilateral framework of rules governing process attributes is less well developed than for most other areas of food regulation. While it would be preferable to shift from process to product safety measurement in most cases of food safety, environmental certification and labelling depends upon process (e.g. means of harvesting) issues. Process issues for both goals have many similarities and parallel requirements (e.g. establishing chains of custody for processed materials). Countries cannot therefore exclude process issues and need to establish monitoring and certification capacities relevant to both food and environmental safety.

While international standards form an important element of non-tariff barriers to trade, regulations imposed by the private sector are considered to be in some cases more stringent and often more rapidly developed and imposed than those by the public sector. Moreover, for certain livestock sub-sectors in some developing countries, large commercial companies influence the formation of national policy and regulations. Therefore, research into trade and food safety standards should accommodate both public and private sector requirements.

General goal: *Enhance livelihoods and competitiveness for smallholder producers, the sustainability of production systems, and food safety for consumers.*

Specific goals:

- Improve food-safety risk assessment capacities for food products in developing countries
- Design improved certification capacities for food and environmental safety in developing countries.
- Assist smallholders to deal with transaction costs from meeting certification and food safety concerns

GOAL 1. *Improve understanding of risk levels and risk sources for exported food products in developing countries as a means towards improved formulation of regulations and standards*

Scope of research: The requirements of SPS are that risk be established on the basis of scientific principles and that risks are quantified based on timely and specific assessments (i.e. relevant to the commodity and food product concerned). Research will be required to examine sources of contamination and disease in food harvesting and production chains for selected key agricultural export commodities. Research will encompass the epidemiology of disease and pest organisms affecting food safety, development of disease monitoring tools, risk modelling capacity linked to assessment of the social and economic impact of risk-reduction strategies. Partnership with national research organisations in the execution of this work will enhance their capacity for future analysis. The research results will prioritise sources of risk, evaluate existing methods of risk management and identify areas where improved technology or management methods are required. Results will assist national, regional and international players in dialogue on the future development of public and private standards (see also sub-priority 5d on livestock).

GOAL 2. *To design improved certification capacities for food and environmental safety in developing countries*

Scope of research: To design equivalence mechanisms (conformity assessment services) in developing countries to meet international food safety standards. Institutional research will examine the development of third party certifying infrastructures based on private (or public-private-NGO coalitions) and when public sector capacity is lacking. Technical research (including on process mechanisms) and legal research to help provide the basis for labelling schemes that can be met by poor producers without compromising health, food safety and environmental concerns.

GOAL 3. *Assist smallholders to deal with transaction costs from meeting certification and food safety concerns*

Scope of research: Examine the costs of compliance with standards (quality, health) by smallholder producers (and their organisational arrangements) for domestic, regional and international trade. Clarify the links between risk, improved certification and food safety concerns to increased market participation by the poor (showing the linkages to sub-priority 5d)

Regions that could benefit: All.

Sub-priority 6d: Livestock and aquatic product health to meet domestic and international trade requirements

Rationale: Roughly 40 % of world fish and 10 % of much larger world meat production by value are traded across international borders. Developing countries currently account

for four-fifths of world fish exports, after being net importers only 25 years ago. Developing countries are also currently small net importers of livestock products, although the absolute amount of net imports of meat and milk to developing countries is projected to increase by a factor of ten by 2020. It is likely that livestock products will be one of the fastest areas of growth of South-South trade in the next 20 years. The fundamental difference in traded proportions and direction of trade between fish and meat is due primarily to the sanitary (animal disease) issues involved in international trade in meat and livestock, which go way beyond the food safety issues common to all perishables. The demand surge for animal foods world-wide - but especially in developing countries - means that a great deal of money is at stake, eliciting a variety of solutions and approaches, some of which are more desirable than others for poverty alleviation and sustainability.

The proposed objective of research in this topic area is to identify known, and develop new, technological, institutional and policy options to control animal diseases effectively under developing country conditions. This requires to be done in a way that that does not end up driving small-scale and poor producers out of the one area of rural economic activity in which they are currently engaged that is growing rapidly in volume and value. If compartmentalisation can allow international trade for intensive commercial production systems, such as poultry production, quarantine systems of animal disease control without vaccination are currently the only way to access high-value markets for ruminant meat and milk in the OECD countries, and increasingly will be an important standard for the rapidly growing developing countries. Research can assist pro-poor livestock development by exploring the alternative impacts of different options, including a new commodity chain approach, for improved disease control in developing countries—all the while recognizing that standards in the developed countries are also changing.

General goal: *Enhance the competitiveness for smallholder producers of livestock and seafood products in meeting food safety requirements for domestic and international markets.*

Specific goals:

- Identifying the best means and practices for smallholder producers to enter into market chains and to meet national and international food-safety requirements.
- Developing and implementing disease control and surveillance systems that support trade in livestock and seafood products
- Formulation of policy recommendations favouring small holder producers

GOAL 1: *Identifying and Documenting Best Practices*

Scope of research:

- Identification and documentation of costs and benefits of best practices for complying with international and domestic SPS regulations for the economy, the livestock and fishery sectors and poor livestock and fish producers in developing countries.

- Identification of main SPS and technical barriers to trade affecting international trade in livestock, livestock, and fishery products and evaluation of the impact of such technical barriers on trade flows, with particular attention to developing countries.
- Analysis of technical risks in livestock and fisheries trade and their potential impacts on developing countries and poor people in those countries under different scenarios.
- Analysis, through selected case studies, of the full costs and benefits of compliance with SPS and private sector sanitary rules and norms, including hidden costs and subsidies, and spin-off and second round benefits.

GOAL 2: *Developing and implementing disease control and surveillance tools and systems that support trade in livestock and seafood products*

Scope of research: Development and testing of tools and methods using epidemiology and economics for analysis of impact of different options for controlling animal diseases of trade (i.e. on the OIE's list A) on market access of poor and small-scale producers to growing livestock product and input markets, and extension to NARS and NGO partners. This includes:

- Analysis of health and food safety issues along the production to consumption chain for smallholder production of meat, milk, fish, and eggs under developing country conditions and matching of critical risk points to distribution of value-added.
- Development of new tools for disease control, such as vaccines and diagnostic tests. New bioengineered products, obtained through genomic and post genomic research, could change the trade standards regulations if they can prevent carriage of pathogens by vaccinated animals and/or allow strict differentiation between vaccinated and infected animals
- Cost/benefit analyses of options for compliance with norms and distributional impacts of same.
- *Ex ante* analysis of the impact of improved FMD technologies on disease control and meat marketing opportunities, with particular attention to second-round and higher effects on world trade flows, prices and the distribution of livestock sector income.

