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COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

Item 9 of the Provisional Agenda

INTERGOVERNMENTAL TECHNICAL WORKING GROUP ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

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REPORT FROM THE CGIAR

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I. INTRODUCTION

1. This report has been prepared by CGIAR in response to an invitation from the Secretariat of the FAO Commission on Genetic Resources for Food and Agriculture. It is structured to correspond, in general, to the agenda items 3, 6 and 7 of the Ninth Session of the Intergovernmental Technical Working Group on Plant Genetic Resources (ITWG-PGRFA). Most of the information included in this report was previously submitted to the Seventh Session of the Governing Body of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) in October-November 2017. Due to the shortness of time since the Governing Body meeting, it was not feasible to gather and synthesize much additional information from all the CGIAR Centres for this report. Nonetheless, the information presented here is certainly relevant for the Ninth Session of the ITWG-PGRFA.

II. REVISED CGIAR STRUCTURE AND GOVERNANCE

2. CGIAR is a global research partnership for a food secure future dedicated to reducing poverty, enhancing food and nutrition security, and improving natural resources. Its research is carried out by 15 CGIAR Centres in close collaboration with more than three thousand partners, including national and regional research institutes, civil society organizations, academia, development organizations and the private sector. The primary geographical focus of CGIAR research and development is developing countries and regions. While most of CGIAR work focuses on crops and crop production, some Centres also work on tree and agroforestry, and fish and livestock production.

3. CGIAR revised its governance model to operate under a 'CGIAR System' with effect from 1 July 2016. The new structure was implemented through the adoption of a CGIAR System Framework and a Charter of the CGIAR System Organization, which define the roles, responsibilities and accountabilities of the various bodies comprising the CGIAR System. The revised governance structure maintains many of the fundamental elements of the previous structure and key components include: CGIAR Research Centres; a CGIAR Trust Fund; a System Council; a System Management Board; a CGIAR System Organization; the Independent Evaluation Arrangement (IEA); the Independent Science and Partnership Council (ISPC); a Partnership Forum; and a General Assembly of the Centres.

4. The CGIAR's Strategy and Results Framework and the United Nations' Sustainable Development Goals (SDGs) underpin the overall strategic direction of the CGIAR. The CGIAR Research Portfolio 2017-2022 is structured around two interlinked clusters of challenge-led research: 1) Innovation in 'Agri-Food Systems' which involves adopting an integrated, agricultural systems approach to advancing productivity, sustainability, nutrition and resilience outcomes at scale; and 2) Four cross-cutting 'Global Integrating Programs' framed to work closely with the Agri-Food Systems Programmes within relevant agro-ecological systems. These clusters are supported by three research support 'Platforms' which underpin the research of the whole system (see Figure 1).

5. The Genebank Platform consists of three modules: Conservation, Use and Policy. The Policy Module coordinates representation of the CGIAR in intergovernmental fora dealing with genetic resources policy issues, including the Commission on Genetic Resources for Food and Agriculture. Governance for the Policy Module in particular is provided by the General Assembly of the Centres and the System Management Board.

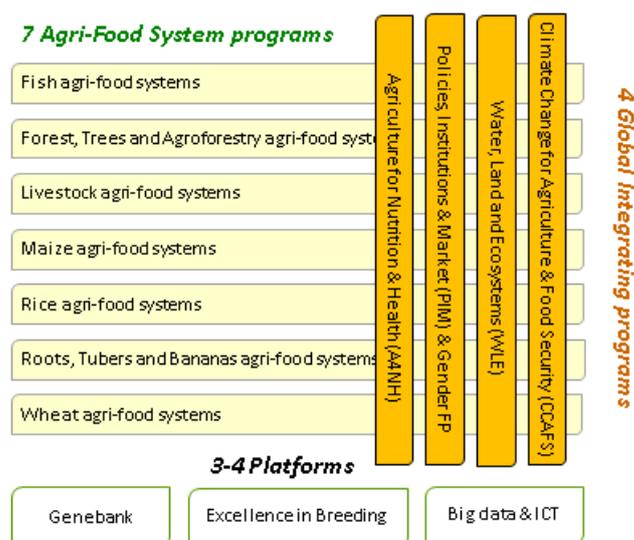


Figure 1: CGIAR Research Portfolio 2017-2022: 11 Programmes + Platforms

III. CGIAR CENTRES ACTIVITIES THAT CONTRIBUTE TO THE IMPLEMENTATION OF THE SECOND GLOBAL PLAN OF ACTION FOR PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE (2ND GPA) - ITEM 3 OF THE PROVISIONAL AGENDA

A. *In situ* conservation and management (2nd GPA priority activities group 1)

6. CGIAR Centres contribute to understanding and conserving crop diversity on farm and in the wild in various forms. The following paragraphs present some illustrative examples of CGIAR Centres' work with farmers, research organizations and other actors for improving management of plant genetic resources *in situ*.

