

# RESILIENT SEED SYSTEMS: HANDBOOK

Second edition



RONNIE VERNOOY, GUY BESSETTE AND GLORIA OTIENO, editors



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Bioversity International is a global research-for-development organization. We have a vision – that agricultural biodiversity nourishes people and sustains the planet. We deliver scientific evidence, management practices and policy options to use and safeguard agricultural and tree biodiversity to attain sustainable global food and nutrition security. We work with partners in low-income countries in different regions where agricultural and tree biodiversity can contribute to improved nutrition, resilience, productivity and climate change adaptation.

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Bioversity International (UK) is a Registered UK Charity No. 1131854.

Citation: Vernooy, R., Bessette, G. and Otieno, G. (editors), 2019.

*Resilient Seed Systems: Handbook*. Second edition. Bioversity International, Rome, Italy.

Bioversity International  
Via dei Tre Denari 472/a  
00054 Maccarese  
Rome, ITALY

Cover Photo: Crop diversity.

Credit: Bioversity International/R. Vernooy

Design and Layout: Luca Pierotti

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ISBN: 978-92-9255-138-4

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# Acknowledgements

The first edition of this handbook (*Resource Box for Resilient Seed Systems: Handbook*), published in 2016, was the result of many useful ideas, examples of good practices and carefully selected references that were first used in a series of training workshops organized by Bioversity International in collaboration with international and national partner organizations around the world. More than 150 researchers, research managers, genebank managers, and extension agents from both government and nongovernmental organizations participated in these training workshops. We thank them for sharing their knowledge and experience.

These training activities and the first edition of the handbook were developed and financed as part of the project ‘Strengthening National Capacities to Implement the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)’, which was funded by the Directorate-General for International Cooperation, Ministry of Foreign Affairs, Kingdom of the Netherlands. This project aimed to promote national implementation of the multilateral system of access and benefit sharing of the ITPGRFA; increase countries’ overall participation in the multilateral system, both as providers and recipients of genetic resources; and pursue options to benefit from other aspects of the ITPGRFA, including technology transfer provisions.

Since 2016, Bioversity International has further developed the resilient seed systems approach and methodology presented in the first edition of the handbook. Research on resilient seed systems and capacity development are ongoing in collaboration with international and national partner organizations in several countries in Africa, Asia and Latin America. The 2<sup>nd</sup> edition of the handbook incorporates several of more recent useful ideas, examples of good practices and the latest references generated by these collaborative initiatives. We thank the colleagues who have contributed and continue to contribute to this new body of work.

We thank the new module co-authors Joseph Kidane and Andrew Mushita for joining our resilient seed systems handbook team, Prem Mathur for the critical review of module 3 on analysis of climate change and identification of germplasm, Essegbemon Akpo, Arnab Gupta and Issoufou Kapran for their contributions to module 6 on seed production and distribution, and Elisabetta Gotor for the critical review of module 8 on participatory evaluation.

The 2<sup>nd</sup> edition of the handbook has been made possible thanks to the financial support of the Ministry of Agriculture, Food Quality and Nature of the Kingdom of the Netherlands under the collaborative agreement on ‘Resilient Seed Systems for Climate Change Adaptation and Livelihood Security.’ We also acknowledge the financial and technical support of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), which is carried out with support from the CGIAR Trust Fund and through bilateral funding agreements. For details, please visit <https://ccafs.cgiar.org/donors>. The views expressed in this document cannot be taken to reflect the official opinions of these organizations.

We thank Evelyn Clancy for the editorial and production support, Sandra Garland for her valuable suggestions for streamlining the structure of the modules and expertly editing the first edition, and Kathleen Sheridan for editing this new version of the handbook.

We also thank Luca Pierotti for updating the design and layout.

The web version of the 1<sup>st</sup> edition is available at: <http://www.seedsresourcebox.org>

The web version of the 2<sup>nd</sup> edition is envisioned for a later stage.

# INTRODUCTION

*Ronnie Vernooy, Guy Bessette and Gloria Otieno*

## Why a handbook for resilient seed systems?

When we meet and work with farmers from all over the world, they all give us the same message: having better access to crop and varietal diversity helps them to adapt to climate change. Under supportive policy and socioeconomic conditions, such strengthened adaptive capacity can contribute to greater food availability throughout the year, with more nutritious and healthy crops, and income generation.

All this sounds very theoretical, but what happens in practice? How can countries design and implement a comprehensive capacity development strategy to access and use crop diversity more effectively to adapt to climate change? That is where the Resilient Seed Systems Handbook, developed by a multidisciplinary team of Bioversity International researchers, comes into play. The handbook is a tool that supports research on resilient seed systems in the context of adaptation to climate change. Bioversity International believes that giving farmers better access to crop and crop varietal diversity will strengthen their capacity to adapt to climate change. Climate and crop modeling tools are increasingly used to project the adaptive capacity of a given crop to the expected changes in climate. Several of these tools are included in the handbook.

The results of these modeling exercises can be used to design strategies to access and use crops and crop varieties that are better adapted to future climate changes in specific sites. Researchers, gene bank managers and farmers could then attempt to gain access to potentially useful plant genetic resources through the multilateral system of the International Treaty on Plant Genetic Resources for Food and Agriculture. Once obtained, they could evaluate these new plant genetic resources in farmers' fields.

Bioversity International is assisting different countries in designing and implementing a comprehensive capacity development strategy to access and use plant genetic resources in the context of climate change adaptation. This handbook aims to support these efforts.

The 2<sup>nd</sup> edition of the handbook updates the 1<sup>st</sup> edition by adding the results of more recent research, expanding on a few topics, refreshing some examples and actualizing the references of each module. It also includes one new module (6) on seed production and distribution, a topic of importance that was missing in the 1<sup>st</sup> edition. All the URLs included in the reference sections were verified in August 2019.

## Smallholder farmers' seed systems under stress

Estimates suggest that 60%-80% of the seeds on which smallholder farmers in developing countries depend is saved on farm or obtained through informal distribution channels, such as exchanges between farmers, community sharing systems, and local markets. Women farmers

play key roles in farmer seed systems, although they are often overlooked by researchers and development personnel, policies, and programs.

This high level of seed autonomy among farmers masks the fact that, almost everywhere, local seed systems are under stress. Agricultural intensification and commoditization, privatization of natural resources, and the strong concentration and expansion of corporate power in the life science industries (including the seed industry) are contributing to a decline in collective local management of plant genetic resources for both conservation and sustainable use.

Many farming households have become more individualized in terms of decision-making and deployment of knowledge, labor, capital and seeds. Traditional seed exchange relationships have become weaker in many areas. Farming practices are becoming more market oriented, and this increased involvement in markets has both benefits and costs depending on local context. Large-scale rural-to-urban migration is contributing to a decline in farming in many countries or transforming small-scale family farming into contract farming. It is also leading to the feminization of agriculture, increasing the workload and responsibilities of women in many regions. These trends are affecting local seed production, selection, storage, distribution, and exchange practices, for example, through substitution of local varieties with hybrids that can be easily purchased at local markets.

Climate change has begun to put additional pressure on farmers' seed and food production systems and on the multiple functions that they fulfill. Although, in many areas, farmers continue to maintain crop diversity, a significant reduction in the number of crops as well as area planted is occurring. Findings from the field point to a decline in diversity of local varieties in many countries. Future impacts of climate change are expected to become more pronounced in many parts of the world, forcing farmers to change their practices and causing them to search for information about crops and varieties better adapted to new weather dynamics.

*Photo: Farmers and  
gourd diversity, Nepal.  
Credit: Bioversity  
International/B. Sthapit*





## Resilient seed systems

When supportive policy and socioeconomic conditions exist, a diversity of seed production and distribution practices makes up a resilient seed system. Such a system will contribute to greater food availability throughout the year and will support the production of more nutritious and healthy crops, income generation and a sustainable resource base. We define a resilient seed system (Subedi and Vernooy 2019) as one which:

- Relies on the ability of seed system actors to absorb disturbances, regroup or reorganize, and adapt to stresses and changes caused by a perturbation in the environment
- Results from multiple seed and knowledge interactions and continuous learning among seed system actors and related institutions
- Is demand driven and responsive to different needs and interests, supporting all users and farming systems
- Recognizes, respects and supports the key roles played by women farmers as seed custodians, managers, networkers and entrepreneurs.

Resilient seed systems reduce vulnerability by:

- Ensuring access to seeds in terms of preference, affordable price and availability when needed
- Ensuring availability in terms of production and distribution
- Guaranteeing seed quality in terms of adaptability, safety and longevity
- Guaranteeing seed choice and diversity
- Producing crops that underpin a healthy diet
- Recognizing and respecting seed as social and spiritual capital.

## The handbook for resilient seed systems

This second edition of the handbook for resilient seed systems provides learning material based on Bioversity International's long experience in seed systems research at local, national and global levels. It contains an action research methodology to build resilient seed systems that meet the needs of tomorrow and help farmers adapt to the effects of climate change.

### **The handbook is intended for:**

- Plant breeders, researchers, genebank managers, extension agents, and policy actors currently involved in climate change adaptation research related to the use of plant genetic resources.
- Other interested plant breeders, researchers, genebank managers and policy actors, as well as university lecturers and advanced students with an interest in plant genetic resources and climate change adaptation.
- Seed sector actors concerned about maintaining crop and crop varietal diversity, in particular in the context of climate change adaptation.

### It can be used as:

- A one-stop address for finding selected resources supporting the research process, to be consulted on an ad-hoc basis or as:
- A learning tool for building capacity in facilitating, conducting and/or participating in such a research process.
- Pedagogical material for higher education classes or on-the-job training workshops.

## Learning objectives

For those participants who would use the handbook as a self-learning course or participate in a structured group learning activity or workshop, they should be able, upon completion to:

- Conduct a situational analysis with communities and other stakeholders
- Plan research for development intervention on resilient seed systems in the context of climate change adaptation, with all stakeholders
- Select the appropriate software and prepare data for seed systems and climate change analysis
- Use selected GIS and related software suitable for the domain of plant genetic resources
- Conduct a climate change analysis in the context of the impact on agriculture and seed systems
- Select appropriate germplasm that is suitable to new and future climate conditions
- Acquire new germplasm from a range of national and international sources
- Plan and implement new germplasm testing on farm and on station
- Learn the different steps of quality seed production and distribution in a farmer-managed seed system
- Understand how germplasm can effectively be conserved and multiplied
- Plan and conduct a participatory evaluation of the research and development intervention
- Share the results of research with different categories of stakeholders.

## Modules

The step-wise action research process is presented in these nine learning modules (figure 1):

**Module 1**, *Situational analysis and planning*, explains how to conduct a situational analysis with farmers and other stakeholders around seed systems and climate change, how to set priorities and objectives and how to plan research for development intervention.

**Module 2**, *Software selection and preparation of data*, presents useful tools, such as DIVA-GIS, Maxent, and Climate Analogue and explains how to prepare relevant data in view of a comprehensive analysis of climate change.

**Module 3**, *Climate change analysis and identification of germplasm*, explains how to conduct a climate-change analysis, in the context of the impact of climate change on agriculture and seed systems, and how to identify appropriate germplasm suitable to new, future climates.

**Module 4**, *Germplasm acquisition*, introduces the reader to the International Treaty on Plant Genetic Resources for Food and Agriculture, and explains how to acquire new germplasm while protecting traditional knowledge and taking into account the phytosanitary aspects of seed production and distribution.

**Module 5**, *Field-testing*, recapitulates the experimentation with new germplasm in farmers' fields and at the experiment station.

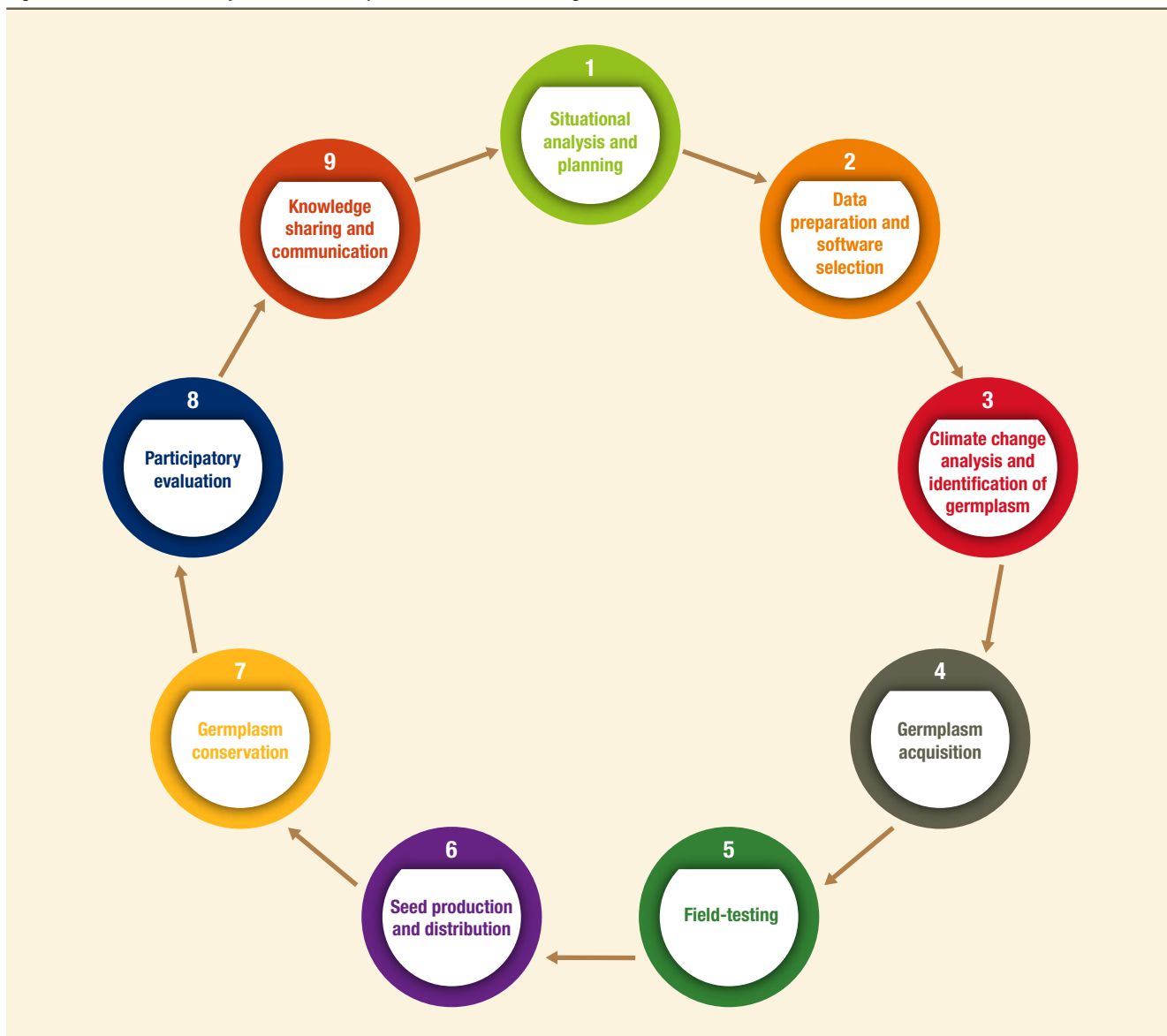
**Module 6**, *Seed production and distribution*, looks at ways in which organized smallholder farmers can produce and market seed, locally and beyond their own communities.

**Module 7**, *Germplasm conservation*, discusses the specific aspects to consider in conserving newly tested and newly acquired germplasm and explains various ways in which it can be safeguarded.

**Module 8**, *Participatory evaluation*, presents a global methodology for evaluating the research process with farmers, genebank managers, extension agents and other stakeholders.

**Module 9**, *Knowledge sharing and communication*, is a module about sharing the research results with the participating actors as well as with different categories of others involved or potentially interested in the results.

Figure 1: Resilient Seed Systems and Adaptation to Climate Change Research Process



## Reference

Subedi, A., Vernooy, R., 2019. Healthy food systems require resilient seed systems. In Bioversity International, *Agrobiodiversity Index Report 2019: Risk and Resilience*. Bioversity International, Rome, Italy, pp. 127-134. Available: <https://hdl.handle.net/10568/100820>.

MODULE 1

# Situational analysis and planning

*Gloria Otieno*



## SITUATIONAL ANALYSIS AND PLANNING

*Photo: Farmers discussing crop growth in the field, Mali. Credit: Bioversity International/R. Vodouhe*

# Introduction

How do women and men farmers in different localities around the world perceive what is happening to the climate? Do they understand how changing climate dynamics are affecting their lives? Farmers must notice that the climate has changed before they can identify useful adaptive practices and explore ways to implement them. The types and range of adaptation options available to farmers depend not only on their perceptions but also on a number of other factors, such as socioeconomic conditions at the household and community levels, the agro-ecology of the farming systems, cultural traditions and practices, and the policy and legal environment. To gain a better understanding of all these factors, a situational analysis must be carried out to lay the foundation for planning and designing an effective climate change adaptation process.

In this module, you will learn the key components of a situational analysis:

- How to conduct a participatory analysis of a community to gain a basic understanding of the baseline conditions and trends
- How to work with farmers to understand their perceptions of climate change, variability, and adaptation; the degree of risk they face; their crop diversity and vulnerability to climate change; and the roles of other institutional actors interacting with the community in relation to adaptation to climate change
- How to develop short-, medium-, and long-term strategies to increase the resilience of smallholders.

By the end of this model, you will have created a plan with farmers that guides research interventions based on a common understanding of the current and desired situations.

## Learning objectives

At the end of this module, you will be able to:

- Work with farmers to determine what is happening in their local environment and their perceptions of climate change.
- Document the effects of climate change on farmers' agricultural activities, livelihoods, and resources, including how gender plays a role.
- Conduct a participatory evaluation of farmers' coping strategies, including a profile of their crop diversity.
- Analyze institutional dynamics in the farming community.
- Conduct a stakeholder analysis.
- Facilitate a participatory adaptation planning process with the community.
- Design an implementation plan and establish priority actions.

## Components of a situational analysis

The situational analysis, which we will conduct in the context of our research on resilient seed systems and adaptation to climate change, involves six steps:

1. Community profiling, an iterative process that involves participatory analysis of a local community
2. Working with farmers to analyze their perceptions of climate change, variability, and adaptation
3. Participatory vulnerability and risk assessment: identifying with communities their strengths and weaknesses in terms of sustaining their livelihoods
4. Assessment of a community's diversity and vulnerability to climate change
5. Stakeholder analysis: identifying the types of relationships between the community and the various existing organizations/institutions working in it and determining their impact on farmers' livelihoods
6. Participatory adaptation planning to develop short-, medium-, and long-term strategies to increase the resilience of smallholders and their adaptation mechanisms

## What do you already know?

- Which aspects of community profiling and crop diversity assessment are you familiar with?
- How do you help farmers assess their vulnerability to climate change and identify the influence of gender?
- Which institutional variables that influence vulnerability are you familiar with?
- Can you give an example of a strategy you have developed with local communities to improve adaptation mechanisms for smallholder farmers?
- What experience do you have in analyzing, summarizing, and communicating the results of a situational analysis?

The six steps are described in the following sections.

## Content summary

- Community profiling
- Analyzing climate change and community mechanisms for adaptation
- Participatory vulnerability and risk assessment
- Assessment of a community's diversity and vulnerability to climate change
- Stakeholder analysis
- Planning participatory adaptation

## Community profiling

Community profiling is a way to gain a basic understanding of the baseline conditions and trends in a community. It is an iterative process that involves the participatory analysis of a community based on four main components: analyzing the sociocultural aspects of the community; identifying agricultural activities and economic livelihoods; mapping landscapes, on-farm diversity, and agro-ecosystems; and identifying land-use characteristics and common resources within the community.

This is complemented by analyzing norms, attitudes and practices, including indigenous traditional knowledge and its application in the use, management, and conservation of agricultural biodiversity and climate change adaptation. An additional method that can be used is “traditional food ways” a participatory tool that captures the whole range of local foods of a community, how food is sourced in the landscape, how it is prepared and consumed, and the roles of the household and community members involved.

The profile establishes the context for decision-making and planning. The profiling process is carried out with the active participation of the community, with the researcher acting as facilitator. The methods and data used for community profiling vary. For instance, one could use secondary sources of information, such as past surveys, or census data, which can provide useful socioeconomic information. Participatory tools, such as the transect walk and village resource mapping, support community participation in the process. A large number of useful tools exist from which a small number can be selected according to the particular characteristics of the community.



## Recommended readings

■ Maundu, P., Kapeta, B., Muiruri, P., Adeka, R., Ombonya, J. (editors), 2013. Safeguarding intangible cultural heritage: a practical guide to documenting traditional foodways using lessons from the Isukha and Pokot communities of Kenya. UNESCO, Paris, France. Available:

<http://www.biodiversityinternational.org/e-library/publications/detail/safeguarding-intangible-cultural-heritage-a-practical-guide-to-documenting-traditional-foodways/>.

*Field manual for assessing communities' food sources in relation to their landscapes and the use and management of diverse sources of food within the community. The approach is valuable to people and institutions interested in safeguarding and promoting the use of local food resources in partnership with local schools.*

■ United Nations Framework Convention on Climate Change, 2013. Best practices and available tools for the use of indigenous and traditional knowledge and practices for adaptation, and the application of gender-sensitive approaches and tools for understanding and assessing impacts, vulnerability and adaptation. Available:

<http://unfccc.int/resource/docs/2013/tp/11.pdf>.

*Literature review and analysis of best practices and available tools for the use of indigenous and traditional knowledge and practices for adaptation and the application of gender-sensitive approaches and tools for understanding and assessing impacts, vulnerability, and adaptation to climate change.*

■ Otieno, G., 2015. Preliminary steps in local climate change adaptation planning: tools and processes for conducting a situational analysis. Biodiversity International, Rome, Italy. Available upon request.

*Succinct and clear description of the tools referred to in this section, namely the transect walk, village resource mapping, the seasonal calendar, livelihood resource and impact assessments, and institutional analysis. Available upon request from Biodiversity International.*

■ Integrated approaches to participatory development (IAPAD), n.d. Transect mapping and diagramming. Available:

[https://siteresources.worldbank.org/EXTTOPPSISOU/Resources/1424002-1185304794278/4026035-1185375653056/4028835-1185375678936/1\\_Transect\\_walk.pdf](https://siteresources.worldbank.org/EXTTOPPSISOU/Resources/1424002-1185304794278/4026035-1185375653056/4028835-1185375678936/1_Transect_walk.pdf).

*This online resource describes the participatory tool, its uses and the process of transect mapping.*

## More on the subject

■ Shrumm, H., Jonas, H. (editors), 2012. Biocultural community protocols: a toolkit for community facilitators. Natural Justice, Cape Town, South Africa. Available:

<http://naturaljustice.org/wp-content/uploads/2015/09/Biocultural-Community-Protocols-Toolkit.pdf>.

*Step-by-step documentation of the process through which external social actors, such as government agencies, researchers, companies, and nongovernmental organizations can interact with communities, considering their customary protocols and governance systems and the ways in which they are codified.*

■ CIP-UPWARD, 2003. Conservation and sustainable use of agricultural biodiversity: a sourcebook, Volume 1: Understanding agricultural biodiversity. CIP-UPWARD, Los Baños, Laguna, the Philippines. Available:

[https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/35111/118718\\_v1.pdf?sequence=4&isAllowed=y](https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/35111/118718_v1.pdf?sequence=4&isAllowed=y).

Offers 33 useful assessment tools in the area of natural resources management explained in a simple to use and illustrated manner. Depending on local context, a small number of tools can be mixed and matched from this collection.