GOAL 3: *Formulation of Policy Recommendations favouring smallholder producers*

Scope of research: Identification of policy and institutional options for animal disease control, surveillance and risk management that enhance smallholder participation in international and domestic livestock and seafood markets. This will entail:

- Analysis of cost-effective means of dealing with health and food safety constraints along the production to consumption chain for smallholder production of meat, milk, fish, and eggs in developing countries.

- Analysis of policy options and desirable institutional changes at both the domestic and international level leading to pro-poor outcomes of globalizing livestock and seafood markets in developing countries.
- Analysis of the impact of institutional arrangements for improved delivery of animal (including aquaculture) health services on trade, income and market participation of the poor.

Regions and beneficiaries:

Trade in animal source food products is changing direction to increasingly emphasize the role of developing countries as lower cost producers. Nevertheless, projected changes in how animal health is protected in the developed countries will continue to play a major role in livestock and fishery markets in developing countries, thus this particular programme of research needs to embrace a global perspective, while also engaging in selected case studies in a stratified sample of exporting and importing developing countries. While some policy changes and technological innovations in livestock and fisheries are likely to show up first in increased exports from Latin American to East Asia, these changes will have world-wide impact through market realignments that occur as a result. It will be vital for poorer countries to be able to pick up opportunities that become available in higher-value markets as a result of the coming realignment of trade flows in this area.

Sub-priority 6e: The “new agriculture”: policies and institutes to promote opportunities for smallholders

Rationale: Smallholder farmers can increase their agricultural incomes through greater sales of high-value commodities such as livestock, dairy products, fish, fruits, vegetables, spices, and ornamentals. These products are typically perishable, of high quality-specific value, and increasingly sold through specialized markets. This part of world agriculture is growing rapidly, and is becoming increasingly capital-intensive and vertically integrated. The requirement is to identify critical areas for trade, marketing, capital market, and regulatory reforms that can facilitate the integration of small-scale and poor developing country farmers in rapidly growing global markets for high-value crop and animal products in a sustainable manner, and thus increase and diversify their incomes over the long-run.

In most low and middle-income countries, the rural areas contain the bulk of the poor. Furthermore, in spite of urbanization, rural population continues to grow. Agro-industry and post-harvest systems can raise the income of the rural poor through the development of value-added activities, institutions, and agro-food based rural industrialization. Agro processing is labour intensive and generates higher value added than unprocessed agriculture products. Since it is usually located in rural areas, it generally benefits the rural poor by increasing their incomes. Such increases in income will play a significant role in poverty reduction, sustainable growth and food security in developing countries.

Increasing urbanization and the opening of access to world markets under globalization raise the demand for storage, quality, convenience, and safety characteristics of food

products that are exported or consumed in the growing formal food sector of cities. Compliance with conditions set under the sanitary and phyto-sanitary (SPS) agreements that accompany WTO negotiations will be critical for the continued participation of both developing countries and small-scale farmers in the expanding markets of the developed countries. Many of the required safety and quality characteristics are largely determined by the handling and treatment of commodities after they leave the farm gate. Meeting these new demands not only requires that the products meet the characteristics, but also that they can be verifiably certified as such, which involves better organization of the supply chain from producer to consumer.

To participate in growing formal urban and export markets, producers need access to well-organized post-harvest chains that can handle the processing and marketing requirements. Agricultural processors and traders, on the other hand, face increasing pressures to certify the safety of production practices (such as to avoid pesticide residues in the final product), exact quality attributes, and on-time deliveries. Informed policies and a conducive regulatory environment increase the incentives for agro-processors to use the produce of small-scale farmers as inputs, and improve their capacity to meet the product attributes required in a rapidly modernizing agricultural marketplace.

General goal: *Help smallholders and the rural poor benefit from the opportunities offered by the 'new agriculture'.*

Specific goals:

- Achieve diversification of cropping patterns away from low profitability traditional crops toward high value crops and local post-harvest value-added opportunities, including in animal and fish products.
- Increase participation of smallholders, especially women, to specialty markets, contracts with supermarkets and agroindustry, and provision of local schools and other public institutions.

Scope of the research: Research will focus on three interrelated areas: (1) identifying trends and issues in world and local markets that offer robust opportunities for sustained commercialization of high-value agricultural commodities; in particular, the interaction between feed and food stuff markets and other inputs to high-value commodity exploitation; (2) analyzing options for addressing policy and transaction cost barriers to increased participation of smallholders, the rural poor, and women in high-value sectors; this will include health-related issues, and (3) encouraging smallholders participating in high-value markets to promote environmental sustainability and lower health risks. The objective is to help policymakers be better informed of the economic barriers that prevent smallholder farmers in developing countries from greater participation in sales of high-value commodities. Policy changes are expected to accelerate growth in production of exportable high value commodities, to contribute towards poverty alleviation, and to increase sustainability. Increasing knowledge management capacities amongst NARS, producer organisations and farmers, to deal with the new agriculture are also discussed in SP10.

- To characterize post-harvest rural agro-industrial systems and agricultural supply chains for developing countries
- To identify and analyze alternatives for enhancing the contribution to income, food security, and employment of the rural poor from improved post-harvest activities and rural agro-industry;
- To identify constraints to the development of post-harvest activities and rural agro-industry, such as credit, infrastructure, institutions for product certification, and access to different kinds of markets and inputs;
- To identify strategies for developing countries to improve their access for selling processed crop, livestock and fish products in global markets, with special emphasis on policies that improve quality attributes and certifiability of processed products;
- To analyze and gain better insights into the process and role of developing countries in on-going international negotiations of the SPS and WTO as they impact processing requirements for crop, livestock, and fishery items.
- To strengthen the local capacity of policy analysts and programme managers to design and develop post-harvest systems for poverty reduction.
- To communicate the strategies and policy options derived from the research at the national and international levels.

