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COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

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Seventeenth Regular Session

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REPORT FROM CGIAR

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I. INTRODUCTION

1. This report from CGIAR is based on contributions from the following CGIAR Centers: Africa Rice Centre, Bioversity International, International Center for Agricultural Research in the Dry Areas (ICARDA), International Center for Tropical Agriculture (CIAT), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Food Policy Research Institute (IFPRI), International Institute of Tropical Agriculture (IITA), International Livestock Research Institute (ILRI), International Maize and Wheat Improvement Center (CIMMYT), International Potato Centre (CIP), International Rice Research Institute (IRRI), International Livestock Research Institute (ILRI), International Water Management Institute (IWMI), and World Agroforestry Center (ICRAF)

2. This report was developed on behalf of CGIAR by the CGIAR Genebank Platform Policy Module. The report follows the general structure and content of the questionnaire related to the CGRFA multi-year programme of work (MYPOW) that was sent to all CGIAR Centers and the CGIAR System Office.[1]

II. COMPONENTS OF BIODIVERSITY FOR FOOD AND AGRICULTURE COVERED BY CGIAR

Animal genetic resources

3. ICARDA and ILRI characterize and improve ruminants (cattle, sheep, goat, yak, water buffalo), pigs and chicken. ICARDA's characterization work investigates genetic diversity, structure and genome dynamics of indigenous sheep and goats found in its mandate areas. It includes the investigation of the genetic basis of adaptation to hot arid environments and prolificacy. The characterization is based on the analysis of genome-wide single nucleotide polymorphism data. The work is done in collaboration with National partners and international research institutes. ICARDA is also developing breed suitability maps that aim at matching genotypes to their appropriate production and eco-climatic environments. ICARDA and ILRI, in partnership with African national research institutes have designed and implemented a new approach to genetic improvement of small ruminants called community-based breeding programs (CBBPs). There are functional sheep and goat CBBPs in more than 8 countries in Africa.

Forest genetic resources

4. ICRAF conserves multipurpose wood and non-wood species. ICRAF and Bioversity International conduct research and development on the conservation and sustainable use of forest genetic resources.

Plant genetic resources

5. Eleven CGIAR Research Centers host international *ex situ* collections pursuant to agreements they have signed with the Governing Body of the International Treaty of Plant Genetic Resources for Food and Agriculture (ITPGRFA). All of them are involved in crop improvement work for their target crops.

6. CGIAR Centers also support on farm and in situ conservation efforts.

[1] For more information please contact Elwyn Grainger-Jones, Executive Director, CGIAR System Organization, at contact@cgiar.org

Centre	Crop	Accessions available with SMTA[2]
AfricaRice	Rice	21,300
Bioversity	Banana	1,546
CIAT	Beans	37,987
	Forages	23,140
	Cassava	6,643
CIMMYT	Maize	28,446
	Wheat	154,476
CIP	Andean roots and tubers	1,173
	Potato	7,009
	Sweet potato	7,968
ICARDA	Lentils	12,547
	Grasspea	4,381
	Forages	29,024
	Fababean	9,994
	Chickpea	15,324
	Barley	32,238
	Pea	6,131
	Wheat	43,001
ICRAF	Multipurpose trees	5,997
	Fruit trees	3,600
ICRISAT	Chickpea	19,425
	Groundnut	15,039
	Pigeon pea	13,482
	Pearl millet	23,434
	Small millets	11,691
	Sorghum	40,332
IITA	Cowpea	17,051
	Cassava	2,496
	Maize	1,561
	Misc. legumes	6,623
	Banana	393
	Yam	5,839
ILRI	Forages & fodder	18,638
IRRI	Rice	125,241
TOTAL		**753,170**

Source: Global Crop Diversity Trust/CGIAR On-line Reporting Tool, covering period up to December 31, 2017.

[2] Source: Global Crop Diversity Trust/CGIAR On-line Reporting Tool, covering period up to December 31, 2017.

Micro-organisms (including bacteria, viruses, protists and fungi)

7. Most CGIAR Centers work with micro-organisms that are related to the plant species that are the focus of their research and development. Several CGIAR Centers (including CIAT, CIP, ICARDA, ICRISAT, IITA and IRRI) work with collections of microorganisms (including fungi, mycorrhiza, bacteria, viruses and rhizobia).

