



Resilient seed systems for climate-change adaptation and sustainable livelihoods in the East Africa sub-region

Report of training workshop, Addis Ababa, Ethiopia, 17-21 September 2019

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RESEARCH PROGRAM ON
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Food Security



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Cover Photo: Farmers explaining about different durum wheat varieties' performance in their crowd-sourcing experiment in Meket woreda, Ethiopia. Credit: Bioversity International.

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Executive summary

Especially in developing countries, farmers face unprecedented climate-change challenges, where their current seed systems do not adequately serve their needs. Despite millennia-long processes of farmer-sections, relatively few locally-adapted varieties or cultivars are available to farmers.

Bioversity International is implementing a Dutch-supported project entitled: *Resilient seed systems for climate change adaptation and sustainable livelihoods in the East Africa sub-region*. This work aims to boost timely and affordable access to good-quality seed for a portfolio of crops / varieties for millions of women and men farmers' and their communities across East Africa. It will do this through combining and scaling successful strategies, methods and tools that build resilient seed systems.

The training featured in this report is an early step in the project scaling work. The first part of the training contextualized the need for and process of effective farmer varietal selection, where workshop participants were first introduced to the concepts of crop domestication, genebanks, seedbanks and climate-change adaptation (section 2). Then participants were introduced to practical demonstrations of some tools and methods used for climate-change analysis (section 3). Section 4 of this report describes how participants were introduced to policy issues associated with managing and accessing crop diversity, including access and benefit-sharing (ABS) issues under the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) and the Nagoya Protocol. Section 5 reports on how participants were introduced to the characterization and evaluation of genetic resources, with reference to on-station trials and Participatory Varietal Selection. Section 6 articulates the gender issues related to seed production and distribution, addressed by the training, and section 7 covers issues related to disseminating elite materials. The final section outlines the field trip that helped to contextualize the whole training.

According to the end of the workshop evaluation, 98% participants declared their overall satisfaction level to be high (74%) or medium (24%). The evaluation indicated the training furnished them with good ideas for using the tools and methods they learned about. In the light of the knowledge and information the participants acquired during the workshop the participants were in a better position to apply knowledge and skills acquired within their own communities and countries. Workshop participants also considered themselves more as part of a network whereby they might refer to each other on how different solutions are working in different situations and share more information on how they are experimenting.

It is recommended that the project team monitors how their knowledge and skills are being applied over the lifetime of the project.

Acronyms

ABS	Access and benefit-sharing (pertaining to germplasm)
CBD	Convention on Biological Diversity
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Centre for Tropical Agriculture
CIP	the International Potato Centre
CTDT	Community Technology Development Trust
CIMMYT	International Maize and Wheat Improvement Centre
FAO	Food and Agriculture Organization
FFS	Farmer Field School
GATT	General Agreement on Tariffs and Trade
GeRRI	Genetic Resources Research Institute, Kenya
GIS	Geographic Information System
GLDC	Grain Legumes and Dryland Cereals
ICARDA	the International Center for Agriculture Research in the Dry Areas,
ICRAF	World Agroforestry Centre
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IITA	International Institute of Tropical Agriculture
IMF	International Monetary Fund
IPRs	Intellectual Property Rights
IRRI	International Rice Research Institute
(IT)PGRFA	(International Treaty on) Plant Genetic Resources for Food and Agriculture
NARO	National Agricultural Research Organization.
ODK	Open Data Kit
PGR	Plant Genetic Resource
PIC	Prior Informed Consent
PVS	Participatory Varietal Selection
QTL	Quantitative Trait Loci
SMTAs	Standard Materials Transfer Agreements
TAHMO	Trans-African Hydro Meteorological Observatory
UK	United Kingdom

USDA	United States Development Agency
USA	United States of America
USSR	Union of Soviet Socialist Republics
WB	World Bank
WTO	World Trade Organization
WW2	World War Two

1. Introduction

1.1. Project context

Especially in developing countries, farmers face unprecedented climate-change challenges. Current seed systems do not adequately serve local farmers' needs for: i) ensuring seed diversity and quality; ii) localized seed production and marketing infrastructures; iii) a dynamic crop-breeding pipeline; and iv) an effective *ex-situ* conservation system, linked to supportive international germplasm-sharing agreements and national seed laws.

Over at least ten millennia, farmers have developed many coping strategies against climate change. Their knowledge and culture, and the genetic characteristics of their crop materials are all important for adaptation to climate change. The relatively few commercial varieties or cultivars that are available to farmers in many parts of the world do not fully meet their needs. It is important that farmers and researchers continue to use, conserve, improve and make available a broader portfolio of varieties from which farmers can choose, including enhanced farmers' varieties and varieties that also accommodate culture and cater for taste preferences. For example, during a field visit in Meket Woreda, Ethiopia, farmers were found to be using different varieties of wheat for different purposes, such as, '*enjera*', '*Kolo*', '*nifro*', porridge, bread and animal feed. It is critical that farmers are recognized as custodians of a range of 'farmer-selected varieties.'

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The training featured in this report is an early step in the scaling work.

1.2. About the training

by Carlo Fadda, Yosef Gebrehawaryat Kidane and Michael Halewood, Bioversity International

The workshop addressed the challenge of determining mechanisms through which farmers could participate in the selection of preferred varieties which subsequently are made available through farmer seed systems for use in food production. There are also policies that discourage or prevent farmers from conserving, improving, exchanging and or adopting potentially useful varieties. The workshop provided an opportunity to review some of the policies and practices that inhibit the active participation of farmers in variety selection. It also focused on how farmers (and research and development organizations working with farmers) can take advantage of evolving policy, legal and institutional frameworks and capacities to access and select from a wider crop diversity of plant genetic resources for food and agriculture. Farmers should be able to access materials that are in national and international crop genebanks around the world (comprised mostly of farmers' varieties and wild relatives, but also sometimes breeders' advanced lines and segregating materials, and even released varieties).

The workshop was organized partly as a follow up to a workshop focusing on the use of crop diversity for climate-change adaptation in March 2019 in Entebbe, Uganda. The workshop was financially supported by the Dutch Ministry of Agriculture. Participants at that workshop identified three strategic areas of work for development as part of a longer-term objective of building capacity in East Africa that can be used for crop adaptation to climate change. The identified areas are: 1) developing and applying crowd-sourcing methods

that engage farmers, and national and private research organizations in crop enhancement activities; 2) promoting and establishing community seedbanks as key frameworks and strategies to strengthen farmer seed systems, and 3) developing a supportive policy framework for the sustainable use of farmers' varieties in seed systems. The workshop focused on the first area and considered policies that support or hinder farmer participatory projects that aim to assemble, evaluate, improve, multiply and disseminate a broad diversity of crop germplasm from numerous potential sources.

At the end of the workshop, the participants were expected to return home with good ideas for using the tools and methods they learned about. In the light of the knowledge and information the participants acquired during the workshop the participants were expected to mainstream these interventions within their own communities and countries, including projects that are being implemented at the national, regional and international levels. One of the expectations of the meeting (and other related Bioversity International meetings) is that workshop participants will consider themselves as part of a network and refer to each other on how different solutions are working in different countries and share more information on how they are experimenting with farmers to find answers.

The first part of the training contextualized the need for and process of effective farmer varietal selection, where workshop participants were first introduced to the concepts of crop domestication, genebanks, seedbanks and climate-change adaptation (section 2). Then participants were introduced to practical demonstrations of some tools and methods used for climate-change analysis (section 3). Section 4 of this report describes how participants were introduced to policy issues associated with managing and accessing crop diversity, including access and benefit-sharing (ABS) issues under the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) and the Nagoya Protocol. Section 5 reports on how participants were introduced to the characterization and evaluation of genetic resources, with reference to on-station trials and Participatory Varietal Selection. Section 6 articulates the gender issues related to seed production and distribution, addressed by the training, and section 7 covers issues related to disseminating elite materials. The final section outlines the field trip that helped to contextualize the whole training.

2. Introducing genetic diversity in agriculture for climate change adaptability

In order to contextualize the need for and process of effective farmer varietal selection, workshop participants were first introduced to the concepts of crop domestication, genebanks, seedbanks and climate-change adaptation.

2.1. Identification of potentially useful and adaptable germplasm

by Carlo Fadda, Bioversity International

The origins of agriculture and crops

Agriculture was born partly through the process of crop species' domestication, originating from within centres of crop diversity, which are spread around the globe. Humans had already begun consuming grains 20,000 to 25,000 years ago, before crop plant species were domesticated, when they were foraged as wild food. Around 12,000 years ago, and as part of an increasingly global process, domestications started in the Middle East; Mesoamerica; the Central Andes; sub-Saharan West Africa; the East African uplands and Ethiopia; India; New Guinea and Indonesia; Central Asia and China.

According to theological and historical records, the first crops were domesticated in the Middle East, and included crops such as einkorn, emmer wheat, barley, faba bean, pea, chickpea, and lentil. These were the first dietary components for agricultural communities. In Africa, domestication occurred between 3,000 and 5,000 years ago for crops such as sorghum, finger millet, pearl millet, and teff.

Domestication has changed the nature of crops, which are very different from their wild relatives. Additionally, of more than 400 higher-plant families, relatively few (<10) lend themselves easily to domestication. These include the Gramineae (cereals and sugar cane), Leguminosae (pulses), Solanaceae (potato, tomato and peppers/capsicums), Cucurbitaceae (squash, cucumber, gourd, melon), Umbelliferae (vegetables, herbs, spices), Cruciferae (vegetables and oil seeds), and Palmae (coconut, oil palm).

Domestication is *the process through which human use of plants and animals leads to morphological and physiological changes that distinguish today's domesticated taxa from their wild ancestors and relatives*. The study of domestication is a multidisciplinary task that combines archaeological and historical evidence with genetics.