The Heirloom Rice Project in The Philippines

7. The Heirloom Rice Project, which started in 2014, is supported by the Department of Agriculture of The Philippines and IRRI with the aim of enhancing the productivity and enriching the legacy of heirloom or traditional rice through empowered communities in unfavourable rice-based ecosystems in the Philippines. Heirloom rice varieties, handed down for several generations through family members and grown by small landholders on their ancestral farms, have exceptional cooking quality, flavour, aroma, texture, colour, and nutritional value. Hence, there is high demand for these varieties and they command higher prices in both domestic and international markets. These varieties are also resilient, showing high levels of resistance to diseases and tolerance of environmental stresses, thus helping farmers make a good income out of every crop. But the huge potential of heirloom rice as a lucrative livelihood is hindered by the inability of local farmers to produce these with higher seed quality and purity and in greater quantity. Moreover, certain heirloom varieties are gradually disappearing; some are even close to extinction. Market and product development, alongside maintaining biodiversity in the region, are crucial for farmers to continue growing these threatened rice varieties in the Cordillera Region and in the Arakan Valley Complex in Mindanao. The project focuses on the following actions: 1. characterize existing heirloom or traditional varieties or landraces and modern climate resilient varieties in selected provinces; 2. enhance local capacity and enterprise building in farming communities; 3. identify opportunities for adding value and creating market linkages for heirloom or traditional rice varieties; 4. document good management practices and disseminate through modern and traditional information, education and communication channels; and 5. improve resistance to disease and tolerance of environmental stresses of selected heirloom varieties.

Collaboration with communities of the Parque de la Papa (the Potato Park), Peru

8. Since 2004, CIP has collaborated with farming communities within the Potato Park. As part of this collaboration and with the support and coordination of Asociación ANDES, CIP has repatriated more than 400 native potato varieties to Potato Park communities, in the form of disease-free seed. The project has also disseminated scientific knowledge among the communities and in the past few years this collaboration has led to a number of joint experiments, notably regarding the effects of climate change and associated biotic and abiotic stresses.

Monetary benefit-sharing with farmers in Peru

9. The Chirapaq Nan initiative links a Dutch seed potato company with the farmers who conserve potato genetic diversity in the Andes region. Several CIP scientists supported the establishment of AGUAPAN (Association of Potato Guardians) which unites farmers from different parts of Peru, all of whom maintain significant potato diversity in their fields. The association receives funds from the corporate social responsibility (CSR) budget of the potato seed company and this money is used by the farmers in accordance with their own decisions within AGUAPAN. The Chirapaq Nan project and the AGUAPAN model offer a complementary alternative to existing benefit sharing mechanisms.

Community-based agricultural biodiversity management

10. Bioversity International runs a number of projects that promote sustainable management of crop diversity on farm. Some of the measures included in these projects are: developing good practices; incentive mechanisms and policy and legal measures to recognize, reward and support custodian farmers and community seedbanks; identifying and promoting the nutritional value of neglected and underutilized species; developing new methods to improve access, availability, quality and diversity of local seeds; strengthening the technical and business knowhow of smallholder farmer seed producers; assessing the feasibility of payments for agrobiodiversity conservation services; identifying effective crop diversity mixes for pest and disease management; promoting the food and nutrition value of biodiversity in healthy diets; and designing new mechanisms for involving farmers in policy processes.

11. Bioversity and national partners in Bolivia, India, Mali, Nepal, Peru and South Africa, have trained farmers to document traditional knowledge of neglected and underutilized species in biodiversity registers and diversity catalogues. Some of these catalogues serve as local, provincial and national reference for agrobiodiversity registers and are the main tools for documenting changes in on farm diversity. In Brazil, based on evidence provided by the Biodiversity for Food and Nutrition project, 64 native food species of nutritional importance are now formally recognized in the 2016 Ordinance No.163, "Brazilian Native Socio-biodiversity Species of nutritional value". The ordinance, jointly signed by the Ministries of the Environment and Social Development and Fight Against Hunger, recognizes for the first time native species of economic and cultural importance for traditional communities such as quilombolas, extractivists, fisher folk and family farmers, among others.

12. Under the Payments for Agrobiodiversity Conservation Services project, farming communities receive in-kind payments for growing different varieties of quinoa, an Andean grain (in Bolivia and Peru) and maize varieties (in Ecuador).

B. *Ex situ* conservation (2nd GPA priority activities group 2)

13. Eleven CGIAR Centres currently conserve and make available (under the Standard Material Transfer Agreements or SMTA) a total of 736 111 accessions of crop, tree and forage germplasm. Details concerning the Centres, crop collections and numbers of accessions available for distribution are included in Table 1.

Table 1: PGRFA conserved and made available by CGIAR Centres' genebanks pursuant to their Article 15 agreements with the Governing Body

Centre	Crop	Accessions available with SMTA
AfricaRice	Rice	21 300
Bioversity	Banana	1 500
CIAT	Beans	37 987
	Forages	23 140
	Cassava	6 643
CIMMYT	Maize	28 193
	Wheat	154 744
CIP	Andean roots and tubers	1 173
	Potato	6 527
	Sweet potato	5 328
ICARDA	Lentils	11 635
	Grass pea	4 193
	Forages	25 556
	Faba bean	9 900
	Chickpea	14 238
	Barley	31 554
	Pea	6 105
ICRAF	Wheat	41 181
	Multipurpose trees	5 594
	Fruit trees	3 600
ICRISAT	Chickpea	19 266
	Groundnut	15 039
	Pigeon pea	13 482
	Pearl millet	23 057
	Small millets	11 365
	Sorghum	39 264
	IITA	Cowpea
Cassava		3 398
Maize		1 561
Misc. legumes		6 623
Banana		321
ILRI	Yam	5 839
	Forages & fodder	18 627
IRRI	Rice	123 019
TOTAL		736 111

14. In 2006, the eleven CGIAR Centres that host collections of PGRFA signed agreements with FAO in representation of the Governing Body of the ITPGRFA. Through these agreements, the CGIAR Centres placed their *ex situ* collections of PGRFA under the ITPGRFA multilateral system of access and benefit-sharing and recognized the authority of the Governing Body to provide policy guidance related to these collections.