8. CIP hosts approximately 1,200 isolates of Phytophthora infestans (pathogenic fungi) and approximately 440 isolates of Ralstonia solanacearum (pathogenic bacteria). ICARDA has a specialized Rhizobium laboratory maintaining 1400 strains. ICRISAT has collections of plant growth-promoting bacteria (23 strains) and entomopathogenic actinobacteria (58). ILRI has collections of rumen microbiome (cattle) and caecum (chicken) microbiome species (prokaryotes and eukaryotes).

9. CGIAR Centers' uses of micro-organisms include: isolation of probiotic bacteria from sorghum and pearl millet flour to exploit as food supplement to improve the gut microbiome (ICRISAT), monitoring of aflatoxin contamination at different levels of groundnut value chain (ICRISAT), development of a strategic initiative of a Global Surveillance System (GSS) to increase resilience against crop diseases and to de-risk global food supplies (CIAT), use of genome sequencing for the discovery of viruses affecting staple crops such as cassava (CIAT), developing biocontrol products that reduce aflatoxin contamination produced by fungi in maize and other crops (IITA), and establishment of a risk assessment framework for seed degeneration caused by multiple pathogens and affecting vegetatively propagated crops (i.e., cassava, potato, yam, banana) mainly low-income countries (CGIAR Research Program on Roots, Tubers and Bananas).

Invertebrates (including insects, spiders, worms)

10. Some CGIAR Centers include invertebrates in their crop breeding and crop management related R&D. Some Centers maintain collections of invertebrates. CIAT, for example, holds an Arthropods Reference Collection with around 560 genera that has been the basis of work on integrated pest management for cassava, beans, and pastures for more than 40 years. ICARDA, through its projects on Farming with Alternative Pollinators is working on promoting the protection of wild pollinators like wild bees, bumblebees, flies etc. within a regional project in countries bordering the Mediterranean Sea. It also works on identification of natural predators for the control of cochnea in cactus.

11. CGIAR Centers have established an ASEAN-wide pest alert network as an information and surveillance platform to report and follow up on the presence and spread of insects pests and diseases transmitted by insects. Centers have also developed and applied diagnostic and monitoring tools such as apps for crowd sourcing pest pressure at different localities, DNA- bar coding toolkits for herbivorous mites, keys for rapid identification of priority pests, and training and education materials for adults. Insights into pest/disease ecology and molecular epidemiology have assisted in assessments of population dynamics of pests and their natural enemies. Centers also evaluate indicators for soil and crop health, and their interrelationship

Vertebrates (including amphibians, reptiles and non-domesticated birds and mammals)

12. AfricaRice and IRRI conduct research on the management of rodents and birds in rice production systems. ILRI works on wild species belonging to the genus Ovis, Capra and Gallus and wild Suidae (European and African species of hogs or boars).

Wild and cultivated terrestrial and aquatic plants other than crop wild relatives

13. AfricaRice and IRRI work on weeds and Azolla in rice production systems.

Regulating and supporting ecosystem services

14. While many Centers are involved in research on regulating and supporting ecosystem services, most work in this area within the CGIAR is concentrated in four CGIAR Research Programs (CRPS) on Water, Land and Ecosystems (WLE), Forest Trees and Agroforestry (FTA), Climate Change, Agriculture and Food Security (CCAFS) and Policies, Institutions and Markets (PIM).

15. Under WLE, Centers' work includes:

- restoring degraded landscapes and enhancing ecosystem services and related benefits, such as food, energy, clean water, carbon sequestration and livelihoods. Various projects under WLE's Restoring Degraded Landscapes Flagship focus on the restoration of wild and domesticated biodiversity in landscapes where agriculture predominates.
- building knowledge and demonstrating application of natural infrastructure (e.g. wetlands, floodplains, watersheds) as a 'nature-based solution' that in combination with built water infrastructure (e.g. dams, levees, irrigation channels) in the Tana (Kenya) and Volta (Ghana-Burkina Faso) river basins can work for poverty reduction, water-energy-food security, biodiversity conservation, and climate resilience. (See WISE-UP Project at http://www.waterandnature.org/initiatives/wise-climate.)
- promoting coexistence of wetlands and other ecosystems with irrigation demands (e.g., large-scale irrigation and inflow of irrigation drainage). This work involved documentation of the relationship between irrigation water management and wetland in an integrated manner, focusing on practical solutions to quantify and manage irrigation water flows that can sustain ecosystems while obtaining optimum agricultural production. (See https://gripp.iwmi.org/natural-infrastructure/)
- working on watersheds where management of fruit trees and pastures are integrated with soils and irrigation management, and livestock management.