System Priority 7

Title: Enhancing Resource-efficient and Equitable forms of Livestock Sector Growth

General Rationale:

Livestock are a crucial part of the livelihood systems of many poor rural, peri-urban and even urban populations in developing countries; livestock play a key role in many farming systems and in decreasing the vulnerability of households. However, current international and national policies, as well as existing livestock services, are often geared intentionally or inadvertently towards large-scale market orientated production. The enhancement of livestock development alone will therefore not necessarily contribute to poverty reduction. On the contrary, without proper targeting, livestock development may contribute to the crowding out of poor livestock keepers from evolving livestock commodity markets. Pro-poor and integrated programmes for livestock and livestock services development are therefore required.

Rapid growth in demand for animal products in many developing countries has, so far, not created many desirable outcomes on the supply side. In many developing countries, rapidly industrializing livestock production on the outskirts of cities cater for the growing urban demand, while rural areas, even though they could potentially access consumption centres, are frequently disconnected from this growing demand because of infrastructural deficiencies, policy distortions and lack of scale-neutral technologies that would enable rural producers to respond to such demand. Therefore, there is a need to conduct research into the environmental and public health implications (including emerging diseases) of geographically concentrated production with rapidly growing unit scales, and to explore ways of directing the growth stimulus from burgeoning peri-urban into rural areas where the livestock sector not only is often the only available viable opportunity for income and employment generation, but where also environmental and public health implications related to expanding livestock production can be effectively managed and minimized.

There is only limited potential for creating benefits to the more marginal areas, distant from markets and with no quality feed surplus, such as in extensive pastoral areas. However, it is here where the livelihood of poor people often entirely relies on the multiple functions of their livestock. A pro-poor livestock strategy requires to encompass these systems and to investigate ways by which the assets (and dependent livelihoods) can be protected, notably the animals themselves and the supporting natural resource base.

Sub-priority 7a: Protecting rural livelihoods

Rationale: In large parts of the developing world, particularly in marginal and low potential environments (arid and semi-arid pastoral zones) economic growth is weak and is not driving a notable expansion in the demand for animal products. Here the situation is characterized by large numbers of highly vulnerable rural poor for whom livestock

represent one of the few opportunities to support and enhance their livelihoods. Distance to markets and severe resource constraints limit the development potential in these areas. Enhancing livestock-related livelihoods through improved access to and control of assets (animals, land, water, capital and credit) will reduce vulnerability and risks.

Access to feed resources is a growing constraint for many poor livestock keepers in marginal and low potential areas. Expansion of quality feed and fodder supply, particularly at the livestock – crop interface (i.e. food-feed cropping) will need to take place. The feed resource narrows as the access by poor people to common lands for grazing (or arable land for fodder production) is being reduced. Most pastoral systems are under severe pressure because appropriate lands are disappearing and herd mobility, a conventional coping strategy, becomes increasingly restricted. Crop farming increasingly impinges on pastureland, particularly good land in humid and sub-humid areas. The poor pastoralists therefore become increasingly dependent on dry and hilly areas, contributing to overgrazing which becomes a typical cause of land degradation. This is exacerbated by insecure land rights and regular periods of severe drought. Access to grazing resources in arid areas is further determined by the access to livestock watering points, and conflicts over access can result which increase livelihood vulnerability.

Worldwide, livestock use 3.4 billion hectares of grazing land (as well as the production of about a quarter of the land in crops). A large part of that area is under severe resource pressure, threatening the livelihood of livestock-based communities. There is a need for novel institutional arrangements to protect the natural, particularly common property resource base together with livestock as the main asset of poor people.

In the context of the above, the following goals are priorities for the CGIAR

General goal: *Protect the livelihoods of poor livestock-based communities against risk and vulnerability while stabilizing the natural resource base*

Specific goals:

- Reduce resource degradation in pastoral areas by developing novel forms of institutional arrangements suited to cope with the changing nature of common property resources; and by providing benefits for environmental protection (e.g. environmental services payments).
- Stabilize production and productivity by developing low cost technologies suited to harsh and marginal environment, with a focus on the management of feed resources and the control of infectious diseases.
- Reduce production risks and vulnerability of rural livelihoods by identifying viable forms of livestock services suited to mobility and low infrastructure endowment.
- Increase the benefits to the poor from rangelands by identifying novel synergistic elements in the interaction between land use for crops and livestock (e.g. food-feed crops; associative nitrogen fixation, enhanced legume use).

Scope of research (asset protection and income diversification):

- Production: control and prevention of ‘killer’ diseases / control and prevention of zoonotic diseases.
- Income diversification: migration and remittances
- Institutions: public interventions to override ‘missing markets’ for inputs and services (e.g. animal health, livestock insurance) / strengthening links to social capital for empowerment / conflict management / environmental services payments
- Alternative delivery of key services and sectoral policy formulation to enhance pro-poor livestock initiatives and linkages with formal services

Main Regional Beneficiaries: WANA, SSA, South Asia

Sub-priority 7b: Creating the conditions for growth

Rationale: The growing demand for animal products in many developing countries potentially offers substantial opportunities for the small-scale livestock producer to participate in, and benefit from, the expanding market. However, in large parts of the developing world, numerous technical, infrastructural and institutional constraints hinder smallholders in rural areas from responding to the increased demand. To create an enabling environment in which poor producers can take advantage of the available development opportunities, such productivity, trade and other barriers will have to be overcome. Unless this is achieved, there is a danger that the livestock-dependent poor will be marginalized further.

To date, the rapid expansion of livestock demand has provided little benefit to poor producers; worse still, rapid smallholder marginalisation and exclusion is occurring. The burgeoning demand is met increasingly by large-scale production in peri-urban areas, out-competing traditional suppliers. Sanitary requirements in evolving food chains combined with the lowering of transaction costs that large operators in these chains can achieve are powerful forces leading to smallholder exclusion and to a progressive reduction in the number of market agents. Benefits from the growing sector thus tend to accrue to a small number of operators and to middle class consumers enjoying affordable animal products.

Therefore, there is a need to create the conditions for livestock sector growth in rural areas where the poor live and where environmental and health concerns that are associated with peri-urban-based livestock production, can be largely avoided. Large areas in the semi-arid and sub-humid zones offer such potential for livestock sector growth and intensification in that potential markets are available and access to the required feed base is feasible. Benefits accrue from increased participation of rural producers in providing livestock commodities for urban markets, but also from income and employment generation.