15. Over the first 10 years of their operation under the ITPGRFA framework – from January 2007 to December 2016 - the CGIAR Centres distributed almost four million samples of PGRFA with over 47 000 SMTAs)under the multilateral system.

16. Details about how much material was distributed by each Centre during this ten-year period (January 2007 to December 2016) is set out in Table 2 below. These figures include PGRFA distributed by Centres' genebanks and their breeding programmes (if they have breeding programmes). Part of the PGRFA distributed by the breeding programmes was as PGRFA under Development (PuD), as defined by the ITPGRFA.

Table 2: CGIAR Centres' distributions of PGRFA using the SMTA, January 2007-December 2016

Centre	SMTAs	Samples	PUD	From	To
AfricaRice	483	46 440	28 492	2007-03-05	2017-01-05
Bioversity	386	6 109	653	2007-01-24	2016-12-22
CIAT	2 547	246 650	36 034	2007-01-05	2017-05-05
CIMMYT	18 127	1 986 228	0	2007-03-16	2016-12-28
CIP	560	15 391	10 183	2007-01-19	2017-05-08
ICARDA	12 977	779 390	698 110	2007-02-13	2016-12-14
ICRAF	154	679	0	2011-09-03	2016-12-04
ICRISAT	3 885	159 362	34 313	2009-11-11	2017-01-19
IITA	728	29 792	0	2007-03-07	2017-04-28
ILRI	777	9 390	0	2007-02-22	2016-11-30
IRRI	7 186	635 090	379 491	2007-01-04	2017-05-18
	Total SMTAs: 47 810	Total Samples: 3 908 412			

17. The proportion of materials distributed by CGIAR Centres' genebanks and breeding programmes varies from year to year; in general approximately 1/5-1/4 of the materials distributed each year is from the genebanks.

18. Most of the 3.9 million samples distributed by the CGIAR Centres was to recipients in developing countries and countries with economies in transition, mostly to public sector research organizations, universities, regional organizations, germplasm networks and other genebanks.

C. Sustainable use (2nd GPA priority activities group 3)

19. From 2012 to 2016, characterization and breeding work in the CGIAR has taken place in the framework of the following CGIAR research programmes: MAIZE, WHEAT, RICE (previously known as the Global Rice Science Partnership- GRiSP), Dryland Cereals, Grain Legumes, Roots, Tubers and Bananas and Livestock (for forages). Table 3 presents the crop and geographical coverage of these programmes, and their main objectives. CGIAR breeding work takes place in partnership with public and private organizations in the target countries. These organizations develop improved varieties derived from CGIAR lines, release these varieties through public and private sector partners, and catalyse deployment of the seed of the improved varieties in the target geographies.

Table 3: Summary of recent CGIAR breeding efforts (2012-2016)

CGIAR Research Programme	Crop	Centre	Target countries and regions	Breeding objectives
MAIZE	Maize	CIMMYT IITA	Sub-Saharan Africa, Latin America and Asia	High grain yield, drought tolerance, heat tolerance, nitrogen use efficiency, resistance to major diseases, including tar spot complex, maize streak virus,

				Turicum leaf blight, Gray leaf spot, etc., resistance to stem borers and post-harvest insect-pests, increased protein quality (QPM), increased pro-vitamin A content, increased kernel-Zinc content, superior stover fodder quality
			Eastern Africa	Resistance to maize lethal necrosis, drought tolerance
			East and West Africa	Resistance to Striga, drought tolerance
DRYLAND CEREALS	Sorghum	ICRISAT	India (Deccan Plateau)	Drought tolerance, delayed foliar senescence (stay-green), stover fodder quality
			Burkina Faso, Mali, Nigeria,	Increased grain yield, high stover quality, drought tolerance and Striga resistance.
			Ethiopia, Eritrea, Tanzania, South Sudan, Kenya, Malawi, Zimbabwe	Shoot fly resistance, high nutrient content (Fe and Zn), leaf disease resistance and Striga resistance
	Finger millet	ICRISAT	Ethiopia, Kenya, Tanzania, Uganda, Malawi	Resistance to blast, resistance to Striga, tolerance to drought, high nutrient content (Ca, Fe and Zn).
	Barley	ICARDA	North and East Africa, Central, West and South Asia	Improved nutritional (Zn, Fe, and β -Glucan) and malting qualities, drought tolerance, resistance to powdery mildew, resistance to stem gall midge, resistance to net blotch, and resistance to yellow dwarf virus.
	Pearl millet	ICRISAT	West Africa	Increased grain yield, resistance to downy mildew, head miner and Striga hermonthica, improved nutrition characteristics, and stay-green types
			India	Increasing genetic base, Downy mildew resistance in popular hybrids. Resistance to blast disease caused by Magnaporthe grisea. Resistance to downy mildew pathotype. High bio-mass.
			India, South Asia	Resistance to blast disease, improved fodder and forage, heat tolerance, high iron
			Eastern and Southern Africa	Resistance to blast disease, improved forage, heat tolerance
			Eastern and Southern Africa	Tolerance to drought and low soil phosphorus
GRAIN LEGUMES	Common bean	CIAT	South America Africa	Heat tolerance