## Analyzing climate change and community mechanisms for adaptation

Analysis of climate change in a community can be done by examining weather data obtained from meteorological stations for trends and comparing this with farmers' perceptions of changes in climate (i.e., longer-term weather dynamics).

Documenting and analyzing farmers' perceptions of climate change and its impact on agriculture are important in developing an adaptation plan. Farmers who do not perceive a change in climate or who lack knowledge about climate change will most likely have no interest or motivation to adapt. The most common way to assess how climate is changing is by using long-term meteorological observations, but these are not always easily available, let alone readable in a form that farmers can understand. Nonetheless, if these data can be collected, synthesized in a simple manner, and presented to farmers, they are a useful basis for discussing climate change with farmers.

In recent years, a number of researchers have developed methods for asking farmers about perceived changes in climate and discussing them. This kind of inquiry can reveal why there might be a discrepancy between meteorological observations and farmers' perceptions as a result of socioeconomic factors and/or biotic stresses that may influence farmers' decisions to adapt or to choose certain measures of adaptation. Qualitative studies often find that the sensitivity of agricultural systems to climate is rarely attributed solely to changes in some exposure or in adaptive capacity to respond to the exposure, as assumed in crop models. Instead, it can be better viewed as a trend over time, influenced by other factors in addition to climate and weather variability.

Various methods and approaches — both qualitative and quantitative — can be used to assess observed changes in climate and their impact on a community. Among them, the seasonal calendar is a tool that involves community members in the process and supports a discussion about significant changes concerning crops and climate. Other methods involve focus-group discussions with farmers.

### Recommended readings

■ Boureima, M., Abasse, A.T., Sotelo Montes, C., et al., 2013. Participatory analysis of vulnerability and adaptation to climate change: a methodological guide for working with rural communities. World Agroforestry Centre, Nairobi, Kenya. Available:

<https://ccafs.cgiar.org/publications/participatory-analysis-vulnerability-and-adaptation-climate-change-methodological-guide#.VvqaUtFJnIU>.

*This guide is designed to help researchers and development workers conduct a participatory analysis of vulnerability and adaptation to climate change with rural communities and to develop action plans that reflect their concerns. Occasional paper 19.*

■ UNU-IAS, Bioversity International, IGES and UNDP, 2014. Toolkit for the indicators of resilience in socio-ecological production landscapes and seascapes. Available:

<http://www.bioversityinternational.org/e-library/publications/detail/toolkit-for-the-indicators-of-resilience-in-socio-ecological-production-landscapes-and-seascapes/>.

*A participatory research tool that aims to clarify and monitor community perceptions of resilience in terms of ecological, agricultural, cultural, and socioeconomic aspects, in both qualitative and quantitative terms. It provides communities with a framework for discussion of the current conditions and problems of the landscapes in which they live or work. Periodic use of the framework enables evaluation of progress toward the project management objectives and identification of priority actors for local innovation and adaptive management.*

■ World Bank, n.d. The seasonal calendar tool. World Bank, Washington, DC, USA. Available:

[http://siteresources.worldbank.org/EXTTOPPSISOU/Resources/1424002-1185304794278/4026035-1185375653056/4028835-1185375811087/3\\_Seasonal\\_calendar.pdf](http://siteresources.worldbank.org/EXTTOPPSISOU/Resources/1424002-1185304794278/4026035-1185375653056/4028835-1185375811087/3_Seasonal_calendar.pdf).

*Detailed description of the key elements of the seasonal calendar and some of its limitations.*

### More on the subject

■ OXFAM-NOVIB, ANDES, CTDI, SEARICE, CGN-WUR, 2013. Building on farmers' perceptions and traditional knowledge: biodiversity management for climate change adaptation strategies. Briefing paper. OXFAM-NOVIB, The Hague, The Netherlands. Available:

[https://www.biodiversityinternational.org/fileadmin/migrated/uploads/tx\\_news/Briefing\\_note\\_Building\\_on\\_farmers\\_perception\\_and\\_traditional\\_knowledge\\_biodiversity\\_management\\_for\\_climate\\_change\\_adaptation\\_strategies\\_1654.pdf](https://www.biodiversityinternational.org/fileadmin/migrated/uploads/tx_news/Briefing_note_Building_on_farmers_perception_and_traditional_knowledge_biodiversity_management_for_climate_change_adaptation_strategies_1654.pdf).

*Initial findings of surveys carried out in Peru, Vietnam, and Zimbabwe to document farmer communities' perceptions of climate change and adaptive actions they have already taken.*

## Participatory vulnerability and risk assessment

Analyzing farmers' vulnerability and risk places importance on local indigenous knowledge and draws on information from communities and their perceptions of this information. The results of the analysis can be used to design strategies for adaptation and can complement other data, such as climate information, weather forecasting, and disaster records.

Participatory vulnerability and risk assessment has four main objectives:

- To analyze vulnerability to climate change and disasters at the community level and determine the potential capacity within the community to deal with climate change and disasters
- To combine community knowledge and scientific data to gain an understanding of local risks
- To assess the risks and vulnerability to climate change of a community's diversity
- To inform local-level adaptation and mitigation action plans directly to reduce the risks from disasters and climate change and the impact of variability.

Participatory vulnerability analysis is based mainly on qualitative data gathered through focus-group discussions with the community. Combining and integrating qualitative and quantitative data (if they are available) can result in rich collections of information. Other data sources can include secondary information obtained from past household surveys or information from key informants or other community or district resource people, such as extension workers and agricultural officers.

The influence of gender and other social variables (class, age, ethnicity) merits special attention and will require appropriate preparations and tools. This can be done by identifying major livelihood activities by gender, age, ethnicity, or class and working with these groups to determine their major livelihoods, the risks and threats they face, and their vulnerabilities.

### Recommended readings

■ Regmi, B.R., Morcrette, A., Paudyal, A., Bastakoti, R., Pradhan, S., 2010. Participatory tools and techniques for assessing climate change impacts and exploring adaptation options: a community based tool kit for practitioners. Livelihoods & Forestry Programme, Kathmandu, Nepal, and UK AID, London, UK. Available:

[https://www.researchgate.net/publication/269409949\\_Participatory\\_tools\\_and\\_techniques\\_for\\_assessing\\_climate\\_change\\_impacts\\_and\\_exploring\\_adaptation\\_options\\_A\\_community\\_based\\_tool\\_kit\\_for\\_practitioners](https://www.researchgate.net/publication/269409949_Participatory_tools_and_techniques_for_assessing_climate_change_impacts_and_exploring_adaptation_options_A_community_based_tool_kit_for_practitioners).

*Presents 13 participatory tools for understanding likely local hazards and risks of climate change and vulnerability of the environment and livelihoods.*

### More on the subject

■ Van Aalst, M.K., Cannon, T., Burton, I., 2008. Community level adaptation to climate change: the potential role of participatory community risk assessment. *Global Environmental Change* 18(1): 165–179. Available:

[http://iciar.lipi.go.id/wp-content/uploads/2012/12/Cannon-et-al\\_participatory-planning-CC.pdf](http://iciar.lipi.go.id/wp-content/uploads/2012/12/Cannon-et-al_participatory-planning-CC.pdf).

*Explores the value of using community risk assessments (CRAs) for climate change adaptation.*

■ Practical Action, 2011. Participatory climate risk vulnerability and capacity assessment (PCR-VCA): tools for operationalizing the Adaptive Livelihood Framework. Practical Action, Colombo, Sri Lanka. Available: <https://www.preventionweb.net/publications/view/17623>.

*A method incorporating climate risk into commonly used vulnerability and capacity assessment. The PCR-VCA set of tools is broadly categorized under three themes: assessing the community's overall risk context, assessing livelihood assets base, and assessing the enabling environment.*

## Assessment of a community's diversity and vulnerability to climate change

A diversified portfolio of crops and crop varieties broadens the genetic base of farming and can be instrumental in creating resilience. An integral part of a situational analysis involves the assessment of a community's crop diversity and its vulnerability to climate change. It also includes evaluation of other factors that affect the status of and trends in crop genetic diversity, with special attention to loss of diversity. If a community's crop diversity has reached a critical state, intervention and adaptation planning may be needed for the short-, medium-, and long term.

Four-cell analysis is a tool used to assess the status of diversity in a community and to monitor diversity at the local level. It is done in a participatory manner with farmers — for one or all crops.



*Photo: Four-cell analysis with farmers, South Africa  
Credit: Bioversity International/R. Vernooy*

Four-cell analysis allows:

- Measurement of the abundance and distribution of local crop diversity within the community
- Identification of common, unique, and rare or endangered varieties or species; understanding and documentation of the reasons why each variety is in a dynamic state; and enhancement of knowledge regarding potential intervention
- Periodic monitoring and assessment of local diversity and inherent changes resulting from climate change or socioeconomic or other environmental factors.

After conducting a four-cell analysis, the next step is to find out from the farmers which varieties they grow are resilient to pests and diseases and which ones could be used for climate change adaptation. During this process, farmers are asked which traits they perceive as making the crop especially resilient. This method also helps plant breeders select possible candidates for plant breeding.

To facilitate this process, we use the technique of participatory ranking of farmers' varieties, a simple exercise where farmers are asked to rank each of the varieties mentioned in the four-cell analysis based on selected traits. The traits and their importance are agreed on with farmers in a focus-group discussion. They may include yield, drought tolerance, water logging capacity, resistance to certain pests and diseases, early maturity, etc. The ranking is done on a scale of 1 to 5 from least to most favorable. The highest ranking varieties can be selected for local adaptation or as good candidates for breeding work.

## Recommended readings

■ Sthapit, B., Rana, R., Subedi, A., et al., 2012. Participatory four cell analysis (FCA) for local crop diversity. In: Sthapit, B., Shrestha, P., Upadhyay, M. (editors). On-farm management of agricultural biodiversity in Nepal: good practices – revised edition. Bioversity International, Rome, Italy; Local Initiative for Biodiversity, Research and Development, Pokhara, Nepal; Nepal Agricultural Research Council, Kathmandu, Nepal, pp. 13-16. Available:

[http://www.bioversityinternational.org/uploads/tx\\_news/On\\_farm\\_management\\_of\\_agricultural\\_biodiversity\\_in\\_Nepal\\_Good\\_Practices\\_revised\\_edition\\_2012\\_1222\\_.pdf](http://www.bioversityinternational.org/uploads/tx_news/On_farm_management_of_agricultural_biodiversity_in_Nepal_Good_Practices_revised_edition_2012_1222_.pdf).

*This case study from Nepal illustrates the uses of four-cell analysis, the process, and implications of the results.*

## More on the subject

■ Vernooy, R., Sthapit, B., Tjikana, T., Dibilane, A., Maluleke, N., Mukoma, T., 2013. Embracing diversity: inputs for a strategy to support community seedbanks in South Africa's smallholder farming areas. Bioversity International, Rome, Italy, Department of Agriculture, Forestry and Fisheries, Pretoria, South Africa. Available:

[http://www.bioversityinternational.org/uploads/tx\\_news/Embracing\\_diversity\\_inputs\\_for\\_a\\_strategy\\_to\\_support\\_community\\_seedbanks\\_in\\_South\\_Africa%E2%80%99s\\_smallholder\\_farming\\_areas\\_1698\\_01.pdf](http://www.bioversityinternational.org/uploads/tx_news/Embracing_diversity_inputs_for_a_strategy_to_support_community_seedbanks_in_South_Africa%E2%80%99s_smallholder_farming_areas_1698_01.pdf).

*This report places four-cell analysis carried out in two smallholder farming areas of South Africa into a broader context of the need for in situ conservation.*

■ Van de Gevel, J.M.J., Bijdevaate, M., Mwenda, P., Morimoto, Y., Fadda, C., 2014. Collecting household level data on varietal diversification and adaptation strategies to climate change in East Africa. Bioversity International, Rome, Italy. Available:

[https://www.bioversityinternational.org/fileadmin/migrated/uploads/tx\\_news/Collecting\\_household\\_level\\_data\\_on\\_varietal\\_diversification\\_1827.pdf](https://www.bioversityinternational.org/fileadmin/migrated/uploads/tx_news/Collecting_household_level_data_on_varietal_diversification_1827.pdf).

*This training manual contains suggestions for field coordinators and researchers who train survey teams in field sites on how to collect data from rural households and communities. The methods were developed and tested in research areas in East Africa.*

■ Van de Gevel, J.M.J., Bijdevaate, M., Mwenda, P., Morimoto, Y., Fadda, C., 2014. Guiding focus group discussions on varietal diversification and adaptation to climate change in East Africa. Bioversity International, Rome, Italy. Available:

[https://www.bioversityinternational.org/fileadmin/migrated/uploads/tx\\_news/Guiding\\_focus\\_group\\_discussions\\_on\\_varietal\\_diversification\\_and\\_adaptation\\_to\\_climate\\_change\\_in\\_East\\_Africa\\_1826.pdf](https://www.bioversityinternational.org/fileadmin/migrated/uploads/tx_news/Guiding_focus_group_discussions_on_varietal_diversification_and_adaptation_to_climate_change_in_East_Africa_1826.pdf).

*This training manual provides suggestions for field coordinators and researchers who are organizing focus-group discussions in farming communities. It serves as a training manual for facilitators and allows them to familiarize themselves with the objectives of the focus groups and the tools used to collect data. The methods were developed and tested in research areas in East Africa.*

## Stakeholder analysis

Stakeholder analysis is used to identify relations between the community and the various organizations and institutions that work in or influence the community and the impact of these relations on the community. It can also be used to identify relations between the stakeholders that work in the community and how these present opportunities or threats to the adaptation process. This type of analysis is useful for clarifying the roles of local actors, how they affect adaptation activities, and the possibility of improving the capacity of the local community to adapt to climate change. In the context of resilience and adaptation, organizations and institutions that can provide alternative measures, such as improved seeds, varietal testing, and general support to smallholders, are of special interest.

The analysis is done by listing and interrelating the various institutions in the area and mapping their relationships with each other and with the community. A number of approaches can be used to assess institutions: for example, the Venn diagram, pictorial representation, and mapping in terms of efficiency, relationships, distance, and access to service. These methods can be complemented by key informant interviews.

## Recommended readings

■ Reed, S.M., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Quinn, C.H., Stringer, L.C., 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management* 90: 1933-1949.

*This paper asks why and how stakeholder analysis should be conducted for participatory natural resource management research.*

■ Regmi, B.R., Morcrette, A., Paudyal, A., Bastakoti, R., Pradhan, S., 2010. Participatory tools and techniques for assessing climate change impacts and exploring adaptation options: a community based tool kit for practitioners. *Livelihoods & Forestry Programme*, Kathmandu, Nepal, and UK AID, London, UK, pp. 41–43. Available:

[https://www.researchgate.net/publication/269409949\\_Participatory\\_tools\\_and\\_techniques\\_for\\_assessing\\_climate\\_change\\_impacts\\_and\\_exploring\\_adaptation\\_options\\_A\\_community\\_based\\_tool\\_kit\\_for\\_practitioners](https://www.researchgate.net/publication/269409949_Participatory_tools_and_techniques_for_assessing_climate_change_impacts_and_exploring_adaptation_options_A_community_based_tool_kit_for_practitioners).

*Tool 12 in this kit, Mapping adaptation partnerships, explores the institutional context in which a community operates and identifies appropriate institutional partners for adaptation.*

## More on the subject

■ Schmeer, K., 1999. Guidelines for conducting a stakeholder analysis. *Partnerships for Health Reform*, Bethesda, Maryland, USA. Available:

<http://www.who.int/management/partnerships/overall/GuidelinesConductingStakeholderAnalysis.pdf>

*Developed in the context of health reform, these guidelines present a systematic process for collecting and analyzing data on stakeholders.*

■ Chevalier, J.M., Buckles, D.J., 2008. Stakeholder identification: identifying stakeholders in a project to prevent and reduce the impacts of floods and landslides in Nepal. In *SAS<sup>2</sup>: a guide to collaborative inquiry and social engagement*. International Development Research Centre, Ottawa, Canada, pp. 165-177. Available:

<http://www.idrc.ca/EN/Resources/Publications/Pages/IDRCBookDetails.aspx?PublicationID=108>.

*This book chapter presents a methodology for identifying stakeholders, illustrated by the case of a project to prevent and reduce the impacts of floods and landslides in Nepal.*

■ Chevalier, J.M., Buckles, D.J., 2013. Module 4: Knowing the actors. In *Participatory action research: theory and methods for engaged inquiry*. Abingdon, Routledge. UK, pp. 253-292. Available:

<https://www.participatoryactionresearch.net/>.

*More information on social analysis and stakeholder identification. A free copy of the book is available with registration on their site.*

## Participatory adaptation planning

The final step in situational analysis is participatory adaptation planning. The aim is to develop short-, medium-, and long-term strategies to increase the resilience of smallholders and their adaptation mechanisms. It includes three main stages. First, analyzing information collected during each step of the situational analysis is an all-inclusive process involving the community, the researchers, and the institutions that work in or close to the community, such as farmers' organizations, extension workers, local community-based organizations, and nongovernmental organizations.

The second stage is development of an implementation plan based on identified vulnerabilities. It should include various intervention strategies, such as using climate-smart technologies, introducing new or improved varieties, and participatory plant breeding, as well as other institutional interventions or policies.

The third and final stage of the implementation plan should spell out who is doing what, where, and how. Priorities should be based on criteria, such as cost effectiveness, feasibility, and impact. Implementation plans can also describe long-, medium-, and short-term strategies, indicate the timeframe for implementing each, and include mechanisms for monitoring, evaluation, and impact assessment. As for the other steps in situational analysis, this is done in collaboration with the local community.

### Recommended readings

■ Regmi, B.R., Morcrette, A., Paudyal, A., Bastakoti, R., Pradhan, S., 2010. Participatory tools and techniques for assessing climate change impacts and exploring adaptation options: a community based tool kit for practitioners. Livelihoods & Forestry Programme, Kathmandu, Nepal, and UK AID, London, UK, pp 44-49. Available:

[https://www.researchgate.net/publication/269409949\\_Participatory\\_tools\\_and\\_techniques\\_for\\_assessing\\_climate\\_change\\_impacts\\_and\\_exploring\\_adaptation\\_options\\_A\\_community\\_based\\_tool\\_kit\\_for\\_practitioners](https://www.researchgate.net/publication/269409949_Participatory_tools_and_techniques_for_assessing_climate_change_impacts_and_exploring_adaptation_options_A_community_based_tool_kit_for_practitioners).

*Tool 13, Community based adaptation planning, gives insight into methods for adaptation planning, stakeholder engagement, and the development of adaptation plans with communities.*

### More on the subject

■ Chaudhury, A.S., Helfgott, A., Thornton, T.F., Sova, C., 2014. Participatory adaptation planning and costing: applications in agricultural adaptation in western Kenya. Mitigation and Adaptation for Global Change, July. Available:

<https://ccafs.cgiar.org/publications/participatory-adaptation-planning-and-costing-applications-agricultural-adaptation#.VvuiAdFJnIU>.

*This paper introduces an analytical framework called Participatory Social Return on Investment, which provides a structured framework for multi-stakeholder planning, selection, and valuation of appropriate methods of adaptation.*



## Testing your knowledge

Here is a quiz that will help you test your newly acquired knowledge. Once you have covered the content sections and completed the assigned readings, please answer the Situational analysis and planning quiz.

You can then compare your answers with those provided at the end of this manual.

**1.** A situational analysis in the context of resilient seed systems and adaptation to climate change encompasses different steps of activities. Which step(s) is (are) missing in the following list: a) Community identification and profiling, b) Analyzing with farmers their perceptions on climate change, variability and adaptation, c) The assessment of a community's diversity and its vulnerability to climate change, d) Participatory adaptation planning.

- a. Transect walk
- b. Participatory vulnerability assessment
- c. Participatory ranking of varieties
- d. Village resource mapping
- e. Seasonal calendar
- f. Stakeholder analysis

**2.** Community profiling is a process that involves a participatory analysis of a community. This is done through:

- a. Identifying the socio-cultural aspects of a community
- b. Identifying land use characteristics and common resources within the community
- c. Discussing the local understanding of climate change and how it affects them
- d. Identifying adaptation mechanisms
- e. Identifying types of agricultural activities and economic livelihoods
- f. Mapping landscapes and diversity on farm and within the community
- g. Assessing the risks and vulnerability of the community to climate change

**3.** Which of these tools are usually used to analyze with farmers their perceptions of climate change, variability and adaptation?

- a. Transect walk
- b. Village resource mapping
- c. Seasonal calendar
- d. Participatory ranking
- e. Four-cell analysis
- f. Livelihood resource assessment

**4.** Participatory vulnerability analysis is usually done through:

- a. A questionnaire distributed and discussed with farmers
- b. A survey of the area
- c. Focus-group discussions
- d. A community meeting
- e. The collection and analysis of secondary sources

5. The method of Four Cells Analysis is usually applied through:
  - a. The distribution of a questionnaire
  - b. A survey of the area
  - c. Focus-group discussions
  - d. A community meeting
  - e. Researching secondary sources
  - f. Ranking
6. Stakeholder analysis is useful for:
  - a. Identifying the relationships between stakeholders that work in the communities and how these relationships present opportunities or threats to the adaptation process
  - b. Identifying the relationships between the community and the different existing organizations and institutions working in or influencing the community and the impact of these relationships on the community
  - c. Understanding the roles of other local actors and how their activities impact shaping adaptation and the possibilities for improving capacities of local communities to adapt to climate change.
7. The main step in participatory adaptation planning is:
  - a. Information collected during each stage of the situation analysis
  - b. Developing an implementation plan based on the vulnerabilities identified, and targeting different intervention strategies while taking into consideration gender and social variables
  - c. Identifying who is doing what, where and how.

## Applying your new knowledge

Now that you are able to conduct a situational analysis, it is time to apply your new knowledge. Please, document this step of the research process by identifying the data collected through:

1. Community profiling
2. Working with farmers to analyze their perceptions of climate change, variability, and adaptation
3. Participatory vulnerability and risk assessment
4. Assessment of a community's diversity and vulnerability to climate change
5. Stakeholder analysis
6. Participatory adaptation planning

# MODULE 2

# Data preparation and software selection

*Gloria Otieno, Jeske van de Gevel,  
Maarten van Zonneveld and Joseph Kidane*



## DATA PREPARATION AND SOFTWARE SELECTION

*Photo: Trying out the climate analogue tool, Nepal.*  
*Credit: Bioversity International/R. Vernooij*

# Introduction

In module 1, you learned the key components of a situational analysis or overview of a community's vulnerabilities. This is needed to be able to plan and prioritize key interventions with the various institutions that work within the community, e.g., introducing new varieties from abroad to increase local diversity, working with the national genebank to restore lost varieties, setting up a community seed bank to conserve threatened varieties, or a combination of these interventions.

In this module, you will learn about the identification, collection, and preparation of existing open-source climate and crop datasets, how to clean and prepare your own data, and how to import geo-referenced data into mapping and modeling software. You will become familiar with key features and the use of software packages and online resources, such as DIVA-GIS, MaxEnt, Climate Analogues, and Google Earth, to determine how patterns of plant genetic resource interdependence may change in the future.

At the end of this module you will be able to start designing one or more strategies to use and safeguard plant genetic resources that are better adapted to climate change.

### Learning objectives

At the end of this module, you will be able to:

- Download climate datasets and data on crop presence
- Prepare and import your dataset for use in DIVA-GIS, MaxEnt, and Google Earth
- Create online maps with the Climate Analogues tool

## What do you already know?

- Do you work with biodiversity data? Have you ever downloaded occurrence data from portals such as Genesys PGR? For what purpose? What was your experience in using these data portals?
- What experience do you have in using climate data in your research? Are you familiar with WorldClim datasets? Which datasets have you used and for what purpose?
- Do you have experience with mapping and modeling software, such as MaxEnt, DIVA-GIS, and Google Earth? Have you used such software to combine biodiversity data with climate data to create multilayered maps or models?
- Have you heard or read about the concept of climate analogues? Have you considered applying this concept in your own research? In what way could it be useful?