Changes occurring during domestication

Changes occurring during domestication vary between crops. In cereals there are some shared characteristics, including loss of shattering and increasing in grain size. Other characteristics include loss of seed dormancy for more uniform and immediate/rapid germination after sowing, synchronization of tillering, a more determinate growth habit (more uniform flowering and ripening), and self-pollination. Also, legumes display increases in seed size, a more uniform growth habit and better synchronization of ripening. In roots and tubers, size of roots and tubers increases are accompanied by almost complete loss of seed production

Some crop plants and some of their wild relatives have been widespread across regions, such that in some crops, domestication only occurred as a single event, while in other crops it occurred independently more than once. Thus, from a genetic diversity perspective, domestication leads to a reduction in genetic diversity

compared to the wild context. Crop domestication knowledge is still incomplete, although several theories exist. Since 2018 several publications have emerged that suggest Ethiopia as the first the centre of origin for crops like durum wheat and barley.

As crops move into new areas that are colder or warmer than their area of origin, genetic diversity often proliferates as a result of adapting to new environments. Thus, for example, wheat grown in Russia differs from the wheat grown in Morocco, because the prevailing environmental conditions in each country are very different and therefore different genotypes have developed in response. There is a bottleneck in terms of genetic diversity, yet at the same time there is genetic expansion as the crops move around due to community seed-sharing activities, and to people migrating or moving around accompanied by their seed stocks. Such diversity bottlenecks also present the opportunity to harness the genetic diversity found in crop wild relatives (CWR) for crop improvement. Hence the increased interest in CWR over the past 50 years. For example, 35 genes for disease resistance found in wild tomatoes are now used in cultivated ones, and traits for stress tolerance have been transferred from *Oryza rufipogon* into cultivated rice (*O. sativa*).

In some parts of the world, sorghum has formed a key part of the food web for more than ten millennia and it is thought that its domestication occurred in Ethiopia, although it may have also occurred in other parts of Africa. Disruptive selection, or the selection of extreme values of a trait over the intermediate values, seems to be responsible for the development of different races and different varieties across Africa. Sorghum reached India about 3,500 years ago. Domestication induced loss of shattering, bigger seeds, and more compact panicles. There are five main races of sorghum: i) *bicolor*- widely distributed in most of Africa and Asia; ii) *caudatum*- found in Sudan; iii) *guinea*, grown in East and West Africa; iv) *durra*, found in Asia and Asia Minor, and v) *kafir*- mainly cultivated in Southern Africa. Quantitative Trait Loci (QTLs), associated with complex genes for certain traits have been found to be linked to crop variability and domestication, and mapped on different chromosomes. These help researchers to better understand the process of domestication and improve breeding effectiveness.

Crops domestication and selection are largely based on cultural, social and local preferences, for example hulled vs naked oats, or 2-row vs 6-row barley, or sticky-, aromatic-, or jasmine rice etc., which are purposefully and differentially selected by farmers in different parts of the world.

Estimates of the time needed to complete domestication remain tentative, with some authors claiming a few centuries and others up to two millennia. What is clear is that post-domestication, populations increased significantly, cities were formed, and society completely transformed.

Most centres of diversity are located in the southern hemisphere. So consequently, most of the current crop and genetic diversities is also largely in the southern hemisphere for a large number of crops.

Crop evolution

For 10,000 years farmers have been growing crops, which have been exposed to natural and efficient selection creating a huge amount of diversity. Many studies illustrate this by matching genetic diversity with population structures based on ethnic groupings. Indeed, when different varieties are clustered into groups, they can be matched 100% with cultural or ethnic groups. In the last 150 years modern breeding has overshadowed farmer selections, producing rapid changes in crops such as rice, wheat, maize, high-value fruits and vegetables, and oil crops. This acceleration through breeding has only occurred for a few crops. There are 7,000 different plant species that can be consumed or be useful for human nutrition, but modern breeding efforts focus mostly on only three cereals (rice, wheat, maize) and some high-value fruits and vegetables.

Adaptation to adverse environments

As elsewhere, crops are also continuously evolving in 'marginal' or stress-prone areas. As the Middle East became drier, farmers began selecting material better adapted for drought. Stress-tolerant types may be adapted to several environments through phenotypic plasticity (the capacity of a genotype to exhibit a variable phenotype in different environments). However, over the centuries, farmers selected the best varieties for any given environment, as well as the ones that were more culturally acceptable. As climate changed over time and new pests and diseases emerged, farmers kept selecting well-adapted material, thus being responsible for today's incredible crop genetic diversity. The traits farmers selected over the centuries are still used today in crop improvement, but the role of farmers as breeders or '*sélectionneurs*' is rarely acknowledged.

History of the system that regulates the seeds industry

Private property was already fairly commonplace in the 15th century. Before then, farmers had free access to 'common' land, as well as having their own piece(s) of land, and there were customary ways of passing the land to their children, so they could freely use the land as they saw fit.

From the mid-16th century, industries were created, mainly starting in Britain and culminating in an industrial revolution, which changed everything. These industries needed manpower, and farming land was enclosed partly to ensure reliable supplies and high productivity. Those who could not access technology, skills and productive capacity were forced off the land into cities as labourers. Major changes in the way we ate and drank occurred between 1700 and 1800.

Such workers' re-organization and major political changes (socialism, revolution all over Europe) stimulated the need to provide adequate food and avoid political instabilities.

Around the end of 19th century and throughout 20th century countries such as Russia, Germany, USA started collecting agricultural genetic resources, the largest being in Russia with over 250,000 accessions of cultivated plants and crop wild relatives by the beginning of World War Two (WW2) as the result of Vavilov and colleagues' collecting missions. These materials were conserved in genebanks, most of them in the public domain, and sometimes close linkages were established between research and genebanks.

The European economies were totally destroyed by WW2, and the Cold War emerged from this conflict, as power moved from Europe to the US. In this new order the US used food to maintain control first in Europe, during the fifties and then mainly in Asia once Europe didn't need further support. Any country against USSR could access the agricultural products produced in USA at very low and subsidized prices. In addition, Global South started developing economies using Keynesian economic policies after de-colonization.

Between 1973 and 1974 oil prices quadrupled, thus making food exports economically unviable, and some countries in the Global South were tired of being dependent on the USSR and USA. At this time the Green Revolution was conceived. During the oil crisis it was easy for individual countries to access loans, mainly from oil producers. At the end of the 1970s, however, a global recession stemmed cash flows and lenders called in their debts. Poor countries needing to honour their debts requested more loans. To avoid national and international bankruptcy, institutions such as the International Monetary Fund (IMF) and the World Bank (WB) were created to give loans to poor countries. However, access to the loans was conditional on loan-recipients making sweeping structural reforms.

The World Trade Organization (WTO) originated to establish the new global order based on free markets imposed on countries wishing to access the loans, free markets, free fluctuations of currencies, and access

to cheap food by Northern countries. In addition to the provisions of WTO's predecessor (the General Agreement on Tariffs and Trade (GATT)), WTO agreements included agriculture, Intellectual Property Rights (IPRs), and sanction mechanisms. During the '50s and '60s agricultural research developed new highly productive varieties and hybrids. These were widely distributed in the '70s when it was no longer convenient to provide Food Aid from the US and other countries. While rice, maize, and barley productivity certainly improved, and this helped combat food crises, the seed prices were inflated. These new 'superior' varieties performed well only in intensive production systems that depended on high levels of pesticides and fertilizers, often under irrigation and so became a major contributor to climate change, loss of biodiversity and environmental degradation. There was also increasing pressure to feed an expanding urban population, and for food supplies to keep abreast of demand.

2.2. Identifying suitable genetic resources for climate-change adaptation

by Gloria Otieno and Tobias Recha, Bioversity International

Introduction

Farmers constantly face challenges related to climate change that include pests and diseases, inaccessibility of "suitable seeds", the narrow genetic base of their crops and nutritional crises. Strategies for adaptation may include finding new (suitable) germplasm, crop improvement and switching to alternative more resilient crops.

Crop and crop variety diversification can be effective in strengthening farmers' capacities to adapt to climate change. Better-adapted germplasm might already be available somewhere in national or international genebanks and/or farmers' fields.

Finding new germplasm

There are several sources that can be used to access germplasm. These include international genebanks, national genebanks, reference communities¹ and other communities. These sources are closely connected. For example, international genebanks are closely connected with national genebanks. The national genebanks get these materials from reference communities and other existing communities.

CGIAR genebanks include those maintained by: the Alliance of Bioversity International and CIAT; the International Potato Centre (CIP), the International Rice Research Institute (IRRI), AfricaRice, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the International Maize and Wheat Improvement Centre (CIMMYT), the International Institute of Tropical Agriculture (IITA), the International Center for Agriculture Research in the Dry Areas (ICARDA), and the World Agroforestry Centre (ICRAF), are the main international providers of plant genetic resources, as well as USDA genebanks and other national genebanks.

Users can also access collections online at: <https://www.genesys-pgr.org/>. Genesys has over 4 million accessions with over 62 crops and crop groups and 408 data sets. Data is detailed with accession identifiers including passport data and holding institution. Most of the listed materials are available from the providers under a standard material transfer agreement (SMTA).

¹ Reference communities are sites for the Open Source Seed System project, these are Hoima in Uganda, Nyando in Kenya, Hombolo and Singida Tanzania.

