Historical Perspectives on the Role of Crop Diversity in Achieving Food and Nutrition Security

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Dr. Sarada Krishnan is the Director of Programs at the Global Crop Diversity Trust based in Bonn, Germany. In this role, she supervises a team of scientists and project managers, overseeing the implementation of strategic projects and programs designed to support the organizational mandate of securing the world's crop diversity. She oversees the planning, development, and implementation of the overall programmatic technical framework of the organization. She currently serves on the United States Department of Agriculture (USDA) National Genetic Resources Advisory Council and is the chair of USDA's Coffee and Cacao Crop Germplasm Committee. She also serves on Colorado State University (CSU) College of Agricultural Sciences' AgIndustry Leadership Council, on the advisory board of 4C Services and is faculty affiliate in the CSU Department of Horticulture and Landscape Architecture. Her broad interests include biodiversity conservation - both ex situ and in situ, conservation and sustainable use of plant genetic resources with a research focus on coffee genetic resources, food and nutrition security, and economic empowerment of women and girls.

Abstracts

Diversity within and among domesticated species has been the cornerstone of agricultural development. Since the advent of agriculture, farmers around the world have served as custodians of this diversity, safeguarding it for future generations. Through thousands of years of cultivation, farmers have selected for plants that are adapted to local climatic conditions, which are called landraces. But the globalization of agriculture and plant breeding has led to the loss of genetic diversity in farmers' fields, causing genetic erosion. Conservation of plant diversity in genebanks safeguards it for use by current and future generations, both directly by farmers and as the raw materials for research and plant breeding. Genebanks therefore ultimately contribute to sustainable crop production systems, and hence food and nutrition security.

The most important person in the history of crop diversity conservation was Nikolai Vavilov. His work on the biogeography of crop plants provided a theoretical basis for the relationship between a crop's center of origin and the amount of genetic variation it displayed. He conducted numerous collecting trips around the world and identified main and secondary centers of diversity for numerous crops.

Another important historical figure in advancing the conservation of crop diversity was Otto H. Frankel. He developed the concepts of the genetic conservation of crop plants and was central to the efforts to organize genetic conservation from the 1960s onwards. He is credited with bringing together the International Biological Programme (IBP) and the United Nations Food and Agriculture Organization (FAO) in the common cause of halting genetic erosion and conserving crop diversity by advocating for the establishment of a network of regional genebanks. This led to the formation of the Consultative Group on International Agricultural Research, which we now know as CGIAR, and the subsequent formation of the International Board for Plant Genetic Resources, which is now under CGIAR as the Alliance of Bioversity International and CIAT.

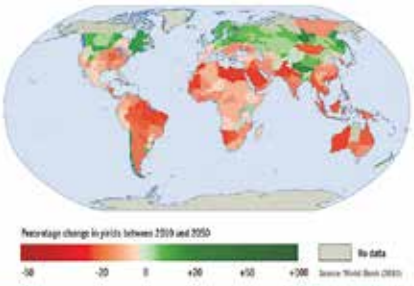
Hundreds of genebanks now conserve the diversity of many crops from all over the world, representing variation at the genetic level, both within and among crop populations. Conservation in genebanks means that landraces threatened with genetic erosion in farmers' fields can be preserved and made available to users. The international genebanks of CGIAR centers conserve the global diversity of some of the major global crops, whereas national genebanks focus on the agricultural heritage of their country, which includes crops more specifically important to the country's culture and its agricultural development. The ultimate security of seed collections is the safety back up in the permafrost at the Svalbard Global Seed Vault. The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) provides a policy framework for the world's genebanks. The Global Crop Diversity Trust is an essential element of the funding strategy of the ITPGRFA and is raising an endowment to support the essential operations of key genebanks around the world, starting with international collections.

Transforming our food systems

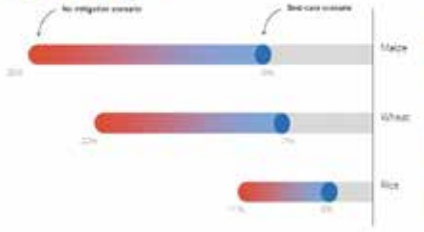
Global Challenges:

- Climate change
- Biodiversity loss
- Increasing population
- Deforestation
- Increased incidence of pests and diseases
- Unsustainable agricultural practices
- Food loss and food waste

Global crop yield loss by 2050 under climate change



Global crop yield loss by end of century under climate change



By the end of the century, the worst-case scenario for crop yield loss would be a disaster, but even the best-case scenario would be devastating for the world's most important crops.