### Content summary

- Data sources
- Preparing data for importing into selected software
- Importing data into DIVA-GIS and MAXENT

## Data sources

The first step in identifying appropriate germplasm for adaptation measures is to gain an overview of which geographic areas are suitable for a specific crop or variety. By combining biodiversity data (e.g., crop presence data for accessions held in national or international institutes) with climate data (e.g., the 19 bioclimatic variables in the WorldClim package), we will be able to map this data for climate change analysis and germplasm identification.

### Sources of climate data

Climate data can be obtained from various sources, including local field observations, national meteorological stations, and global agencies and databases.

Regional meteorological data can be acquired by contacting individual regional and national weather stations. These data are usually observations of parameters, such as temperature and precipitation for a specific day and time. For this information to be useful in detecting trends, it should span 30 years or more. However, in developing countries, weather stations are often few and do not cover large areas. Data may lack precision, and meteorological organizations might charge a fee for use of their data. The quality of the datasets and the format in which they are distributed depends on the organization.

Environmental sensors can be used to collect your own local weather information, such as iButtons and Trans-African HydroMeteorological Observatory (TAHMO) portable stations, for example. iButtons are small, affordable devices that measure temperature and humidity at predetermined intervals. They can be placed in less accessible areas where local weather data are not available at a high resolution. Biodiversity scientists have written a manual that describes

in detail how to use iButtons for weather observation. iButtons are bought in combination with devices to connect them to your computer and specialized software to process and store the readings in comma-separated variable (CSV) format.

A TAHMO station is a portable, medium-sized, cylindrical sensor suite with the capability to measure all standard meteorological variables (air temperature, relative humidity, barometric pressure, wind speed and direction, and rainfall). Just like iButtons, TAHMO stations can be installed in areas where high-resolution data is not available. The station has a data logger and sensor suite. The data logger uses Pod's Best Signal Multi-Network SIM cards to connect to the best available signal on device start-up, and to automatically switch networks in case of outage. The sensor suite is programmed to collect data at specific intervals in 24 hours, and the data logger relays the collected data to individual online accounts at <https://datahmo.org/login> to enable access and download in comma-separated values (CSV) format. The installation process is simple, and guiding resources can be found at <https://tahmo.org/installation-resources/>. These stations can be connected to a computer using either a USB cable or a free software application called Zentra that can be downloaded at the TAHMO website (<https://tahmo.org/>). In addition, they have very low maintenance costs and can be monitored online using [s2s@tahmo.org](mailto:s2s@tahmo.org).

WorldClim is a set of global climate layers that can be downloaded for free via <http://www.worldclim.org>. These layers cover all global land areas except Antarctica and consist of 19 bioclimatic variables derived from monthly temperature and precipitation values. Bioclimatic variables represent annual trends, seasonality, and extremes. They are in the latitude/longitude coordinate reference system (not projected), and the datum is WGS84. Table 1 summarizes various climate datasets.

Table 1: WorldClim and National Oceanic and Atmospheric Administration climate data

Datasets	Period covered	Source data	Available spatial resolutions
Present conditions Download via <a href="https://www.worldclim.org/current">https://www.worldclim.org/current</a>	1950–2000	Interpolations of observations	30 seconds 2.5 minutes 5 minutes 10 minutes
Projected future conditions Download via <a href="https://www.worldclim.org/cmip5v1">https://www.worldclim.org/cmip5v1</a>	To about 2050	Climate projections from the Fifth Assessment Report of the Intergovernmental Panel on Climate Change	30 seconds 2.5 minutes 5 minutes 10 minutes
Past conditions Download via <a href="https://www.worldclim.org/paleo-climate1">https://www.worldclim.org/paleo-climate1</a>	Last glacial period (22 000 years ago) to mid-Holocene (6000 years ago)	Downscaled paleoclimate data	30 seconds 2.5 minutes 5 minutes 10 minutes
Surface marine data Download via <a href="http://icoads.noaa.gov/">http://icoads.noaa.gov/</a>	1800 to present 1960 to present (more detailed)	Gridded monthly summaries using observations from many systems	2° × 2° longitude boxes (from 1800) and 1° × 1° boxes (from 1960)

The datasets are available at four spatial resolutions: from 30 seconds (0.93 km × 0.93 km = 0.86 km<sup>2</sup> at the equator) to 2.5, 5, and 10 minutes (18.6 km × 18.6 km = 346.0 km<sup>2</sup> at the equator). The highest resolution (30 seconds) is available per tile (region) in georeferenced TIFF format (GeoTIFF file) and can be used in any GIS application. WorldClim data at lower resolutions can be downloaded in ZIP-files in a generic grid (raster) format and in Environmental Systems Research Institute (ESRI) grids (for use with ESRI products). Table 2 summarizes the approximate grid resolutions.

Table 2: Approximate grid resolutions

Resolution	Approximate unit area
30 arc seconds	1 km <sup>2</sup>
2.5 arc minutes	5 km <sup>2</sup>
5 arc minutes	9 km <sup>2</sup>
10 arc minutes	18 km <sup>2</sup>

To import the generic grid (raster) format into DIVA-GIS, first download and unzip the ZIP-files. Use: Data\Import to gridfile\Multiple Files (BIL/BIP/BSQ). Some of these files have the extension .GRD. In this case, if you rename the .BIL files to .GRI, they can be opened in DIVA-GIS without the import procedure. High resolution physical climate data can also be obtained from the Intergovernmental Panel on Climate Change (IPCC) through its data distribution center.

Climate model data from IPCC AR4 (2007) and IPCC TAR (2001) are viewed through the DDC file navigator and can be downloaded in CSV format. Data are available in 10- or 30-year intervals ranging from 1900 to 2000 for the following variables: temperature, wet days, precipitation, daily maximum temperature, daily minimum temperature, ground frost frequency, water vapor, diurnal temperature range, and cloud cover.

MarkSim is a third-order Markov rainfall generator, which has been developed over 20 years. It was not designed as a general circulation model (GCM) downscaler, but it does now work as such, employing both stochastic downscaling and climate typing. MarkSim also estimates daily maximum and minimum air temperatures and daily solar radiation values from monthly means of these variables, using the methods originating with C.W. Richardson (first published in 1985). It does not require any registration to download the data; the user just visits <http://gismap.ciat.cgiar.org/MarkSimGCM/>. The platform also adopted the IPCC assessment report (AR5), which provides different possible climate scenarios called “representative concentration pathways” (RCPs). MarkSim has RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5, which are selected depending on the requirements of the study. The downloaded climate data file has to be unzipped and is usually in CLX and WTG formats.

## Sources of biodiversity data

Biodiversity and environmental data can also be obtained from various sources, including (national) genebanks, herbariums, field observations, and global agencies and databases. A few of these sources are mentioned here.

Global or national genebanks serve as repositories of plant genetic materials. Passport and evaluation data for accessions can be obtained by contacting individual banks. Passport data include the source and origin of an accession as well as taxonomic identification. Genebank collections can also contain characterization and evaluation data on phenotypic traits or provide more specific trait data, including those of underutilized crops which are not covered in global databases. Examples of genebanks with clear trait data or the ability to request germplasm online are listed in Table 3.

Table 3: Examples of genebanks that offer easily accessible and clear trait data

Name	Source
National Plant Germplasm System (also GRIN Global)	United States Department of Agriculture <a href="https://www.ars-grin.gov/npgs/">https://www.ars-grin.gov/npgs/</a>
Centre for Genetic Resources (Dutch national genebank)	Wageningen University and Research Centre, the Netherlands <a href="http://www.wageningenur.nl/en/Expertise-Services/Statutory-research-tasks/Centre-for-Genetic-Resources-the-Netherlands-1.htm">http://www.wageningenur.nl/en/Expertise-Services/Statutory-research-tasks/Centre-for-Genetic-Resources-the-Netherlands-1.htm</a>
European catalogue of <i>ex situ</i> collections of plant genetic resources (EURISCO)	Secretariat of the European Cooperative Programme for Plant Genetic Resources <a href="http://eurisco.ipk-gatersleben.de/apex/f?p=103:1">http://eurisco.ipk-gatersleben.de/apex/f?p=103:1</a>

Not all genebanks make their collection data available online. Quality and access to the data depend on the regulations and resources of individual institutes.



Open access biodiversity data on all types of life on earth — plants, animals, and microbes — are available through the Global Biodiversity Information Facility (GBIF) web portal. This is the largest biodiversity database on the Internet as it accesses data from hundreds of institutions. The data from GBIF are georeferenced, allowing you to download maps with specific occurrences of species or varieties within a species. Data can be further refined by geographic area, elevation, and climate. To download the data you must register. After you select the relevant data, a direct download link is sent to your email address which will allow you to download a ZIP-file. The ZIP-file consists of text and XML files. The downloaded files can be imported into GIS software to create maps, which can be overlaid with climate maps to visualize the effect of climate change on diversity. More on this can be found in Module 3. Website: <http://www.gbif.org/>



GENESYS is an online database that provides access to millions of accessions held in genebanks around the world. Information includes crop name, genus, species, accession number, scientific name, country of origin, biological status of accession, holding institute, and the latitude, longitude, and elevation where it was collected. The dataset provides information in addition to standard passport data, such as characterization and evaluation data (i.e., plant height, growing periods at given locations, seed color, response to specific pests or diseases, response to various climatic conditions, and possible end uses), and environmental data based on the longitude and latitude at collection sites. This allows users to identify specific accessions with desirable traits for climate change adaptation, such as drought tolerance and water logging. Users can get additional information on whether the accession has been made available through the multilateral system of the International Treaty on Plant Genetic Resources for Food and Agriculture, whether it has been safely duplicated in the global seed vault located in Svalbard, Norway, and whether it is available for distribution. Data can be filtered online through the accession browser, viewed as maps or downloaded as CSV files, and imported into GIS applications. Website: <https://www.genesys-pgr.org/>.



## Recommended readings

■ Dias, S., MacKay, M., 2011. Promoting conservation and use of Plant Genetic Resources for Food and Agriculture – Information services for users worldwide. Wageningen, The Netherlands. Available: [http://www.seedsresourcebox.org/recommended-readings/detail/?tx\\_news\\_pi1%5Bnews%5D=1368&cHash=b9f2a83fb48d37584f5020aafada39c4](http://www.seedsresourcebox.org/recommended-readings/detail/?tx_news_pi1%5Bnews%5D=1368&cHash=b9f2a83fb48d37584f5020aafada39c4).

*This PowerPoint presentation gives an overview of the key features of EURISCO and GENESYS and how to use these data portals.*

■ Jones, P.G., Thornton, P.K., Heinke, J., 2009. Generating characteristic daily weather data using downscaled climate model data from the IPCC Fourth Assessment. Project report. ILRI, Kenya. Available: <https://cgspace.cgiar.org/handle/10568/2482>.

■ Mitra, S., van Etten, J., Franco, T., 2013. Collecting weather data in the field with high spatial and temporal resolution using iButton. Bioversity International, Rome, Italy. Available: <http://www.bioversityinternational.org/e-library/publications/detail/collecting-weather-data-in-the-field-with-high-spatial-and-temporal-resolution-using-ibutton/>.

*This manual describes in detail how to use iButtons for weather observations.*

■ Saarenmaa, H. n.d., Sharing and accessing biodiversity data globally through GBIF. Global Biodiversity Information Facility, Copenhagen, Denmark. Available: <http://www.esri.com/news/arcuser/0206/biodiversity1of2.html>.

*This short paper explains how one can become a GBIF data provider, and how users can access the data using web services and the GIS functions on the GBIF data portal.*

## More on the subject

■ Samy Gajji, S., Chavan, V., Arino, et al., 2013. Content assessment of the primary biodiversity data published through GBIF network: status challenges and potential. Biodiversity Informatics, 8: 94–172. Available: <https://journals.ku.edu/index.php/jbi/article/view/4124>.

*This paper is the first comprehensive assessment of the content mobilized so far through GBIF, as well as a reflection on possible strategies to improve its “fitness for use.”*

# Preparing data for importing into selected software

What software you use for data analysis will depend on the type and format of the data.

Georeferenced climate and accessions data can be used to create multilayered maps in a wide range of GIS software programs. However, it is important to choose software that can do both mapping and analysis from points to grids to landscape. A number of free software programs exist for this type of analysis.

Species distribution models and crop models are used to predict climate change impact on crop suitability and yield. Application of processed-based models may require specialized knowledge and a detailed set of parameters for specific areas. Therefore, niche models that predict climate change impact on crop suitability may be a good option to provide recommendations in the context of the uncertainties involved in climate change projects and the often limited amount and quality of data.

## Ecocrop

Ecocrop is a simple niche-based empirical model that uses environmental ranges to define the suitable area of a crop. It draws on the Food and Agriculture Organization's Ecocrop plant database, which includes optimal environmental ranges of more than 2000 species. The model allows adjustment of minimum and maximum temperature based on local research findings. The Ecocrop database is available at <http://ecocrop.fao.org/ecocrop/srv/en/home> and is also included in DIVA-GIS. Selecting a crop and setting parameters based on your own research findings allows you to create maps that show the suitability of a certain crop now and in the future.

Other resources for species distribution modeling:

- ModEco — integrated software for species distribution analysis and modeling
- DesktopGarp — software package for biodiversity and ecological research
- OpenModeller — a generic approach to species' potential distribution modelling

## Recommended readings

■ Hijmans, R.J., Guarino, L., Mathur, P., 2012. DIVA-GIS version 7.5 manual. Available: [http://www.diva-gis.org/docs/DIVA-GIS\\_manual\\_7.pdf](http://www.diva-gis.org/docs/DIVA-GIS_manual_7.pdf).

*Use of the Ecocrop model is explained on pages 54–56.*

## Mapping Software

In this module, we focus on four programs: DIVA-GIS to map the distribution of biological diversity and query climate data; MaxEnt, species distribution modeling software, to model the range in which a species can occur; Google Earth to create maps with georeferenced occurrence data or accessions data against high-resolution satellite imagery; and Climate Analogues to project future climate conditions for a particular location and match this to sites that currently have similar rainfall and climatic conditions.

## DIVA-GIS

DIVA-GIS is an open-source software program used to create maps and carry out geographic data analysis. It can create a wide range of maps, from a map of the world, to a map of a very small area, such as a district or even a village, showing, for example, state boundaries, rivers, a satellite image, and sites where an animal species was observed. This program can be downloaded at <http://www.diva-gis.org>.

DIVA-GIS comes with the option to download free spatial data, such as administrative boundaries, roads, etc., and species occurrence data from GBIF, Genesys, LandSat, etc. As noted above, the Ecocrop model is built in.

Using DIVA-GIS, you can also download free spatial data at <http://www.diva-gis.org/Data> for the whole world, which can then be used in DIVA-GIS or other GIS programs, such as Arc-GIS. DIVA-GIS is particularly useful for mapping and analyzing biodiversity data, such as the distribution of a species or other “point distributions.”

Climate data from WorldClim can be downloaded directly into DIVA-GIS at <http://www.diva-gis.org/climate>. This makes it possible to overlay climate information with species occurrence or other georeferenced data to provide an overview of the way the distribution of a species changes due to climate over certain periods.

## Recommended readings

- Hijmans, R.J., Guarino, L., Mathur, P., 2012. DIVA-GIS version 7.5 manual. Available: [http://www.diva-gis.org/docs/DIVA-GIS\\_manual\\_7.pdf](http://www.diva-gis.org/docs/DIVA-GIS_manual_7.pdf).

*This manual includes a step-by-step guide to downloading and installing DIVA-GIS, a summary of its uses, and a list of its features. It also gives an overview of data analysis and how to generate maps and shape files.*

## MaxEnt

Maximum entropy modeling uses layers of environmental variables (elevation, precipitation, etc.) as well as a set of georeferenced occurrence locations to produce a model of the range of a given species. One of the main applications of MaxEnt is prediction of species occurrence. From current species locations and environmental predictors (e.g., precipitation, temperature) across a user-defined landscape divided into grid cells, MaxEnt extracts a sample of background locations that it contrasts with present locations to predict species occurrence.

Available: [https://biodiversityinformatics.amnh.org/open\\_source/maxent/](https://biodiversityinformatics.amnh.org/open_source/maxent/)

## Recommended readings

- Merow, C., Smith, M.J., Silander Jr., J.A., 2013. A practical guide to MaxEnt for modeling species' distributions: what it does, and why inputs and settings matter. *Ecography* 36: 1058–1069. Available: [https://www.researchgate.net/publication/264532217\\_A\\_practical\\_guide\\_to\\_MaxEnt\\_for\\_modeling\\_species\\_distributions\\_What\\_it\\_does\\_and\\_why\\_inputs\\_and\\_settings\\_matter](https://www.researchgate.net/publication/264532217_A_practical_guide_to_MaxEnt_for_modeling_species_distributions_What_it_does_and_why_inputs_and_settings_matter).

*This article gives a detailed explanation on how MaxEnt works, and different types of analysis that can be performed by it. It also provides insights on data requirements, formats, and conversions that might be necessary when performing analysis in MaxEnt.*

## More on the subject

- Phillips, S.J., Dudik, M., Schapire, R.E., 2004. A maximum entropy approach to species distribution modeling. Proceedings of the Twenty-First International Conference on Machine Learning, pp. 655-662. Available: [https://www.cs.princeton.edu/~schapire/papers/maxent\\_icml.pdf](https://www.cs.princeton.edu/~schapire/papers/maxent_icml.pdf).
- Phillips, S.J., Anderson, R.P., Schapire, R.E., 2006. Maximum entropy modeling of species geographic distributions. *Ecological Modelling* 190: 231–259. Available: [https://www.who.edu/cms/files/phillips\\_et\\_al\\_2006\\_53467.pdf](https://www.who.edu/cms/files/phillips_et_al_2006_53467.pdf).

*These two articles provide details on maximum entropy modeling.*

## Google Earth

Google Earth is a geobrowser that provides satellite and aerial imagery, ocean bathymetry, and other geographic data over the Internet to display the Earth as a three-dimensional globe. It has many features, including an increasing set of layers of mappable data, the ability to display third-party data, tools for creating new data, and the ability to import GPS data.

Georeferenced occurrence data or accessions data can be imported and mapped in Google Earth. The resolution is as high as 1 m and, therefore, specific names and locations can easily be obtained. The free version of Google Earth is downloadable at <http://www.google.com/earth/download/ge/agree.html>.

Google Earth is searchable and allows the user to pan, zoom, rotate, and tilt the view of the Earth. Its layers of data, such as volcanoes and terrain, reside on Google's servers, and can be displayed. Its elevation data, primarily from NASA's Shuttle Radar Topography Mission, provide a terrain layer that adds depth to the landscape. Google Earth can also be used to acquire the coordinates of collections or occurrences with location names but no GPS information.

## Recommended readings

■ Scheldeman, X., van Zonneveld, M., 2010. Training manual on spatial analysis of plant diversity and distribution. Bioversity International, Rome, Italy. Available: [http://www.bioversityinternational.org/uploads/tx\\_news/Training\\_manual\\_on\\_spatial\\_analysis\\_of\\_plant\\_diversity\\_and\\_distribution\\_1431\\_07.pdf](http://www.bioversityinternational.org/uploads/tx_news/Training_manual_on_spatial_analysis_of_plant_diversity_and_distribution_1431_07.pdf).

*A description of the step-by-step procedure for importing data into Google Earth is available on pages 74–78.*

## Climate Analogues

Climate Analogues is an open-access tool developed by the program on Climate Change, Agriculture and Food Security in conjunction with the International Center for Tropical Agriculture and the Walker Institute. Used to support adaptation to climate change in the agricultural sector, its main applications are in agricultural policy and planning. The tool can be used to identify future climate conditions at a particular location, sites that currently resemble these conditions, and locations that have or will have similar climate conditions.

The tool can facilitate knowledge-sharing among communities, providing the opportunity to transfer practices and technologies to improve adaptive capacities. It can also provide insights into whether successful adaptation options in one location can be transferred to a future climatic analogue site. The temporal analogues are time specific and make use of past climates to create a representative time series for future climates. This allows the identification of historic events that might provide insight into the possible future consequences of climate change.

Based on careful analyses using the tool and supported by data from actual conditions in farmers' fields, scientists can formulate possible intervention strategies, including identification of appropriate plant genetic resources, or develop new varieties for specific locations of interest.

The Climate Analogues tool can be accessed at <http://analogues.ciat.cgiar.org/>. The procedure for using this tool and interpreting analogue maps is described in a tutorial: <https://www.youtube.com/watch?v=tRwWTsqx2ks>. The manual is available at: [https://www.ccafs-analogues.org/wp-content/uploads/Online\\_manual.pdf](https://www.ccafs-analogues.org/wp-content/uploads/Online_manual.pdf).

## Recommended readings

■ Ramírez-Villegas, J., Lau, C., Köhler, A.K., et al., 2011. Climate Analogues: finding tomorrow's agriculture today. Working paper 12. CGIAR Research Program on Climate Change, Agriculture and Food Security, Cali, Colombia. Available: <https://ccafs.cgiar.org/sites/default/files/assets/docs/ccafs-wp-12-climate-analogues-web.pdf>.

*This paper provides a general explanation of Climate Analogues, including the conceptual framework used and the models applied in building the analogues. It also explains how to interpret the results and notes the limitations of the method.*

## Importing data into DIVA\_GIS and MAXENT

A common feature of the data referred to in this module is that they include georeferenced information and/or basic passport data. The data must be organized in a format that can be recognized by software such as DIVA-GIS and MaxEnt.

These software applications have the capability of processing vector and raster data. Vector data come in the form of shapefiles with extensions, such as .SHP, .SHX, and .DBF, which store spatial features. Environmental data from specific geographic areas may be organized in rasters, which consist of a matrix of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing information, such as temperature. Rasters can be digital aerial photographs, imagery from satellites, digital pictures, or even scanned maps.

The level of detail in a raster is referred to as resolution. Raster sizes range from 1° (111 km) to 30 seconds (approximately 1 km at the equator).

### Preparing data for use in DIVA-GIS and MaxEnt

#### Converting data into appropriate formats

Presence points, which consist of passport data, can be entered or downloaded into an Excel file and then converted into appropriate formats for spatial analysis using GIS applications, such as DIVA-GIS or MaxEnt. Your data should include an identification code, a scientific or taxonomic name, and coordinates (latitude and longitude). Other relevant information can also be added. Records downloaded from GBIF or Genesys will contain this information, but always check to ensure that the data are complete (e.g., no blank fields) and that the coordinates are in decimal degrees.

**Table 4: Convert geographic coordinates from degrees, minutes, and seconds or degrees and decimal minutes to decimal degrees.**

Decimal Degrees = [(Degrees (°) + Minutes (') / 60 + Seconds(") / 3600)] \* H

H = 1 when the coordinate is in the Eastern (E) or Northern (N) Hemisphere

H = -1 when the coordinate is in the Western (W) or Southern (S) Hemisphere

Longitude	Degrees, Minutes & Seconds	Decimal Degrees	Latitude	Degrees, Minutes & Seconds	Decimal Degrees
Eastern Hemisphere	60°20'15"E	+ 60.3375	Northern Hemisphere	24°00'45"N	+ 24.0125
Western Hemisphere	60°20'15"W	- 60.3375	Southern Hemisphere	24°00'45"W	- 24.0125

*Source: Scheldeman and van Zonneveld (2010: 24–26); see section on Google Earth above for full reference.*

If the data set you are working with is missing coordinates, you can add them manually using a gazetteer database. A gazetteer is an alphabetical database of administrative units combined with geographic coordinates. Gazetteer databases can be downloaded from the DIVA-GIS website (<http://www.diva-gis.org/gdata>).