		Africa	Greater potential of symbiotic nitrogen fixation
Cowpea	IITA	West Africa Burkina Faso, Ghana, Mali, Niger, Nigeria	Tolerance to drought, heat and low soil phosphorus Pest and disease resistance (including aphids, thrips, bacterial blight and viruses) Striga tolerance
		Eastern and Southern Africa Mozambique, Tanzania, Zambia	Pest and disease resistance (including aphids, thrips, bacterial blight and viruses) , resistance to Alectra
Soybean	IITA	Sub-Saharan Africa	Resistance to pests and diseases. Tolerance to abiotic stress. Increased yield.
Groundnut	ICRISAT	Eastern and Southern Africa, West and Central Africa, South Asia	Short duration, low aflatoxin incidence, drought tolerance, rosette resistance, leaf spots resistance, high fodder quality
Chickpea	ICRISAT	India	Heat tolerance (for late sown cultivation)
		India, Bangladesh, Ethiopia, Kenya	Early maturing and short duration varieties
		Turkey, Lebanon, Tunisia, Georgia, Azerbaijan, Iran, Kazakhstan, Russia, India.	Machine harvestable varieties, resistance to ascochyta blight, resistance to fusarium wilt
		North Africa, Central Asia, South Asia	Tolerance to herbicides
		South Asia Africa	Greater potential of symbiotic nitrogen fixation (SNF) under limited soil phosphorus
Pigeonpea	ICRISAT	India	Early and medium maturity, resistance to Fusarium wilt and Sterility mosaic disease, drought tolerance, pod borer tolerance
		Kenya, Tanzania, Malawi, Mozambique, Uganda, Zambia	Medium maturity, photoperiod insensitivity, resistance to Fusarium wilt and Cercospora leaf spot, pod borer and pod fly tolerance, grain quality, drought tolerance
Lentil	ICARDA	Bangladesh, Nepal and India	Early maturing and short duration varieties. Extra early maturing varieties for rice-lentil-boro rice systems
		North and East Africa	Tolerance to herbicides, resistance to asochyta blight, tolerance to Orobanche spp (parasitic weed)
Faba bean	ICARDA	North and East Africa	Tolerance to herbicides, tolerance to Orobanche spp (parasitic weed), tolerance to various diseases.

RICE	Rice (sativa and glaberrima)	IRRI AfricaRice CIAT	World wide	High grain yield, superior grain quality (taste, texture, shape); tolerance to major rice pests and diseases; increased iron and zinc content
		IRRI	South Asia, South East Asia	Tolerance to drought, submergence, salinity, high temperature, low temperature, low solar radiation, tolerance to region-required combination of abiotic stresses, earliness and mechanized dry direct seeded and alternate wetting and drying, high straw quality, tolerance to major diseases- blast, bacterial blight, sheath blight, false smut, tolerance to major insects- brown plant hopper, stem borer, region preferred grain and cooking quality traits- low chalkiness, medium to high amylose content, high head rice recovery, export oriented segmented market quality traits.
		CIAT	Latin America	High grain yield, superior grain quality, tolerance to major rice diseases, good performance under reduced light
		AfricaRice	Africa	Tolerance to drought, submergence, salinity and low temperatures, tolerance to major biotic stresses, region preferred grain and cooking quality traits
WHEAT	Wheat (Bread and Durum)	CIMMYT, ICARDA	World wide	More durable yellow, stem, leaf rust resistance based on combinations of minor, slow rusting genes Resistance to other diseases of global importance (7 diseases) High Zinc and Iron content Industrial/bread-making quality
			Central Asia (Aral Sea and Fergana Valley)	Resistance to frost, salinity and yellow rust
			South America South Asia Ethiopia, Nigeria, Sudan	Heat tolerance
			South America South Asia	Resistance to various diseases, including wheat blast, Septoria leaf blotch, leaf rust, and Fusarium head blight
			North Africa and Middle East	Tolerance to Septoria tritici blotch in durum wheat