3. Climate change analysis – Tools and methods

by Tobias Recha, Bioversity International

3.1. Course objectives

- To identify climate data capture tools
- To download climate datasets and data on crop presence
- To prepare and import datasets for use in DIVA-GIS, MaxEnt and Google Earth
- To create temperature and precipitation maps
- To generate suitability maps for sorghum and millet crops

3.2. Source of climate data

Generally, climate data is unavailable to most scientists and research institutions. It takes years to be collected and therefore, it is costly to access it. This module provided the participants with an opportunity to identify both primary and secondary sources of climate data, which can be used to publish their work, and also make predictions and decisions that can improve crop production and diversity. The following are some of the sources of climate data that were identified:

- Local field observations
- National meteorological stations
- Global agencies
- Data bases
- Environmental sensors that include iButtons & Trans-African HydroMeteorological Observatory (TAHMO) weather stations
- Online platforms: WorldClim, Maxim, Google maps, Climate analogues

For environment sensors, which the Bioversity International uses for its work in East Africa, the participants were given a demonstration of TAHMO weather stations which can measure and send data on air temperature, relative humidity, barometric pressure, wind speed and direction, and rainfall. The iButtons allow measuring temperature and humidity at predetermined intervals.



Figure 1:iButtons: Credit: Bioversity International/Kidane Y.G.



Figure 2:TAHMO weather station: Credit: Bioversity International/T. Recha.

The participants were also shown each of the climate sources tools. Practically, the focus was on on-line platforms which included WorldClim, Maxim and Google Maps.

Using WorldClim, a dataset at a spatial resolution of 2.5 was downloaded and later used in Diva GIS for spatial climate trend analysis.

Management and analysis of data downloaded from Maxim was practically demonstrated for estimating daily maximum and minimum air temperature and daily solar radiation values under different climate scenarios. This included creating temperature and rainfall maps from the downloaded data.

Google Earth was used to generate locational maps and also create historical maps of different locations. Amongst many things, Google Maps, can be used to identify sites to set up experiments or to identify households for surveys.

3.3. Using Diva GIS

The use of Diva GIS was practically demonstrated in generating climate maps and crop suitability maps. With Diva GIS, this included the step-by-step procedure from downloading and installing the Diva software from www.diva-gis.org/climate, assembling climate data and world boundaries shapefiles, loading them into Diva and running the model to get different maps of rainfall and temperatures. In addition to this, ECOCROP model was used to create crop suitability maps for sorghum, durum wheat and maize. This model uses environmental ranges to define the suitable area of a crop and is incorporated in Diva GIS.

At the end of the training, participants were able to identify sources of climate data and download the data, create graphs from climate data, absorb basic skills in the use of Diva GIS and design crop suitability maps.

4. Policy issues - ABS issues under the Treaty and Nagoya Protocol

by Michael Halewood, Bioversity International

At the beginning of the training on policy issues, there was a group discussion about laws and material transfer agreement practices in participants' respective countries. Participants were able to review how they are currently transferring the genetic materials to and from other countries, based on the existing material transfer agreements.

4.1. Scene-setting scenarios

Scenario 1: Imagine that there is an outbreak of a new wheat disease in Ethiopia and the Ethiopian national government wants to assemble a programme to manage the spread of this disease and its impacts on local farmers. Looking around, you realize that the same disease doesn't seem to affect farmers growing the same crops in the neighbouring countries. You want to get the wheat crop diversity from these countries to test and use in your Ethiopian emergency response programme. How are you going to get those materials?

Responses/discussion:

From **Tanzania**, the materials are free if they are sent by the national programme. They can be accessed from the Ministry of Agriculture. The provider will issue an export permit and the requested materials will go through phytosanitary check before being transported to Ethiopia. They will be sent using the standard materials transfer agreement (SMTA) adopted for all exchanges under the Plant Treaty's multilateral system of access and benefit-sharing.

As far as **Kenya** is concerned, the Ethiopian research organizations need to send an Import Permit to Genetic Resources Research Institute, then the materials are sent to Kenya Plant Health Inspectorate Services before they are cleared for export. Again, the materials would be sent, by the Genetic Resources Research Institute, Kenya (GeRRI -which is a national public organization), using the Plant Treaty's SMTA.

Concerning **Zambia**, the Ethiopian researcher would need to write to the Ministry of Agriculture to request materials from the genebank. However, there are certain specifications for each crop in terms of treatments and therefore the plant protection and phytosanitary services will issue a phytosanitary certificate for the materials based on the requirements of the requested materials. Zambia is a member of the Plant Treaty and therefore it is legally obliged to share plant genetic materials of the crops listed in Annex 1 of the Plant Treaty that are held by national public research organizations using the SMTA.

Scenario 2: Staying with the same scenario – the wheat disease outbreak in Ethiopia -- assume that you know that in Uganda, there are communities that are using wheat varieties that are not affected by the disease, and the national genebank does not have any samples of those materials. What process should be followed to get these materials from the community to conserve at the genebank?

Responses/discussion:

There are a few ways this could work out. The first step is to identify the farmer(s) with the germplasm that you wish to collect. There is a national law in Uganda that sets out conditions for access to plant genetic

resources: The National Environment (Access to Genetic Resources and Benefit Sharing) Regulations, 2005.²

“A person intending to access GR is required to apply to the local community for Prior informed consent (PIC) The local community may grant PIC after considering the application. Before the local community grants PIC, it will enter into accessory agreement with the applicant. The format for the accessory agreement is provided in the national ABS legislation. Where the GR is on land which is occupied, used or managed by local communities, the PIC and the accessory agreement shall be concluded between the applicant and authorized agent of the local government representing the local communities. Upon obtaining PIC and entering into accessory agreement, the applicant can then enter into MTA.”

-Quotation from the Uganda country pages of the CBD’s Access and Benefit-sharing Clearing House, available at <https://absch.cbd.int/countries/UG>

Probably the easiest approach for the Ethiopian research organization would be to work through the Uganda national agricultural research organization (NARO). NARO works closely with farmers helping them improve their materials, so they are likely to be willing to share material through NARO, but these farmers have to be informed about how the materials will be used, and they have to agree first.

In Uganda, given the way things are set up, it would make sense for the materials to be collected by NARO and deposited in the genebank. NARO could then take responsibility for making sure the materials were free of quarantinable pests and diseases before sending them to the requestor/recipient in Ethiopia. Then they could send them to Ethiopia (again, subject to agreement by the farmers as required by the national law).

Scenario 3: Let’s imagine Zambian agricultural researchers want to get good accessions of groundnuts from Zimbabwe. How do they go about this?

The researcher from Zambia will have to write a request letter to the genebank curator in Zimbabwe. Zimbabwe has ratified the Plant Treaty, but groundnut is not included in Annex 1 of the Plant Treaty, so Zimbabwe is not obliged to provide it using the SMTA. However, the national Zimbabwe genebank has adopted the practice of voluntarily providing non-Annex 1 materials with the SMTA as well. So, the genebank would send samples of the groundnut accessions using the SMTA after all phytosanitary regulatory standards have been met.

Scenario 4: What about the procedure in Ethiopia?

You request the materials from the Ethiopian genebank. However, if the material is endemic like coffee, then it is not allowed to be exported. Otherwise all the materials from the genebank can be accessed so long as you fulfil the requirements to qualify as an importing institution.

² Available on the CBD’s Access and Benefit-sharing Clearing House at <https://absch.cbd.int/database/record/ABSCH-MSR-UG-206734>

4.2. Policies and institutions to support researchers, plant breeders and farmers access to crop genetic diversity

The scenarios above, and the tools and methods for participatory evaluation of varieties described by Carlo, Tobias (and later Yosef) clearly demonstrate the importance of having policies in place to support the accessibility of crop genetic diversity both within countries, and across international borders.

The International Treaty on Plant Genetic Resources for Food and Agriculture (Plant Treaty) came into force in 2004. It currently has 144 country member states, including most of the countries represented at this workshop. The member states agreed to create the multilateral system of access and benefit sharing which includes the Plant Genetic Resources for Food and Agriculture (PGRFA) of 64 crops and forages listed in Annex 1 that are:

- 1) under the management and control of Contracting Parties and in the public domain,
- 2) voluntarily contributed to by natural and legal persons,
- 3) in collections hosted by international institutions (like the CGIAR Centres) that sign agreements with the Governing Body of the Plant Treaty.

There are currently approximately 4.2 million accessions of PGRFA available through the multilateral system from national and international genebanks and other organizations around the world.

Anyone in any member state – public research organizations, seed companies, farmers, hobby gardeners, ... anyone – has the right to ask for samples of those materials, no matter where they are around the world, and receive them for free, or for minimal administrative costs.

All materials in the multilateral system of access and benefit-sharing are transferred using the standard material transfer agreement (SMTA). Those materials can be used for research, training and breeding for food and agriculture. If the recipient uses the materials they got from the multilateral system to develop a new crop variety which they commercialize, and if they don't allow others to use that variety for further research and breeding, they need to make payments to an international benefit-sharing fund created by the Plant Treaty. The governing body of the Plant Treaty decides how that money should be spent. So far, all the money has been distributed to recipients in developing countries to support conservation, sustainable use and crop enhancement projects. So far, US\$ 22 million have been dispensed from this fund. (Almost

all that money came from voluntary donations from donor agencies; very little has come from mandatory payments.)

In the last 12 years of its operations, over 5 million PGRFA samples have been distributed around the world, under 60,000 standard material transfer agreements, as summarised in figure 3.

The Plant Treaty is useful in making all those materials available around the world for adaptation to climate changes. The following case-study demonstrates this utility, based on a methodology followed with research partners in several countries.