Find a description of the location of your data point in your dataset; this could be the name of a village or town or a larger administrative unit, such as a municipality or a region. Use this information to search the gazetteer database for matches. Caution must be exercised to avoid

assigning coordinates of a different village with the same name in another administrative unit. Alternatively, use Google Earth to locate the missing coordinates by typing in the description of the location and pinpointing the data point.

The placemark will contain the coordinates, which you can copy to your dataset.

In summary:

- Your dataset contains the required ID, label (taxonomic name), and latitude, longitude columns.
- Coordinates are in decimal degrees.
- Presence points with missing coordinates are removed completely from the dataset or missing coordinates are assigned using a gazetteer database.

## Importing data into DIVA-GIS

Before continuing, make sure you have DIVA-GIS version 7.5 installed. Go to the DIVA-GIS website and click on the download page (<http://www.diva-gis.org/download>). For full functionality, you should also download the WorldClim climate data from the DIVA-GIS website (<http://www.diva-gis.org/climate>) or from the downscaled GCM data portal (<http://www.cgiar-csi.org/88>).

Once you have DIVA-GIS up and running, take some time to familiarize yourself with the program. A good starting point is the DIVA-GIS 7.5 manual by Hijmans et al. (2012) which can be found at [http://www.diva-gis.org/docs/DIVA-GIS\\_manual\\_7.pdf](http://www.diva-gis.org/docs/DIVA-GIS_manual_7.pdf)

### *Importing occurrence data:*

From the Data menu select “Import Points to Shapefile” and choose which type of file you want to import. DIVA-GIS allows direct imports from text (.TXT), Access database (.MDB), Excel (.XLS), or dBase (.DBF) files. You are asked to specify your dataset (input file) and the columns that contain latitude and longitude. Click “Save to Shapefile” to generate a vector file (.SHP). This shapefile contains all the presence points in your dataset.

### *Importing climate data (WorldClim):*

Previously, you downloaded climate layers from the DIVA-GIS website. The files in the ZIP-file are CLM files, which you should extract and store in a folder on your hard drive. To load the climate data into DIVA-GIS, go to Tools/Options/Climate and select the folder in which you stored the WorldClim files. Check to ensure that DIVA-GIS selected the right columns for each parameter and press “Apply.” You have now loaded the climate data into DIVA-GIS. This is not visible on your screen, but you have also set the WorldClim database as your default. You will use the climate data in Module 3.

## Importing data into MaxEnt

After installing and starting MaxEnt, you will be asked to load a file with occurrence data (samples) and another file containing environmental variables (environmental layers). The occurrence data should be a .CSV file and the environmental layers in ASCII raster grids (each environmental variable represents one layer).

For example, the 19 bioclimatic values representing the WorldClim datasets would appear as separate layers. After specifying an output file, you are ready to proceed to the next step of running the MaxEnt model. More on this topic in Module 3.

A full description of the procedure is available in Scheldeman and van Zonneveld (2010: 28–33).

### Recommended readings

■ Hijmans, R.J., Guarino, L., Mathur, P., 2012. DIVA-GIS version 7.5 manual.

Available: [http://www.diva-gis.org/docs/DIVA-GIS\\_manual\\_7.pdf](http://www.diva-gis.org/docs/DIVA-GIS_manual_7.pdf).

*The use of the Ecocrop model is explained on pages 54–56.*

■ Scheldeman, X., van Zonneveld, M., 2010. Training manual on spatial analysis of plant diversity and distribution. Bioversity International, Rome, Italy, pp. 1–40. Bioversity International, Rome, Italy. Available:

[http://www.bioversityinternational.org/uploads/tx\\_news/Training\\_manual\\_on\\_spatial\\_analysis\\_of\\_plant\\_diversity\\_and\\_distribution\\_1431\\_07.pdf](http://www.bioversityinternational.org/uploads/tx_news/Training_manual_on_spatial_analysis_of_plant_diversity_and_distribution_1431_07.pdf).

*See in particular pages 1–40 on plant diversity and distribution.*

## Testing your knowledge

Here is a quiz that will help you test your newly acquired knowledge. Once you have covered the content sections and completed the assigned readings, please answer the Data preparation and software selection quiz.

- 1.** Which of the following statements are true?
  - a. Regional meteorological data can be obtained from national meteorological stations.
  - b. These data must cover at least a span of ten years to be useful.
  - c. This type of data can also be collected by field observations using environmental sensors.
- 2.** Biodiversity and environmental data can also be obtained from the following sources:
  - a. Global or national genebanks
  - b. Field observations
  - c. Herbariums
  - d. Global agencies
  - e. Specialized data bases
- 3.** Which of these software tools can be used for data analysis?
  - a. Ecocrop
  - b. ModEco
  - c. OpenModeller
  - d. DIVA-GIS
  - e. MaxEnt
  - f. Google Earth
  - g. The Climate analogue tool
- 4.** What are the main prerequisites for importing data in DIVA-GIS and MaxEnt?
  - a. Data have to be entered or downloaded in an Excel file and converted into appropriate formats for spatial analysis.
  - b. Data need to be accompanied by an identification code, a scientific or taxonomic name and coordinates (latitude and longitude).
  - c. Coordinates need to be presented either in Degrees, Minutes and Seconds (DMS) format, Degrees, Minutes (DM) or Degree Decimal (DD).
  - d. It is possible to assign coordinates manually to missing values.
- 5.** Which of these statements are true?
  - a. In DIVA-GIS, you can download free spatial data for the whole world.
  - b. The Ecocrop model is built in DIVA-GIS.
  - c. It is possible to download climate data from WorldClim directly in DIVA-GIS.
  - d. One of the main applications of DIVA-GIS is the prediction in population, ecology and biogeography.



## Applying your knowledge

Now that you are able to select, prepare, and clean data and use it to create maps, it is time to apply your new knowledge. Please document this step of the research process by:

1. Listing two data sources for both biodiversity and climate data.
2. Explain the use of DIVA-GIS, MaxEnt, Google Earth, and the Climate Analogues tool in climate change analysis.
3. Describe the steps for loading data into DIVA-GIS and MaxEnt.



# MODULE 3

# Climate change analysis and identification of germplasm

*Sarika Mittra*



## CLIMATE CHANGE ANALYSIS AND IDENTIFICATION OF GERMPLASM

*Photo: Testing new rice varieties for climate change adaptation, Guangxi, China.  
Credit: Bioversity International/R. Vernooy*

### Introduction

In module 2, you learned how to model crop adaptation using spatial data in a geographic information system (GIS) and how to select appropriate software and tools. Learning included the identification, preparation, downloading, and analysis of useful data, as well as cleaning and preparation of data to make it compatible with the selected GIS software. Climate change analysis can help identify differences in climate variables at different sites over various periods. This, in turn, can enable researchers, farmers, and other stakeholders to identify potential adaptation measures, such as assessing the vulnerability of the target sites (i.e., your own project site) to climate change and selecting pre-adapted genotypes from reference sites (one or more climate-matching or analogous sites) for testing and implementing measures to conserve agricultural biodiversity.

In this module, you will learn how to conduct climate change analysis and use the results to identify promising genebank collections. The key questions are:

- How can geographic coordinates be added to an accession that was collected without such coordinates? How can a collection be classified according to climate to make it more manageable?
- What are the current climate conditions at the collection site? What changes in climate have occurred at that site over what period?
- Which climate variables have been most affected?
- For any target site, what reference site best matches its changed climate?
- Which germplasm accessions from the reference site are the best candidates for potential adaptation at the target site?

At the end of the module you will know how to make a list of germplasm accessions of interest, some or all of which you might want to access for field-testing at your research site.

## Learning objectives

At the end of this module, you will be able to:

- Classify germplasm collecting sites based on adaptation to climatic conditions
- Identify germplasm accessions that may be suitable for introduction under specific climate conditions
- Prioritize germplasm collecting sites that are vulnerable because of expected climate change at those sites
- Have a better understanding of models and approaches for climate change that are applicable to management of plant genetic resources.

## Analyzing climate change and its impact

*Climate* is a region's long-term (~30-year) average weather, including temperature, precipitation, sunlight, wind and cloud cover. *Climate change* refers to the rapid alterations in typical weather patterns that result from changes in the Earth's atmospheric chemistry (CO<sub>2</sub>, O<sub>3</sub>) leading to a global change in the Earth's energy and water balance. Evidence of climate change can be seen in increasing temperatures, changes in precipitation patterns and changes in the number, duration and intensity of extreme events. Agriculture will be affected because of changes in the growing season, availability of arable land, incidence of pests and diseases and losses due to weather shocks and stressors (droughts, floods, etc.). The effects can be variable and not always negative: increased concentrations of carbon dioxide can potentially be beneficial for photosynthesis (C4 plants more than C3), and warming temperatures can open up arable land that was hitherto not suitable. However, rainfed cultivation will be more vulnerable, and even irrigated cultivation will have to be adapted to losses of freshwater sources.

Twelve percent of the global land area is planted to crops. Despite the gains of the Green Revolution, research on the effect of climate change on agriculture is already predicting a plateau in yields or, in worst-case scenarios, a decline in yields in the first quarter of the 21<sup>st</sup> century. Studies have shown that, for the period 1980–2008, global maize and wheat production declined by 3.8% and 5.5%, respectively, under current climate trends. Global food yields will generally decrease by roughly 1.5% per decade under current warming trends if adaptation measures are not taken. From the farm level to the level of national policy, adaptation strategies require accurate and timely information on the weather in order to facilitate a rapid planning response for the season ahead. On the other hand, farmers can prepare for adverse weather conditions by planting a diverse variety of crops that are capable of handling single or multiple stressors, such as heat-tolerant or drought-tolerant varieties. Scientists can facilitate that through targeted plant breeding and identifying and testing germplasm collected from different climate conditions. Geographic information system (GIS) software and tools have been widely used and documented to model the impact of climate change and develop adaptation strategies. Any variable (germplasm, climate parameters) that has location data, either embedded or in the metadata, can be incorporated into a GIS application to visualize and model the effects of climate change at the local, regional, national and global level. Results can either be spatially up-scaled or down-scaled to adjust to the needs of the user.

## What do you already know?

- Does the passport data for the germplasm collection you are working with contain geographic coordinates for the collecting sites? If not, how do you collect location information that can be used to extract the geographic coordinates for the collecting sites of the collection?
- How do you use geographic coordinates to find environmental information about this collection?
- How do you find out the current climatic conditions at the collecting sites and the climatic conditions at these sites in the past?
- What experience do you have with climate modeling?
- How familiar are you with the concept of climate analogues, i.e., areas where climate conditions match your target site in the past, the present, and the future?
- What experience do you have in using climate analysis information to plan adaptation strategies and identify accessions that can be tested?

### Content summary

- Classification of germplasm collections based on climate
- Climate change analysis
- Identification of potential germplasm for testing

## Classification of germplasm collections based on climate

A key function of centers for plant genetic resources is germplasm collection, which has been practiced throughout the world in varying degrees over centuries. Although the norm has always been to record the location of the collecting site, standardized formats for passport data attached to accessions are relatively new. Even more recent is the method of recording location by using geographic coordinates. Although earlier collectors often reported such details as administrative unit, closest town or village, distance from the road, etc., this information can never be as precise as geographic coordinates, which are unique to any point on the Earth's surface.

Geographic coordinates are a set of numbers (or letters) assigned to every location on the Earth. They are derived from a mathematical model to calculate the horizontal position (using two numbers) and the vertical position (using one number) of a location. Longitude and latitude (for horizontal position) and altitude (for vertical position) are the most common geographic coordinates.

Handheld Global Positioning System (GPS) units are usually used to record geographic coordinates, and this method became available only after 1980 when the United States Department of Defense made the GPS available for civilian use. Even in the 1980s and the 1990s, handheld GPS units were too expensive for general use, and most collectors recorded



*Photo: Farmers testing vegetable production under dryer conditions, Lao PDR  
Credit: Bioversity International/R.Vernooy*

only qualitative location information. However, methods are available to determine geographic coordinates from secondary sources that are precise or nearly so.

The availability of precise location information is important, as that will affect the subsequent analyses and results. Currently, the most popular method for determining locations is to use Google Earth, which has a huge database of georeferenced sites. In addition, websites like <http://www.latlong.net> allow a user to enter the name of a location or the nearest town or village and obtain the geographic coordinates instantly. Most of these sites are available free to the user. If digital databases on the Internet do not provide a useful result, then detailed analogue maps, such as large-scale topographical sheets, can be used to find the coordinates.

Information and communication technology (ICT) can also be harnessed to collect missing passport data, especially through crowdsourcing. Portals like Zooniverse and iNaturalist provide good examples of engaging local citizen scientists to collect and create significant databases on plants and animals. While these databases might not provide information on historical collections, the ubiquitousness of mobile phones that indicate location allows researchers to collect data by building simple apps or designing user-friendly interfaces (e.g., ODK).

Passport, characterization and evaluation data on *ex situ* collections have been published by several organizations and can be accessed from their online databases. These include GENESYS, European Search Catalogue for Plant Genetic Resources (EURISCO), the United States Department of Agriculture Germplasm Resources Information Network (USDA-GRIN), SESTO (NordGen) and the FAO's World Information and Early Warning System (WIEWS) database on Plant Genetic Resources. At the local level, well-established community seed banks with recorded metadata on their collections can provide information on locally adapted germplasm. Work is underway with some community seed banks to develop this capacity (e.g., in Nepal).

Geographic coordinates are needed to obtain other data about a collection site, such as climate, soil type, water availability and other factors affecting growing conditions. Once accessions have been assigned geographic coordinates, the dataset can be classified according to climate. It will then be feasible to organize the collection in a more efficient manner and allow patterns to be easily deduced.

Several methods can be used to extract information (past, present, and future) from climate databases in GIS software based on geographic coordinates; these are explained in Module 2. Online platforms, such as the MarkSim DSSAT Weather File Generator (<http://gismap.ciat.cgiar.org/MarkSimGCM/>), can be used both to find geographic coordinates (through its Google Earth plugin) and to extract daily data for a year for the three key climate variables: rainfall, temperature, and radiation. Although MarkSim has web versions for both IPCC CMIP3 and CMIP5 data, other available online tools contain global, regional, or country-specific data (e.g., <http://www.hko.gov.hk/wxinfo/pastwx/extract.htm>). One can also use offline tools with any GIS software to extract data from climate databases.

The Climate Data Online (CDO) tool from the National Climatic Data Center at the National Oceanic and Atmospheric Administration (NOAA) provides access to global historical data on several climate parameters. Users familiar with climate data and modeling can download high-resolution spatial climate data at different spatial scales (e.g., global data from the University of East Anglia's Climate Research Unit [CRU]) and build their own climate analogue models for the past, present or future. Extracted climate data can then be used to classify sites. GIS software or statistical software, such as MS Excel and R, can be used to classify accessions using a variety of clustering techniques.

## Recommended readings

■ Scheldeman, X., van Zonneveld, M., 2010. Training manual on spatial analysis of plant diversity and distribution. Bioversity International, Rome, Italy. Available: [http://www.bioversityinternational.org/uploads/tx\\_news/Training\\_manual\\_on\\_spatial\\_analysis\\_of\\_plant\\_diversity\\_and\\_distribution\\_1431\\_07.pdf](http://www.bioversityinternational.org/uploads/tx_news/Training_manual_on_spatial_analysis_of_plant_diversity_and_distribution_1431_07.pdf).

*This manual describes in detail all the tools available in the DIVA-GIS software (<http://www.diva-gis.org/>). It contains links to exercise data that can be downloaded and used to perform spatial analysis of plant diversity and distribution using DIVA-GIS and visualization methods to display the end results. (See also Hijmans R.J., Guarino L., Mathur P., 2012. DIVA-GIS. Manual. Available: [http://www.diva-gis.org/docs/DIVA-GIS\\_manual\\_7.pdf](http://www.diva-gis.org/docs/DIVA-GIS_manual_7.pdf).)*

■ Jones, P.G., Thornton, P.K., Heinke, J., 2011. Generating characteristic daily weather data using downscaled climate model data from the IPCC Fourth Assessment. Project report. ILRI, Kenya. Available: <https://cgspace.cgiar.org/bitstream/handle/10568/2482/Jones-Thornton-Heinke-2009.pdf?sequence=3>.

*This article describes the method for the downscaling of GCM data that are available in the MarkSim DSSAT Weather File Generator, the use of the tool, and the accuracy of the downscaled data.*

## More on the subject

■ Vogel, K.P., Schmer, M.R., Mitchell, R.B., 2005. Plant adaptation regions: ecological and climatic classification of plant materials. United States Department of Agriculture, Agricultural Research Service, Paper 206. Available: <http://digitalcommons.unl.edu/usdaarsfacpub/206/>.

*This paper offers an example of how a database of plant species can be made more meaningful and useful by classifying the data by ecology and climate.*

■ Wilby, R.L., Troni, J., Biot, Y., et al., 2009. A review of climate risk information for adaptation and development planning. *International Journal of Climatology* 29: 1193–1215. Available: <http://onlinelibrary.wiley.com/doi/10.1002/joc.1839/epdf>.

*This paper describes the development of tools for forecasting climate change scenarios for use in the assessment of adaptation mechanisms in several sectors and the knowledge gaps and improvements required to improve adaptation planning.*



## Climate change analysis

Selection of the suitable adaptation measures to cope with changing climate conditions requires climate models that simulate future conditions and provide a glimpse of a set of possibilities both spatially and temporally. Several portals like the CRU and NOAA's CDO provide modeled climate data (past and future) at global and national scales that can be downloaded by the user. Climate data from numerical models like the IPCC's General Circulation Models (GCMs) can provide a view of current and future scenarios (under various probable pathways or scenarios) and allow evaluation of the vulnerability of a site to changing climate.

Based on the results of the climate change analysis of a site, adaptation measures can be implemented that are best suited to mitigate the adverse effects. These measures include corrective strategies aimed at undoing or coping with adverse effects through a diverse set of actions and pre-emptive strategies that anticipate future changes and implement actions to prevent the simulated future change.

Corrective strategies include developing improved genotypes that are resilient to such stresses as extreme temperatures, flooding, or drought. In the pre-emptive strategies, scientists and researchers can find a reference site whose climate matches (with a degree of probability) the climate of the target site, although they may be separated both spatially and temporally. One could then identify germplasm that might have traits of interest and explore options to test it in the target site. This is known as the climate analogue technique. Using climate analogues can provide a set of potential options for adaptation for the target site. Researchers at Bioversity International have used climate analogues in collaboration with national partners for various purposes.

### Recommended readings

■ Intergovernmental Panel on Climate Change assessment reports. Available:

<https://www.ipcc.ch/reports/>.

*Contains links to all IPCC assessment reports on climate change up to the most recent assessment report. These reports are "published materials composed of the full scientific and technical assessment of climate change, generally in three volumes, one for each of the Working Groups of the IPCC, together with their Summaries for Policymakers, plus a Synthesis Report." Also contains links to technical papers, supporting material, a glossary, and supporting data.*

■ Intergovernmental Panel on Climate Change literature on general circulation models. Available:

[http://www.ipcc-data.org/guidelines/pages/gcm\\_guide.html](http://www.ipcc-data.org/guidelines/pages/gcm_guide.html).

*This web page provides general information about GCMs, scenarios and data used; a glossary of terms; and various links for downloading data from different GCMs. Users not familiar with GCMs should read the literature first before using data for climate modeling.*

## More on the subject

■ Alexandratos, N., Bruinsma, J., 2012. World agriculture towards 2030/2050: the 2012 revision. ESA Working Paper 12-03. Agricultural Development Economics Division Food and Agriculture Organization of the United Nations, Rome, Italy. Available: <http://www.fao.org/docrep/016/ap106e/ap106e.pdf>.

*This FAO report is about the trends for world agriculture for 2030-2050 based on updated data on population, climate change, nutrition and production.*

■ Lobell, D.B., Gourdji, S.M., 2012. The influence of climate change on global crop productivity. *Plant Physiology* 160: 1686–1697. Available: <http://www.plantphysiol.org/content/160/4/1686.full.pdf+html>.

*This article contains a detailed analysis of the effects on crop yields based on present estimates of past and future impacts of climate and CO2 trends.*

■ Lobell, D.B., Schlenker, W., Costa-Roberts, J., 2012. Climate trends and global crop production since 1980. *Science* 333(6042): 616–620. Available: <http://science.sciencemag.org/content/333/6042/616.long>.

*This paper analyzes how global crop production has been affected by assessing the effect of climate change using available climate data from 1980 to 2008.*

■ Vernooy, R., Otieno, G., Bessette, G., et al., 2015. A novel strategy to discover and use climate-adapted germplasm, Bioversity International, Rome, Italy. Available: <https://www.bioversityinternational.org/e-library/publications/detail/a-novel-strategy-to-discover-and-use-climate-adapted-germplasm/>.

*This brief summarizes the various novel applications of the climate analogue tool in the work of Bioversity International in collaboration with national partners from around the world.*



Photo: Local maize diversity in a community seedbank, the Cuchumatanes, Guatemala. Credit: Bioversity International/R. Vernooy

## Identification of potential germplasm for testing

Once a site's vulnerability to climate change has been assessed and its potential climate-matched sites identified, it is necessary to apply the outcomes of the analysis to identify those genotypes that can be tested in the vulnerable site. For example, if the temperature and precipitation conditions in target site A (in Asia) for 2030 match the temperature and precipitation conditions in reference site B (in Africa) for 2019 with a degree of probability of more than 60%, then the accessions grown currently in reference site B can be considered potentially pre-adapted for target site A and planted at target site A for testing.

Although suitable climate conditions are a basic requirement for growing crops, other physical factors such as soil conditions and topography and non-physical factors such as socioeconomic conditions and the market also play an important part. Hence, testing for a few seasons under various conditions is necessary to conclude whether the identified genotype from reference site B can be grown successfully at target site A.

### Recommended readings

■ Phillips, S.J., Anderson, R.P., Schapire, R.E., 2006. Maximum entropy modeling of species geographic distributions. *Ecological Modelling* 190: 231–259. Available: <http://www.cs.princeton.edu/~schapire/papers/ecolmod.pdf>.

*This is a study of the background of the Maxent tool, explaining the concept and interpretation of results and assessing its accuracy.*

■ Ramírez-Villegas, J., Lau, C., Köhler, A.K., et al., 2011. Climate analogues: finding tomorrow's agriculture today. Working paper 12. CGIAR Research Program on Climate Change, Agriculture and Food Security, Cali, Colombia. Available: <https://ccafs.cgiar.org/sites/default/files/assets/docs/ccafs-wp-12-climate-analogues-web.pdf>.