ROOTS, TUBERS AND BANANAS	Sweetpotato	CIP	Sub-saharan Africa	Resistance to fusarium (FHB), nematodes and root diseases
			South and South East Asia	Pro-vitamin A orange flesh, increased yield and earliness, Sweetpotato virus disease (SPVD) resistance, storability, high dry matter, non-sweet, adaptation to drought-prone environments, dual purpose use for pig feed
	Banana and plantain	IITA Bioversity	Worldwide	High yield, resistance to Black Leaf Streak
			East Africa	Earliness, drought tolerance, resistance to nematodes and weevils, Fusarium wilt resistance, Banana Xanthomonas Wilt resistance.
			West and Central Africa	Earliness, drought tolerance, resistance to nematodes and weevils.
			Latin America and Asia	Resistance to Black Sigatoka complex and Fusarium Wilt
	Cassava	CIAT, IITA	Worldwide	Yield, high dry matter
			West and Central Africa	Cassava Mosaic Disease resistance, high carotenoids content, preemptive Cassava Brown Streak Disease resistance, improved poundability, low cyanogenic potential..
			East Africa	Cassava Mosaic Disease and Cassava Brown Streak Disease resistance, preferred culinary attributes
			Latin America	High carotenoids content, value-added starch functional properties, resistance to Cassava Bacterial Blight and green mites.
			Asia	New starches, resistance to Cassava Witch's Broom Disease, earliness for multi-cropping systems
			Worldwide	Earliness
	Potato	CIP	African & Andean highland tropics	Drought tolerance, late blight resistance, Fe & Zn biofortification, table-potato preference
			African & Asian mid-elevation tropics	Resistance to late blight and Potato Virus Y, chipping ability, heat tolerance, low anti-nutrient content
			Asian subtropical lowlands (Indo-	Virus resistance, heat tolerance, long dormancy period, cold chipping ability, high dry matter content

			gangetic Plains, Indochina)	
			Central Asia temperate lowlands and mid-altitude	Photoperiod insensitivity, drought tolerance, salinity tolerance, virus resistance, red skin
	Yam	IITA	Worldwide	Yield, earliness, anthracnose resistance
			West Africa	High dry matter, nematode resistance
			Asia, East Africa, Latin America & the Pacific	Tuber quality, yam mosaic virus resistance
Livestock	Urochloa decumbens U.brizantha ruzizensis	CIAT	Global tropics	Tolerance to biotic (Spittlebug, Rhizoctonia) and abiotic (drought, water-logging, aluminium, soil fertility) stresses, productivity, Water Use Efficiency, Nutrient Use Efficiency, Nutritive Quality, seed yield
	Urochloa humidicola	CIAT	Global Tropics	Nutritive Quality, Biological Nitrification Inhibition, Tolerance to biotic (Spittlebug, Rhizoctonia) and abiotic (drought, water-logging, aluminium, soil fertility) stresses, productivity, Water Use Efficiency, Nutrient Use Efficiency, seed yield
	Megathyrsus maximus	CIAT	Global Tropics	Tolerance abiotic (drought, water-logging, aluminium, soil fertility) stresses, productivity, Water Use Efficiency, Nutrient Use Efficiency, Nutritive Quality, seed yield

Pre-breeding

20. Much work has taken place at the pre-breeding stage, where efforts have concentrated on identifying desirable characteristics and/or genes from unadapted materials that cannot be used directly in breeding populations and to transfer these traits to an intermediate set of materials that breeders can use further in producing new varieties for farmers. These are necessary steps in the use of diversity contained in wild relatives and landraces and allow breeders to broaden the genetic base of crops. In the last decade, CGIAR pre-breeding work has increased attention to traits and genes that will allow crops to respond and adapt to climate change, increased demand for nutritious food and soil degradation. Characteristics such as heat and drought tolerances, improved nutritional values, adaptation to poor soils and increased potential of nitrogen fixation (of legumes) are the focus of a number of pre-breeding activities that aim to develop and test interspecific lines with valuable traits that can be later integrated in CGIAR Centres' and national partners' breeding programmes. Examples include CIAT's work on heat tolerant bean lines crossing the wild relative *Phaseolus acutifolius* (source of heat tolerance) with *Phaseolus vulgaris*, ICRISAT's work for introgressing genes/alleles conferring botrytis grey mold (BGM) resistance from chickpea wild relatives into early maturing but BGM susceptible chickpea cultivars and CIP's work for the incorporation of novel late blight resistance from wild potatoes of Piurana series to cultivated potato.

Phenotyping

21. Phenotypic characterization has continued to be the basis for plant selection in CGIAR breeders' work and CGIAR Centres have continued their efforts to set up and maintain robust phenotyping platforms based on global partnerships. Phenotyping remains by far the most expensive and time-consuming activity for breeding programmes. In order to accelerate phenotyping, increase the quantities of high quality phenotype data and reduce costs, some CGIAR research programmes have started to implement improvements such as remote and ground sensing, increased efficiency in routine physico-chemical laboratory analysis, and mechanization and automation of seed preparation, and field and greenhouse trials. One example is the high-throughput phenotyping platform called LeasyScan that has been recently established in ICRISAT to assess the dynamics of leaf development and leaf conductance, traits that are the focus for plant drought adaptation. Examples of large phenotyping efforts in the period 2012-2016 are ICRISAT's work on finger millet in East African countries (phenotyping for nutrient concentration, resistance to various diseases and drought tolerance), on pearl millet in India (for resistance to blast disease), on groundnut in West and Central Africa (for tolerance to drought and reduced presence of aflatoxin), and CIP's work to identify sources of heat tolerance in potato and improve iron content in Andean- and commercial-type potatoes. Over the years, CIMMYT has put in place an extensive phenotyping network in sub-Saharan Africa, Asia and Latin America for screening maize germplasm under managed drought stress, as well as a heat stress phenotyping network at 23 sites in four countries in South Asia (Bangladesh, India, Nepal and Pakistan).