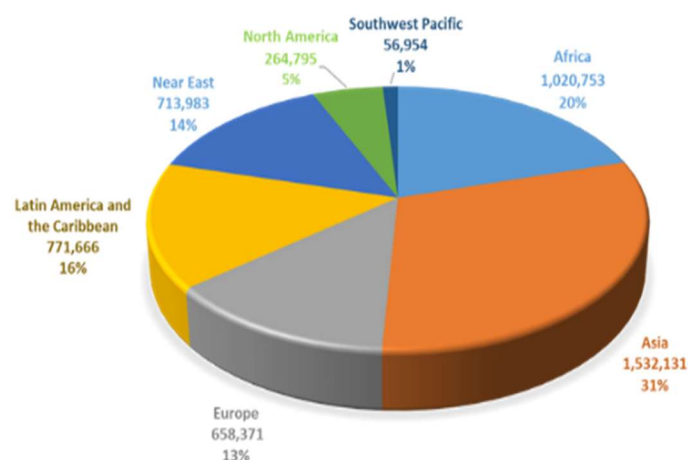


Figure 3: Regions of recipients of germplasm from CGIAR Centers' genebanks and breeding programs 2007-2018 inclusive

First, the team conducted climate change vulnerability analyses within selected communities, to determine the impacts of recent climate changes on farmers production of food security crops.

Second, the team looked for varieties or populations from the national genebank of the country concerned that might have the requisite traits to be adapted for use under changing climate conditions.

Third, they looked for potentially adapted materials from other countries' genebanks, and international genebanks. They did this using publicly available climate data from WorldClim, accession-level passport data from Genesys (with information on over 4.1 million accessions from national and international genebanks around the world) and crop suitability information from Maxent. Following this methodology, they were able to identify portfolios of potentially adapted materials from collections all around the world. Some of those materials had originally been collected from the countries where the team was conducting the research, or from neighbouring countries. But in some cases, the materials were originally collected from other continents.

Most of the materials identified were included in the multilateral system, so all the team had to do was ask for it, and wait for it to be sent and clear phytosanitary regulatory mechanisms.

Fourth, once received, it could be multiplied and distributed to farmers, researchers, plant breeders for further experimentation and use, to see how it performed in the case-study communities or on national research stations.

The multilateral system under the Plant Treaty constitutes an extremely important resource for these kinds of studies. To date, the multilateral system is not exploited to anywhere near its full potential in support this kind of research and development, using genetic diversity to adapt to climatic changes. Part of the reason is that many countries still don't have systems in place to respond to requests, and because they have not published accession-level information about their collections. Perhaps the most limiting factor is that many researchers and communities simply don't know that so much diversity is currently available, for free (or almost for free). Nor do they know how to work through all data needed to identify the materials that are potentially useful in the areas needing to be served. This requires capacities that are beyond many of the farmers' organizations, NGOs and even national agricultural research organizations that might otherwise be interested in taking advantage of the multilateral system. For this reason, it may be useful to establish centres of excellence that could provide support to organizations that want to pilot activities to exploit the resources available through the multilateral system for climate change adaptation, and other agricultural research and breeding.

5. Characterization and evaluation of genetic resources: On-station trials and Participatory Varietal Selection

by Yosef Gebrehawaryat Kidane, Bioversity International

Climate change is accelerating, and its unpredictability is the most challenging aspect. Small-scale farmers are the most vulnerable to change, where key meteorological information might not be available, and local accuracy is questionable. On-farm crop and varietal diversification offers a solution to minimize the risks associated with climate change. A single variety cannot normally perform well everywhere, due to the difference in altitude, local microclimate, and disease and pest pressure. Therefore, a dynamic pipeline of new varieties as well as delivering the seeds of these varieties is crucial. But with the current system it is difficult to test varieties for all locations and deliver seed of a selected varieties.

To tackle the unpredictability of climate change and the wide variability of locations, it is important to conduct research in real conditions where farmers and the prevailing environment can select the best performing varieties.

A relatively new crowdsourcing approach is allowing farmers to interact with different sets of varieties and widen their options to choose what best suits their specific contexts environment and needs.

The first question raised for the training participants was about the advantage and disadvantage of on-farm research. It was compiled as follows.

On-farm trials are usually conducted to:

- Test varieties directly in target environments, under local management practices and production conditions
- Test varieties for farmers' and other end-users' preferences
- Expose farmers to a range of varieties to identify their preferred choices
- Generate adequate variety recommendations for extension
- Minimize the risk of climate change by diversifying crop varieties.

5.1. Challenges in running on-farm trials

Workshop participants were given a chance to name some of the challenges they face while conducting on-farm trials. The following were pointed out:

- i. They are expensive because they require frequent travel to sites and organize farmers who are engaged in conducting and evaluating the experiment,
- ii. Usually, they only manage to conduct a limited number of on-farm trials / limited scale, and this results in exclusion of a big number of farmers,
- iii. On-farm trials are still not so representative for the wide range of target environments and diverse user groups,
- iv. Often, the data is of relatively poor quality despite substantial efforts, compared to on-station trials.

To address some of these challenges, there is a need for more trials to ensure that more target environments are represented in the trials. This will help in compensating for lower data quality, but the trials need to be manageable and not too expensive.

Variety evaluation can also be in the hands of farmers who can undergo training on the required parameters to be collected. This will reduce the cost of production. Farmers who are involved in such types of research are volunteers and can be considered as “citizen scientists”.

In order to compensate for the poor data quality obtained from on-farm trials, researchers need to rethink their statistical methods, and the parameters to be used should be identified by farmers and be as simple as possible. These help in designing and carrying out research that has high adoption by farmers, as they address the needs of the farmer in diverse environments and farm conditions. The work can also be simplified by capacity building of farmers through trainings and minimal supervision. The data collection should also become digital to reduce error and staff need to ensure real time feedback.

5.2. Crowd sourcing methodologies

Crowdsourcing comparisons of technologies can help to introduce new varieties, inputs and practices to rural areas, because the approach empowers farmers to identify the most suitable technologies for the local conditions that prevail on their own farms. Crowdsourcing is a research methodology that involves many farmers in the testing and/or validation of new and promising technologies, like crop varieties, as ‘farmer researchers’.

This means that large numbers of farmers carry out many small and simple trials, instead of a few big trials realized at research stations. The participants provide the observations from their trials to the agricultural research centres, where the data from all mini-trials is merged and analyzed. The research centres then feedback the findings to all participants.

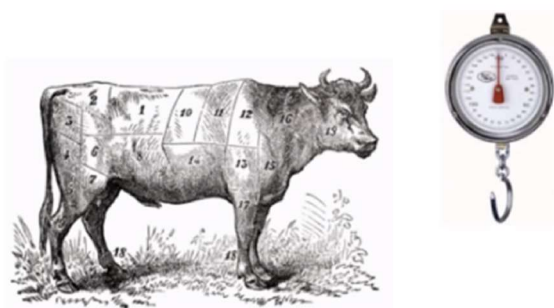
With a crowdsourcing approach, research centres get the opportunity to validate and disseminate new technologies at scale and in a participatory way, collaborating with a large number of participants under diverse conditions. Valid results about the qualities of different technologies (e.g. various varieties of one crop) can be generated from a big number of trials in different environments. Important adoption criteria are easily overlooked in researcher-managed trials, which are generated by the participants. Therefore, higher technology adoption rates and a stronger impact of the research on farming can be expected.

Additionally, rural households benefit from discovering new technologies that are suited to their environmental and socio-economic conditions and have a higher probability of improving their productivity. Crowdsourcing can help farming households to identify the technology that best satisfies their needs, especially in regions where environmental conditions or socio-cultural preferences to crops vary widely in the landscape. Crowdsourcing is a strategy that can overcome the “bottleneck” of technology dissemination to users that many research institutes face.

The training focuses on variety innovation, but the principles of crowdsourcing can be applied equally to other agricultural technologies, like use of fertilizers, biofertilizers and other inputs, or post-harvest technologies. Crowdsourcing with crop varieties may be most useful when it is applied together with other linked interventions directed at strengthening the local seed system: For example, training for farmers in quality seed production, or the establishment of local seed banks.

In the case of crop varieties, one approach has been for participating farmers to receive a package with small quantities of seed of three varieties, from a pool of up to 20 varieties (hence called the ‘Tricot’ approach). These seeds need to be cultivated along with the farmers’ regular cultivation. Each variety is grown on a very small part of their land, and the farmers observe their development. The participants report their observations in a simple format to a local crowdsourcing facilitator, who is a contact person between the researchers and the participants. After harvest, the information from all participants is analyzed, and the farmers receive farm-specific information and recommendations.

This is the practice of obtaining information or input into a task or project by enlisting the experienced services of many people. In this case, the participants were exposed to a crowdsourcing methodology developed by Bioversity International. To demonstrate the power of crowds in increasing accuracy in statistics, the trainer used pictures of a cow and three presidents and the participants were tasked to guess their ages, by guessing the oldest and the youngest.



average of 800 guesses = 1,197
actual weight of the ox = 1,198

Figure 4: Guessing the weight of an Ox: Source: (Galton 1907, *Nature*)

As another example, figure 4 shows that the average results of 800 farmers who guessed the weight of the cow and had only a variance of -1kg/1198kg (less than 0.1%) from the actual weight. When you increase the replication, you draw increasingly near to the reality. This is how crowdsourcing works. The participants were also able to correctly identify the youngest and the oldest presidents despite the small difference in their age and looks.

In crowdsourcing, a very big task is broken down into small multiple tasks to accomplish a big job that is well done.

Ranking is the main approach for data collection in crowdsourcing as it makes it easier to assess the varieties and compare across sites.

For the trial-site layouts, farms are used as incomplete blocks, instead of trying to replicate everything on each farm (Atlin, 2002). A digital platform is used to streamline the process of data collection and analysis to enable provision of faster feedback to farmers.

Table 1: Strengths and limitations of the crowdsourcing methodology

<i>Strengths</i>	<i>Limitations</i>
Quick dissemination of new / unreleased varieties.	Farmers may initially need training and assistance, requiring investment.
Participants can identify a variety they like and that fits to the conditions on their farm.	There is a risk that some or all participants will find none of the tested varieties better than their own varieties.
A large number of farm households can be involved in the approach.	Tricot requires many participants to work well.
Local seed systems are strengthened, because more choices are available to adapt to the changing climate.	If the number of farmers reporting back data is too low, the project may yield less meaningful results for the researchers (although the trials can still be useful to farmers).
New varieties can be tested in many different environments, under real-life farming conditions.	
Unreleased varieties can be matched to the environment where they are best adapted.	