16. Under FTA, Centers research focuses on using trees as part of strategies to manage water sheds, water cycles, carbon sequestration, soil improvement, and erosion control, among other aspects.

17. Under CCAFS, Centers work includes mainstreaming agrobiodiversity conservation and use in agroecosystems as part of community, national and subregional climate change adaptation strategies.

18. Under PIM, Centers are engaged in

- Assessing collective action and institutions for common pool resource governance for sustainable conservation of ecosystem services.
- Analysing the connection between mobile agent-based ecosystem services (such as natural pest regulation and pollination) and landscape-scale land use diversity and non-crop habitat in agricultural landscape by using socio-economics, GIS and ecological data and methods.
- How biodiversity and ecosystem services should be measured for assessing progress on SDG 2.4.1 on sustainable agriculture.
- Examining the long-term interplay between climate, crop management, land use change, and pest pressure by exploring how pest control ecosystem services can help mitigate global agricultural commodity trade shocks induced by invasive pest outbreaks; and by conducting economic valuation study to understand the economic value of increased natural enemy population, as well as the "true" cost of chemical pesticide use.

19. Some research projects that promote sustainable use of agricultural biodiversity for better provision of ecosystem services include the following:

- Using intra-specific diversity of crops to manage abiotic and biotic stresses on farm
- Mainstreaming agrobiodiversity conservation and use in Sri Lankan Agroecosystems for improved livelihoods and climate change adaptation

- Bridging managed and natural landscapes in the interplay of agrobiodiversity conservation in Man and the Biosphere Reserves in Cuba.
- Using a traditional crop genetic diversity approach to buffer against unpredictable environmental change in the Nepal Himalayas.
- Developing resilient and multifunctional landscapes in Ethiopia.
- Understanding the interaction of forests and paramos ecosystems in Colombia.
- Promoting sustainable systems for forest conservation, climate change mitigation and peace building in Colombia.
- Conservation and sustainable use of agricultural biodiversity to improve regulating and supporting ecosystem services in agriculture production in Uzbekistan and East Africa.

20. CGIAR has contributed to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) for 2018 assessment report on biodiversity and ecosystem services with regional reports for Africa, Asia and the Americas and with options for governance and decision-making across scales and sectors. See for example assessments https://www.ipbes.net/deliverables/2b-regional-assessments, https://www.ipbes.net/system/tdf/spm_africa_2018_digital.pdf?file=1&type=node&id=28397; https://www.ipbes.net/assessment-reports/americas. ICARDA published on economically self-sustaining policies for pollinator protection, which would allow combat of global pollinator decline even in Low Income Countries (Christmann 2018; COP 14 CBD).

III. POLICIES, PROGRAMMES AND ACTIVITIES RELEVANT TO THE PRIORITIZED THEMES OF THE COMMISSION'S SEVENTEENTH REGULAR SESSION

A. Cross-sectorial matters

Follow up to The State of the World's Biodiversity for Food and Agriculture

21. As part of the development of *The State of the World's Biodiversity for Food and Agriculture*, the Platform for Agrobiodiversity Research (PAR), hosted by Bioversity International, prepared a thematic study "The contribution of biodiversity for food and agriculture to resilience of production systems to environmental change and uncertainty" (A. Duval, D. Mijatovic and T. Hodgkin). A number of CGIAR scientists authored a thematic study entitled "Contributions of biodiversity to the sustainable intensification of food production". At national level, some Centers (e.g., CIAT) contributed to the Sixth National Report on Biodiversity under the Convention on Biological Diversity compiled by respective Ministries of Environment by informing on diagnosis and Centers-adopted measures during 2014-2017 towards achieving Aichi Goal 13 ("maintenance, reduction of the erosion and safeguarding genetic diversity of cultivated and related wild species").