General Goal: *Increase benefits to poor livestock producers, and generate income and employment opportunities along the value chain through rural-based livestock sector growth*

Specific goals:

- Improving the livelihoods of small livestock keepers by increasing livestock productivity and their ability to take advantage of market opportunities through novel forms of collaborative action (contract farming, cooperatives), animal disease control and access to scale-neutral technologies
- Developing appropriate sanitary and other technical product standards and certification mechanisms
- Exploiting positive rural-urban linkages and multiplier effects from a growing livestock value chain
- Reducing market risks through partnerships, insurance schemes and other forms of safety nets

Scope of research: To increase productivity and to increase access to national and regional markets research will be carried out on:

- Production: Control of production limiting and zoonotic diseases / preparedness planning for infectious diseases / improving animal breeds / improving feed base / improving management skills. For animal disease resistance the focus will be on identification of genes for trypanotolerance in cattle and helminth-resistance in sheep and goats, based on earlier parasitological and breeding work in these species in SSA, and SSA and Asia respectively, and linked to international consortia mapping bovine and ovine/caprine genomes.
- Income diversification: expansion to higher value commodities (HVCs)/ the cross-sectoral nature of income growth and inter-relationships between livestock, cropping and non-farm sectors in enabling pathways out of poverty / combining livelihood strategies as key to moving out of poverty / exploitation of regional and national market potential;
- Policy and institutional research identifying sectoral and inter-sectoral bottlenecks and required investments to create an enabling environment for improved livestock production and market participation at various levels e.g. access to assets and market information / enhanced private – public mix in the provision of animal health services / exploring applications of vertical integration schemes, contract farming at these scale and type of operations / strengthening producers organizations, extension and the provision of credit services;
- Managing impact of trade; expanding access to regional and international markets, and mapping of national level outcomes of trade agreements and effects on this category of smallholders, and on the poor in general;
- Food regulation in regional and international markets: addressing vertical integration arrangements to domestic markets / standards compliance.

Main Regional Beneficiaries: South Asia, East Asia, LAC, SSA, WANA

Sub-priority 7c: Coping with growth

Rationale: In areas where economic growth is driving a burgeoning demand for animal products with a correspondingly dynamic production response, rapid industrialization and geographic concentration of livestock production around cities occur. Here the primary public goods at stake are social equity, environmental pollution, animal and public health, including the risk of emerging diseases. Policies and institutions are required to address these issues, some of which may gain a global dimension (emerging diseases).

Coping with the unbalanced growth in the livestock sector, with industrial systems covering more than 80% of the incremental demand, requires an understanding of the features of structural change associated with the on-going livestock revolution, and its driving forces. Such change is often facilitated by policy distortions in the form of subsidized grain and of other inputs to intensive and industrial livestock production, favourable tax regimes for large scale investments, access to credit, differential infrastructure development, etc., and the neglect of externalities (mainly environmental but also public health). Studies in developing countries have shown that large-scale production has larger environmental externalities per unit of product than small-scale. Removal of these policy distortions would, in itself, be a pro-poor intervention as it would take away some of the unfair advantage that large-scale production has over small-scale competitors.

General Goal: *Reduce the negative social, environmental and health effects stemming from rapid structural change in the livestock sector*

Specific goals:

- Developing policies and institutions to limit the negative environmental and animal and public health impact of urban based large scale livestock production
- Developing methods and procedures for the effective assessment and management of the animal health and veterinary public health risks involved in intensive livestock production
- Developing appropriate policies for managing (peri)urban-based livestock sector

Scope of research:

To increase access to regional and international markets, research would include:

- Production: Control of product quality through certifiable good stock, feed and pharmaceuticals / biosecurity / contingency planning against infectious diseases / good agricultural and manufacturing practices, including waste management;
- Institutions: Strengthening producer and trader associations / strengthening skills for management of risk / strengthening skills for dealing with vertical integration in value chains / strengthening of rules, regulations and laws for international commodity exchanges;

- Managing impact of trade; expanding access to regional and international markets: Strengthening WTO, RTAs and preferential access arrangements for meat and dairy products / alternative farm policy instruments to minimize barriers / policies for handling externalities of intensive animal production (e.g. zonation, tax systems)
- Managing transition from more traditional production systems to intensive modern production to minimize social costs
- Food regulation in regional and international markets: Addressing cost of compliance as barriers to entry / addressing legitimacy of safety and quality standards / assessing scope of problems faced due to international and national food regulations that could exclude current exporters

Main Regional Beneficiaries: East Asia, South-East Asia, SSA, South Asia, WANA, LAC

System Priority 8

Title: Improved Management and Use of Aquatic resources

General Rationale:

Fish, as a nutritionally important and relatively high value product, has the opportunity to be a key component of improved livelihood strategies for the poor in certain areas of the world. However, weak management and governance systems, perverse incentives and poor implementation of existing controls, have been identified as the root causes of overfishing and overcapacity in fisheries. Innovative ownership and management arrangements need to be developed, including the participation of fishers and their communities, on the basis of social, institutional and policy research and capacity building of stakeholders for active participation. Research must examine the broad underlying issues of governance, trade and inter-sectoral linkages. The issue of poor governance is generic to small-scale fisheries in developing countries (including coastal marine fisheries, inland water fisheries and aquaculture developments). While solutions must be found for each individual fishery, a wider comparative research programme is needed to examine fisher and community incentives and responsibilities for compliance and identify longer-term trends and best practice examples. The stabilisation of capture fisheries is part of the production equation. It will also be possible to augment overall fish supply through the farming of fish through aquaculture.

Fish consumption per person has doubled since the 1950s, with growth in demand expected to continue with rising global per capita incomes and populations. To meet this demand, aquaculture has expanded rapidly and consistently, averaging over 11% growth per annum since 1985. Capture fisheries production has however levelled off since the 1990s, with no prospects for further major increases. The market outlook for aquaculture is therefore highly positive. This opens significant opportunities for the poor in the developing world: over 80% of total aquaculture production comes from developing countries, and in some large developing countries aquaculture accounts for 30% to 60% of total fish production. On the consumption side, the poor depend on fish for 20% of their animal protein intake, highlighting the need to continue raising production of low value fish like tilapia and carps to feed the growing ranks of the poor. One of the key components that would sustain this growth of aquaculture would be the use of improved varieties of these species.

There are key opportunities to arrest declines in catches and habitat degradation in small-scale coastal fisheries and inland fisheries. The CGIAR goals would focus on the protection of livelihoods and nutrition for artisanal fishers, and to appropriately exploit aquaculture and stock enhancement techniques to meet local and wider market food demands.