Generating and using gene sequence information

22. Genotyping and genome sequencing information are increasingly used for pre-breeding and breeding. For most target crops, DNA sequencing of thousands of accessions have generated a critical mass of data to create more accurate crop phylogenies and link genomic regions to traits. This research has shed new light on the relationships among crop varieties, landraces and wild relatives in collections and has helped breeders identify populations with desired traits. Genomic information has been extensively used and combined with classic breeding for guiding selection, crossing and evaluation in ongoing breeding programmes for several crops. For example, promising cowpea lines resulting from marker assisted selection at IITA are currently being screened by the Institut de l'Environnement et de Recherches Agricoles in Burkina Faso, the Eduardo Mondlane University in Mozambique and the Institut Sénégalais de Recherches Agricoles, covering a specific set of target traits in each country, including grain yield, drought tolerance, heat tolerance, *Striga* resistance and *Macrophomina* resistance.

23. Genomic work has allowed Centres and their partners to identify genes that control important traits. For example, under the RICE programme, researchers have identified an anaerobic germination gene that enhances rice germination under anaerobic conditions. Tolerance of anaerobic soil during germination enables uniform germination and seedling establishment under submergence, and is a key trait for the development of tropical direct-seeded rice, which represents a means of intensification and economization of rice production. ICRISAT researchers have identified the molecular markers for quantitative trait loci controlling grain iron and zinc content in sorghum, with the long range potential impact of combatting malnutrition in sorghum producing and consuming countries. Researchers working under the CGIAR programme on Roots, Tubers and Bananas have identified quantitative trait loci associated with resistance to cassava green mite, cassava mosaic disease and cassava brown streak disease, as well as those associated to high pro-vitamin A or dry matter content in storage roots. MAIZE researchers have developed and deployed breeder-ready production markers for pro-vitamin A content, maize streak virus resistance, maize lethal necrosis resistance, and high haploid induction rate. CIAT work on forages has led to the identification of the genomic region associated with apomixis in *Urochloa* species which allows accelerating the breeding cycles and therefore faster achievement of high quality grasses.

24. Genomic work is now included to varying degrees in CGIAR Centres' breeding work on most of the CGIAR mandate crops as listed in Table 4 above. It involves partners (mainly public research organizations) from many countries including India, China, Mexico and the USA. CIMMYT, ICRISAT, IITA, ILRI and IRRI have facilities for engaging in genomic work. Some of these facilities provide

genomic services to organizations in the region, like for example the KALRO (Kenyan Agriculture and Livestock Research Organization)/ CIMMYT facility for screening maize germplasm of public and private sector partners against MLN under artificial inoculation, established in 2013 at the KALRO Naivasha research station in Kenya's Rift Valley. The Bioscience Centre at IITA (Ibadan, Nigeria) serves a regional hub for national programmes and Universities. Most genomic sequencing information and genomic tools are made publicly available through online platforms and databases. Examples of these platforms and databases are the one maintained by the International Rice Informatics Consortium (<http://iric.irri.org/>), the Sweet Potato Gene Index (https://cipotato.org/sweetpotato_gene_index), the Cassava Genome Hub (<http://www.cassavagenome.org/>) and the Banana Genome Hub (<http://banana-genome-hub.southgreen.fr/>). Genomic work is directly linked to, and feeds into breeding programmes at the CGIAR Centres and in partner organizations.

25. In general, data and information flows are increasingly important aspects of breeding programmes. Recent developments such as CassavaBase, YamBase and Breeding for Results (B4R) improve data management and sharing and facilitate collaboration in breeding.

Enhancing seed systems

26. Breeding programmes are part of CGIAR's holistic approach to crop production challenges. All the mentioned CGIAR research programmes include, in addition to breeding, other activities related to sustainable use of PGRFA, such as improving agronomic practices, strengthening seed systems, delivery of clean seed and planting material, developing markets for target crops and crop based products, and integrating and empowering women and youth in crop research, development and market chains. The following two paragraphs present examples of some Centres' efforts to integrate farmers who are seed producers and local seed systems in national seed sectors as a way to improve seed accessibility, quality and diversity.

27. In 2015, Peruvian authorities launched a review of their existing potato seed regulations. CIP took an active part in this process and contributed scientific knowledge and international experience to the policy discussions. CIP organized decentralized meetings in potato growing communities to assist national authorities and farming communities to discuss and contribute to developing suitable legislation. In November 2015, during the one-month public consultation process of the final draft of the Potato Seed Regulations, CIP organized a workshop at its headquarters in Lima, Peru, with participation from farmers' organizations, civil society organizations, the national seed regulatory authority, agricultural extension services, representatives from the national Congress, and international experts. Participants reviewed the proposed regulations and prepared written submissions to the regulatory authority responsible for the draft. One of the major achievements of this participatory process will be official recognition of the existence and value of farmer selected varieties in the new national potato seed law. The introduction of sui-generis quality control mechanisms, such as the Quality Declared Planting Material (QDPM) system, will enable the multiplication and commercialization of seed of good quality at an affordable price.