*This working paper on climate analogues was prepared by the developers of the tool. It explains the concept, its terms and assumptions, the method, how to use the tool, interpretation of the results, and its applications.*

## Testing your knowledge

1. How is germplasm-related information usually recorded in a collection, nowadays?
  - a. The location information of the collection site is noted through details like administrative units, presence of a nearby town/village, distance from the road, etc.
  - b. Passport data collection of accessions is recorded through standardized formats.
  - c. Location information is recorded in the form of geographic coordinates.
2. Why is assigning geographic coordinates to germplasm important?
  - a. The location of each collecting site is critical to obtain other data about that accession, such as soil data.
  - b. Assigning geographic coordinates is necessary to access georeferenced sites that can be used as reference.
  - c. Once the accessions have been assigned geographic coordinates, the random dataset can then be classified according to climate, which will organize the collection in a more efficient manner and from which patterns can be easily deduced.
3. How can we identify locally adapted adaptation measures to climate change?
  - a. Develop climate models that simulate future conditions and provide a glimpse of a set of possibilities both spatially and temporally.
  - b. Use General Circulation Models (GCMs), which provide the current and future scenarios (under different probable conditions) to gauge the vulnerability of a site to changing climate.
  - c. Develop improved genotypes that are resilient to any number of stresses like extreme temperatures, flooding or drought.
4. What is the climate analogue technique?
  - a. A pre-emptive adaptation strategy
  - b. A corrective adaptation strategy
  - c. A technique consisting in finding a reference site whose climate matches (with a degree of probability) the climate of the target site, although both may be separated both spatially or temporally.
5. What are the next steps after carrying out the assessment of a given site's vulnerability to climate change and identifying potential climate-matching sites?
  - a. Identify those genotypes that can be tested in the vulnerable site.
  - b. Take into consideration other physical factors like soil conditions, topography and non-physical factors like socioeconomic conditions and the market.
  - c. Test under different conditions for a few seasons.

## Applying your knowledge

In this module, you learned how to conduct climate change analysis and use the results to identify promising genebank collections. Now your task is to establish the current and future climate conditions of a site and identify potential pre-adapted genotypes that can be tested at that site. Please document this step of the research process by identifying the following:

1. How do you assign geographic coordinates to a database of germplasm accessions?
2. How do you classify a GIS database of accessions according to climate to make it more meaningful and useful?
3. What inferences can you make about the current and future sites from which these accessions are collected?
4. What adaptation strategies can you recommend for the vulnerable site?
5. What potentially useful germplasm have you identified?



# MODULE 4

# Germplasm acquisition

*Isabel López-Noriega, Ronnie Vernooy  
and Michael Halewood*



## GERMPLASM ACQUISITION

*Photo:  
Diversity fair,  
Sri Lanka.  
Credit: Bioversity  
International/R. Vernooij*

## Introduction

In module 3, you learned about tools that allow farmers and breeders to look further afield for germplasm that is adapted to stresses caused by climate change. Such germplasm can come from various sources, including farmers' fields in your own country or from abroad; community seed banks in your own country or abroad; national and international crop improvement programs and projects; international, national, or community-based seed companies; or national and international genebanks, including those managed by the CGIAR centers.

In this module, you will find out how to acquire germplasm. This may seem easy, but there are a number of important steps to take to ensure that you comply with international and national rules and regulations. Relevant questions are: What key aspects of the overall legal framework influence germplasm acquisition? What are the most important international agreements and the rules you need to follow? How do these agreements translate into national rules and regulations? This module also includes the steps you must take to gain access to traditional knowledge related to genetic resources.

At the end of the module, you will know what procedures to follow to obtain germplasm and associated traditional knowledge under international and national rules and regulations.



## Learning objectives

At the end of this module, you will be able to:

- Identify relevant elements of the international laws pertaining to germplasm acquisition, namely, the protection of traditional knowledge, access to and benefit sharing of germplasm
- Identify the rules for germplasm acquisition applicable to the context and specific objectives of your research
- Know who to contact to request access to the materials you are interested in
- Take into account applicable rules, procedures, and standards that countries establish to meet their obligations under the Convention on Biological Diversity (CBD), the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization, and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)
- Follow the steps required to access traditional knowledge subject to free prior informed consent

## Acquiring new germplasm

Over the last 25–30 years, access to and benefit sharing of genetic resources have become subjects of formal international law. Key pieces of legislation are the CBD (<https://www.cbd.int/>), the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the CBD (<https://www.cbd.int/abs/>), and the ITPGRFA (<http://www.planttreaty.org/>). As countries sign these agreements, they are establishing national systems to implement them.

However, many still do not have such systems, and this is one of the complexities you will need to address as you seek access to plant germplasm.

In some cases, the acquisition of new germplasm may be relatively easy; for example, through informal exchanges among farmers in a particular region or between community seed banks in a country. Such informal or traditional exchanges are often exempt from national access and benefit-sharing laws. However, in other cases, the formal international and national laws and implementing processes and standards will have to be taken into account to acquire new germplasm and associated traditional knowledge.

## What do you already know?

- How familiar are you with the rules and regulations for new germplasm acquisition defined by the CBD, the Nagoya Protocol, and the ITPGRFA?
- Have you had experience with the process of obtaining prior informed consent from communities in which you are working? If you are a member of a community that has been approached for access, have you had experience developing such agreements?
- Are you knowledgeable about the various access and benefit-sharing rules and regulations regarding the acquisition of new germplasm that exist in your country and internationally? What about those that apply to accessing traditional knowledge?

## Content summary

- International legal frameworks
- Dealing with national legislation on traditional knowledge
- Practical tips for acquiring germplasm

## International legal frameworks

Under the CBD, countries are encouraged to establish systems that allow national authorities and germplasm users to negotiate access and benefit-sharing agreements on a bilateral basis. The terms of access and benefit sharing must be written in the form of a contract. The Nagoya Protocol extends the commitments of member states to put systems in place to facilitate negotiations and to track, monitor, and enforce access and benefit-sharing agreements (in the countries of both the provider and the users of germplasm).

The ITPGRFA takes another approach. Although it too recognizes countries' sovereign right to regulate access to genetic resources, under the ITPGRFA, member states agree to create a multilateral system for facilitated access to a limited number of agricultural crops (64 are listed in Annex 1 of the ITPGRFA) and for multilateral benefit sharing. In short, member states agree to create a virtual pool of the genetic resources of 64 crops and forage plants and give each other access for the purposes of research, training, and plant breeding for food and agriculture. If anyone makes money from commercializing materials, it goes into an international fund and is disbursed by the governing body of the ITPGRFA.

Currently, Contracting Parties of the ITPGRFA are in the process of enhancing the functioning of the multilateral system. A subscription system for users of germplasm in the multilateral system is being negotiated as a core element of this enhancement. Subscription fees paid by the users would allow a more predictable and stable flow of funds into the international benefit-sharing fund.

In addition to the rules and regulations established by the CBD and ITPGRFA, many countries have national policies and laws (or are in the process of developing them) that concern the acquisition and use of new germplasm.

A more detailed explanation of the contents of the CBD, the Nagoya Protocol, and the ITPGRFA is beyond the scope of this module. However, this information can be found in Greiber et al. 2012 and Moore and Tymowski 2005 (see "More on the subject" below).

Before acquiring germplasm, perhaps the major initial challenge is to find out what laws apply to the material you are seeking to obtain and the purpose(s) of your activities. You may do this in a number of ways:

- If the country from which you are seeking materials has a full-fledged system for implementing the CBD, Nagoya Protocol, and/or the ITPGRFA, it will have published lists of contact people who receive enquiries about access to materials in their country. You may seek their advice. Unfortunately, not many countries have made such appointments or publish that information online.

- An alternative is to write to the national focal point for each of the agreements in the country concerned. Updated lists of these focal points are maintained by the secretariats of the various agreements (for the ITPGRFA, see <http://www.fao.org/plant-treaty/countries/national-focal-points/en/> for the CBD and Nagoya Protocol, see <https://www.cbd.int/information/nfp.shtml>).
- Alternatively, you may ask the organization or individual from whom you are seeking access what rules apply. National public organizations that deal with genetic resources (e.g., national genebanks and national agricultural research organizations) will likely be able to provide advice about the laws that apply, standards to follow, etc. That said, any good lawyer will advise you to seek additional independent sources of information to confirm what you have been told. National organizations may not have the full story, and you must be sure that you are in compliance.
- A complementary course of action requires some research on your part, but it is important for you to appreciate the rules of the game. Search the Internet, the CBD Access and Benefit-Sharing Clearing-House (<https://absch.cbd.int/>), and the Food and Agriculture Organizations FAOLEX (<http://faolex.fao.org/>) for laws that the country may have passed to implement the CBD, Nagoya Protocol, or ITPGRFA. Those laws should provide details about whom to contact for more information. Once you have found the right person to contact, the rules and processes you must follow will be informed by the applicable law. In some cases, because the laws are new and countries may not have a lot of experience implementing them, it is a good idea to try to form your own opinion. Here are some basic rules of thumb:
  - » Verify that the country from which you are attempting to access germplasm has ratified the CBD/Nagoya Protocol and the ITPGRFA. Updated lists of contracting parties can be found online: CBD <https://www.cbd.int/information/parties.shtml>; Nagoya Protocol <https://www.cbd.int/abs/nagoya-protocol/signatories/default.shtml>; ITPGRFA <http://www.fao.org/plant-treaty/countries/en/>.
  - » Confirm that the type of germplasm you want is one of the 64 crops or forage species included in Annex 1 of the ITPGRFA and compare your purpose for seeking this material with those spelled out in the ITPGRFA (i.e., research, breeding, and training in food and agriculture).
  - » If the germplasm you are seeking is listed in Annex 1 and it is in a collection hosted by a national public organization, it is likely available under the multilateral system. If it is not in Annex 1 nor in a national collection, it is likely not in the multilateral system.
  - » If the material you are seeking is in the multilateral system of the ITPGRFA, you may receive it under the Standard Material Transfer Agreement (SMTA; see copies at <http://www.fao.org/plant-treaty/areas-of-work/the-multilateral-system/the-smta/en/>). Some countries have policies to make non-Annex 1 material available under the SMTA as well. Note: in case of germplasm that is “under development” as defined in the ITPGRFA, providers are not obliged to provide access. However, if they do provide access, the material must be transferred under the SMTA and the provider may stipulate terms additional to those included in the SMTA.
- If the country has ratified both the Nagoya Protocol and the ITPGRFA and the materials you seek are not included in the multilateral system, they will be subject to an access and benefit-sharing agreement that satisfies the standards established in the Nagoya Protocol and national laws of the country concerned.

- You must comply with the relevant phytosanitary rules for export/import of germplasm. Such regulations are sometimes defined unilaterally by providers of germplasm, but many providers follow international standards. Standards define what measures must be taken to produce and distribute healthy seeds in a manner that minimizes health risks, such as the spread of pests and diseases from one location to another, and guarantee maximum germination and growth potential. International rules and regulations in this regard have been developed by the International Plant Protection Convention (<http://www.ippc.int>).

## Recommended readings

■ Halewood, M., Andrieux, E., Crisson, L., et al., 2013. Implementing 'mutually supportive' access and benefit sharing mechanisms under the Plant Treaty, Convention on Biological Diversity, and the Nagoya Protocol. *Law, Environment and Development Journal* 9(1): 68. Available: <https://www.biodiversityinternational.org/e-library/publications/detail/implementing-mutually-supportive-access-and-benefit-sharing-mechanisms-under-the-plant-treaty-con/>.

*This article sets out the fundamental issues that must be addressed and the steps that national policymakers must follow when implementing ITPGRFA's multilateral system of access and benefit sharing. It identifies the main points of intersection, at the national level, between the ITPGRFA's multilateral system and laws to implement access and benefit-sharing norms under the CBD.*

■ López Noriega, I., Wambugu, P., Mejías, A., 2013. Assessment of progress made to make the multilateral system functional: incentives and challenges at the country level. In: Halewood, M., López Noriega, I., Louafi, S. (editors), *Crop genetic resources as a global commons: challenges in international law and governance*, Routledge, Oxon, UK and New York, USA, pp. 199–225. Available: <http://www.biodiversityinternational.org/e-library/publications/detail/crop-genetic-resources-as-a-global-commons/>.

*This chapter assesses the progress made (as of 2013) in national-level implementation of the multilateral system, the incentives that encourage users to become full participants in the system, and the challenges or disincentives encountered.*

■ Halewood, M. (editor), 2015. Mutually supportive implementation of the Plant Treaty and the Nagoya Protocol: a primer for National Focal Points and other stakeholders. Discussion draft Biodiversity International, Rome, Italy. Available: <http://www.biodiversityinternational.org/e-library/publications/detail/mutually-supportive-implementation-of-the-plant-treaty-and-the-nagoya-protocol/>.

*This report presents the results of a series of activities (survey, workshop, post-workshop analysis) aimed at producing a tool to support implementation of the ITPGRFA and the Nagoya Protocol. It includes a series of scenarios and options for improved coordination in implementation.*

## More on the subject

■ 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](https://cmsdata.iucn.org/downloads/eplp_057_explanatory_guide_to_the_international_treaty_on_plant_genetic_resources_fo.pdf).

*This comprehensive guide describes the special nature of plant genetic resources for food and agriculture and the origins of the ITPGRFA; it summarizes the main components of the ITPGRFA and describes and explains its 35 articles. The complete text of the ITPGRFA is included as well.*

■ Moore, G., Goldberg, E. (editors), 2010. The International Treaty on Plant Genetic Resources for Food and Agriculture: learning module. Bioversity International, Rome, Italy. Available: <http://treatylearningmodule.bioversityinternational.org/>.

*This on-line learning module, which was produced by CGIAR's System-wide Genetic Resources Programme, Bioversity International, and CGIAR's Generation Challenge Programme, explains the ITPGRFA in a step-by-step sequence. Available in English, French, and Spanish and on CD.*

■ Greiber, T., Peña Moreno, S., Åhren, M., et al., 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](https://cmsdata.iucn.org/downloads/an_explanatory_guide_to_the_nagoya_protocol.pdf).

*This comprehensive guide introduces the concepts of access and benefit sharing and the road that led to the Nagoya Protocol. It then presents and explains the 36 articles of the Nagoya Protocol in detail. The full text of the Nagoya Protocol is included as an annex.*

■ Morgera, E., Tsioumani, E. Buck, M. 2015. Unraveling the Nagoya Protocol: a commentary on the Nagoya Protocol on Access and Benefit-sharing to the Convention on Biological Diversity. Brill, Leiden, The Netherlands. Available: <https://www.jstor.org/stable/10.1163/j.ctt1w76vwq>.

*This commentary explains each of the Protocol's Articles in accordance with the Vienna Convention on the Law of Treaties. It focuses on a systematic interpretation wherever a strict literal interpretation may prove problematic due to the peculiar way in which the final text of the Protocol was arrived at. The commentary pays particular attention to the principle of effectiveness – that is, it engages in interpretations that contribute to coherent meaning and ensure the full effect of the treaty – and the principle of good faith.*

■ Medaglia, J.C., Perron-Welch, F., Phillips, F-K., 2014. Overview of national and regional measures on access and benefit sharing: challenges and opportunities in implementing the Nagoya Protocol. CISDL, Montreal, Canada. Available: <http://www.cisdl.org/publications/overview-of-national-and-regional-measures-on-abs/>.

*This third edition of the CISDL study reviews the ABS measures in countries from Latin America and the Caribbean, Asia, the South Pacific, Africa, Europe, and North America as well as the regional measures of the Andean Community, the Association of South-East Asian Nations (ASEAN), the African Union (AU), the European Union (EU), and the Nordic countries. It examines relevant laws and policies, and their provisions on scope, prior informed consent, mutually agreed terms on benefit-sharing, compliance, and monitoring and enforcement, as well as any access agreements that have been granted, or relevant experience gained in the implementation of ABS measures. It also presents a discussion and conclusions on the main legislative challenges to implementing the Protocol.*

## Dealing with national legislation on traditional knowledge

Germplasm is not only “seed” in a material sense, but also includes the knowledge that generations of farmers and cultivators have invested in growing, conserving, and improving crops. For many local farming communities around the world, germplasm also has religious, ethical, spiritual, and sociocultural meaning and values. For those farming communities, seeds are living entities and intrinsic elements of the cosmos on which we all depend.

Acquisition of germplasm, therefore, requires recognition of and respect for the local agricultural practices that have led to the development and improvement of germplasm over a long period.

The CBD, and Article 8(j) in particular (text below), triggered a series of policy processes at national and international levels that seek to offer legal protection of traditional knowledge, including agro-ecological practices. To some extent, these processes have also helped to revalue (from economic and legal perspectives more than from social or political ones) the role and importance of traditional knowledge, long acknowledged in social and agricultural disciplines and within local and indigenous contexts.

### Article 8(j)

Each contracting Party shall, as far as possible and as appropriate:

Subject to national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge innovations and practices (Source: <https://www.cbd.int/convention/text/>).

The Nagoya Protocol requires contracting parties to adopt measures together with local and indigenous communities to ensure that access to traditional knowledge is subject to prior informed consent (PIC), which includes the right of local communities to be involved in decisions about issues that affect them. Communities and farmers must be well informed and involved in a timely process, in which decisions are based on appropriate data and information provided by potential users of the traditional knowledge and resources. The definitions of terms and conditions must also be agreed to by both those who seek access to the traditional knowledge and the communities who hold the knowledge.

Before these mechanisms became part of international law through the Nagoya Protocol, they had already been used in the context of a number of research and development projects, and some countries had incorporated them in national legislation. However, documentation of experience using PIC and negotiating terms is still scarce.

If using traditional knowledge associated with particular crops and varieties is part of your research, you will have to ensure that you obtain access to such knowledge and that you use it in compliance with national and local rules. Thus, the first step is to find out whether the country or countries where the plant germplasm and the traditional knowledge are found have national, regional, or local laws pertaining to access and use of traditional knowledge associated with genetic resources. If the source country or countries are party to the Nagoya Protocol, you may



*Photo: Improved rice varieties in the Paro valley, Bhutan. Credit: Bioversity International/R.Vernooy*

contact the national focal point designated to deal with applicants and rely on the guidance provided by this person.

If a national focal point has not been designated or if you cannot communicate with him or her, for whatever reason, it is advisable to take one or all the measures described in section 1:

- Get in touch with the general focal point for the Nagoya Protocol or the CBD, using the list of national focal points published by the CBD Secretariat
- Ask advice from the organization or individual from whom you would like to get the germplasm, or a legal expert from the country
- Find out about the existence and the content of legislation on the protection of traditional knowledge, by using online databases, such as the CBD ABS Clearing House mechanism, the FAOLEX, and the WIPO (World Intellectual Property Organization) Lex.

If permission from local communities is required by national law, you may find that the processes and structures established to allow researchers and local communities to negotiate PIC and mutually agreed terms are unclear or non-existent. Again, you might seek the advice of national experts and observe generally accepted good practices in relation to collecting and using germplasm and traditional knowledge.

A number of international codes of conduct have also been developed, such as the FAO code for plant germplasm collecting and transfer, and the International Society of Ethnobiology code of ethics (references below). Bioversity International has also developed guidelines for access and benefit sharing in research projects (reference below).

## Recommended readings

■ Greiber, T., Peña Moreno, S., Åhren, M., et al., 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](https://cmsdata.iucn.org/downloads/an_explanatory_guide_to_the_nagoya_protocol.pdf).

*This comprehensive guide introduces the concepts of access and benefit sharing, the road that led to the Nagoya Protocol and then presents and explains the 36 articles of the Nagoya Protocol in detail. The full text of the Nagoya Protocol is included as an annex.*

■ Lapeña, I., López, I., Turdieva, M., 2012. Guidelines: access and benefit sharing in research projects. Bioversity International, Rome, Italy. Available: [http://www.seedsresourcebox.org/recomended-readings/detail/?tx\\_news\\_pi1%5Bnews%5D=1486&cHash=7080be604f1ee303b270b9c7d1c4b75b](http://www.seedsresourcebox.org/recomended-readings/detail/?tx_news_pi1%5Bnews%5D=1486&cHash=7080be604f1ee303b270b9c7d1c4b75b).

*This is a handy booklet with practical tips to take into consideration key issues of access and benefit in research projects.*

■ Food and Agriculture Organization of the United Nations. n.d., International code of conduct for plant germplasm collecting and transfer. Available: <http://www.fao.org/docrep/x5586e/x5586e0k.htm>.

*This voluntary code describes the shared responsibilities of collectors, donors, sponsors, curators, and users of germplasm to ensure that its collection, transfer, and use are carried out to provide the maximum benefit to the international community and to minimize adverse effects on the evolution of crop plant diversity and the environment. The code emphasizes the need for cooperation and a sense of reciprocity among donors, curators, and users of plant genetic resources.*

■ International Society of Ethnobiology, 2006. The ISE code of ethics. ISE, Bristol, Vermont, USA. Available: <http://www.ethnobiology.net/what-we-do/core-programs/ise-ethics-program/code-of-ethics/code-in-english/>.

*With 2008 additions, this is a clearly written, comprehensive and widely used code of ethics.*

■ Secretariat of the Convention on Biological Diversity, 2011. The Tkarihwaié:r code of ethical conduct to ensure respect for the cultural and intellectual heritage of indigenous and local communities relevant to the conservation and sustainable use of biological diversity. Secretariat of the Convention on Biological Diversity, Montreal, Canada. Available:

<https://www.cbd.int/doc/publications/ethicalconduct-brochure-en.pdf>.

*Ethical conduct guidelines for working with indigenous and local communities on biological diversity.*

■ Mo'otz kuxtal voluntary guidelines. Available: <https://gearights.org/?p=362>.

*Voluntary guidelines for the development of mechanisms, legislation or other appropriate initiatives to ensure the free, prior and informed consent or approval and involvement (depending on national circumstances) of indigenous peoples and local communities for accessing their knowledge, innovations and practices; for fair and equitable sharing of benefits arising from the use of their knowledge, innovations and practices relevant for the conservation and sustainable use of biological diversity; and for reporting and preventing unlawful appropriation of traditional knowledge.*

■ Food and Agriculture Organization of the United Nations. 2016. Free prior and informed consent: an indigenous peoples' right and a good practice for local communities. Manual for project practitioners. FAO, Rome. Available: <http://www.fao.org/documents/card/en/c/5202ca4e-e27e-4afa-84e2-b08f8181e8c9/>.

*Guidelines for establishing free prior and informed consent.*



## Practical tips for acquiring germplasm

Rules and regulations surrounding germplasm acquisition address the questions of who may have access to and make use of germplasm and under what conditions. To a considerable extent, farmers' local-level agricultural practices (i.e., seed exchange, community fund) have traditionally been based on some form of equitable benefit sharing that often stems from regular and ancestral practices. It is only since the adoption of the CBD that a legal obligation has arisen in this regard. Although a number of countries have developed or are developing a specific access and benefit-sharing policy or law, this is still a relatively new area. However, it is gaining ground around the world.

In the meantime, you can learn from examples of good practices that showcase how germplasm users/providers can observe general access and benefit-sharing principles even when national laws do not exist, are unclear, or are not properly implemented.

These good practices refer to:

- Obtaining access to germplasm and knowledge from farmers and other users in proper ways
- Sharing benefits with farmers and other users fairly
- Providing access to germplasm to other researchers and negotiating benefits with them in an appropriate manner.

Since 2008/2009, the ITPGRFA has supported a large number of projects that aim to promote fair access and benefit sharing through the Benefit-sharing Fund. The purpose of this fund is to accelerate the conservation and use of plant genetic resources on a global scale through technology transfer, capacity building, high-impact projects, and innovative partnerships involving farmers, plant breeders, civil society, and other stakeholders. For an overview of the fund and projects supported to date, see: <http://www.fao.org/plant-treaty/areas-of-work/benefit-sharing-fund/overview/en/>.

The following are examples of access and benefit-sharing practices and mechanisms (see recommended reading for related information):

- Communities as partners in national conservation efforts, for example, through collaboration with the national genebank and the exchange of seeds and related knowledge
- Biocultural heritage areas that promote the conservation and revival of native crops and crop varieties and related traditional knowledge and practices
- Legally protected farmers' seed production and commercialization enterprises based on the improvement of local varieties
- Formal agreements between farmers and breeders on the distribution of monetary and non-monetary benefits derived from collaborative activities, such as participatory plant breeding
- Community biodiversity management funds to promote the conservation and sustainable use of local varieties
- Community seed banks with multiple functions, supported technically and financially by the national government

## Recommended readings

■ Swiderska, K., Argumedo, A., Song Y., Li, J., Pant, R., Herrera, H., Mutta, D., Munyi, P., Vedavathy, S., 2009. Protecting community rights over traditional knowledge: implications of customary laws and practices. Key findings and recommendations 2005–2009. International Institute for Environment and Development, London, UK. Available: <http://pubs.iied.org/14591IIED.html>.