22. CGIAR Centers have developed a number of studies and tools for assessing the status of agrobiodiversity. In one study, "Origins of food crops connect countries worldwide" (see http://dx.doi.org/10.1098/rspb.2016.0792) CGIAR Scientists quantify that, on average, countries rely on crops that originated in other parts of the world for 68% of their food supply, underscoring the case for international collaboration on plant genetic resource conservation and sustainable use. In terms of crop wild relatives, CGIAR scientists demonstrated that 95% of 1,076 taxa of wild plant species related to 81 crops are underrepresented in ex-situ collections globally, and identified priority areas for conserving and collecting 70% of such taxa (see https://dx.doi.org/10.1038/nplants.2016.22). Complementing this work, a developed online indicator tool measures conservation of useful wild plants that countries can use to measure progress towards ambitious Aichi Targets and SDG conservation-related goals set out for 2020. (See https://ciat.cgiar.org/usefulplants-indicator/). Bioversity has partnered with a number of organizations to develop an Agrobiodiversity Index that seeks to assist governments and other stakeholders to measure agricultural biodiversity conserved as genetic resources in situ and ex situ, in production systems, and in markets and people's diets (see https://www.bioversityinternational.org/abd-index/)

Explanatory notes for subsectors of GRFA to complement the ABS Elements

23. Representatives from four Centers participated in the International Workshop on Access and Benefit Sharing for Genetic Resources for Food and Agriculture (IWABS) organized by the CGRFA

Secretariat in Rome, on 10-12 January 2018, contributing to the development of the expanded explanatory notes.

24. The CGIAR Genebank Platform and several Centers have engaged with the ITPGRFA and CBD Secretariats and the ABS Capacity Development Initiative to conduct regional workshops for ITPGRFA and CBD National Focal Points promoting the mutually supportive implementation of the Nagoya Protocol and the ITPGRFA. One spin-off publication from work is Mutually supportive implementation of the Nagoya Protocol and the Plant Treaty: Scenarios for consideration by national focal points and other interested stakeholders (available in English, French and Spanish; see https://cgspace.cgiar.org/handle/10568/96525).

25. In 2018, the CGIAR System Management Board adopted Guidelines on the Nagoya Protocol for CGIAR Research Centers, signaling CGIAR's commitment to operate in compliance with the ABS framework of both the ITPGRFA and the Nagoya Protocol (available in English, French and Spanish; see https://cgspace.cgiar.org/bitstream/handle/10568/96240/Guidelines-for-CGIAR-Research-Centers-to-operate-in-compliance-with-the-Nagoya-Protocol.pdf?sequence=6)

26. CGIAR scientists participated in the development of the Decision-making tool for national implementation of the Plant Treaty's multilateral system of access and benefit-sharing released by the Joint Capacity Building Program of the ITPGRFA (available at https://cgspace.cgiar.org/handle/10568/93396).

27. CGIAR has participated actively in the ITPGRFA's Ad-hoc Working Group for the Enhancement of the Functioning of the Multilateral System of Access and Benefit Sharing (WG-EFMLS) to increase the scope of the multilateral system and payments to the international benefit sharing fund.

28. CGIAR scientists have participated to the evaluation of proposals for the Benefit Sharing Grant of the Treaty on Plant Genetic Resources for Food and Agriculture (ICARDA, Bioversity)

29. ILRI, assisted by GIZ, established an institutional research & ethics committee and an ABS committee that implement ABS guidelines for Center's work.

30. CGIAR submitted a report to the Seventh Session of the Governing Body of the ITPGRFA in 2017 describing non-monetary benefits generated and shared by CGIAR. (See CGIAR Report, Appendix 1 (IT/GB-7/17/24) and Supplementary information to CGIAR Report (IT/GB-7/17/Inf.20)).

Use of "digital sequence information[3]" on GRFA and the potential implications for conservation, sustainable use and ABS of GRFA

31. In 2017, CGIAR submitted a report to the Convention on Biological Diversity entitled 'Potential implications of the use of digital sequence information on genetic resources for the three objectives of the Convention on Biological Diversity. A submission from CGIAR to the Secretary of the Convention on Biological Diversity'. The report describes how CGIAR Centers generate and use digital sequence information (DSI) to improve conservation and sustainable use of GRFA and to generate and share benefits associated with the use of those resources. The report focuses mainly on plant genomic information but includes some examples of DSI of fish and farm animals (see https://www.cbd.int/abs/DSI-views/CGIAR-DSI-en.pdf). That report is equally relevant to the ongoing work of CGRFA with respect to DSI and ABS. Therefore, we reproduce key passages from the report's Executive Summary here:

> "CGIAR experience to date confirms that digital genomic sequence data can play important roles in the management and sustainable use of biological diversity and in the sharing of benefits associated with the use of that diversity. With respect to conservation, digital genomic sequence data has been used to assess genetic diversity of *ex situ* collections and to identify unique germplasm in farmers' fields which is not included in *ex situ* collections; this baseline information