Sub-priority 8a: Sustainable production systems in the coastal zone

Rationale: Small-scale fisheries are generally labour intensive, utilizing no or comparatively small vessels. It is estimated that over 90% of all fishers operate in this

mode and they produce nearly 60% of global fish catches. CGIAR research within this area needs to address urgent issues facing key production systems in developing countries: small-scale fisheries and coastal aquaculture. Balancing trade issues (e.g. sustainable harvest levels, product and human health requirements and constraints to marketing) whilst safeguarding the needs of the poor requires integrated research approaches and a poverty focus.

General goal: *To safeguard and enhance the livelihoods of the poor by protecting and improving the aquatic resources and other endowments of the coastal zone.*

Specific goals:

- Enhance the sustainable development of small-scale fisheries to maintain and increase their role in poverty alleviation.
- Ensure that coastal aquaculture development is sustainable and benefits flow to the poorer communities in developing countries.
- Promote appropriate trade policies and institutions to address the challenges of globalization with respect to the sustainability of the fisheries resources, small-scale fisheries and aquaculture.

Scope of research: (to be developed against the goals)

Main Regional Beneficiaries: Asia, Africa and Small Island Developing States. Means to establish cooperative, community or devolved governance approaches and improved pro-poor trade policies would be important globally.

Sub-priority 8b: Sustainable inland fisheries

Rationale: Inland fisheries contribute some 6% of global fish production. More importantly, in many countries of the developing world, these fishery resources provide the main source of animal protein and an essential contribution to rural livelihoods. Over 50 million people in the developing world derive income, food and livelihoods from river fisheries, including those involved in processing and marketing. Many of these are not full-time “fishers” but farmers and pastoralists who derive a small, but crucially important part of their income from fishing and related activities during part of the day or year. Recent analysis of future demand and supply of fish have underlined that these capture fisheries need to be sustained and, in the case of sub-Saharan Africa increased by 2% per annum if per capita consumption is to be kept at present levels. At the same time it has been recognized that the development benefits of these fisheries can be increased substantially through better market access and post-harvest management. To achieve this, small-scale producers need to be enabled to participate in emerging market opportunities. Linking them to urban, regional and global markets requires market reforms, investment facilitation (through targeted loans), as well as capacity building among small-scale producers (training in marketing strategies, technical skills for quality control, business and co-operative development).

Despite their importance and potential additional development benefits, inland fisheries are increasingly at risk. In much of the developing world, aquatic ecosystems and the fisheries that depend upon them are facing unprecedented threats, including physical encroachment and loss, pollution, and over-harvesting of resources. By far the most important threat, however, comes from the changes in land and water management that can alter the river flows that ensure the seasonal and inter-annual production in these ecosystems. In this context of increasing competition for water, the fisheries sector is usually marginalized in national policies and local fishing populations are normally excluded from the decision-making processes, reinforcing their geographical isolation and socio-economic vulnerability. Among the most important factors explaining this, is the failure to properly account for the contributions that freshwater fisheries and, more generally, inland aquatic resources play in providing income and nutrition to resource-poor households. This difficulty to adequately evaluate inland fisheries by the decision-makers is itself related to the lack of data and information regarding these fisheries, and in particular to the failure to establish their full socio-economic values.

General goal: *To safeguard and enhance the livelihoods of the poor by sustaining and developing inland water fisheries and their use.*

Specific goals:

- Develop governance systems that will improve inland fisheries management and livelihoods and other pro-poor benefits of inland fisheries.
- Reduce the risk to poor fisher folk by developing better modeling tools that can be used to predict the water requirements of inland fisheries so that these can be integrated into water management decisions at basin level.

Scope of research: (to be developed against the goals)

Main Regional Beneficiaries: All, but in particular South, South-East, and East Asia, sub-Saharan Africa

Sub-Priority 8c: Sustainable Aquaculture

Rationale: Analysis of future demand and supply projections (to 2020) has shown that aquaculture needs to continue to develop if per capita consumption is to be sustained and the role of aquaculture in supporting rural livelihoods and food security enhanced. In sub-Saharan Africa in particular it is projected that aquaculture production will need to increase by 267% up to 2020 if per capita consumption is not to decline (even if there is a simultaneous yield increase from capture fisheries by 2% per annum). Such continued successful development of aquaculture in the developing world will be conditional on more detailed understanding of the scope for, and dynamics of, growth in the sector and the associated risks, on sustained investment in development of technologies that are adapted to the needs of poor farmers, and to improved information on markets and marketing. The integration of selective breeding and genomics/genetic approaches to aquaculture improvement for traits such as growth, disease resistance, and other

production traits suited to developing country situations, will be a key component of meeting the necessary increases in production.

General goal: *To enhance the development of sustainable aquaculture practices and increase opportunities for aquaculture to contribute to food security, livelihood and environmental demands in developing countries.*

Specific goals:

- Increase livelihood opportunities for the poor, by identifying where aquaculture at different scales (integrated aquaculture agriculture practices up to intensive commercial scale) is biologically, socially, economically, and institutionally feasible and assess what policies are needed to support such development.
- Develop and make available to aquaculture investors a portfolio of aquaculture technologies that can be adapted to the different biophysical conditions and market opportunities and constraints.
- To integrate quantitative methods of genetic improvement for aquaculture species with molecular approaches, leading to improved strains of fish for aquaculture in developing countries.

Scope of research: (to be developed against the goals)

Main Regional Beneficiaries: South, South-East, and East Asia, West Asia and North Africa, sub-Saharan Africa

System Priority 9

Title: Policy and Institutional Innovation to Reduce Poverty and Hunger to Enhance Competitiveness of Smallholders

General rationale:

For the globalization of the world economy to assist, rather than hinder, the rural poor find their way out of poverty, they must be able to maintain or increase access to assets, and find opportunities to use these assets productively and competitively. These are under-studied areas from a policy perspective, but they hold considerable promise for achieving CGIAR goals.

Poverty is to a significant extent determined by insufficient control over productive assets. However, the value of assets in generating income and security depends on the quality of the context where they are used. Hence, to offer pathways out of poverty, access to assets must be accompanied by the development of a set of markets, institutions, public goods, and policies that service the poor and allow them to achieve competitiveness. Rapidly changing markets in the context of globalization, the penetration of supermarkets in food distribution, and agro-industrial transformation, pose new challenges for small farmers. Best practices need to be identified in setting up a quality context that will help the poor use their resources to escape poverty.