While applying the crowdsourcing methodology, one needs to embrace variation in environment and crop management. This means that one does not try to control the environment but observe it, one does not look for an average or general trend but a representative of the range of target environments.

Advantages and disadvantages of ranking

Advantage of ranking

- Avoids drifting during the judgment process
- Avoids different interpretations between judges of the scoring scale
- Ranking is easier and faster to explain to participants than rating plus judge calibration

Disadvantage of ranking

- Ranking does not give an absolute zero or an absolute scale
- The information contained in the data is limited
- It is difficult to understand the level of difference between the ranking distance among different measures

Overview of a tricot project:

Each project consists of ten steps, which are summarized below.

1. The researchers define a total set of up to 20 promising crop varieties that they want to evaluate and provide seed to the project implementers.
2. The implementing organization (NGO, a governmental extension service, etc.) design the tricot project, using the free online software ClimMob (www.climmob.net).
3. The implementers recruit at least 200 dedicated farmers who are interested in improving their farming by getting to know new varieties.
4. The implementers prepare the trial packages, each of which includes seed samples of three varieties in a randomized order, as well as an observation card, and disseminate them to the participating households.
5. The participants receive the trial packages with a random combination of three varieties, and plant all three separately, but next to each other in a mini-trial on a part of their farm.
6. Every participant is responsible for their trial and makes various easy observations during growth and after harvest. For example: Which variety had highest yield? And which one had lowest yield?
7. The participants mark these observations in the observation card. The local facilitators collect this data and pass it on to the implementing organization.
8. The implementers compile and analyze the data from all trials, using ClimMob.
9. The implementers feedback the information to every participant: the names of their three varieties, which variety is most suited for their farm, and where to get more seed.
10. Crowdsourcing is an iterative process: After every project cycle, researchers, implementers and farmers together evaluate how the process may be improved in the next cycle.

5.3. Practical training on ClimMob

The trainers were taken through the ClimMob platform on how to use the platform from designing to data analysis. The platform uses open data kit (ODK) for field data collection on tablets or smart phones. The trainers were also practically trained how to use ODK and link with the ClimMob.

Crowdsourcing resource materials include:

- Steinke, J., van Etten, J. and Mejía Zelan, P. 2017. The accuracy of farmer-generated data in an agricultural citizen science methodology. *Agronomy for Sustainable Development* 37: 32.
- Steinke, J., and van Etten, J. 2017. Design and validation of “AgroDuos”, a robust and engaging method for farmer-participatory priority setting in plant breeding. *Journal of Crop Improvement*, Online.
- Beza, E., J. Steinke, J. van Etten, P. Reidsma, K. Lammert, C. Fadda, S. Mittra. 2017. What are the prospects for large-N citizen science in agriculture? Evidence from three continents on motivation and mobile telephone use of resource-poor farmers participating in “tricot” crop research trials. *PLoS ONE* 12(5): e0175700
- van Etten J., Steinke J., van Wijk M.T. 2017. How can the Data Revolution contribute to climate action in smallholder agriculture? *Agriculture for Development* 30, 7.
- van Etten, J., E. Beza, L. Calderer, K van Duijvendijk, C. Fadda, B. Fantahun, Y.G. Kidane, J. van de Gevel, A. Gupta, D.K. Mengistu, D. Kiambi, P. Mathur, L. Mercado, S. Mittra, M. Mollel, J.C. Rosas, J. Steinke, J.G. Suchini, K. Zimmerer. First experiences with a novel farmer citizen science approach: Crowdsourcing participatory variety selection through on-farm triadic comparisons of technologies (tricot). *Experimental Agriculture*, Online.
- Steinke, J., and J. van Etten. 2016. Farmer experimentation for climate adaptation with triadic comparisons of technologies (tricot). A methodological guide. Rome: Bioversity International. (English and Spanish).
- van Etten, J., E. Beza, L. Calderer, K van Duijvendijk, C. Fadda, B. Fantahun, Y.G. Kidane, J. van de Gevel, A. Gupta, D.K. Mengistu, D. Kiambi, P. Mathur, L. Mercado, S. Mittra, M. Mollel, J.C. Rosas, J. Steinke, J.G. Suchini, K. Zimmerer. First experiences with a novel farmer citizen science approach: Crowdsourcing participatory variety selection through on-farm triadic comparisons of technologies (tricot). *Experimental Agriculture*, Online.

6. Gender issues related to seed production and distribution

by Andrew Mushita, Community Technology Development Trust

6.1. Introduction

Gender equality envisions men and women being treated equally in social, economic and all other aspects of society and not being discriminated against the basis of their gender. The Food and Agriculture Organization of the United Nations (FAO) defines gender as the socially constructed relationship between men and women both perceptual and material. It is a central organizing principle of societies and often governs the processes of production and reproduction, consumption and distribution (FAO, 1997). Gender relations affect household food security, family well-being, planning, production and many other aspects of life (Bravo-Baumann, 2000)

Through their daily work, smallholder farmers have accumulated knowledge and skills concerning their ecosystems, local crop varieties, animal breeds, agricultural systems and the nutritional values of various under-utilized crops and plants.

They have become adept at maintaining their own scarce resources. Men and women act differently, because of their socially ascribed roles and therefore they have different sets of knowledge and needs. Both men and women decide how much each crop variety to plant each year and how much seed to save from their own production and what to buy or exchange.

All this affects the total amount and nature of genetic diversity that is conserved and used. Therefore, gender equity and equality become fundamental considerations in all our project interventions if we are to achieve inclusiveness, collective decision-making, present equal opportunities and realize engendered sustainable development.

6.2. Course objectives

This module will focus on a series of gender aspects on seed production and distribution activities related to participatory crop testing, farmer-managed seed production and distribution practices. The module will help participants to understand:

- The role of gender-awareness / sensitivity in farmers' accessing good quality seed that is adaptable to their local environment in sufficient quantities, accessibility at the right time, cost effectiveness, responsiveness to local needs and preferences;
- The role of maintenance of crop diversity on the farm and in the local community, and their contribution to seed, food and nutrition security that is gender sensitive

6.3. Gender and crop choice

Cash and export crops are frequently regarded as men's crops while subsistence crops as women's crops. Women are responsible for feeding the family and thus prefer to grow subsistence crops for the household, whereas men are responsible for providing cash income and thus raise cash and export crops.

It is difficult to tell whether women grow lower-value subsistence crops because they have different preferences and concerns or because they cannot access the land, inputs, credit, information and markets that would permit them to do otherwise (Doss, 1999). For instance, in Ghana, women farmers view maize

production as a productive, income-generating activity yet refrain from growing maize because they lack the capital to purchase the required inputs (fertilizer, herbicide) or hire someone to plough the fields.

Most women farmers consider maize cultivation to be a risky enterprise because the crop is sensitive to drought (AdjeiNsiah et. Al, 2007). The cultivation of different crop varieties may or may not vary by gender. Maize, for example, may be grown as a cash or subsistence crop by both men and women.

High-yielding maize varieties were introduced in many areas to generate a marketable surplus, but many of these varieties had different processing, cooking and storage characteristics than the local varieties. Cultivation of various crop varieties by women aims to meet specific needs such as bio-cultural practices, ceremonies, nutritional requirements and food security needs.

High-yielding varieties were often promoted as cash crops which are specifically market-oriented. Consequently, in many places local varieties are considered “women’s” crops, and high-yielding varieties are considered “men’s” crops (Badstue et al, 2007). As long as high yielding varieties are grown for cash and local varieties for food, this gender crop production system may persist. However, as high-yielding varieties that meet the consumption preferences of smallholder farmers are developed, the distinctions between ‘subsistence’ and ‘cash varieties’ may become blurred. For example, both hybrid maize and local maize can be viewed as either subsistence or cash crops, depending on a farmer’s circumstances and market opportunities.

A case study in Tanzania (FAO, 2008) showed that groundnut yields would determine whether the crop was controlled by men or women. If the groundnut harvest was good, men sold the produce in the market; if it was not, the control of the crop would remain with the women.

Gender differentiation also occurs with respect to the combination of crop species and varieties. Commercial systems feature homogeneous varieties of a single crop species, whereas traditional cropping patterns are much more diverse thereby ensuring crop diversification. Women tend to manage complex and species-rich production systems designed to ensure overall production stability and resilience. Some traditional crops determine the social status of men and women and are linked closely to traditional knowledge and culture.

Understanding women farmers’ production strategies with respect to crop stability and resilience will enable agricultural research and development interventions to strengthen farmers’ capabilities to adapt to climate change and improve family food and nutrition security. The large part of the seed that is produced and distributed by the commercial system is too expensive or not easily accessible and often not suited to the specific local environments of most farmers.

Farmer-managed seed systems have the advantage of being responsive to local needs and preferences while contributing to maintaining crop diversity on the farm and in local communities. This is an important contribution to seed and food security.

The importance of farmer-managed seed systems is evident from field data in most developing countries and Africa in particular. For example, estimates for West Africa indicate that farmers access 90%–98% of their seed needs from farmer seed systems, and for the rest of Africa, it is 70%–95%.

In Zimbabwe, despite the presence of many commercial seed companies, it is estimated that 80% of seed needs are satisfied by smallholder farmer seed systems, except for maize. However, challenges affecting farmer-managed seed systems include technical seed-processing requirements, time and effort to develop entrepreneurial expertise, distribution and marketing constraints, and policy and legal restrictions.