*This publication presents results from original research in China, India, Kenya, Panama, and Peru on novel tools to protect traditional knowledge rooted in customary laws and practices rather than based on existing intellectual property rights. The focus is on collective rights instead of individual rights.*

■ The Potato Park Communities, International Institute for Environment and Development, 2012. Community biocultural protocols: building mechanisms for access and benefit sharing among the communities of the Potato Park based on Quechua customary norms. IIED, London, UK. Available: <https://pubs.iied.org/G03340/?a=A+%28Peru%29>.

*This is an example of a locally developed biocultural protocol to guarantee fair and equitable access and benefit sharing of the rich potato diversity of the Potato Park.*

■ Vernooy, R., Ruiz, M., 2013. Access to and benefit sharing of plant genetic resources: novel field experiences to inform policy. *Resources* 2(2): 96–113. Available: <https://www.mdpi.com/2079-9276/2/2/96>.

*This article presents a number of novel access and benefit-sharing (ABS) practices that are built on local realities while taking into consideration formal policy and legal processes related to the CBD and the ITPGRFA. Case studies are from China, Cuba, Honduras, Jordan, Nepal, Peru and Syria.*

■ Shrestha, P., Sthapit, S., Subedi, A., Sthapit, B., 2013. Community biodiversity management fund: promoting conservation through livelihood development in Nepal. In: de Boef, W.S., Subedi, A., Peroni, N., Thijssen, M., O'Keeffe, E. (editors), *Community biodiversity management: promoting resilience and the conservation of plant genetic resources*. Routledge, Oxon, UK, and New York, USA, pp. 118–122. Available: [https://www.researchgate.net/publication/273059041\\_Community\\_biodiversity\\_management\\_fund\\_Promoting\\_conservation\\_through\\_livelihood\\_development\\_in\\_Nepal](https://www.researchgate.net/publication/273059041_Community_biodiversity_management_fund_Promoting_conservation_through_livelihood_development_in_Nepal).

*This chapter describes and reflects on the experiences of establishing pilot community biodiversity management funds in Nepal. It presents the achievements, challenges, and lessons learned and concludes with a number of recommendations to make this type of community-driven mechanism successful and sustainable.*

■ Ruiz, M., Vernooy, R. (editors), 2012. *The custodians of biodiversity: sharing access to and benefits of genetic resources*. Earthscan, Oxon, UK, and International Development Research Centre, Ottawa, Canada. Available: <https://www.idrc.ca/en/book/custodians-biodiversity-sharing-access-and-benefits-genetic-resources>.

*This book addresses the challenges of local and indigenous communities (the custodians) to conserve biodiversity, improve their crops, and manage the precious natural resources that are under threat. Using the case of participatory plant breeding, where farmers, researchers and others join forces to improve existing crop varieties or develop new ones, based on shared knowledge and resources, it presents country experiences from China, Cuba, Honduras, Jordan, Nepal, Peru and Syria. In particular, the challenges are addressed within the context of the CBD and the ITPGRFA.*

## Testing your knowledge

Here is a quiz that will help you test your newly acquired knowledge. Once you have covered the content sections and completed the assigned readings, please answer the Germplasm Acquisition Quiz.

1. In many cases, germplasm acquisition must follow formal rules and regulations. What do these rules cover?
  - a. The scientific aspects of seed production
  - b. The phytosanitary aspects of seed production
  - c. The protection of traditional knowledge
  - d. Access to germplasm
  - e. The phytosanitary aspects of seed distribution
  - f. Benefit sharing of germplasm
  - g. The protection of biodiversity
  
2. In relation to the Convention on Biodiversity (CBD) and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA or Plant Treaty), which of these answers is or are true?
  - a. The CBD is crafted on a bilateral system of access and benefit-sharing agreements.
  - b. The ITPGRFA does not recognize national sovereign rights over plant genetic resources.
  - c. The ITPGRFA represents a multilateral system for facilitated access to all agricultural crops related to food security.
  - d. Many countries have national policies and laws that concern the acquisition and use of new germplasm, but the rules and regulations set by the CBD and ITPGRFA take precedence once they have been ratified.
  - e. The ITPGRFA represents the application of the CBD to the domain of plant genetic resources for food and agriculture.
  
3. How would you characterize the relation between the ITPGRFA and farmers' rights?
  - a. The Plant Treaty includes a special charter on farmers' rights.
  - b. Protection of traditional knowledge is a key dimension of the Plant Treaty.
  - c. Farmers' rights are addressed in the CBD, not in the Plant Treaty.
  - d. The Plant Treaty regulates the acquisition of germplasm in terms of respect for and recognition of local agricultural practices.
  - e. The Plant Treaty only regulates the acquisition of germplasm that has been accessed through legal arrangements.
  
4. What are access and benefit-sharing rules and regulations concerned with?
  - a. The access to new germplasm, its use, and conditions of sale
  - b. The questions of who may have access to and make use of germplasm and under what conditions
  - c. The intellectual property rights of breeders, and conditions of access of new germplasm
  - d. All of the above

5. Who defines the phytosanitary regulations related to the exchange of germplasm?
- a. The providers of germplasm
  - b. Internationally agreed standards
  - c. The national agency for phytosanitary regulations
  - d. The national agency in each country implementing the ITPGRFA

## Applying your new knowledge

Now that you are able to acquire new germplasm, it is time to apply your new knowledge. In the previous step, following a climate change analysis, you identified new germplasm and you are now ready to acquire it, following the various rules and regulations and choosing the appropriate mechanisms.

Please, document this step of the research process by identifying the following:

1. At the end of the previous module, which new germplasm did you identify?
2. What questions are you asking to acquire this new germplasm?
3. What mechanism(s) for germplasm acquisition are you choosing and why?
4. Which rules, regulations, and standards apply to your case for the protection of traditional knowledge and access to and benefit sharing of germplasm?
5. How are you conducting the process to ensure free prior informed consent?

# MODULE 5

## Field-testing

*Jacob van Etten, Jonathan Steinke  
and Ronnie Vernooy*



FIELD-TESTING

Photo:  
Participatory potato trial,  
Bolivia.  
Credit:  
Fundación PROINPA

## Introduction

In the previous module, you learned how to acquire new germplasm according to the rules and regulations that exist at international and national levels, so that it can be tested in farmers' fields without any impediments.

In this module, you will be introduced to a number of participatory approaches to test the newly acquired germplasm. These approaches put farmers at the center of the experimental cycle(s). Two of them, participatory variety selection and participatory plant breeding, have a considerable track record whereas the third, crowdsourcing of field trials, is a more recent technique.

### Learning objectives

At the end of this module, you will be able to:

- Identify the key characteristics of three participatory crop-testing approaches
- Differentiate these key characteristics from those of conventional approaches
- Be aware of some of the challenges inherent in these participatory approaches
- Prepare a plan for participatory field-testing of the newly acquired germplasm

### The importance of local field-testing

For decades, national and international research and breeding institutes have been developing new crop varieties that have led to remarkable increases in yield potential, market value, and the capacity to adapt to climatic hazards, such as dry spells, floods, etc. Although conventional crop research has contributed to substantial yield increases, mainly in high-input areas, smallholders

with limited access to inputs or credit, often relying on rain-fed farming at marginal sites and under variable climatic conditions, have enjoyed little benefit. In Africa and Latin America in particular, even farmers who have had access to improved varieties have often stopped growing them after a few years because the seeds failed to meet their needs in their production systems.

Farmers often have different priorities from scientists or breeders. To identify varieties that are of maximum use to farmers — for household consumption, sales, cultural use, animal feed, or a combination of these — locally specific characteristics need to be taken into account, beyond purely agronomic attributes like productivity.

These characteristics might include cooking quality, marketability, or the quality of stubble for animal feed — features that are of high local and cultural specificity.

In addition, past experience has shown that not all farmers have the same needs, interests, and preferences. Women farmers often have different ideas than men about what traits or characteristics are important. Younger farmers may have different views from older ones, as a result, for example, of their higher education levels or more exposure to influences from outside the community.

Participatory crop improvement emerged as a response to the shortcomings of conventional approaches. It is based on the principle that farmers participate as equal partners alongside agricultural scientists, fairly sharing their knowledge, expertise, and seeds. The results of such collaboration include not only more effective crop improvement practices, but also strengthening of farmers' capacity to experiment, learn, and adapt.

### What do you already know?

- Have you had any previous experience with participatory crop testing? What did you learn from these experiences?
- Have you heard about the concept of crowdsourcing in the field of agricultural research? Or in another research field?
- Have you worked with farmer (expert) breeders to improve local varieties through a long-term collaborative arrangement? What did you learn from these experiences?

### Content summary

- Participatory variety selection
- Crowdsourcing field trials
- Participatory plant breeding

## Participatory variety selection

In successful participatory variety selection (PVS), organized farmer groups (usually made up of a mix of women and men farmers, but sometimes women only or young farmers only) grow a set of promising varieties or fixed lines in experimental quantities on one or more plots that have been volunteered by one or more farmers in the group. In other words, experimentation takes place in target environments that represent real-life agro-ecological conditions. Together with a facilitator, the farmers evaluate the varieties according to the attributes that matter most to them and

maintain the best materials for replication in the next season. Farmer groups may intuitively select a variety that complies with local needs and preferences and discard varieties recommended by breeding stations or governments.

PVS includes five steps:

- Needs assessment: identification of a portfolio of farmer-preferred traits
- Searching for resources that have the desired traits
- Small-scale field experimentation: comparison of newly introduced varieties or fixed lines with a local one
- Wider dissemination of successful varieties or fixed lines
- Monitoring of further spread and, possibly, adaptation.

PVS has been in use since the 1990s and has become a mainstream practice in many plant breeding and rural development programs and projects. The extent of farmer participation in selection activities may range from merely visually selecting among a few pre-release varieties at a field day to selecting and ranking during the growing cycle; participating in selection from a larger, initial pool of materials; cultivating a large number of varieties and selecting on farm; or following seed production and marketing of promising materials.

At the lesser end of participation, preselected, improved varieties at physiological maturity are presented to farmers by researchers at a breeding station. Usually during a field day, the invited farmers select a variety they would prefer to grow and are then offered small amounts of seeds to test on farm. In more participatory-oriented approaches, farmers make key decisions throughout the whole process, although usually in close consultation with researchers. This allows the farmers to take into account qualities that do not show up at the field day: resistance to wind, drought, or flooding; weed incidence; labor requirements, etc.

In Latin America, farmer research committees (or CIALs [*Comité de investigación agrícola local*], as they are called locally) repeat multi-variety trials of unreleased materials in a breeding program over several growing periods. Some CIALs begin their variety trials with 35 different lines, to see which new accession is most suitable to the environment. Spreading the process over several seasons helps them form an accurate picture of the varieties under varying climatic conditions and generates profound local learning with regard to the varieties' advantages and disadvantages during the whole growing cycle.

A well-established practice in PVS, "mother–baby trials" combine the benefits of trials at a research station or at one farm (with enough land for the experiment) with trials under farmer management. In "mother" trials, breeders and researchers usually assess 10–20 varieties under controlled conditions and measure yield and other variables. A smaller number of these varieties is tested by a larger group of farmers under diverse farming conditions, either in a subsequent cycle or concurrently. These are the "baby" trials.

Observations may then be collected from farmers about the varieties' performance under realistic management conditions and constraints as compared with a local variety (assessment may be simply better than/worse than/same as a local variety), in terms of days to maturity, plant height, disease incidence, taste, yield, and overall preference. The initial information from the mother trial is complemented by that from the baby trials and sometimes even corrected or discarded. This is an effective way to increase varietal diversity and relay information to farmers.



Varieties that are released after PVS often have a higher adoption rate and higher field sustainability, because they respond to the specific requirements of marginal environments, whereas conventional released varieties often do not. PVS is, therefore, especially suitable for typical staple crops of smallholders or vulnerable dryland farmers, such as legumes, maize, wheat, barley, rice, sorghum, or tef. Although PVS is considered to be a mainstream method now, there has been some criticism about the possibility of the approach leading to researcher bias, lack of sustainability, or socially unacceptable outcomes. Pitfalls include biased questioning at the time of selection or providing an incentive for “correct” answers, e.g., by letting farmers hope that answering in a certain way will increase their chances of getting further benefits from the research program. Special attention must be paid to not attaching an incentive to productivity in baby trials, as this could lead farmers to over- or underreport observations of yield.

Restricting participation to final field days also brings the risk of “impulse” selection based on the snapshot impression farmers have on that day, regardless of climatic conditions, soil, stress, and other circumstances during the production cycle. When the selected variety is later grown under usual farmers’ conditions, this knowledge gap can have serious repercussions. Farmers might then observe characteristics that are perceived as not desirable. However, despite these possible shortcomings, PVS has been very successful in numerous countries, particularly when combined with community seed banking and seed production and distribution (e.g., Honduras, Nepal, Zimbabwe).

## Recommended readings

■ Joshi, A., Witcombe, J.R., 1996. Farmer participatory crop improvement. II. Participatory varietal selection, a case study in India. *Experimental Agriculture* 32(4), pp. 461–477. Available: [https://www.researchgate.net/publication/231846829\\_Farmer\\_Participatory\\_Crop\\_Improvement\\_II\\_Participatory\\_Varietal\\_Selection\\_a\\_Case\\_Study\\_in\\_India](https://www.researchgate.net/publication/231846829_Farmer_Participatory_Crop_Improvement_II_Participatory_Varietal_Selection_a_Case_Study_in_India).

*This article describes the pioneering experience when PVS was used for chickpeas and rice in India. The results led to several important recommendations concerning the Indian variety testing and release system.*

■ Ashby, J.A., Braun, A.R., Gracia, T., et al., 2001. Investing in farmers as researchers: experience with local agricultural research committees in Latin America. Centro Internacional de Agricultura Tropical, Cali, Colombia. Available: <https://cgspace.cgiar.org/handle/10568/54100>.

*This book is the number one resource for anyone who is interested in the CIAL method; it includes experiences, tips for practitioners, and references to practical handbooks, many of which are useful for the implementation of a PVS and/or participatory plant breeding program.*

■ International Rice Research Institute, 2006. Module 6. Participatory approaches. Lesson 1. Participatory variety trials for rainfed rice cultivar evaluation In IRRI’s Rice Breeding Course. International Rice Research Institute, Los Baños, Philippines. Available: [http://www.knowledgebank.iri.org/ricebreedingcourse/bodydefault.htm#Participatory\\_Variety\\_Trials\\_For\\_Rainfed\\_Rice\\_Cultivar\\_Evaluation.htm](http://www.knowledgebank.iri.org/ricebreedingcourse/bodydefault.htm#Participatory_Variety_Trials_For_Rainfed_Rice_Cultivar_Evaluation.htm).

*A handy guide on how to carry out PVS, especially mother–baby trials. A section on how to collect farmers’ observations is especially useful.*

■ Misiko, M., 2013. Dilemma in participatory selection of varieties. *Agricultural Systems* 139, pp. 35–42. Available: <https://doi.org/10.1016/j.agsy.2013.04.004>. (Limited access)

*Participatory variety selection has become a standard practice, but this publication discusses a number of shortcomings.*

## More on the subject

■ Vernooy, R., Shrestha, P., Ceccarelli, S., Ríos Labrada, H., Song, Y., Humphries, S., 2009. Chapter 23. Towards new roles, responsibilities and rules: the case of participatory plant breeding. In: Ceccarelli, S., Guimarães, E.P., Weltzien, E. (editors), *Plant breeding and farmer participation*. Food and Agriculture Organization of the United Nations, Rome, Italy, pp. 613–628. Available: <http://www.fao.org/docrep/012/i1070e/i1070e00.htm>.

*This book chapter provides an overview of various context-adapted, yet successful, experiences in participatory breeding and variety selection from Asia and Latin America. It highlights how participatory crop improvement requires a new way of doing research in terms of roles, responsibilities, and rules.*

■ Vernooy, R., Netnou-Nkoana, N., Mokoena, M., et al., 2019. “Coming together” (Batanai): learning from Zimbabwe’s experiences with community biodiversity conservation, participatory crop improvement and climate change adaptation. Bioversity International, Rome, Italy; Department of Agriculture, Forestry and Fisheries, Pretoria, South Africa; Community Technology Development Organisation, Harare, Zimbabwe. Available: <https://hdl.handle.net/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 neighboring Zimbabwe, to learn about the roles of farmer field schools, the functions and operations of community seed banks and various forms of participatory crop improvement, promoted by the Community Technology Development Organisation of Zimbabwe.*

## Crowdsourcing field trials

Crowdsourcing is an approach used by scientists and companies worldwide to collect data from a large number of volunteers instead of just from a few researchers. Well-established crowdsourcing projects include initiatives in which thousands of hobby birdwatchers contribute to regular national surveys on bird migration, or citizens measure the quality of the bodies of water close to their residences. “Crowds” can fulfill many tasks that highly specialized researchers cannot, because of their geographic spread, the accumulated time they can dedicate to a task, and the sheer number of contributors. Crowdsourced data collection can be helpful in generating a broad and holistic response to a research question.

Crowdsourcing field trials of new crop varieties implies that many farmers carry out small trials instead of a research station conducting one large trial. Researchers merge and analyze data from all trials. This offers the possibility of testing promising material in different climatic regions, on different soil types, under different management regimes, and, most important, under the real-life conditions of many participating farmers. However, crowdsourcing requires special preparation to motivate enough contributors and ensure data quality.

A crowdsourced project can operate over a large geographic area, but is most effective when it focuses on one crop only. A sufficient amount of promising plant material, such as advanced lines from breeding programs, released varieties that are not well known in the area, or promising landraces, is preselected. Within one crowdsourced project, many varieties may be assessed, but every variety must be tested various times in comparable environments to make statistical analysis possible.

Local learning is stimulated if all varieties are present in each community and if some varieties are repeated in the trial. In this way, farmers can compare varieties empirically by visiting plots within their community and making at least one observation of each variety. For example, if there

are only five participants in a community, the total number of tested varieties should not exceed 10 in order to ensure that all varieties occur at least once in the random sample assigned to the community and that some varieties are repeated in the trial.

Farmers receive and grow small, experimental quantities of three varieties that are randomly allocated and identified only with a code (A, B, C). They closely observe their growth, and report their observations and yield results to the researchers. Farmers do not know the names of the varieties until the final evaluation workshop that closes the experimental cycle. Farmers who are already organized in some way (in rural cooperatives or agricultural research committees) can be more easily approached than individual farmers for crowdsourced trials. As a first step, a trial managed by the group at large could be set up. Subsequently, individual farmers may carry out trials on their own farms to fully benefit from the potential of the approach.

Selected seed is produced by researchers in a sufficient quantity to allow testing in a small plot, e.g., five 6m rows per variety. In the case of common beans in Central America, for example, that means about 120g of seed per variety per participant. A local implementing agency, such as an NGO, university, or extension bureau, then establishes a distribution pathway: this could be through existing farmer groups or other grassroots organizations, or through publication about the trials via corner shops or agricultural fairs, for example. The implementer must also define the criteria for evaluation in consultation with farmers.

The user-friendly software package and online platform, ClimMob ([www.climmob.net](http://www.climmob.net)), is a free all-in-one tool used to design and execute crowdsourcing projects.

It allows randomization of varieties for setting up the project and monitoring its progress. It carries out statistical analysis and automatically generates useful information for both the researcher/project leader and the participants. Not only are data about the performance of the varieties collected and analyzed, but differences in varietal preferences and field performance across households and environments are also explained. Varietal preferences are often influenced by the socioeconomic profile of households, while field performance of varieties depends on land characteristics, agronomic management, and weather. ClimMob can also determine whether different groups of participants have different preference profiles. The more information available about factors that might explain farmers' evaluation, the more useful the results will be, specifically in terms of targeting variety recommendations to types of households and areas.

Some aspects of the performance of varieties, such as early vigor and disease resistance, are evaluated during the cultivation cycle, while others, such as yield and consumption characteristics, are assessed post-harvest. Local trained facilitators are responsible for keeping track of the collection and reporting to the project.

Various channels are available for entering information into ClimMob. Data can be collected on paper observation sheets by the farmers and then handed over to researchers.

Information can also be collected by telephone interviews. New data can be added regularly by filling out and uploading a spreadsheet, via an online form, or using an application for Android smartphones (the Android operating system is used by more than 80% of smartphones worldwide at the time of writing). The variety of channels available for information flow enables flexible adaptation to local conditions.

When all available information has been uploaded, the researchers compile and merge data from all implementation areas, carry out analyses using ClimMob, and send the results back to the local facilitators. Because the analysis is automated, results can be ready the day the last information is added to the system. This makes it possible to present the results in workshops

to local groups of participants shortly after harvest. In these workshops, participants discuss the results and make suggestions for improvements. Seed exchange could be encouraged, and registration for the following project cycle could take place.

ClimMob generates two final outputs: an analytical report and a set of information sheets. The analytical report sums up the research results. It presents which varieties were ranked highest for each criterion, whether there were any significant differences in the performance of varieties, and whether specific producer groups reported different evaluation results (e.g., variety X was ranked best by women, whereas variety Y was ranked best by men).

The information sheets contain personalized results for every participant. An individual sheet shows all relevant information about the trial and project results, including the names of the varieties that were included in the package for this participant, which are only revealed now. It also includes a specific variety recommendation based on the information available about the farm and the household. At the final workshop, the information sheets serve as a comparison of the experiences among small groups of farmers.

Incentives for farmers to participate are mainly the overall learning experience and the information about crop varieties that they gain through the project. Disclosure of the identity of the varieties only at the end is an incentive to complete the whole cycle. Farmers can also be encouraged to participate by giving them the opportunity to obtain a larger quantity of seed of their preferred variety for free or at a discount; this incentive is made clear at the beginning of the project. Additional appropriate motivations may include information about aspects of crop production practices. Care must be taken not to create incentives that are conditional on providing information, as this may encourage farmers to submit data even when the trial has failed or when no accurate observations were made.

Crowdsourcing is a relatively new approach in this area. Bioversity International is using it in its Seeds for Needs initiative, reaching a total of more than 25,000 farming households in 2015, including:

- Durum wheat farmers in Ethiopia: <http://www.bioversityinternational.org/e-library/publications/detail/a-crowdsourcing-approach-to-detect-farmers-preferences/>.
- Wheat growers India: <http://www.bioversityinternational.org/news/detail/1700-farmers-at-farmers-field-day-and-seed-production-training-in-india/>.
- Common-bean farmers in Honduras and other Central American countries: <https://ccaafs.cgiar.org/blog/more-wiser-exploring-how-farmer-citizen-science-can-deliver-solid-results>.
- Partnerships in crowdsourcing: <https://www.bioversityinternational.org/news/detail/usa-id-partners-with-bioversity-international-on-crowdsourced-crop-improvement/>.

In addition, the approach is being used by other CGIAR centers (IITA, ILRI) and the Integrated Seed Sector Development program in Ethiopia.

Crowdsourcing provides an alternative to the mother–baby trials discussed above. Each approach has advantages, but there are two main differences. First, in crowdsourcing, the varieties tested by farmers are randomly allocated, whereas generally, in mother–baby trials, farmers each select the varieties they want to grow in their baby trials. Thus, analysis of the farmer trials is more robust under crowdsourcing. A second difference is that crowdsourcing omits mother trials altogether.