[3] The term is taken from decision CBD COP XIII/16 and is subject to further discussion. There is a recognition that there is a multiplicity of terms that have been used in this area (including, *inter alia*, "genetic sequence data", "genetic sequence information", "genetic information", "dematerialized genetic resources", "*in silico* utilization", etc.) and that further consideration is needed regarding the appropriate term or terms to be used.

is essential for developing more effective *ex situ* and *in situ* conservation strategies. Concerning sustainable use, genomic sequence information, coupled with phenotypic and other data, can be used to identify genotypes that are well adapted to different, and changing, agroecological conditions. Integrated into crop breeding programs, genomic sequence information is increasingly useful for achieving targeted, efficient uses of genetic diversity in sustainable agriculture. The most important benefit to be shared from the use of genomic sequence information in agricultural research and development and plant breeding is improved food and livelihood security. Other non-monetary benefits associated with the use by CGIAR Centers of genomic sequence information are farmers' improved access to technologies, enhanced institutional capacities of developing country research organizations, shared research results, and local and regional economic development. Monetary benefits linked to Centers' uses of PGRFA are largely under the multilateral system of access and benefit-sharing of the ITPGRFA. The multilateral system regulates access to material genetic resources, and not to genetic sequence information. One option currently under consideration for revising the multilateral system – introduction of a subscription system – could have the effect of dissolving the distinction between access to and use of material genetic resources and genomic information, since benefit sharing would be based on total seed sales which would in turn reflect the benefits to the commercial user of accessing and using both genetic resources and genomic sequence data.

Technological capacities to generate genomic sequence data, currently known as Next-Generation Sequencing Technologies, have accelerated faster than capacities to enable practical use of this information. Relatively small investments in the initial generation of genomic sequences, must then be coupled with significantly larger investments to comparatively analyse genomic sequences, to link genetic variability to useful phenotypic traits or performance, to 'optimize' those traits, and ultimately, to develop new crop varieties for release and use in farmers' fields.

CGIAR's experiences generating and using genomic sequences is still relatively new, although for analysis of germplasm collections we are further ahead. We anticipate that genomic sequence information will play an increasingly important role in CGIAR genetic resources conservation and breeding programs, and in turn will create benefits for resource poor farmers in developing countries. CGIAR underscores the importance of capacity building for developing country research and development organizations to generate and use genomic sequence information as part of their own conservation and crop improvement programs, and to be able to participate on equal footing in internationally coordinated and funded research and development programs. As part of its mission, CGIAR seeks to enable national partners in developing countries to take advantage of these and other potentially revolutionary and rapidly evolving technologies, to enhance food stability and security and close potential technological gaps. To that end, CGIAR Centers are providing training and technology transfer for scientists in developing countries so that the impact and advantages from digital sequence data can benefit all."[4]

32. A CGIAR representative participated in the CBD's Ad Hoc Technical Expert Group on Digital Sequence Information and the CBD/SBSTTA and CBD/COP meetings in July and November 2018. CGIAR also participates actively in meetings convened under the ITPGRFA where DSI and benefit sharing has been discussed, most notably at the 8th session of the ITPGRFA Governing Body in October/November 2017 and the recent meetings of the WG-EFMLS, and informal consultation meetings convened by the ITPGRFA Secretariat.

33. Some additional publications by CGIAR scientists addressing ABS issues in relation to DSI are "Plant genetic resources for food and agriculture: opportunities and challenges emerging from the science and information technology revolution" (https://doi.org/10.1111/nph.14993) "Plant Genetic Resources: Needs, Rights, and Opportunities" (https://www.cell.com/trends/plant-science/fulltext/S1360-1385(16)30064-4), "Using Genomic Sequence Information to Increase Conservation and Sustainable Use

[4] The full report is available in English, French and Spanish at https://www.cbd.int/abs/DSI-views/CGIAR-DSI-en.pdf; https://www.cbd.int/abs/DSI-views/CGIAR-DSI-fr.pdf , and https://www.cbd.int/abs/DSI-views/CGIAR-DSI-es.pdf respectively.

of Crop Diversity and Benefit-Sharing" (https://doi.org/10.1089/bio.2018.0043); and "A Case of Need: Linking Traits to Genebank Accessions" (https://www.liebertpub.com/doi/10.1089/bio.2018.0033).