6.4. Potential seed sources farmers can use

- Purchases from the (local) market and traders.
- Exchanges with family, friends and neighbours.
- Exchanges with other farmers.
- Receiving seed from the national genebank or a community seedbank.
- Receiving seed directly from plant breeders (could be local breeders or national or international breeders)
- Women mostly use multiple seed sources which are complimentary to each other (formal and farmer seed systems)

6.5. Steps to produce and maintain good quality seed of a crop variety

- **Seed sourcing.** A farmer should acquire clean, pure seeds (so-called “foundation seeds” or registered seeds) from a reliable and reputable source.
- **Land/field selection.** A farmer who intends to produce seed should select the best land for seed production.
- **Isolation of seed fields.** Selection of the field should also consider isolating the crop from any potential seed contamination by pollen grains (airborne or soil borne or easily transmitted by roaming animals).
- **Agronomic management.** This includes good weed management, regular pest and disease control and appropriate crop nutrition.
- **Rogueing off-types.** This is the complete physical removal of off-type or ‘rogue’ plants or plant parts within a seed crop field, which might cross-pollinate or contaminate the seed crop. This should be done throughout the lifespan of the crop but is best to implement this before the seed crop reaches the reproductive stage.
- **Harvesting.** Selecting seed from a field for the following growing season requires continuous observation of the growing process.
- **Processing.** Seed should be inspected at the source and be uniform in shape, size and colour.
- **Storage.** Once harvested, the crop should be stored in a cool dry place so that the quality of the seed is not compromised.
- **Seed monitoring.** To track the health of the seeds stored, verifying seed quality regularly is recommended. (In this case ‘seed quality’ refers to “seed viability tests, pest and diseases infestation, moisture content and seed health”).

6.6. Seed exchanges with other farmers and relevant institutions

Seed exchanges can be realized during farm visits or at social / commercial events such as seed fairs, where women and men play different key roles. The means of seed acquisition include direct barter or purchase or deferred exchange (seed will be repaid later with seed or with a part of the harvest, or sometimes with labour). Farmers rely on reputation and/or visual assessment of the seed to assess seed quality but women have acquired local but time-proven skills in seed quality assessment.

Receiving seed from the national genebank or a community seedbank is another key seed source. Farmers can go to the genebank or community seedbank and request seed of one or more crops of interest. In the

case of a community seedbank, once a seed borrower has harvested the requested crops, she or he returns a small quantity back to the seedbank.

Receiving seed directly from plant breeders (could be local breeders or national or international breeders), where required, should be done according to the rules and regulations of international agreements and/or national policies and laws.

There is a need to strengthen these institutional linkages to enhance seed exchanges. Some plant breeders have crop varieties (old or new) that could be beneficial to farmers and can disseminate these crop varieties to farmers to grow and multiply. However, in this case, the farmers have to rely on reputation and/or visual assessment of the seed to assess seed quality.

In order to produce and maintain good-quality seed of a crop variety over time, certain quality assurance steps and practices have been designed, which should be followed at all times, assuming that the prerequisite time and resources are available. These steps and practices have been taken up by many countries around the world to produce and distribute quality seed that is said to be “true to type,” meaning it is genetically authentic regarding its declared parentage. The steps include the following aspects: land preparation techniques to conserve moisture, timing of planting, plant spacing and population, isolation of seed fields, soil fertility and agronomic management, pest and diseases management, harvesting, seed treatment, processing and storage among others.

Farmers, especially women, require the necessary capacity, skills and entrepreneurship models that will strengthen their role in meeting quality seed production modalities

6.7. Seed certification practices

Seed certification and distribution has the following important steps: Seed harvesting, selection, storage and distribution. Seed certification is the responsibility of the national regulatory authority designed to ensure high quality seed and propagating material. Seed production is concerned with site selection and isolation, sowing, weeding, harvesting, seed processing.

For example, in order to capacitate farmers to improve their plant breeding and variety development methods, Community Technology Development Trust (CTDT) has engaged in facilitating the establishment of Farmer Field Schools (FFSs) (over 300) in 22 wards of the Zimbabwe.

7. Dissemination of Elite Lines

by Andrew Mushita, Community Technology Development Trust

Elite lines are plants (or planting material) that possess phenotypic (physical), agronomic and quality properties which are preferred by farmers. These materials are pre-released materials used in plant breeding in crosses aimed at variety development. Elite lines are usually high yielding, disease and pest tolerant, adapted to local soil conditions and possess tolerances to heat and water stress. These lines form the bases of plant breeding and are owned by plant breeders in research stations or by farmers in their on-farm variety development efforts.

7.1. Utilisation of Elite Lines

Elite lines are there to increase crop biodiversity through the development of new varieties. Utilization of elite lines should aim to advance livelihoods of farming communities by improving their biodiversity and accessing varieties that are adapted to farmers agro-ecological conditions. Such materials should be preferred for physical and agronomic traits by farmers.

7.2. Usage and dissemination of Elite Lines

Forging partnerships with research and plant breeding institutions such as Crop Breeding Institutes (Government), private sector and the CG centres is important for accessing such materials;

Through such institutional arrangements, accessing elite lines of crops desired by and adaptable to farmers conditions in the face of adverse climate change is critical. For the east African sub-region these crops include banana, barley, beans, durum wheat maize, sorghum, and teff, among others.

For example, in order to capacitate farmers to improve their plant breeding and variety development methods, Community Technology Development Trust (CTDT) has engaged in facilitating the establishment of Farmer Field Schools (FFSs) (over 300) in 22 wards of the country

7.3. Participatory Variety Selection by farmers

In these farmer field schools, CTDT has partnered with farmers, researchers, extension workers and plant breeders to train and develop farmers' skills of Participatory Variety Selection (PVS).

PVS is an interactive process in which elite lines are disseminated by research and plant breeding units to farming communities. Farmers grow out the lines in distinct plots and set out traits that they desire for each crop type. These traits can be phenotypic such as head size/shape or agronomic such as days to maturity, efficiency in fertilizer utilization, or biotic, such as pest tolerance. Farmers also have utility traits such as taste and cooking time.

Over seasons the farmer field schools evaluate and select those plants that bear the qualities that are desired.

Feedback is provided to the plant breeders on which of the elite lines evaluated best meets farmer's needs. Breeders then utilize this feedback to develop varieties for commercial release.

Varieties released in this process can then be contracted to seed companies for seed multiplication, production and marketing which leads to increased availability of farmer preferred varieties on the market.

Two Pearl Millet varieties were successfully released by CBI following PVS by CTDT facilitated FFSs in 2018

7.4. Participatory Plant Breeding using Elite Lines

Elite lines are also utilized to improve farmer varieties by introducing new and preferred traits through crossing. CTDT facilitates this through the practice of Participatory Plant Breeding in their Farmer Field Schools. Farmers can introduce traits to already adaptable varieties to combat challenges such as developing resistance to pests and diseases, improving grain yield and shortening days to maturity.

Research once again interacts with farmers, and extension services in developing elite lines into new and improved varieties for farmer utilization and improved productivity.

7.5. Conclusion

Elite lines are superior material developed by plant breeders and used to create new and improved varieties. Where the elite lines are accessed for participatory evaluation and development by farming communities, they result in the release of “farmer-preferred” varieties- those bearing traits desired by and beneficial to farmers and thus most likely to be adopted by farmers.

Dissemination of elite lines is fundamental as it promotes increased biodiversity through increased variety of cultivars each addressing specific farmer needs as it is difficult to have one wonder crop variety.

8. Field Trip to Meket woreda, Amhara region

A field trip to the Bioversity project site took place on 19th and 20th September. The participants were able to interact with farmers who are engaged in wheat crowdsourcing trials. The team visited three crowdsourcing farms and one field trial site. Farmers explained how they have been able to test and rank the productivity, disease resistance and quality of the materials that were introduced and are being tested.

One of the objectives of the field trip was to expose the participants to the crowdsourcing methodology and the ease of using it to get feedback from farmers.

In addition to visiting trials, participants also visited the community genebank where farmers store their selected germplasm for conservation, borrowing and multiplication.

9. Conclusion and evaluation

by Ronnie Vernooy, Bioversity International

Of the 26 workshop participants, 22 completed an evaluation form, providing feedback on the most and least useful elements, suggestions for improvements and other feedback. The tables are provided in annex 10.3, with the main points articulated below:

FEEDBACK- Note: Multiple answers to the following questions were given. The [number] indicates the total number of responses given more or less similar to the statement.

9.1. Most useful elements

Course topics

- The crowdsourcing (TRICOT) approach supported by the ClimMob and Open Source Data Kit. (15)
- Climate change, GENESYS, the DIVA-GIS software and related issues. (10)
- Field visit to farmers. [I was surprising to learn that some farmers use 6-7 varieties.] (5)
- Appreciating the importance of the farmer's social seed network and acknowledging the need for farmer capacity building in seed production and distribution as farmers are the custodians of Plant Genetic Resources for Food and Agriculture. (4)
- How to work with farmers in choosing the best or appropriate germplasm to be developed or improved through breeding or production in the field. (3)
- Law and policy elements. (3)
- Policy and gender Issues related to seed production in a community. (2)
- Practical exercises on use of tools and practical field experience. (2)
- Characterization and evaluation of genetic resources: On-station Trials and Participatory Varietal Selection. (2)
- Having an appreciation of different approaches used by scientists worldwide to collect data from a number of volunteers and be able to carry out some statistical analysis. (2)
- Conservation of genetic diversity.
- We were talking about seed. The most important input for agriculture and the untouched sector in the country.
- The farmers knowledge in selecting varieties (not only yield, parameters such as Injera quality, biomass etc.).
- Methodological steps in a resilient seed system's approach to climate change adaptation.
- Visiting the local seed system was also useful even though it was over-flooded, but you could see the creativity the farmers have for the cold storage.