At the same time, small holders can seize opportunities to add value to their production by engaging in product differentiation (quality, labelling), post-harvest transformation, and arbitrage of production in time and space. Developing information systems, innovating post-harvest technologies, and promoting agro-industries based on small and medium rural enterprises are important for this purpose.

Inadequate policies, institutions, and rural infrastructure lead to agricultural markets that do not function efficiently. As a consequence, the poor pay more for their food and receive less for their produce. To enhance the efficiency of markets, and support their development, attention must be paid to agricultural market reforms, crop and income diversification, post-harvest activity, and agro industry.

Countries moving from a subsistence or centrally controlled economy to a commercial market-oriented economy face a difficult period of transition. This transition is typically accompanied by changes in both the availability of public support and the opening of new market opportunities, requiring changes in product mix, technologies used, and sources of household income. The prospects for reducing rural poverty, assuring food security, and improving rural livelihoods depend on how governments manage this change and how the private sector responds to new opportunities. Work will seek to understand how countries can best develop markets, institutions and infrastructure in ways that contribute to agricultural growth, help alleviate poverty, vulnerability and risk and ensure food security.

Sub-priority 9a: Globalization and farm policies

Rationale: The real or perceived strains of globalization on different segments of societies have led to often vocal opposition to further trade or financial liberalization. OECD farm subsidies have come under increasing criticism for depressing the international commodity markets of temperate climate crops for developing countries. There is a need to examine if and how developing countries benefit from WTO rulings, regional trade agreements, and the descaling of OECD farm subsidies, and what capacities must be improved in these countries to profit from these policy changes and avoid negative effects on poor producers and consumers.

General goal: *Redesign the global food system to reduce poverty and hunger among smallholders, agricultural workers, and rural and urban consumers in developing countries.*

Specific goals:

- Implement international agreements and domestic policy reforms to achieve:
- Trade liberalization in more developed countries and significant descaling of OECD farm subsidies by 2010.
- Incentive prices in developing countries for agriculture and small holders to adopt improved technologies.
- Protection of smallholders against market risks.
- Compensation of, and provision of new options for, losers among the poor due to the reforms.
- Protection of the environment from negative effects of policy reforms.

General scope of the research: Research will evaluate the impact on agriculture, the rural economy, and the poor of: (1) global trade reforms and reduction of OECD farm subsidies under the WTO; (2) regional trade arrangements designed to promote economic integration; and (3) different components of the globalization process, including those linked to world capital flows, increased presence of multi-national agribusiness, and technological diffusion.

Sub-priority 9b: Rural development strategies to offer pathways from poverty

Rationale: Rural households typically pursue livelihood strategies that include not only farming systems (based on crops, livestock, forestry and agro-forestry, and fish), but also non-agricultural home based microenterprises (processing, handicrafts), and off-farm activities (such as wage employment in agriculture, employment in non-agricultural activities, and migration). It is the mix of these income strategies that eventually provides them with pathways from poverty. Rural development strategies that offer these pathways must consequently look at agricultural activities in the context of these multiple pathways and how they are inter-related. This often requires designing approaches to rural development from a territorial perspective, where the potential offered by agricultural research is a component, often the essential one, of a broader regional and local approach to poverty reduction. This implies that agricultural research needs to be coordinated with

the other regional and local interventions that can provide pathways from poverty. Particularly in locations where a blueprint approach to technological innovations has proved unsuccessful because many other dimensions needed to capitalize on the potential these new technologies offer for poverty reduction are missing, an integral territorial approach offers largely unexplored potential. This is particularly applicable to Sub-Saharan Africa, where the full benefit from investments in agricultural research has rarely been reached. Given the heterogeneity of local conditions, these territorial approaches need to be based on extensive participation of local stakeholders, both public and private.

General goal: *Meet the Millennium Development Goals for rural poverty reduction through locally and regionally adapted rural development strategies.*

Specific goals:

- Increase access to assets for poor people in the regions targeted for intervention.
- Improve the context where assets are used (regional development) to provide poor people with employment and investment opportunities in agriculture and related activities.
- Facilitate livelihoods strategies that provide pathways from poverty for a majority of households in the locality or the region where they are located.

Scope of the research: Research should seek identify best practices in defining and implementing an integral approach to rural development, specific to particular localities and effective for poverty reduction. Successful cases exist, but they remain insufficiently understood and in need of extensive scaling up. Much can be learned from detailed analysis of these cases. Experimentation is needed with integral territorial approaches, and the role that agricultural research can contribute to their success. Such experiments should be set up for Sub-Saharan Africa, and designed to maximize the learning that will be derived from them.

Sub-Priority 9c: Policies and institutions for nutritional improvement and food/water safety enhancement.

Rationale: Under-nutrition, malnutrition, and over-nutrition and not only consequences of poverty, but also important determinants of poverty. The nutrition problem, both quantitative (hunger) and qualitative, thus requires priority attention in any meaningful strategy of poverty reduction. Ill-nourished people are unable to learn, to work efficiently, and to manage assets productively. Part of the malnutrition problem can be solved through biofortification, including through breeding and genetic modification as pursued under Sub-Priority 2.d. This, however, is only one component of a broad front attack on malnutrition. Specific government programmes such as conditional cash transfers for nutrition, health, and education have been successfully implemented in many countries, even though large efficiency gains are still possible in the design and implementation of these programmes. Targeted food subsidies are needed for poverty reduction, and to provide safety nets and induce risk-taking among the poor in seeking higher expected incomes, for instance through the adoption of superior but more risky technologies. Best practice for relief programmes and crisis responses to secure the

nutritional status of populations, especially pregnant women and infants, need to be devised. Water borne diseases are an important factor in malnutrition. Hence, programmes for the cheap access to safe water are also part of the solution, yet generally under-provided and subject to conflicts as recently shown in Bolivia.

General goal: *Improve the nutritional status and the food safety of rural and urban poor populations*

Specific goals:

- Reduce malnutrition (under-nutrition and major qualitative diet deficiencies) significantly by 2010.
- Define best practice with Community-Driven Development and Conditional Cash Transfer approaches to nutrition improvement, and integrated nutrition-health interventions.