To deal with these global challenges we need crop diversity

Why crop diversity is crucial for a resilient food supply

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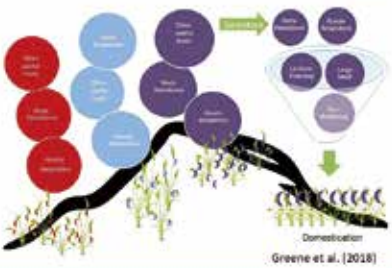
Importance of Crop Diversity

- Domestication -> loss of adaptive traits
- Crop diversity -> source of genetic diversity
  - Climate resilience (heat, drought, difficult soils)
  - Resistance to pests and diseases
  - Key to more and better food with less environmental impact



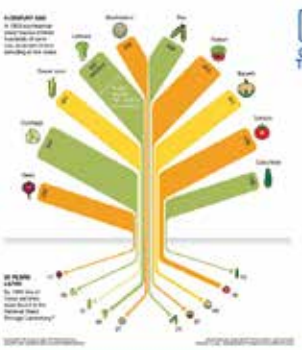
Greene et al. (2018)

Diversity exists between different crop species

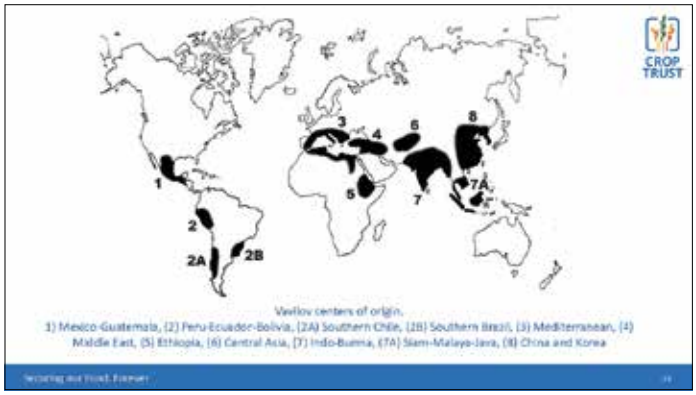
Diversity exists within individual crop species

Loss of biodiversity is real

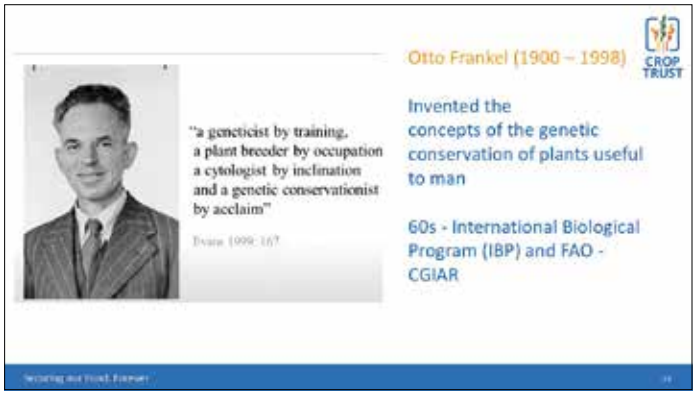
- In review of hundreds of scientific papers on genetic erosion almost **80% of studies found evidence of loss.**
- At least **90% of vegetable varieties** in the US **have gone extinct** since 1903.
- Of the more than **1,000 apple varieties** that used to be grown in Europe, **only six varieties** are the source of apples **grown commercially today.**
- Countless other examples of such 'genetic erosion' are also reported from other crops.



History of Crop Diversity Conservation



Vavilov centers of origin.
1) Mexico-Guatemala, (2) Peru-Ecuador-Bolivia, (2A) Southern Chile, (2B) Southern Brazil, (3) Mediterranean, (4) Middle East, (5) Ethiopia, (6) Central Asia, (7) Indo-Burma, (7A) Siam-Malaya-Java, (8) China and Korea



Otto Frankel (1900 – 1998)

"a geneticist by training, a plant breeder by occupation a cytologist by inclination and a genetic conservationist by acclaim"

Invented the concepts of the genetic conservation of plants useful to man

60s - International Biological Program (IBP) and FAO - CGIAR

Important Milestones

1971 – CGIAR established
1974 – IBPGR established by the CGIAR (FAO administrative host)
1975 to 1995 – collection of >200,000 samples of landraces, CWRs and other materials in 136 countries
1991 - 1993 – Convention on Biological Diversity (CBD) negotiations and enters into force
1994 – "In-trust" agreement of CGIAR genebanks with FAO
2001 – Adoption of ITPGRFA
2004 – ITPGRFA enters into force (Multilateral System of Access and Benefit Sharing, Annex 1 crops – 64 majors crops and forages)
2004 – Crop Trust established by FAO and CGIAR to provide sustainable, long-term funding for *ex situ* conservation
2010/2014 – Nagoya Protocol adopted/entered into force

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In situ *Ex situ*

Role of Genebanks

What is a genebank?

> Genebanks are repositories where genetic materials are safely conserved and available for use

Some plants have seeds that cannot be dried and cooled for storage. These plants are often conserved as small plantlets, growing very slowly under specialized conditions in test tubes in an *in vitro* genebank, or cryopreserved. Others, like fruit trees, can be conserved as adult living specimens in a field.

Plant breeders and farmers can draw on genebanks in their search for particular traits that they need.