28. The project Improving Seed Systems for Smallholder Farmers' Food Security took place from 2013 to 2016 in Bolivia, Burkina Faso, Nepal, Uganda and Uzbekistan. It was funded by the Swiss Development and Cooperation Agency and coordinated by Bioversity International. The project contributed to increasing scientists, farmers, seed enterprises and seed sellers' knowledge about the varietal diversity of the target crops. The value of traditional and farmers' varieties was promoted through variety catalogues, radio and TV programmes and the distribution of diversity kits. The project increased scientists' and authorities' knowledge about the seed value chains of the target crops and specially the interfaces between formal and informal seed systems in the target sites. Thanks to training, new facilities, technical equipment and good quality foundation seed provided by the project, seed producer groups and individual farmers increased their capacities to produce and sell good quality seed of a broader range of varieties of the target crops, which resulted in good quality, more diverse and traceable seed made available from individual farmers, farmers' seed producer groups, nurseries and community seedbanks in the target sites of Bolivia, Nepal, Uganda and Uzbekistan. Linkages between

national seedbanks and community seedbanks were also reinforced in the project sites of Nepal and Uganda, resulting in germplasm and knowledge flowing between them. The awareness of local, departmental and national government officers in relation to the role of informal seed systems was raised in Bolivia, Nepal and Uganda, and discussions are slowly progressing in these countries to support and reinforce both informal and formal systems together. More relaxed quality control schemes like the FAO's Quality Declared Seed Systems (QDS) are being considered by national authorities for areas where the presence of formal seed sector is limited and for crops and varieties that are not usually produced by seed enterprises.

D. Building Sustainable Institutional and Human Capacities (2nd GPA priority activities group 4)

29. Capacity building and technology co-generation and transfer are at the core of CGIAR Centres activities. This section summarizes activities of the Centres in the last five years that have contributed to increase human capacities within national research organizations, development agencies, civil society groups and farmers.

Capacity development

30. CGIAR Research Programmes have supported a number of students doing their BSc, MSc and PhD degrees. For examples, the CGIAR Research Programme on Maize (MAIZE) co-supervised a total of 130 PhD, MSc, BSc students in 2015; in 2016, CGIAR Research Programme on Roots, Tubers and Bananas (RTB) hosted and co-supervised 124 students; and the CGIAR Research Programme on Dryland Cereals programme 28 MSc students, and 24 PhD candidates from 2012 to 2016.

31. Various long-duration courses (more than 90 days) on crop improvement (including breeding, pathology and marker assisted selection) have been organized and supported by CGIAR Research Programmes for advanced degree students and junior and mid-career scientists from all over the world. One example is the Basic Wheat Improvement Course which is organized annually under the CGIAR Research Programme on wheat (WHEAT). CGIAR has supported various funding schemes for students in developing countries, like the Legume Scholars Programme and the Dryland Cereals Scholarship Programme.

32. Numerous additional short-term regional and national training courses have been organized through CGIAR Research Programmes and projects. These have been oriented not only to scientists in research organizations, but also to officers and technicians working in governmental agencies and NGO staff.

33. Capacity development for farmers has covered a wide range of topics including sustainable intensification, postharvest practices, production using hybrid seed, produce processing and marketing, seed selection, seed multiplication, business model development, and gender awareness. Training events have taken place in the form of field days, farmer schools and travelling workshops. For example, under WHEAT, more than 18 425 farmers took part in 335 training events in 2016, in Afghanistan, Bangladesh, Ethiopia, India, Kenya, Mexico, Nepal, Pakistan and Turkey. In 2015, under RICE, IRRI and national partners provided training to 10 826 extension staff and lead farmers in Asia. In Bangladesh alone, 130 446 farmers were trained and 47 472 trials and demonstrations were conducted. Across Southeast Asia in 2015, 60 997 farmers were trained in different aspects of rice production. Box 1 presents a concrete case of capacity building under the Arab Food Security Project.

Box 1: Impact story. Results of the capacity building efforts under the first phase of the Arab Food Security Project

The first phase of the Arab Food Security Project took place under WHEAT from 2011 and 2014. As part of this project, 25 700 farmers benefited from field days, farmer schools and travelling workshops where they learned about improved wheat varieties and agronomic practices. It is estimated that these efforts contributed to an average 28 percent increase in wheat yield across all countries. Mechanized raised-bed planting for smallholders led to an average 25 percent savings in irrigation water, a 30 percent increase in wheat yield and a 74 percent improvement in water-use efficiency on farmers' fields in Egypt. Substantial improvements in rainfed systems included a 45 percent gain in yields in Yemen and gains of 24 percent in Jordan and Tunisia. No-till systems increased wheat yields 16 percent in Syria, 20 percent in Jordan and 50 percent in Morocco. The project's Young Scientist Training Program mentored and trained 34 young scientists.

34. Hundreds of capacity-building materials have been made available by CGIAR Centres during the course of the first series of CGIAR Research Programmes (2012-2016). Despite increasing efforts to publish these materials in other languages beyond English, language continues to be a limitation to their full accessibility.

Information sharing

35. In the past decade, CGIAR Centres have explored innovative approaches to facilitate the generation and exchange of information among different actors, taking advantage of advances in information and communication technologies. The numerous open-access databases maintained by CGIAR Centres are used by thousands of scientists from almost all countries of the world each year. For example, the 19 open-access databases maintained by WHEAT received nearly 500 000 unique visits in the period 2011-2016. MAIZE's open-access databases were used by 383 032 unique users in the same period. IRRI's Rice SNP Seek database (which provides genotype, phenotype, and variety Information for rice) was accessed 74 121 times by 8 459 different users in 2015.