Scope of the research: (to be determined)

Sub-priority 9d: Environmental regulations, payments for environmental services, and sustainability

Rationale: Use of many resources implies negative externalities on others (water pollution, emissions of CO₂, pesticide and insecticide residues) and sometimes positive externalities (carbon capture, maintenance of biodiversity, watershed management, landscape preservation). In both cases, markets fail to give individual users of the resources proper incentives to use them in a socially optimum manner. As both negative externalities and demands for more environmental services keep on rising, government interventions are needed to regulate and/or provide the proper incentives. Sustainable production systems will otherwise not be achieved, imposing costs on future generations. Productivity in many production systems is declining because of lack of control over negative externalities. Mitigating climate change due to CO₂ emissions, preserving biodiversity as sources of future biological innovations, and efficient irrigation systems all require improved provision of environmental services. Payments for environmental services can be important instruments to reduce under-provision of these services, but also sources of cash transfers toward the rural poor. They can be put into place through market mechanisms or contractual agreements. Marginal agricultural lands (MAL) are often well endowed in socially valuable environmental services that justify transfers. Some of the world's poorest are found in forestry production systems. Both efficiency and equity gains can thus be attained by introduction of these schemes.

General goal: *Achieve sustainability in resource use by introducing policies and administrative mechanisms to create incentives and to regulate.*

Specific goals:

Develop and put into place complete policy, institutional, and regulatory mechanisms to secure:

- The maximum complementarities between efficiency and sustainability gains (win-win) provided by new technological packages.
- The internalization of negative externalities via regulation using emissions taxes and/or quotas.
- Payments for environmental services, when there are positive externalities, via introduction of efficient markets and of contracts for the provision of these services.

Scope of the research: Little is known about how to define, introduce, and implement environmental regulation for agriculture and payments for environmental services. Best practices can be established through good INRM theory, accurate empirical validation, and well-designed experiments. This research is complex and has demanding spatial and time dimensions. Translation of research into management and policy guidelines is required.

Sub-Priority 9e: Property rights and sustainable management of natural resources

Rationale:

Property rights and collective action play key roles in determining access to natural resources critical to sustaining rural livelihoods, and the likelihood that resources will be available to meet future needs. Therefore, a deeper understanding of the nature and alternatives offered by these institutions is essential for developing effective solutions to combat poverty. Property determines long-term incentives to invest in, extract from, and improve resources. Depending on their distribution, property rights shape patterns of equality and inequality with respect to resource access.

The spatial scale of many natural resources and their accompanying technologies often mean that resources can be managed more effectively by groups of people. Examples are forests, rangelands, fisheries, and irrigation systems. Aside from productivity considerations, collective action by multiple resource users can also enable a more equitable distribution of resource benefits. However, collective action requires voluntary adherence to a common set of rules for maintenance of and extraction from the resource, and thus cooperation among participants. The success of collective action will therefore depend on the incentives in place to evoke and sustain compliance.

General goal: *Develop locally relevant policies and institutions that influence the efficiency, equity, and sustainability of natural resource use.*

Specific goals:

- Achieve complete definition and allocation of property rights over natural resources relevant to the crops, livestock, trees, and fish-related activities of the poor, including private, collective/associative, and public forms of ownership.
- Achieve significant gains in the capacity of self-selected groups and natural communities to engage in collective action as an instrument for the sustainable management of natural resources, the delivery of public goods, and poverty reduction.

Scope of research: Research will be conducted to increase knowledge of the emergence and performance of voluntary, self-governing community organizations and property institutions in natural resource management. It will identify policy instruments that facilitate and encourage the formation, improved functioning, resilience and spontaneous evolution of organizations of users and property institutions. Trade off analysis will be a key ingredient of this research. Particular emphasis will be placed on institutions and arrangements which help structure devolution of natural resource management.

Sub-priority 9f: Reducing risk and vulnerability of the poor

Rationale:

Natural and human disasters disproportionately affect poor people and marginal areas around the globe, often causing irreversible loss of productive assets (e.g., land, livestock, businesses) and long run impacts on human capital development through short-term illness, malnutrition and withdrawing children from school. Growing evidence suggests shocks can trap people in long-term poverty, reversing progress associated with productivity gains and reproducing poverty across generations due to malnutrition, ill health, low educational attainment and poor asset endowments. Reducing exposure to risk and improving households' capacity to manage risk, *ex ante* or *ex post*, can encourage greater investments in productive activities, selection of higher expected return technologies and markets that also typically bring higher risk. New technologies and institutions to manage risk are necessary to reduce risk and vulnerability for rural populations.

General goal: *To reduce vulnerability to adverse shocks and improve ex ante risk management capacity and to provide access to risk coping mechanisms that do not have adverse long-term consequences.*

Specific goals:

- To reduce the incidence of biophysical and socioeconomic shocks through improved crop and livestock resistance to abiotic and biotic stresses, through marketing institutions to reduce price volatility, and through natural resources management practices to reduce conflict and increase resilience of farming systems.
- To improve ex ante risk management through livelihood diversification, formal and informal insurance mechanisms, financial and in-kind savings, futures and forward markets and improved information systems.
- To improve ex post risk coping mechanisms through credit, safety nets and more efficient and stable asset markets.

Scope of research: (to be defined)

System Priority 10

Title: Strengthened National and Regional Capacities for Agricultural Research and Rural Institutions

General rationale:

The CGIAR has traditionally committed around 20% of its total budgetary resources to assistance to NARS. Much capacity building has been done through the sharing of information, collaborative research and training of individual NARS scientists in association with scientific projects of the type listed in other SPs. It is assumed that this will continue in relation to the research priorities of the CGIAR System. In some sense, therefore, NARS capacity building can be considered as a strategic, cross cutting issue that is being addressed by the CGIAR. In the future, the strategy should encompass how to structure additional aspects of capacity building to meet NARS needs more specifically (e.g. through improved provision of existing technical knowledge, mid-career training for NARS staff). Importantly, however, there are many aspects of *research* on NARS capacity and institution building which are not captured or covered by collaborative project-related approaches and which merit address through a specific System priority.

The structure and composition of NARS are becoming more pluralistic (composed of government R & D institutions, the academia, private sector research institutions, rural producers association, the civil society, etc) and governments are struggling to address global developments such as trade, advances in science such as biotechnology and information technology, and challenges to budgets for research. There is growing recognition of a shift from the traditional paradigm of generating technologies with little or no market orientation and with the government providing more than 90% of the R & D expenditures, to one that is market-driven and private sector-led, aimed at the private sector providing 75 % of R & D expenditures. The links between the technical capacity of NARS and policy development are often poor and need to be improved. A reorientation in the technical, management and institutional aspects of research planning and capacity enhancement - which meets both the new paradigm of global competitiveness, but which also plans for poverty alleviation and resource sustainability goals, is particularly challenging.