Review of work on GRFA and nutrition

34. Under the CGIAR Research Program on Agriculture for Nutrition and Health (A4NH), several initiatives tackle nutrition from varied angles. Food Systems for Healthier Diets (FSHD) analyses global diet trends, urban consumers' food systems, multi-stakeholder platforms and social networks and their role in food system transformations. Biofortification, meaning the increase of micronutrients content in food crops, is the goal of HarvestPlus, a CGIAR program co-lead by CIAT and IFPRI with the participation of multiple CGIAR Centers, which has delivered multiple crops such as beans, maize, lentils, wheat, pearl millet and sorghum with increased contents of iron, zinc, vitamin A, and/or essential aminoacids mostly in African and Asian countries. At the intersection of resilience, climate change and nutrition, some CGIAR Centers work on revitalizing local food systems and promoting measures and practices that support sustainable agriculture production and resilient livelihoods. This work includes participatory variety selection and characterization (including for nutrition relevant traits), raising awareness about nutritious foods and diverse diets, establishment of community seed banks and farmer producer companies for certified seed production; organization of seed fairs; promotion of new food recipes; conducting food policy analyses; and doing policy advocacy. The scope of this work extends to various continents and major cereals and tubers, vegetable crops (including traditional leafy vegetables), legumes, temperate and tropical fruits, and neglected and underutilized species (for example chaya, tepary bean, fonio, bambara groundnut, jute mallow, minor millets).

35. Various Centers have included better nutritional characteristics in the priorities of their crop breeding work. Some examples are: rice germplasm characterization for iron and zinc content, low glycemic index, and anti-oxidants; evaluation of barley and wild Hordeum for beta glucans and micro-elements, and enhancing protein content in chickpea and pigeonpea, and oil content and quality (high oleic) in groundnut. To assist this work, technologies have been developed by Centers, such as mobile sensors for estimation of grain nutritional profile to enable rapid selection for nutritional qualities.

36. ILRI has led various projects which seek to improve consumption of animal-based food for improved nutrition. A relevant example is the ATONU (Agriculture to nutrition) project in Ethiopia and Tanzania.

B. Sectorial matters

Forest genetic resources:

Review of implementation of the Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources

37. Under FTA, CGIAR Centers have been engaged in conservation, domestication and delivery of tree genetic resources over the last 6 years. In 2018, a Thematic Study on Indicators of the Genetic Diversity of Trees – State, Pressure, Benefit and Response went to press with FAO.

38. Under the FTA framework, Bioversity has contributed to all 27 strategic priorities of the Global Plan of Action (GPA) for the Conservation, Sustainable Use and Development of Forest Genetic Resources (FGR) through different activities clustered in the 4 priority areas of the GPA -- (1) Improving the availability of, and access to, information on FGR, (2) In situ and ex situ conservation of FGR, (3) Sustainable use, development and management of FGR and (4) Policies, institutions and capacity-building – through activities with partners in Asia, Latin America and Africa.

Plant genetic resources:

Review of status and trends of seed policies

39. In relation to seed systems and seed policies, CGIAR Centers:

- have engaged in a number of research coalitions (e.g., Integrated Seed System Development – Africa) with partners from national agricultural research organizations, ministries of agriculture, farmers' organizations, subregional economic organizations to analyse national and regional seed policies and laws and support initiatives for seed policy development. This work includes analyzing the extent to which seed policies and laws create incentives/support

for a) farmer-led variety improvement and registration, seed multiplication and marketing, b) integration of so called formal and farmer led seed systems, and ultimately c) conservation, management of genetic diversity in integrated seed systems. CGIAR Centers have been able to integrate use of the Voluntary Guide for National Seed Policy Formulation endorsed FAO's CGRFA in seed policy research and development activities. These guidelines usefully highlight the importance of flexibility for countries to develop policies which, among other things, promote use of genetic diversity in production systems;

- have studied wheat seed production and delivery systems and variety registration regulations in Morocco;
- have reviewed small holder breeders' rights for clones developed through participatory domestication of agroforestry trees, and
- have explored policy and regulatory options to strengthen seed systems and markets in developing countries as an important step toward increasing agricultural productivity growth rates among smallholder farmers. Emphasis placed on variety registration procedures, quality assurance systems, plant variety protections, licensing arrangements, and extension strategies to increase the timely supply of diverse and quality seeds and traits to smallholders across a range of crops.