About the trainees

- The interaction among the diverse participants from different countries was inclusive and attractive. (4)
- It created networking among agricultural experts in Eastern and South Africa that would help for future collaboration in project development and implementation.

9.2. Suggestions for improving the training

Topics

- Include approaches of linking the National Genebanks to Community Seed Banks, not only through germplasm exchange, but mostly PGRFA information.
- Visit to the National Genebank.
- Ranking Low, Medium and High by number or meaning.
- Gender was not well-addressed.
- More in-depth data analysis.
- More time to formally discuss with researcher-farmer(s).
- Since Ethiopia is a center of diversity for durum wheat, teff, Noug ... and others. It is better if the crowdsourcing will be done for those crops too.
- In our field visit, I have seen that areas under crowdsourcing grow mostly cereals (i.e. mono cropping). It would be better if legumes are included in crowdsourcing in the future because it helps to break the disease cycle and increase soil fertility, which in turn help to increase productivity.

Time, trainers, preparations and materials

- The time of training was short; maybe it is best to acquire more knowledge if the time is longer. Exercises should be spread over more days. [Results could be evaluated by the trainers.] (6)
- Training guides/materials should be provided shortly after or before training to enable practicing and to share with colleagues in own institutions. (3)
- Most the training topics were covered by a single trainer; off course, he definitely delivered very successfully his chapters, but for the future, it would be great if you could arrange more trainers/resource persons and share the workload better. (3)
- The local people who are also part of the training could be more hands on in terms of showing the participants around their own country.
- Future training could offer foreigners a half-day time for visit and shopping.
- Training on use of data collection applications, such as ClimMob and ODK, needs a manual to which the learners can always refer in case they forget the procedures.
- Inclusion of representatives from other African countries to participate in presentations to have some knowledge on what is done in other countries. This also help in identifying areas, which require further research within the region.
- Organizing future trainings in different countries to learn from farmers' experiences in their local conditions.

9.3. Final comments

Learning experiences

- We learned a lot from the training, and it was very well organized. [Kudos for Yosef to coordinate things]. (7)
- It was a very successful training and I would like to express my heartfelt gratitude to the organizers who made it possible for every participant to have a chance to learn and collaborate with different colleagues from different agricultural and scientific backgrounds. The beauty of it all was that the platform allowed participants to share experiences on how to help the farmer adopt to climate change and eventually change the livelihood of the farmer and promote food and nutrition security.
- The training is very useful and increased my understanding on how crowdsourcing is to be done, and how to prepare data collection sheet on the computer and how to do data collection with ODK.
- Overall, the training exceeded my expectations. I have learnt a lot. Specially, the modules on crowdsourcing, climate monitoring, and germplasm exchange were very interesting. I can now piece together the concept of resilient seed system for climate change adaptation.
- The training was very impactful, and I hope to use the different methodological approaches in resilient seed systems for my PhD in gender integration in the open source seed systems.
- The Ethiopian seed sector is a dynamic sector because of different interests of the government and private sectors. Training events such as these have the power to encourage collaboration and sharing of ideas. The network should be strengthened in the future. I advise to embed or institutionalize the crowdsourcing activities, by the research centers and Bureau of Agriculture. The result of the crowdsourcing activities should go beyond this and support the seed demand and supply. Some administrators and researchers do not like to think out of the box, focusing on business as usual and complaining about the crowdsourcing model. Facilitating meetings and workshops will help us to erode their attitude.
- We visited very experienced farmer's trial at Geregera and observed their organizational potential. If they could receive support or make a farm cluster, they would be able to multiply seed in bulk and distribute seed to other farmers in the country.
- I have learnt a lot from it and realize that there is a huge gap in South Africa for seed systems, but hopefully this was the beginning of a good collaboration.
- Timing of the season was good, I therefore advice to maintain the same so that participants can appreciate the difference in performance of different accessions.

Networking and collaboration

- The training was very informative and inspiring not forgetting the networking that forms a basis for future collaboration. (4)
- In terms of reception and social interaction, the workshop was the best. (3)
- Keep the trainer's team together.
- Thank you so much for showing the experience of Bioversity International through training and building the foundation for future collaboration.
- I hope if we work together, we can make a meaningful contribution in changing the smallholder farmer's livelihood.
- [Please] Organize a follow up training crowdsourcing and climate change analysis.
- Training be conducted in other countries to see and learn on how they do.

Logistics

- Welfare related issues should be considered as important, especially the out of pocket allowances to aid simple ailments, requirements, transport etc.
- Ensure that the training benefits all invited participants on time and fairly.
- Participants from abroad benefitted to receive their per diem on the first day. Some of them arrived with no money.

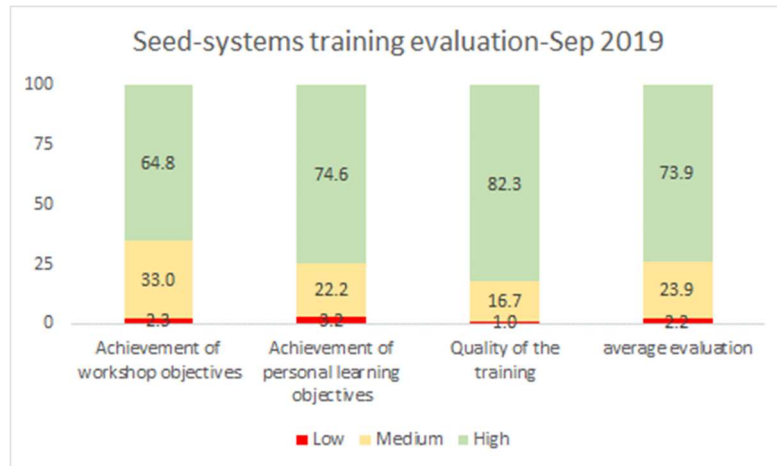


Figure 5: Workshop evaluation

In summary and conclusion, according to the end of the workshop evaluation (see fig 5 and annex 11.2), 98% participants declared their overall satisfaction level to be high (74%) or medium (24%). The evaluation indicated the training furnished them with good ideas for using the tools and methods they learned about. In the light of the knowledge and information the participants acquired during the workshop the participants were in a better position to apply knowledge and skills acquired within their own communities and countries. Workshop

participants also considered themselves more as part of a network whereby they might refer to each other on how different solutions are working in different situations and share more information on how they are experimenting.

It is recommended that the project team monitors how their knowledge and skills are being applied over the lifetime of the project.

10. Reference materials

Workshop participants were provided with the following list of course reference materials, to provide useful background information before attending the workshop.

RESILIENT SEED SYSTEMS PROJECT BACKGROUND

- Recha, T.; Vernooy, R.; Halewood, M.; Otieno, G. (2019) *Resilient seed systems for climate change adaptation and sustainable livelihoods in the East Africa subregion. Report of the consultative workshop, 5-8 March 2019, Entebbe, Uganda. Rome, Italy: Bioversity International, 44 p. ISBN: 978-92-9255-127-8. <https://cgspace.cgiar.org/handle/10568/101278>*
 - This report presents the main results of the consultative start-up workshop for the 'Resilient seed systems in East Africa' initiative which aims to combine and scale from the local to the global level, successful strategies, methods and tools that increase the timely availability, affordability and improved access by women and men farmers and their communities, to good-quality seed of a portfolio of crops and crop varieties, including novel crops and varieties that are better adapted to current and predicted future climate conditions.

RESILIENT SEED SYSTEMS HANDBOOK: 2nd edition

(hard copy also received)

- Vernooy, R.; Bessette, G.; Otieno, G. (eds.) (2019) *Resilient seed systems: handbook. Second edition. Rome (Italy): Bioversity International, 158 p. ISBN: 978-92-9255-138-4. <https://hdl.handle.net/10568/103498>*
 - The Resilient Seed Systems Handbook Second Edition, developed by a multidisciplinary team of Bioversity International researchers and research partners, is a tool that supports research and capacity building on resilient seed systems in the context of adaptation to climate change. The nine modules of the handbook represent steps of a participatory research cycle from situational analysis to knowledge sharing and communication. This second edition includes a new module on seed production and distribution and incorporates several of more recent useful ideas, examples of good practices and the latest references.

CROWDSOURCING, CITIZEN SCIENCE, TRICOT

- Etten, J. 2011. Crowdsourcing crop improvement in sub-Saharan Africa: a proposal for a scalable and inclusive approach to food security. *IDS Bulletin* 42(4), pp. 102–110. Available: <https://bulletin.ids.ac.uk/idsbo/article/view/403>.
 - This article lays the foundation for a comprehensive crowdsourcing approach to crop trials and climate change adaptation, through the massive distribution of promising crop varieties.
- Van Etten, J., de Sousa, K., Aguilar, A., Barrios, M., Coto, A., Dell'Acqua, M., Fadda, C.,
- Gebrehawaryat, Y., van de Gevel, J., Gupta, A., Kiros, A.Y., 2019. Crop variety management for climate adaptation supported by citizen science. *Proceedings of the National Academy of Sciences*, 116(10), pp. 4194-4199. Available: <https://doi.org/10.1073/pnas.1813720116>.
 - This article shows how the crowdsourced citizen-science approach was applied in three different contexts (Nicaragua, Ethiopia, India) and generated new insights on varietal climate adaptation.