Three areas that have been highlighted for the coming plan period for particular attention are:

(1) Assistance to NARS with institutional reorientation and establishing research and management capacity in dealing with emerging agricultural paradigms and technologies; there is a need to assist capacity development in NARS, broadly defined, to deal with emerging issues (such as in genetics, research management, and policy formulation). Several of the newly developed research technologies (such as many biotechnology tools) are expensive and out of reach of individual institutes, certainly in the smaller countries. In addition the pathway to impact requires intensive collaboration with organizations that have a better feeling for the issues at stake in the sector, or that have more potential to scale-up the use of new research results. The future strengthening of NARS will require

considerable institutional change in the nature and the mode of operations of NARS.

(2) Enhancement of the role of producer organisations. It will be necessary to explore how POs can become full-scale partners in the process of research: priority setting, conduct of the research, and dissemination and use of the results. Empowerment of such organizations will be achieved through participation in research, and will be an effective means of enhancing the role of women agriculturalists.

(3) Identification of new forms of partnerships to undertake agricultural research in developing countries, taking into account the descaling of the role of the state and multiplication of agents in the private and civil society sectors. An important component of the private sector are producer organisations which can link the small-scale farmer (fisher, forester) to research support on the one hand, and to the necessary market outlets on the other. Thus not only national agricultural research institutes, but also the whole array of emerging actors in agricultural research, including the private sector and non-profit organizations, should be considered in the development of partnership-building capacity. Three types of partnerships merit special attention: public-private partnerships, especially to increase chances for successful scaling-up of new technologies; partnerships with producer organizations, which not only enhances capacity but allows for collaborative research and technology dissemination agendas that reflect the grass root concerns; partnerships with public agencies from other sector to contribute to the solution of problems that cross over several sectors (such as environmental and health problems). The development of capacity for the formation of different sorts of partnership is the most essential topic for strengthening the efficacy of national and regional agriculture in the coming decade.

Implementation of these modalities would benefit from coordinated approaches by the CGIAR as a whole and with other actors such as the FAO. Such an approach accords with the recommendations of the World Bank's OED, with GFAR's global programme No.3, and with priorities identified by Regional and Sub-Regional organizations.

General goal: *Improve national agricultural, livestock, forestry and fisheries benefits to the poor in partner countries through more effective, focused and better managed research and extension in NARS and regional research organizations.*

Sub-Priority 10a: Strengthening NARS

Rationale:

Substantial research is required on the organisation and management of NARS as they seek to address multidisciplinary research issues in agriculture, emerging issues (e.g. in biotechnology, the use of information and national competitiveness) and the appropriate transformation of institutions.

General goal: *Help strengthen the capacities of NARS organizations to manage and carry out research through improved institutional organisation and various collaborative arrangements and partnerships.*

Specific goal:

Enhance the capacity of NARS to address the current and emerging issues in agricultural research and development

Scope of research:

Research areas will include:

- Constraint identification in moving to new agricultural paradigms.
- Research on institutional organisation and management (including formation and management of new institutional arrangements, such as research consortia, public private partnerships, and institutional learning)
- Capacity building in areas such as priority setting (e.g. for commodities in the face of market demand), impact assessment and research management, and policy formulation (which do not necessarily flow from project-associated training).
- Capacity building in areas of direct importance to the priorities of the CGIAR (e.g. concerns with poverty and with sustainability of resource use).
- Knowledge management (development of tools and methods on the basis of CGIAR experience for use by NARS and their university suppliers of science).
- Structured approaches to needs-based training (NARS, university and mid-career training), including catalyzing the CGIAR involvement with the Open University and learning best practice approaches derived from these experiences.

Sub-Priority 10b: Strengthening Producer organisations

Rationale: The CGIAR must understand better how farmer organizations can be strengthened and how this contributes to sustainable agricultural development and enhanced technological and institutional change. This research of the CGIAR will need to focus on the two main roles that farmer organizations may play: The increased bargaining power of farmer organizations allows them to influence the research and development agenda. In addition it may also influence pricing in agricultural markets, or the design of the public institutions concerned with the management of the agricultural sector.

The increased level of organization allows for the better distribution of new knowledge and technologies to the individual farmer.

General goal: *Enhance the role that producer organisations play in maximising impact from agricultural research and in creating marketing platforms for smallholder producers.*

Specific goal:

Identify mechanisms for the strengthening of producers' organizations and for modes of participatory research.

Scope of research:

While the effects of strengthened farmer organizations are well understood, it is more difficult to understand and predict when and how farmers are effectively able to organize themselves. Through participating in the strengthening of farmer organizations and

through comparing the lessons from many cases, generic guidelines may be developed that contribute to the development of farmer organizations.

Further research will also be required on the design monitoring and evaluation of participatory processes within farmer organizations, in order to obtain the maximum benefits from the existing organization and in order to understand the effect of the structure and culture of the organization on the sharing of new knowledge and technologies.

Sub-Priority 10c: Institutional arrangements for public-private-NGO partnerships

Rationale:

Few institutions have the capacity to meet all the varied challenges associated with agricultural research for development. Forming national, regional and international partnerships is the means to address complex issues in research but many developing countries have little experience in the development and management of such partnerships. Research is required on how to set up effective and equitable partnerships, which will provide affordable benefits for national programmes and the poor in developing countries. The treatment of intellectual property in private-public contracts for research requires to be explored to meet the needs of both collaborators.

General goal: *Through research on innovative institutional arrangements, act as catalyst in encouraging South-South and North-South partnerships aimed at strengthening research and research management capacities.*

Specific goal:

Identify new forms of partnership with NARS, especially with NARI, the private sector, NGOs and producers' organizations, and public agencies from other sectors such as environment and health.

Scope of research: The CGIAR's efforts in identifying and improving appropriate research and development partnerships will increasingly build on collaborative models themselves, within which partnership issues are explored; solutions are developed, tested and made available through networks of collaborators. In these new partnerships, Regional and Subregional Organizations will be major partners, with the appropriate research suppliers and/ stakeholders in development. Choice of modality by region depends on the goals, endowment, the income level and the degree of development of the countries that will be involved. Size of countries will also be an important criterion: for instance, effective biotechnology capacity is expensive and more readily attained by large rather than small countries; small countries will be more interested in international value chains than in domestic value chains.