Distributing material for crowdsourcing trials is easier than organizing community plots for variety trials and organizing events during the crop cycle. Thus, crowdsourcing can reach more

farmers, as costs per farmer are lower and even local organizations with limited technical capacity can help to organize the trials. Opportunities for training in crop observation, close control of experimental conditions, and detailed interaction on evaluation aspects are more difficult in crowdsourcing. However, in compensation, crowdsourcing provides many more data points representative of a range of growing conditions in an area.

The two approaches, mother–baby trials and crowdsourcing, may be used in combination: the former allowing more detailed observations and in-depth discussions with farmers in a smaller number of locations; the latter following as a scale out to reach a much larger group of farmers without losing the participatory aspect.

## Recommended readings

■ Van 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.*

■ CLIMMOB crowdsourcing smart agriculture, 2015. Bioversity International. Available: <https://climmob.net/blog/>.

*This website provides training manuals, instructional videos, and other information and resources for designing and executing successful crowdsourcing projects.*

■ 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.*

■ 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.*

## More on the subject

■ Sumberg, J., Okali, C., Reece, D., 2003. Agricultural research in the face of diversity, local knowledge and the participation imperative: theoretical considerations. *Agricultural Systems* 76(2), pp 739–753. Available: [https://doi.org/10.1016/S0308-521X\(02\)00153-1](https://doi.org/10.1016/S0308-521X(02)00153-1).

*This article supports the claim that farmer participation can lead to more successful outcomes in marginal environments and advocates the supply of sufficient experimental material, such as (diverse) varieties, for farmer experimentation.*

■ Dickinson, J.L., Shirk, J., Bonter, D., et al., 2012. The current state of citizen science as a tool for ecological research and public engagement. *Frontiers in Ecology and Environment* 10(6), pp 291–297. Available: <http://onlinelibrary.wiley.com/doi/10.1890/110236/full>.

*This article provides an inspiring overview of the different, creative ways citizen science is being used as a tool for ecological research.*

■ Meldrum, G., Sthapit, S., Rojas, W., King, O., 2013. Agricultural biodiversity enhances capacity to adapt to climate change. *New Agriculturalist* 13(6). Available: <http://www.new-ag.info/en/focus/focusitem.php?a=3154>.

*This short article highlights some examples of the multiple ways farmers worldwide use agricultural biodiversity to adapt to climate change and backs the demand for more variety availability.*

## Participatory plant breeding

Like PVS, participatory plant breeding (PPB) was born out of the insight that small farmers in unfavorable conditions benefit very little from formal crop research. In PPB, farmers and plant breeders jointly select cultivars by segregating materials in target environments. PPB is more difficult than PVS because some degree of knowledge of heritability and genetic gain is required.

Officially released varieties are often designed for high-input farming practices used in large agro-ecological areas. In contrast, smallholder farmers practice agriculture in micro-regions where particular environmental conditions predominate. In other words, conventional breeding fails to take smallholders' constraints, needs, and preferences into account.

To produce varieties that match the specific requirements of small-scale farmers, PPB involves producers at earlier stages of the plant breeding process than PVS. In PPB, farmers set breeding goals and select parental material; they are trained in the identification and choice of parent lines, making crosses, and managing trials of a large number of varieties. Professional researchers and breeders act as facilitators in this process, guided by the paradigm that the more decision-making power the farmers have in the breeding program, the better adapted and more useful the outcome will be.

PPB relies on lasting relations between researchers and farmers and seeks out “custodian farmers” or local farmer experts who can be further trained in breeding techniques, conserve varietal diversity on their farms, and act as links between the scientific world and their fellow farmers. Experience in various parts of the world has shown that farmers are able to distinguish between very large numbers of crop lines and make choices that are at least as effective as those made by researchers. Moreover, the learning process and access to new varieties can stimulate and encourage farmers to perform further on-farm experimentation and keep adapting varieties to the environmental conditions via selection. A local or regional PPB programme can include



*Photo: Evaluating bean varieties, Honduras.  
Credit: Bioversity International*

many farmers at all stages, provided that some technical and financial support is available over several years of experimentation.

There is no general roadmap for PPB. Successful experiences in various countries have taken very different paths, but they all share the acknowledgment that:

- The top-down approach to plant breeding has brought limited benefit to small-scale farmers.
- Farmers are able to participate and take responsibility at all stages of a plant breeding program.
- Participatory, decentralized approaches are likely to lead to more effective outcomes: varieties that are adapted to the local environmental and economic conditions, are higher yielding, and are socially acceptable.

In a barley breeding project undertaken by the International Center for Agricultural Research in the Dry Areas (ICARDA), Syria, promising parent lines were identified from both research station germplasm and farmers' fields. Farmers from various villages were involved as partners from the beginning in deciding on breeding objectives, the number of varieties, plot size, the development of a common rating system, etc. Nine "host farmers" then planted over 200 varieties in small quantities on their farms and carefully recorded their observations in a field book throughout the growing cycle. Based on various categories of interest (e.g., tillering and grain size), each variety was given a numeric score, and a final score for each variety was assessed after harvest.

Using this method of farmer evaluation and selection from an early stage of the breeding program, promising lines of barley were identified. In fact, some of them would have been rejected had professional breeders carried out the selection alone. The varieties released and disseminated after this PPB success were widely adopted and yields increased in areas where plant breeding had not been successful before.

Although the Syrian example was still "breeder-led," i.e., initiated by the researchers, farmers in Honduras took the lead and, forming CIALs, requested new maize and bean plant material and technical assistance from a breeding facility. In some cases, breeding objectives were well defined by the farmers and specific crosses were provided accordingly by professional breeders.

For example, CIAL members decided to send seeds of a popular, yet disease-susceptible bean landrace to a breeding station, where it was crossed with five resistant lines. Farmers then received seed of the F3 (third) generation, cultivated it, and carried out evaluation and selection up to the F8 generation, when a line was prepared for local release by the CIAL members. Throughout the PPB process, the farmers received agronomic advice and training from an NGO-funded agronomist. The resulting bean variety became one of the most popular varieties in the impact area. The CIAL has proved to be a very successful structure for PPB, empowering farmers throughout Latin America. The CIAL approach has also been used in Africa and Asia, but with a different name, e.g., farmer (biodiversity or crop improvement) field school (e.g., Nepal, Zimbabwe).

These two examples are meant to illustrate that PPB is feasible in very different environments and conditions. Numerous other examples exist from countries as diverse as China, Cuba, Ethiopia, Jordan, Mali, Nicaragua and Zimbabwe (see recommended reading). Creating a system adapted to local conditions and capacities requires motivation and creativity, but can lead to rewarding outcomes.

## Recommended readings

■ Sthapit, B.R., Joshi, K.D., Witcombe, J.R., 1996. Farmer participatory crop improvement. III. Participatory plant breeding, a case study for rice in Nepal. *Experimental Agriculture* 32(4), pp 479–496. Available: [https://www.researchgate.net/publication/231914859\\_Farmer\\_Participatory\\_Crop\\_Improvement\\_III\\_Participatory\\_Plant\\_Breeding\\_a\\_Case\\_Study\\_for\\_Rice\\_in\\_Nepal](https://www.researchgate.net/publication/231914859_Farmer_Participatory_Crop_Improvement_III_Participatory_Plant_Breeding_a_Case_Study_for_Rice_in_Nepal).

*This article describes the initial results of a rice PPB program carried out in high mountain areas of Nepal. In addition to identifying better performing varieties, the research also increased crop diversity in the area.*

■ Witcombe, J.R., Joshi, A., Joshi, K.D., Sthapit, B.R., 1996. Farmer participatory crop improvement. I. Varietal selection and breeding methods and their impact on biodiversity. *Experimental Agriculture* 32(4), pp. 445–460. Available: [https://www.researchgate.net/publication/231903529\\_Farmer\\_Participatory\\_Crop\\_Improvement\\_I\\_Varietal\\_Selection\\_and\\_Breeding\\_Methods\\_and\\_Their\\_Impact\\_on\\_Biodiversity](https://www.researchgate.net/publication/231903529_Farmer_Participatory_Crop_Improvement_I_Varietal_Selection_and_Breeding_Methods_and_Their_Impact_on_Biodiversity).

*This pioneering article reviews various forms of PVS and PPB and compares their key features. It makes the case for PPB as an approach that can lead to more acceptable products, particularly in marginal environments.*

■ Ceccarelli, S., Grando, S., Tutwiler, R., et al., 2000. A methodological study on participatory barley breeding. I. Selection phase. *Euphytica* 111(2), pp. 91–104. Available: [https://www.researchgate.net/publication/226264671\\_AMethodological\\_Study\\_on\\_Participatory\\_Barley\\_Breeding\\_I\\_Selection\\_Phase](https://www.researchgate.net/publication/226264671_AMethodological_Study_on_Participatory_Barley_Breeding_I_Selection_Phase).

*One very successful PPB project, ICARDA's participatory barley breeding project, showed that farmers can handle large numbers of unreleased varieties in their fields. Farmers select for different criteria than researchers, and their selections are at least as high yielding as those of breeders, especially off-station.*

■ Vernooy, R., 2003. Seeds that give: participatory plant breeding. International Development Research Centre, Ottawa, Canada. Available: <http://www.idrc.ca/EN/Resources/Publications/Pages/IDRCBookDetails.aspx?PublicationID=337>.

*This concise booklet, which is also available in Arabic, Chinese, French, Nepali, Spanish and Vietnamese, offers an overview of key learning and recommendations for practitioners based on a decade of experience in PPB.*



## More on the subject

■ Halewood, M., Deupmann, P., Sthapit, B.R., Vernooy, R., Ceccarelli, S., 2007. Participatory plant breeding to promote farmers' rights. Bioversity International, Rome, Italy. Available: [http://www.bioversityinternational.org/fileadmin/migrated/uploads/tx\\_news/Participatory\\_plant\\_breeding\\_to\\_promote\\_Farmers\\_Rights\\_1254.pdf](http://www.bioversityinternational.org/fileadmin/migrated/uploads/tx_news/Participatory_plant_breeding_to_promote_Farmers_Rights_1254.pdf).

*This brief seeks to raise the profile of PPB as an additional, complementary, and powerful strategy for advancing the rights and interests of farmers.*

■ Witcombe, J.R., Joshi, K.D., Virk, D.S., Sthapit, B.R., 2011. Impact of introduction of modern variety on crop diversity. In: Lenné, J.M., Wood, D. (editors), Agrobiodiversity management for food security: a critical review. CABI International, London, UK, pp. 87–98. Available: [https://www.researchgate.net/publication/272887389\\_Impact\\_of\\_introduction\\_of\\_modern\\_variety\\_on\\_crop\\_diversity](https://www.researchgate.net/publication/272887389_Impact_of_introduction_of_modern_variety_on_crop_diversity).

*These authors discuss whether and how PPB changes crop diversity over a long period based on three case studies from India and Nepal for which good data are available. The study concludes that diversity has not decreased due to PPB. PPB has been successful in improving crop production, although sustaining PPB through institutionalization has not been achieved.*

■ Ruiz, M., Vernooy, R. (editors), 2012. The custodians of biodiversity: sharing access and benefits of genetic resources. Earthscan, London, UK, and International Development Research Centre, Ottawa, Canada. Available: <https://www.idrc.ca/sites/default/files/openebooks/532-8/index.html>.

*This book illustrates a number of successful examples of collaboration between breeders and farmers through the lens of access to and benefit sharing of plant genetic resources. Case studies include PPB experiences in China, Cuba, Honduras, Jordan, Nepal, and Syria.*

## Testing your knowledge

Here is a quiz that will help you test your newly acquired knowledge. Once you have covered the content sections and completed the assigned readings, please answer the Field-testing quiz.

- 1.** Why did participatory crop improvement emerge as an alternative to conventional approaches to crop experimentation?
  - a. While conventional crop research has contributed to substantial yield increases, mainly in high-input agricultural production areas, smallholders with limited access to inputs or credit have enjoyed little benefit.
  - b. Farmers often have different priorities than plant breeders that often were not taken into account.
  - c. Women, men, and younger farmers have different needs, interests and preferences, which were not always recognized.
  - d. Some researchers felt that farmers are the best placed to decide what varieties to develop and how to test them in their fields.
  - e. Conventionally bred varieties often failed to respond to the specific requirements of marginal environments in which smallholder farmers operate.
- 2.** How does participatory variety selection take place?
  - a. Organized farmer groups grow a set of promising varieties in experimental quantities on one or more plots that have been volunteered by one or more farmers in the group.
  - b. Pre-selected, improved varieties at physiological maturity are presented to farmers by researchers at a breeding station. Farmers select a variety they would prefer to grow and then are offered small amounts of seeds to test on farm
  - c. The cultivation of trials is completely under farmer management.
  - d. The practice of “mother-baby trials” combines the benefits of trials at research stations with trials under farmer management. In “mother” trials, breeders and researchers assess a large range of varieties under controlled conditions and measure yield
- 3.** What can be the main limits of participatory variety selection?
  - a. Researcher-biased questioning at the time of selection
  - b. Incentivizing productivity in baby trials
  - c. Selection based on snapshot impressions
  - d. Knowledge gaps
  - e. Lack of scientific validation
- 4.** What is the crowdsourcing field trials approach?
  - a. An approach used to collect data by large numbers of specialized researchers and breeders.
  - b. An approach used by scientists and companies worldwide to collect data by large numbers of volunteers.
  - c. An approach enabling farmers to carry out large trials.
  - d. An approach that usually focuses on many crops at the same time.

5. Which of these statements, regarding participatory plant breeding (PPB) is true?
- Farmers are able to participate and take responsibility in all steps of a plant breeding program.
  - Participatory, decentralized approaches are likely to lead to varieties that are adapted to the local environmental and economic conditions, higher yielding and socially accepted.
  - PPB relies on lasting relationships between researchers and “custodian farmers.”
  - Although farmers cannot make choices that are as effective as trained researchers, they can supervise the trials and inform researchers of progress. Researchers will then decide what is best for farmers.

## Applying your new knowledge

In this module, you were introduced to a number of participatory approaches to test newly acquired germplasm. These approaches put farmers at the center of the experimental cycle(s). Now your task is to select the most appropriate approach given the context in which you are working and to develop a plan for field-level implementation. Please, document the following:

- Which of the three approaches is the most appropriate given the context in which you work and why?
- What are the challenges inherent in the approach you selected?
- What are the steps in your field-testing plan?



# MODULE 6

# Seed production and distribution

*Andrew Mushita and Ronnie Vernooy*



## SEED PRODUCTION AND DISTRIBUTION

*Photo:  
Traditional way of cleaning  
seeds, Gumbu, South  
Africa. Credit: Bioversity  
International/R.Vernooij*

## Introduction

In the previous module, you familiarized yourself with a number of participatory approaches (such as participatory variety selection and participatory plant breeding) to test newly acquired germplasm. These approaches put farmers at the center of the experimental process.

This module, on seed production and distribution, will take the experimental process one important step further. You will be introduced to a series of seed production and distribution activities, which allow scaling of the results of the participatory crop testing. We focus on farmer-managed seed production and distribution practices. We use the term farmer-managed practices instead of “informal” practices, which, in practice, are often difficult to define. To run a farming enterprise, farmers need access to good-quality seed adaptable to their local environment, in sufficient quantities at the right time and cost, crop cycle after crop cycle. Seed is the genesis of crop production, determining the quality of growth and quantity of yield of a crop.

The focus of this module is on farmer-produced seed, given that a 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 particular local environment 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. 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. However, this does not mean that there are no challenges and bottlenecks. There are – such as technical seed-processing requirements, time and effort to develop entrepreneurial expertise, distribution and marketing constraints, and policy and legal restrictions.

At the end of the module, you will be able to identify the different steps, and some of the challenges involved, in seed production and distribution as they take place in farmer-managed seed systems.

## Learning objectives

At the end of this module, you will be able to:

- Explain why farmer seed systems are essential to food and nutrition security
- Understand farmer seed preferences
- Identify strategies to meet locally driven farmer seed requirements
- Value the contribution of farmer action research to meet local seed requirements
- Appreciate the importance of farmer social networks for seed acquisition
- Acknowledge the need for farmer capacity building in the areas of seed production and distribution

## What do you already know?

- How familiar are you with farmer-managed seed systems?
- Do you know how to assure the production of quality, true-to-type seed? What are the steps and requirements?
- In your opinion, what are effective and successful mechanisms for distributing seeds?
- Drawing on your experience, can you identify some of the challenges and bottlenecks of farmer-managed seed systems?

## Content summary

- Seed production: stages and practices
- Seed certification and distribution

## Seed production: stages and practices

### Potential seed sources farmers can use

What are potential seed sources farmers could use? There are several:

1. Purchases from the (local) market and traders. Traders can be both representatives of commercial companies and independent traders. Seed can also be obtained from agro-dealers who usually sell other farm inputs as well (e.g., fertilizers, bags, tools, equipment). Farmers have to rely on the reputation of the supplier and/or visual assessment of the seed to assess seed quality.
2. Exchanges with family, friends and neighbors. Usually, farmers are able to witness firsthand the growth and performance of the crop variety during the growing season. Based on this, they will be able to make an informed decision to request seed.
3. Exchanges with other farmers. These exchanges can be realized during farm visits or at social events such as seed fairs. Means of 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 labor). Farmers have to rely on reputation and/or visual assessment of the seed to assess seed quality.
4. Receiving seed from the national genebank or a community seed bank. Some national genebanks have collected and stored seed of almost all or many of the crops grown throughout the country. Farmers can go to the genebank or community seed bank and request seed of one or more crops of interest. In the case of a community seed bank, once a seed borrower has harvested the requested crops, she or he returns a small quantity back to the seed bank. Sometimes, a community seed bank will request a payment for seed. Farmers have to rely on reputation and/or visual assessment of the seed to assess seed quality.
5. Receiving seed directly from plant breeders (could be local breeders or national or international breeders). Where required, this should be done according to the rules and regulations of international agreements and/or national policies and laws. 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.

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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,” which means authentic (i.e., not fake). (The FAO has for several decades provided technical support on the subject to countries worldwide and maintains a webpage dedicated to seed production: <http://www.fao.org/seeds/en/>.) Although these procedures were initially developed mainly to organize and monitor commercial seed production by the government, parastatal and private seed companies, they are also useful for farmer seed production. Paying very careful attention throughout the seed production cycle is simply a good professional and entrepreneurial habit.



These stages and steps include:

**Seed sourcing.** A farmer should acquire clean, pure seeds (so-called “foundation seeds” or registered seeds) from a reliable and reputable source. This ensures that the farmer is obtaining the crop variety that is wanted. Experience suggests that seed producers can benefit from obtaining pre-basic seed or even breeder seed directly from research organizations. This will allow multiple cycles of seed production before distribution, which gives better control over the seed production process and reduces investment costs.

**Land/field selection.** A farmer who intends to produce seed should select the best land for seed production. The land should be fertile with good soil texture and easy to cultivate. The land should be free from soil-borne diseases and pests, as these can cause crop damage that can lower the yield. Also, the same crop should not be grown in the same piece of land because “volunteer plants” (plants belonging to the previous cropping cycle) might contaminate the new crop. However, many international organizations (and also local certification agencies) allow crops of the same species to be grown in the same field if those grown in the previous season were of the same variety or a seed class higher than the current seed class.

**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). Minimum isolation distances should be maintained and adhered to. Isolation can be by distance or time (i.e., staggering the planting times), but note that time isolations are only allowed for a few crops (e.g., maize).

- Distance isolation: Here, depending on the crop that is being grown, it is separated from a possible contaminating field or crop. Most cross-pollinating crops (e.g., maize) require a minimum of 300m from the seed crop to another maize crop. Self-pollinating crops, on the other hand, such as beans and groundnuts, require a minimum isolation distance of only 3m. For most smallholder farmers, distance isolation can be a major constraint, given their limited access to land and neighboring fields that in most areas are close together.
- Time isolation: With this strategy, planting of the seed crop is scheduled so that it reaches the reproductive stage either before or after the contaminating crop. For cross-pollinating crops, a minimum of four weeks is usually acceptable. This method is suitable for most smallholder farmers as they can grow two crops close together. A late-maturing maize seed crop can be grown close to an early-maturing commercial maize crop. The commercial crop will flower earlier than the seed crop, thereby reducing the chances of contamination.

**Agonomic management.** This includes good weed management, regular pest and disease control and appropriate crop nutrition. Crop rotation with the use of crops from other plant families is another good practice.

**Rouging of off types.** This is the complete physical removal of off-type plants or plant parts within a seed crop field, which might cross-pollinate or contaminate the seed crop. This should be done throughout the life span of the crop, but is best before the seed crop reaches the reproductive stage. Any plants that look physically different from the majority of plants in a field should be removed. Differences may be in leaf shape and orientation, plant height, flower shape and color and plant growth habit. Rouging can also involve removing diseased plants or plant parts. With seed-borne diseases such as smut, infected plant parts should be removed to avoid further spread of the disease within the field.

**Harvesting.** Selecting seed from a field for the following growing season requires continuous observation of the growing process. Areas within the field where the seed crop is not growing well should especially be taken care of. Seeds should be collected from the parts of the field where plants are (the most) healthy looking, actively growing and showing good plant vigor. The seeds from such plants are more likely to have good vigor during their growing cycle.

Harvesting should be well timed to ensure that maximum yield and seed quality are obtained. Care should be taken while harvesting with machines, ensuring proper cleaning of equipment before starting a new variety.

**Processing.** Seed should be inspected at the source and be uniform in shape, size and color. It should be healthy looking with no signs of disease and insect damage. Shriveled seed may produce weak crops and, subsequently, poor yields. Insect-damaged seed may fail to germinate and result in a poor crop stand. Some crop diseases are transmitted through seed, and thus seed from affected crops should not be used. The International Seed Trade Association (ISTA) has a published list of seed-borne diseases, which should be taken into account while rouging and/or approving a field for seed production (see <https://www.seedtest.org/en/ista-reference-pest-list-content---1--3477.html>).

**Storage.** Once harvested, the crop should be stored in a cool dry place so that the quality of the seed is not compromised. Indigenous practices (e.g., use of ashes, neem, orange peel) and/or chemicals can be used to protect the harvested seed from storage pests and keep the harvest safe until the next planting season. Chemicals should be used with caution at all times. The seed should always be stored separately from the commercial crop and admixtures should be avoided at all cost. Storage could be at home or in community seed banks, which sometimes have a special family collection room where member households can store their seed “privately,” respecting the same quality standards as for the community seed bank collective/community collection.

**Seed monitoring.** To track the health of the seeds stored, verifying seed quality regularly is recommended. This can be done visually by checking the containers or bags and/or removing part or all of the seeds from a container/bag and verifying moisture level and pest and disease incidence. A useful piece of equipment is a hygrometer that registers room temperature and humidity (some modern containers have a hygrometer built in so that one can easily check the moisture level and temperature inside at all times). Hydrion® Humidicator Paper can also be used. When problems are observed, immediate action should be taken to avoid the spread of mold, disease or pests.

## Recommended readings

■ ACB, 2018. Status report on the SADC, COMESA and EAC Harmonised Seed Trade Regulations. African Center for Biodiversity, Johannesburg, South Africa. Available: <https://www.acbio.org.za/en/status-report-sadc-comesa-and-eac-harmonised-seed-trade-regulations>.