36. Many online platforms for knowledge sharing target extension agents and technicians. One example is the Rice Knowledge Bank, which showcases rice production techniques, agricultural technologies and best farming practices based on IRRI's pool of knowledge from research findings, media resources and in-country projects.

Technology transfer

37. CGIAR Centres and partner organizations generate and share technologies and innovative practices for the conservation, characterization, evaluation and use of plant genetic resources for food and agriculture as part of their activities for efficient and rational conservation of germplasm, phenotyping, genotyping, phytosanitation and seed production. Global partnerships for large scale phenotyping and genotyping within CGIAR programmes have facilitated the co-generation and sharing of innovative technologies and techniques.

IV. ACCESS AND BENEFIT-SHARING FOR PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE - ITEM 6 OF THE PROVISIONAL AGENDA

38. CGIAR pursues its mission by generating non-monetary benefits for use by national programmes, companies, farmers in developing countries. Many examples of the kinds of non-monetary benefits developed by the Centres are described above.

39. Most of the CGIAR Research Centres' activities related to the conservation, research and development and distribution of plant genetic resources are governed by the multilateral system of the

ITPGRFA. However, there are some situations where the CGIAR Centres will need to comply with regional, national and sub-national mechanisms that implement Article 15 of the Convention on Biological Diversity (on access and benefit-sharing) and/or the Nagoya Protocol on access and benefit-sharing, for example, when accessing plant genetic resources that are not available through the ITPGRFA's multilateral system. CGIAR has developed guidelines for Centres' compliance with the ITPGRFA and Nagoya Protocol.

40. Under the framework of the FAO/Bioversity/ITPGRFA Secretariat Joint Programme to strengthen capacity of the national partners to implement the multilateral system, the CGIAR Centres were involved in the following activities related to the development and implementation of policies and laws on access and benefit-sharing:

i) "Embedding Mutually Supportive Implementation" of the ITPGRFA and the Nagoya Protocol in the Context of the Broader National Policy Goals – A Workshop for National Teams of Policy Actors, 16th – 20th November 2015, hosted by ILRI, Ethiopia and

ii) Workshop for Nagoya Protocol and ITPGRFA National Focal Points in South and Southeast Asia, 27 to 30 March 2017, hosted by IRRI, the Philippines. Bioversity International, the Secretariats of the ITPGRFA and CBD, the ABS Capacity Development Initiative, African Union Commission and ASEAN Centre for Biodiversity (ACB) worked together to organize these workshops.

41. The same partners (minus ACB) constitute the Expert Guidance Committee for a three year Darwin Initiative funded project entitled "Mutually Supportive Implementation of the Plant Treaty and Nagoya Protocol in Madagascar and Benin". Finally, with support from the Government of the Netherlands, Bioversity coordinated a five-year project supporting implementation of the multilateral system, linked to sustainable use, climate change adaptation and farmers' rights with national partners in Bhutan, Burkina Faso, Costa Rica, Cote d'Ivoire, Guatemala, Nepal, Rwanda and Uganda.

42. Representatives from four CGIAR Centres participated in the International Workshop on Access and Benefit Sharing for Genetic Resources for Food and Agriculture (IWABS) organized by the Secretariat of the CGRFA on 10-12 January 2018.

V. "DIGITAL SEQUENCE INFORMATION" ON PGRFA - ITEM 7 OF THE PROVISIONAL AGENDA

43. In 2017, CGIAR submitted a report to the Convention on Biological Diversity (CBD) in preparation for the Ad Hoc Technical Expert Group on Digital Sequence Information under the CBD. It highlighted particular cases where the generation and use of genomic sequence information has contributed to the conservation and sustainable use of plant genetic resources and sharing benefits associated with the use of those resources. That report is equally relevant for the ongoing deliberations of the ITWG-PGRFA and the larger CGRFA. We hope that delegates to both fora will have the opportunity to read it. The Executive summary is included in Box 2 below. The full report is available in English, French and Spanish on the CBD website¹.

¹ See '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', available at <https://www.cbd.int/abs/DSI-views/CGIAR-DSI-en.pdf>. French and Spanish translations are also available: 'Implications potentielles de l'utilisation de l'information génétique numérique sur les ressources génétiques sur les trois objectifs de la Convention sur la diversité biologique Document soumis par le CGIAR au Secrétariat de la Convention sur la diversité biologique' at <https://www.cbd.int/abs/DSI-views/CGIAR-DSI-fr.pdf>; and 'Posibles repercusiones del uso de la información digital sobre secuencias de recursos genéticos para los tres objetivos del Convenio sobre la Diversidad Biológica Informe del CGIAR presentado ante la Secretaría del Convenio sobre la Diversidad Biológica', at <https://www.cbd.int/abs/DSI-views/CGIAR-DSI-es.pdf>

The Secretary of the CBD called on relevant organizations and stakeholders “to submit views and relevant information on any potential implications of the use of digital sequence information on genetic resources for the three objectives of the Convention”. CGIAR conducts strategic research for agricultural development ensuring food security with a mission to benefit small holder farmers in developing countries. 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 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, agro-ecological 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 Centres 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 Centres’ 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 Centres are providing training and technology transfer for scientists in developing countries so that the impact and advantages from digital sequence data can benefit all

Box 2: Executive summary of ‘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’.