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Genebank operations

Long-term storage

Safety duplication

Regeneration & characterization

Information management

Disease testing

Distribution

By end of 2020....

- 5.7 million accession of PGRFA conserved
- in 831 genebanks
- by 114 countries and 17 regional and international research centers

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International Policy Agenda

The global community has specifically recognized the importance of safeguarding crop diversity for a sustainable future:

- United Nations **Sustainable Development Goals** (SDGs)
- **Paris Agreement** at UNFCCC COP21
- **Convention on Biological Diversity** (CBD): Strategic Plan 2011-2020, including the Aichi Biodiversity Targets and Post-2020 Global Biodiversity Framework

Convention on Biological Diversity

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SUSTAINABLE DEVELOPMENT GOALS

RECOGNIZED IN THE UN SDGS

GOAL 2: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

TARGET 2.5: By 2020 maintain genetic diversity of seeds, cultivated plants, farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at national, regional and international levels, and ensure access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge as internationally agreed

Indicator 2.5.1

Number of plant and animal genetic resources for food and agriculture secured in either medium or long-term conservation facilities

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We work closely with the International Treaty

- Funding and implementation mechanism
- Article 15 collections
- Policy training and guidance
- Policy advising and support
- Emergency reserve for genebanks
- Global information system on PGRFA
- Global crop conservation strategies

20 years CROP TRUST

International Treaty on Plant Genetic Resources for Food and Agriculture

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Global system of *ex situ* conservation

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Safety duplication at Svalbard Global Seed Vault

- Opened in February 2008
- > 1.2 million seed samples from 80 countries
- October 2024, more than 30,000 new seed samples deposited from 21 countries

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Future Actions for Food System Transformation

Nutritious and Underutilized Species (NUS) OR Opportunity Crops

The known, the less known and the little known: some examples

	Well researched and well utilized crops (much professional breeding)	Less researched and less well utilized crops (little professional breeding)	Little researched and underutilized crops (very limited professional breeding)
Cereals	Wheat, rice, maize	Millets, quinoa, buckwheat	Teff, kanawa, fonio
Legumes	Beans, chickpeas, soybeans	Cowpea, Lima bean	Bambara groundnut, lablab, lupins
Tubers	Potato, sweetpotato, taro	Yams, jerusalem artichoke	Yam bean, arracacha
Fruits	Apple, watermelon, orange	Guava, breadfruit, litchi	Ackee, longan, carambola
Vegetables	Lettuce, tomato, cabbage	Amaranthus, sorrel, okra	Spider plant, orache
Oilseeds	Sunflower, canola, palm oil, coconut	Macadamia, safflower	Oiticica, chotaduro

We need collective action to deliver food systems:

- that embrace opportunity crops, and
- in which farmers are the agents of change and partners of innovation.

Four mutually reinforcing pillars:

1. Securing crop diversity
2. Research and breeding
3. Value chains and seed systems
4. Policy support

1

Securing crop diversity

- Expanding conservation efforts on opportunity crops, enhancing their availability.

2

Research and breeding

- Making the diversity of opportunity crops available for use by researchers, plant breeders and farmers, by characterizing the collections for specific traits related to climate change resilience and nutrition.
- Integrating this diversity in breeding programs, including the development of public-private partnerships

3

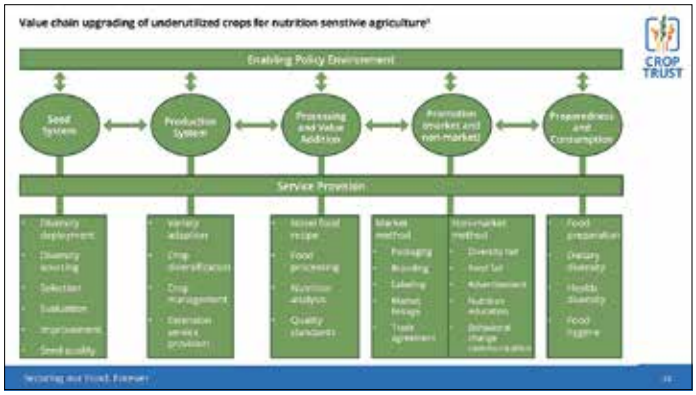
Value chains and seed systems

- Identifying socio-economic obstacles that prevent large-scale adoption of opportunity crops in current food systems
- Supporting integrated seed system development
- Strengthening extension services for opportunity crops

4

Policy support

- Working with international policy frameworks (first and foremost the Plant Treaty) and national governments on enabling environment of policies and regulations that are supportive of diverse food systems
- Raising awareness among broad stakeholder groups



→ A shift from intensive production of major staples to embracing a much wider diversity of crops, their products, and systems of cultivation is no small task.

→ Such an ambitious task is only possible with the support of a wide range of actors, including national governments, multilateral institutions, civil society organizations, the private sector, foundations, think tanks, farmers and others.

→ Genebanks can be at the forefront of this challenge, serving as engine and catalyst.

→ The Crop Trust is an important partner to help advance these ideas together with a wide range of actors.