- Van Etten, J., Beza, E., Calderer, L et al. 2016. First experiences with a novel farmer citizen science approach: crowdsourcing participatory variety selection through on-farm triadic comparisons of technologies (tricot). Experimental Agriculture. Available: DOI: <https://doi.org/10.1017/S0014479716000739>.
 - This article summarizes important methodological lessons from the first experiences with the crowdsourced citizen-science approach.
- Bessette, G. 2019. Can agricultural citizen science improve seed systems? The contributions of crowdsourcing participatory variety selection through on-farm triadic comparisons of technologies. CGIAR Research Program on Grain Legumes and Dryland Cereals, Hyderabad, India and Bioversity International, Rome, Italy. Available: <http://oar.icrisat.org/11180/>.
 - Based on a review of several years of crowdsourcing experiences in countries around the world, this report summarizes the different features and contributions of the tricot methodology to improve the functionality of seed systems.
- CLIMMOB crowdsourcing smart agriculture, 2015. Bioversity International. Available: <https://climmbob.net/blog/>.
 - This website provides training manuals, instructional videos, and other information and resources for designing and executing successful crowdsourcing projects.

Related Bioversity International website:

- <https://www.bioversityinternational.org/innovations/seeds-for-needs/crowdsourcing/>

SEED BUSINESS DEVELOPMENT

- ISSD Africa. 2017 Making business out of low-profit seed. ISSD Africa synthesis paper. KIT Working papers 2017-1. KIT Amsterdam, the Netherlands. Available: http://www.issdseed.org/sites/default/files/case/issd_africa_twg1_sp1_seed_business_170412.pdf.
 - This paper describes 10 strategies for establishing a farmer-based seed business out of low-profit seed, illustrated by business examples from Africa.
- Manicad, G. 2016. Towards a Business Model: Piloting a Farmer Seed Enterprise in the Sowing Diversity = Harvesting Security (SD=HS) Programme. Oxfam Novib, The Hague, The Netherlands. Available: <https://www.sdhsprogram.org/assets/wbb-publications/361/2.%20Towards%20a%20Business%20Model%20FSE%20of%20the%20SD=HS%2023%20June%202016%20final.pdf>.
 - This paper describes a proposed trajectory for the establishment of a viable farmer seed enterprise.
- Vernooy, R., Netnou Nkoana, N., Mokoena, M., Sema, R., Tjikana, T., Kasasa, P., Mbozi, H., Mushonga, J., Mushita, A. 2019. Coming Together (Batanai): Learning from Zimbabwe's Experiences with Community Biodiversity Conservation, Crop Improvement and Climate Change Adaptation. Bioversity International, Rome, Italy; Department of Agriculture, Forestry and Fisheries, Pretoria, South Africa; Community Technology Development Organization, Harare, Zimbabwe. Available: <https://cgspace.cgiar.org/handle/10568/101241>.

- This brief presents the findings and lessons learned of a study tour by a team from the Department of Agriculture, Forestry and Fisheries of South Africa to neighbouring Zimbabwe, to learn about the roles of farmer field schools, functions and operations of community seed banks and various forms of participatory crop improvement, promoted by the Community Technology Development Organisation of Zimbabwe.

POLICY AND LEGAL ISSUES

- Joint Capacity Building Programme. 2018. Decision-making tool for national implementation of the Plant Treaty's multilateral system of access and benefit-sharing. Bioversity International, Rome. Available:
https://cgspace.cgiar.org/bitstream/handle/10568/93396/Decision_JCBP_2018.pdf?sequence=6&isAllowed=y
- Joint Capacity Building Programme. 2017. Mutually supportive implementation of the Nagoya Protocol and the Plant Treaty: Scenarios for consideration by national focal points and other interested stakeholders. Bioversity International, Rome. Available:
https://cgspace.cgiar.org/bitstream/handle/10568/96525/Mutually_Joint_2017.pdf
 - These two publications were developed as part of the Joint Capacity Building Programme for Developing Countries on Implementation of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) and its Multilateral System of Access and Benefit-sharing (Joint Capacity Building Programme).
- Otieno, G. et al. 2018. Enhancing the capacity of local communities to access crop genetic diversity for climate change adaptation. CCAFS Info Note. CIAT, Cali. Available at
https://cgspace.cgiar.org/bitstream/handle/10568/96090/Benin%20InfoNote_year2_4June2018%20MVE%20%20clean_AB_3July2018%20MVE%20clean.pdf
- Two useful manuals:
- Greiber, T., Peña Moreno, S., Åhren, M., Nieto Carrasco, J., Kamau, E.C., Cabrera Medaglia, J., Oliva, M.J., Perron-Welch, F., in cooperation with Ali, N. and Williams, C. , 2012. An explanatory guide to the Nagoya Protocol on Access and Benefit-sharing. International Union for Conservation of Nature, Gland, Switzerland. Available:
https://cmsdata.iucn.org/downloads/an_explanatory_guide_to_the_nagoya_protocol.pdf
- Moore, G., Tymowski, W., 2005. Explanatory guide to the International Treaty on Plant Genetic Resources for Food and Agriculture. International Union for Conservation of Nature, Gland, Switzerland. Available:
https://cmsdata.iucn.org/downloads/eplp_057_explanatory_guide_to_the_international_treaty_on_plant_genetic_resources_fo.pdf
- Related Bioversity International website:
 - <http://www.bioversityinternational.org/research-portfolio/policies-for-plant-diversity-management/mutual-implementation-of-nagoya-protocol-and-plant-treaty>

11. Annexes

11.1. Workshop agenda

Day 1 -16th	Arrival in Addis
Day 2 - 17th November 2019	
08.30-09.00	Registration
09.00- 10.00	Opening Session - Welcome, note – <i>Yosef Gebrehawaryat & Andrew Mushita, Michael Halewood</i> Introduction of newly arrived participants Introduction to the workshop and workshop Agenda – <i>Yosef Gebrehawaryat</i>
10.00-11.00	Climate change Analysis – Tools and Methods – <i>Tobias Recha</i>
11.00 – 11:30	TEA AND COFFEE BREAK
11.30-13.00	Introducing gene banks: Identification of and identification of potentially adaptable germplasm from genebank collections & climate profiling – <i>Carlo Fadda</i>
13.00-14.00	LUNCH BREAK
14.00-15.30	Exercise on various tools and methods for identification of germplasm – <i>Carlo Fadda</i>
15.30-16.00	TEA AND COFFEE BREAK
16.00-17.00	Q& A
DAY 3 – 18th September 2019	
09.00 – 9.30	Recap Day 1
09.30-10.00	Germplasm Acquisition: Processes, rules and requirements – <i>Michael Halewood</i>
10.00-11.00	Exchange and Use of Genetic Resources: Policy issues (, MLS and SMTAs) – <i>Michael Halewood</i>
11.00-11.30	TEA /COFFEE BREAK
11.30-12.30	Policy Issues - ABS Issues Under Treaty and Nagoya Protocol
12.30-13.00	Q&A
13.00-14.30	LUNCH
14.30-15.00	Introduction to Characterization and evaluation of genetic resources: Crowd sourcing – <i>Yosef Gebrehawaryat</i>
15.00-16.00	Crowd sourcing methodologies and examples – <i>Yosef Gebrehawaryat</i>
16.00-16.30	TEA BREAK
16.30-17.30	Exercises: Crowd Sourcing – <i>Yosef Gebrehawaryat</i>
DAY 4 and 5 – (19th and 20th) Field Trip to Lalibela	
	Identification of traits and potentially suitable crops/varieties in collaboration with farmers of targeting countries (field trip)
Day 6	
09.00 – 9.30	Recap Day 4&5
09.30-11.00	Characterization and evaluation of genetic resources: On-station Trials and Participatory Varietal Selection – <i>Yosef Gebrehawaryat</i>
11.00-11.30	TEA BREAK
11.30-13.00	Identification of genotypes of selected crop species – pre-breeding populations – <i>Yosef Gebrehawaryat</i>
13.00 - 14.30	LUNCH
14.30-15.30	Gender issues in selection of varieties – Dissemination of Elite lines – <i>Andrew Mushita</i>
15.30-16.00	TEA & COFFEE BREAK
16.00-16.30	Q&A
16.30 – 17.00	Wrap up

11.2. Evaluation of the Resilient Seed Systems Training Workshop

Compiled and synthesized by Ronnie Vernooy, Bioversity International

The workshop was attended by 26 participants. 22 submitted the evaluation form.

Achievement of workshop objectives

Workshop outcomes	Low	Medium	High
<i>To be able to follow the different methodological steps in a resilient seed system's approach to climate change adaptation</i>	0	3	19
<i>To be aware of gender and social dimensions that could play a role in participatory crop improvement</i>	0	9	13
<i>To be aware of key policy and legal issues related to all the steps of participatory crop improvement</i>	1	10	11
<i>To be able to find and use relevant sources and resources to put the resilient seed system's approach in practice</i>	1	7	14

Achievement of personal learning objectives

Personal learning objective (please write down)	Low	Medium	High
Multiple learning objectives per participant ranging from 1 to 6, for example: -Climate change analysis -Hands-on practice for using new software -Knowing the benefits of crowdsourcing -Acquisition of materials from genebank for research -Learn about in situ conservation -Awareness of resilient seed systems in local communities -Climate change and adaptation at farm level -Work with farmers to identify their preferred traits -Make connections with other countries -Learn about gender issues -Understand seed systems in a changing environment -Understand policy issues -Visit the field	2	14	47

Quality of the training

Feature	Low	Medium	High
<i>Preparations</i>	1	4	17
<i>Schedule</i>		6	16
<i>Materials</i>	1	3	18
<i>Venue</i>			22
<i>Plenary presentations and explanations</i>		6	16
<i>Exercises</i>		7	15
<i>Knowledge of the trainers</i>		2	20
<i>Overall approached of the trainers</i>		4	18
<i>Capacity of the trainers to respond to your questions</i>		1	21

Analysis:

Area	Level of satisfaction (%)		
	Low	Medium	High
<i>Achievement of workshop objectives</i>	2.3	33.0	64.8
<i>Achievement of personal learning objectives</i>	3.2	22.2	74.6
<i>Quality of the training</i>	1.0	16.7	82.3
<i>average evaluation</i>	2.2	23.9	73.9



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