*This critical paper provides a brief background and status update on efforts by regional economic communities to harmonize seed trade and marketing policies and legislation in East and Southern Africa: the Technical Agreements on Harmonisation of Seed Regulations of the Southern African Development Community (SADC, 2008), the Seed Trade Harmonisation Regulations of the Common Market for East and Southern Africa (COMESA, 2014), and the regional seed harmonization programme of the East African Community (EAC). The paper contends that these harmonization initiatives do not support smallholder seed production and supply and neglect the rights of smallholder farmers, particularly women farmers.*

■ FAO, 2010. Promoting the growth and development of smallholder seed enterprises for food security crops: best practices and options for decision making. Food and Agriculture Organization of the United Nations, Rome, Italy. Available: <http://www.fao.org/docrep/013/i1839e/i1839e00.pdf>.

*The policy guide, developed in response to the request by governments and decision-makers in developing countries, presents a number of guidelines on options to build efficient seed-delivery systems adapted to the level of their agricultural development.*

■ FAO, 2018. Seed production and handling manual for community based seed inspectors and producers. Food and Agriculture Organization of the United Nations, Lilongwe, Malawi. Available: <http://www.fao.org/3/ca1082en/CA1082EN.pdf>.

*This easy-to-read manual deals with seed production practices, seed quality, agronomic practices and seed certification.*

■ FAO, 2018. Seed toolkit. Food and Agriculture Organization of the United Nations, Rome, Italy. Available (see links below).

*This six-module toolkit is likely the most comprehensive seed toolkit available on-line. It supports practitioners along the entire seed value chain in acquiring the knowledge and skills they need in order to deliver quality seeds and planting materials of well-adapted crop varieties to farmers. It is designed primarily for capacity-building activities, especially for small-scale farmers and small- and medium-scale entrepreneurs. The six modules are:*

Module 1: Development of small-scale seed enterprises

<http://www.fao.org/3/CA1490EN/ca1490en.pdf>.

Module 2: Seed processing: principles, equipment and practice

<http://www.fao.org/3/ca1491en/CA1491EN.pdf>.

Module 3: Seed quality assurance

<http://www.fao.org/3/CA1492EN/ca1492en.pdf>.

Module 4: Seed sector regulatory framework

<http://www.fao.org/3/ca1493en/CA1493EN.pdf>.

Module 5: Seed marketing

<http://www.fao.org/3/ca1494en/CA1494EN.pdf>.

Module 6: Seed storage

<http://www.fao.org/3/ca1495en/CA1495EN.pdf>.

## More on the Subject

■ Vizcayno, J.F., Wilson, H., Sanz Alvarez, J., 2014. Appropriate seed varieties for small-scale farmers: key practices for DRR implementers. Food and Agriculture Organization of the United Nations, Rome, Italy. Available: <http://www.fao.org/3/a-i3768e.pdf>.

*This technical brief provides concise and clear descriptions of the key aspects for the promotion of quality seed of appropriate varieties for use by small-scale farmers, in the context of the disaster risk reduction/management (DRR/M) activities in the Southern African region.*

■ ZIMSOFF, 2018. A study on farmer managed seed systems (FMSS) in Zimbabwe: case studies of Mutoko, Zvishavane and Masvingo Districts. Zimbabwe Smallholder Organic Farmers' Forum, Harare, Zimbabwe. Available: <https://www.grain.org/media/W1siZiIsIjJwMTgvMTAvMjkwMTJfMTThfNDJfOTI4X1ppbWJhYndlX3JlcG9ydF9FTl8ucGRmlI1d>.

*This study confirms the key role of farmer-managed seed systems in Zimbabwe's agriculture, although they lack government recognition and support. Authors call for a change in policies and practices in support of farmer-led conservation, crop improvement and seed production and marketing.*

## Seed certification and distribution

Once the seed has been harvested, selected and stored, the organization of distribution can begin. In the commercial system, there is one important step prior to distribution: (formal) certification by a national authority. Seed certification is the “regulatory process designed to maintain and make available to farmers high quality seed and propagating materials of superior crop varieties, grown and distributed to ensure genetic identity and genetic purity. It also ensures other factors, including absence of weeds and diseases, analytical purity and viability” (FAO 2018, module 3). (This definition was first developed by the International Crop Improvement Association.)

In order to conform to seed-certification standards, production must meet certain requirements in the field and after harvest. This concerns planting stock, site selection and isolation, sowing, weed control, harvest management, seed processing, seed packaging and labeling, and storage of processed seed. Once seed has been certified, a certification label is affixed on the packaging and a second label is placed inside. Sealing and labelling take place after seed treatment. Certified seed is then distributed throughout the country via government or private stores (agro-dealers, garden centers, supermarkets) and/or agricultural cooperatives.

In farmer-managed seed production and distribution, certification by a national authority usually does not take place, since seed is not produced as part of or for the commercial seed-production system. Farmers themselves are responsible for quality control. In some countries, the situation is more complicated: seed laws have excluded seed from farmer seed systems from entering the market through any distribution channels. In Zimbabwe, for instance, seed from the farmer seed system cannot be packed and labeled and distributed throughout the country. If a farmer producer or trader packs and labels the seed and sells it through formal channels, the seed can be seized and confiscated by government inspectors and the trader can be charged. The Zimbabwean Seed Act states that farmer seed can only be sold within a radius of 10km from where it was grown. There are, however, a few exceptional instances where the government of Zimbabwe could allow the distribution and sales of farmer varieties throughout the country.



Photo: Quality Declared Seed: beans (Uganda).  
Credit: Bioversity International/R. Vernooy

The conditions for this are 1) only if there is a shortage of seed of a particular crop within the country, 2) only seed of known crop varieties can be distributed, 3) the seed can only be sold as “Standard Graded Seed” (which will affect the price).

The outlook seems more positive in some regions of the world, such as Western and Central Africa, where farmer seed cooperatives appear to be on the rise. In a recent study including 15 countries in these two sub-regions, many cooperatives were identified that have been formally recognized as seed producers by national authorities. For example, in Burkina Faso, the study counted 54 formally recognized seed-producing cooperatives; in Senegal, 32; in Togo, 10.

In other countries, governments have approved and adopted some novel alternative regulations to ensure seed quality of farmer-produced seed and to label it accordingly. Two of these alternatives are “Quality Declared Seed” (known as QDS, originally developed in 1993 and promoted by the FAO; used, for example, in Ecuador, Ethiopia, Peru, Rwanda, Tanzania, Uganda and Zambia), and “truthfully labeled seed” (used, for example, in India and Nepal). These alternatives, particularly designed for countries with limited resources, are less demanding than full seed-quality control systems, but guarantee a satisfactory level of seed quality. To be able to apply and use QDS, seed producers need to register, and only seed of crops authorized by the national authority can be so labeled. “Truthfully” labeling can be done by farmer producers and private companies without the necessary approval of the national seed certification authority, but quality standards need to be respected according to national rules and regulations (standards for purity and germination).

In Myanmar, for example, where there are laws governing seed certification, but the national body (Ministry of Agriculture, Livestock and Irrigation, MOALI) has limited human resources to conduct field inspections for certification, an informal system of certification exists. Though not mainstream, this system is called the “Participatory Guarantee System” (PGS), where farmers’ groups conduct peer-level field inspections to ascertain seed quality. MOALI is partnering with experts to make this system more reliable, by increasing government involvement.

### **An example from Zimbabwe: Champion Seeds**

The nongovernment organization Community Technology Development Trust (CTDT), in partnership with Oxfam Novib of the Netherlands, recently established the Champion Farmer Seeds Cooperative Company (formally registered in 2016, launched in 2017). (Oxfam Novib developed the seed business model for the company.) Champion Seeds is both a commercial and social enterprise, with farmers as stakeholders, producers (on a contract basis) and buyers of high-quality, certified seed of highly adaptable and high-yielding varieties of dryland grains and legumes. Now in its third year and still benefitting from Oxfam Novib support, the company is making good progress toward organizational and financial sustainability. In its first two years of operation, the company produced almost 150,000 MT of certified seed.

CTDT first stimulated farmer seed production and distribution in the 1990s, but initial attempts were not very successful. After the establishment of the first community seed bank in the Uzumba-Maramba-Pfungwe (UMP) province in 1999, more systematic work was done, which was further improved through farmer field schools using the so-called “cluster method,” where farmers take responsibility for producing seed of one to four crops on an area ranging from 0.2ha to 0.6ha. At the moment, crops include Bambara nut, cowpea, groundnut, pearl millet, finger millet, maize (open-pollinated varieties and, in some cases, hybrids) and sorghum. In many communities, seed produced through this method is sold locally, via the community seed bank, at seed fairs and during field days. CTDT and the national extension service, AGRITEX, provide technical support. Farmers from the UMP community seed bank explained that this form of seed production has primarily a social function: to make sure that everyone has access to good-quality seed of crops important for smallholder farmers and neglected by the large seed companies.

**Dealing with bottlenecks:** How do farmer seed producers deal with bottlenecks in seed production and distribution? What are some feasible mechanisms for avoiding these? Recent studies have identified a number of opportunities.

**Satisfying local demand for particular crops with low profit margins for the seed (e.g., bean, cassava, groundnut, millet, rice, sorghum):** Within communities, individuals or groups of seed producers, recognized as a source of seed and a source of new varieties, could get together to establish a seed business. They could be supported by a government agency or an NGO. Through training and learning-by-doing, they could become professionalized. For example, in the Integrated Seed Sector Development (ISSD) programme in Uganda, this has proven to be an effective approach to increasing the availability of bean seed with low profit margins.

**Satisfying seed demand of local producers' groups:** Some farmers who are members of a local producers' group could get together to respond to the seed demand of the group (association or cooperative) and specialize in seed production and delivery to fellow group members. Those who produce the seed can be rewarded by the group. In the event of seed surpluses, these can be sold to outsiders. Some community seed banks in Zimbabwe apply this approach.

**Satisfying seed demand in particular value chains:** A group of farmers could enter into a contractual farming agreement with a value-chain operator (e.g., food-processing company) to produce seed of a particular crop or variety in high demand but not readily available. For example, in Burundi, farmers produce a particular sorghum variety for the brewing of sorghum beer by a company operating in the country.

**Seed portfolio diversification:** Once a seed-production group has gained some experience in one crop, other crops could be added to respond to emerging demands.

**Producing seed to complement well-performing crop production:** Experienced farmers with well-performing crops could venture into related seed production to diversify livelihoods and sources of income.

**Catering to the seed demands of public seed-sector agencies:** Well-organized farmer groups could explore collaboration with public entities that play a key role in the seed sector. This can improve the reputation and market reach of low-profit seed businesses. Such collaboration could also lead to better access to seed of early generations, increased chances of receiving support from projects and programs in seed business development, and priority access to new varieties.

## Recommended readings

■ Access to Seeds Foundation, 2018. The rise of the seed-producing cooperative in Western and Central Africa. Access to Seeds Foundation, Amsterdam, the Netherlands. Available: <https://www.agricord.org/sites/default/files/the-rise-of-the-seed-producing-cooperative-in-western-and-central-africa.pdf>.

*This study profiles 54 seed-producing cooperatives that were identified through landscaping studies in 20 countries. Two models are identified: 1) foundation seed, which is used for multiplication by members of the cooperative, is sourced from national authorities or programmes organized by international organizations and is then distributed among members and sold to neighboring farmers; 2) seed is produced through partnering with national or international research institutes to test and select varieties, and is distributed through collaboration with seed companies, NGOs or government agencies.*

■ David, S., 2004. Farmer seed enterprises: a sustainable approach to seed delivery? *Agriculture and Human Values* 21(4): 387-397. Available: <https://link.springer.com/article/10.1007/s10460-004-1247-5>.

*Drawing on experiences in Uganda with the common bean, the paper proposes seed production by farmer seed enterprises as a strategy for meeting dual objectives: to sustainably distribute and promote modern crop varieties and to establish a regular source of "clean" seed of either local or modern varieties.*

■ David, S., 2008. Farmer seed enterprises in Uganda. In: Thijssen M.H., Bishaw Z., Beshir A., de Boef, W.S. (editors), *Farmers, seeds and varieties: supporting informal seed supply in Ethiopia*. Wageningen International, Wageningen, the Netherlands: pp. 254-254. Available: [https://www.researchgate.net/publication/253328092\\_Farmers\\_seeds\\_and\\_varieties\\_Supporting\\_informal\\_seed\\_supply\\_in\\_Ethiopia](https://www.researchgate.net/publication/253328092_Farmers_seeds_and_varieties_Supporting_informal_seed_supply_in_Ethiopia).

*Drawing on experiences in Uganda with the common bean, this paper, among the first on the subject, proposes seed production by farmer seed enterprises (FSEs) as a strategy for meeting dual objectives: to sustainably distribute and promote modern crop varieties and to establish a regular source of "clean" seed of either local or modern varieties. It reports on lessons learned from the Ugandan experience and offers a conceptual framework and guidelines for establishing economically and institutionally sustainable FSEs.*

■ ISSD Africa, 2017. Making business out of low-profit seed. ISSD Africa synthesis paper. KIT Working papers 2017-1. KIT Amsterdam, the Netherlands. Available: <https://www.kit.nl/wp-content/uploads/2018/08/Making-business-out-of-low-profit-seed.pdf>

*This paper describes 10 strategies for establishing a farmer-based seed business out of low-profit seed, illustrated by business examples from Africa.*

■ Ojiewo, C.O., Kugbei, S., Bishaw, Z., Rubyogo, J.C. (editors), 2013. *Community Seed Production*. Workshop Proceedings 9-11 December 2013. FAO, Rome and ICRISAT, Addis Ababa. Available: <http://www.fao.org/3/a-i4553e.pdf>.

*These comprehensive proceedings give an overview of the state of the art of community-based seed production by 2013, covering experiences from Africa, Asia and Latin America; strategies for enhancing effective uptake and implementation of community seed production in developing countries; challenges and critical points necessary for effective implementation.*



## More on the Subject

■ Katungi, E., Karanja, D., Wozemba, T., Mutuoki, T., Rubyogo, J.C., 2011. A cost-benefit analysis of farmer based seed production for common bean in Kenya. *African Crop Science Journal* 19(4): 409-415. Available: <https://cgspace.cgiar.org/handle/10568/96958>.

*This study examined the profitability of farmer based common bean seed production in Kenya using data collected from farmers and one seed company participating in seed multiplication. The principal finding was that farmer based common bean seed production was a profitable enterprise and was less sensitive to price fluctuations. Compared to certified common bean seed production, net profit margins were five times higher for certified common bean seed than for farmer based common bean seed production. With the current varieties, profitability depends on access to irrigation and good agronomy.*

■ 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.*

■ Vernooij, R., Netnou Nkoana, N., Mokoena, M., et al., 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 from a study tour by a team from the Department of Agriculture, Forestry and Fisheries of South Africa to neighboring 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.*

■ Neate, P.J.H., Guei, R.G., 2010. Promoting the growth and development of smallholder seed enterprises for food security crops. Food and Agriculture Organization of the United Nations, Rome. Available: <http://www.fao.org/3/i1839e/i1839e00.pdf>.

*This guide is in response to the request by governments and decision makers in developing countries for guidelines on options to build efficient seed-delivery systems adapted to the level of their agricultural development.*

## Testing your knowledge

Here is a quiz that will help you test your newly acquired knowledge. Once you have covered the content sections and completed the assigned readings, please answer the following quiz on the dissemination of new varieties.

- 1.** Which of the following statements describe the key features of a farmer-managed seed system?
  - a. It is not part of the commercial seed system.
  - b. It is often defined as the informal seed system.
  - c. It combines components from the formal and informal systems.
  - d. It contributes to maintaining crop diversity on the farm and in the community.
- 2.** Among the following practices, which contribute over time to producing and maintaining good-quality seed of a crop variety?
  - a. Seed sourcing
  - b. Land/field selection
  - c. Isolation of seed fields
  - d. Agronomic management
  - e. Rouging of off types
  - f. Inspection before harvest
  - g. Storage in a cool dry place
  - h. Verifying seed quality regularly after storage
- 3.** Once farmer-managed seed has been harvested, selected and stored:
  - a. It has to be certified.
  - b. It cannot be certified.
  - c. In some countries, it can sometimes be certified or receive a quality guarantee label.
- 4.** Seed produced in farmer-managed seed systems:
  - d. Can usually be labeled and distributed in the seed market throughout the country
  - e. Can only be sold in the country if there is a shortage of seed from the formal seed system
  - f. Can only be sold within a radius of 10km from where it was grown
  - g. The situation varies among countries.

## Applying your new knowledge

In this module, you were introduced to farmer-managed seed production and distribution activities. 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 communities.

Document this step of the research process by identifying the following:

1. In your context, what are the potential seed sources farmers can use?
2. What are the key quality-assurance steps and practices that characterize the seed production process?
3. What are the challenges you will be facing in your country in terms of farmer-managed seed certification and distribution?



MODULE 7

# Germplasm conservation

*Ronnie Vernooy*



## GERMPLASM CONSERVATION

Photo: Traditional seed storage basket, Kenya.  
Credit: Bioversity International/ Y. Morimoto

### Introduction

In the previous module, you learned about tools that allow farmers, working together with plant breeders and other researchers, to test newly acquired germplasm under real-life conditions. Hopefully, after one or more experimental cycles, some of these materials will have led to selection of varieties or lines with useful traits adapted to local farming conditions. It is also expected that more and more farmers in the immediate area and beyond will want to try growing these new materials as well. To keep the production of the new varieties and lines alive and dynamic, effective conservation of germplasm is required. Seed fairs with the participation of farmers and researchers are effective ways to improve access to new germplasm. Seed fairs can also be used to collect rare and unique varieties that enrich the collections of community seed banks.

In this module, you will learn how to conserve the newly acquired and selected germplasm, especially at the community level, as a way to guarantee access to and availability of seeds. The key questions in this module are: What are the differences between *ex situ* and *in situ* conservation? What are the strengths and weaknesses of each strategy? What options for *in situ* conservation have been developed and tested? What experiences and insights have been gained? What gaps still exist? Who are custodian farmers and what is their role in *in situ* conservation? What are the three major functions of community seed banks? What are the main components of an effectively functioning community seed bank? How can the roles of women be recognized and supported?

At the end of the module, you will be able to prepare a plan for the establishment of a community seed bank and strengthening of local conservation efforts.

## Learning objectives

At the end of this module, you will be able to:

- Describe the key features of the two main strategies for conservation of plant genetic resources: *ex situ* and *in situ* conservation.
- Define what a community seed bank is and recognize the three major functions it can fulfill.
- Identify the major components of an effectively functioning community seed bank.
- Apply a framework for making decisions about the establishment of a community seed bank.
- Use the conceptual insights in this module about the conservation of plant genetic resources to establish or strengthen local conservation efforts.

## What do you already know?

- Have you had any practical experience with *ex situ* conservation? With *in situ* conservation?
- What kind of practical experience do you have with *in situ* conservation, such as that practiced by individual farmers or farming households known as custodian farmers or by groups of farmers organized in a community genebank or seed bank?
- Are you familiar with the three major functions of community seed banks?
- What are the main components of an effectively functioning community seed bank?
- Do you know how to do an *ex ante* evaluation to decide whether it makes sense to establish a community seed bank?
- What are the various ways in which you can support a group of farmers to establish and manage a community seed bank in terms of its organizational and technical aspects?
- What are the main factors that influence the viability of a community seed bank?

## Content summary

- *Ex situ* and *in situ* conservation: two complementary strategies
- Custodian farmers
- Community seed banks

## *Ex situ* and *in situ* conservation: two complementary strategies

Two complementary methods for the conservation of plant genetic resources exist: *ex situ* and *in situ* conservation. *Ex situ* conservation is the storing of samples of species outside their natural habitat or growth conditions, most notably in national or international genebanks, field genebanks and botanical gardens. In recent decades, *ex situ* conservation efforts have received considerable financial and technical support and their scientific development has progressed significantly. Farmers have little or no say in the governance and management of *ex situ* conservation agencies.

*In situ* conservation takes place on farm in the case of crops and “in the wild” (natural habitats or protected areas) for the wild relatives of these crops. The conservation of crop wild relatives is an important task, even more so in the context of climate change. Crop wild relatives could have traits of special value for adaptation to changing climate and agro-ecological conditions.

Through collaborative and interdisciplinary research, the understanding of the importance of crop wild relatives and their conservation can be deepened. An example is a recently completed initiative in the South African Development Community (SADC) and especially in the partner countries of Mauritius, South Africa and Zambia. National capacities for conservation planning of crop wild relatives were strengthened and an interactive toolkit developed (available at: <http://www.cropwildrelatives.org/conservation-toolkit/>). In addition, templates and tools for preparing National Strategic Action Plans for the conservation and use of crop wild relatives as well as National Strategic Action Plans for Mauritius, South Africa and Zambia were developed.

Community seed banks (see section 3), a collective form of crop conservation, occupy an intermediate position between these two approaches. Farmers have a very strong say in most community seed banks.

Photo: Diversity fair,  
South Africa.  
Credit: Bioversity  
International/R. Vernooy





*Ex situ* conservation is largely in the hands of professional curators, while *in situ* conservation is carried out by environmental, forest and wildlife officials (protected area managers) and by rural people, who are sometimes remunerated for their efforts but most often work on a voluntary basis.

One novel approach to promoting on-farm conservation efforts of agrobiodiversity by local communities is payment for ecosystem services. Bioversity International has piloted this approach in Bolivia, Ecuador, Guatemala, India, Nepal and Peru, to assess the potential of competitive tenders in creating cost-efficient strategies to conserve priority endangered species and also improve the livelihoods of indigenous farmers. Results to date have been encouraging and efforts are underway to scale the approach.

When rural households join forces to promote and practice *in situ* conservation through a well-designed strategy, one might refer to it as community-based biodiversity management. *Ex situ* and *in situ* strategies both have strengths and weaknesses. In recent years, interest has emerged in combining these strategies; however, this has proved to be easier said than done, considering the technical, organizational, and institutional (policy and legal) factors that come into play.

## Recommended readings

■ Brush, S.B., 2000. Genes in the field: on-farm conservation of crop diversity. In: Brush, S.B. (editor), *Genes in the field: on-farm conservation of crop diversity*. Lewis, Baton Rouge, Louisiana, USA; International Development Research Centre, Ottawa, Canada; International Plant Genetic Resources Institute, Rome, Italy, pp. 3–28. Available: <http://www.idrc.ca/EN/Resources/Publications/Pages/IDRCBookDetails.aspx?PublicationID=262>.

*This chapter, in a groundbreaking book about in situ conservation (with a focus on on-farm conservation), defines two types of in situ conservation, the rationale for in situ conservation as a complementary strategy to ex situ conservation, the possible scope, market and non-market mechanisms for promotion, and a number of key institutional issues including, farmers' rights.*

■ Engelmann, F., Engels, J.M.M., 2002. Technologies and strategies for ex situ conservation. In: Engels, J.M.M., Rao, R., Brown, A.H.D., Jackson, M.T. (editors), *Managing plant genetic resources*. International Plant Genetic Resources Institute, Rome, Italy, pp. 89–104. Available: <http://www.bioversityinternational.org/e-library/publications/detail/managing-plant-genetic-diversity/>.

*This chapter introduces the concept and practice of ex situ conservation and discusses achievements and challenges covering orthodox and non-orthodox seed species.*

■ Sthapit, B., Shrestha, P., Upadhyay, M. (editors), 2012. *On-farm management of agricultural biodiversity in Nepal: good practices*. Revised edition. Bioversity International, Rome, Italy; Local Initiative for Biodiversity, Research and Development, Pokhara, Nepal; Nepal Agricultural Research Council, Kathmandu, Nepal. Available: [http://www.bioversityinternational.org/uploads/tx\\_news/On\\_farm\\_management\\_of\\_agricultural\\_biodiversity\\_in\\_Nepal\\_Good\\_Practices\\_revised\\_edition\\_2012\\_1222\\_.pdf](http://www.bioversityinternational.org/uploads/tx_news/On_farm_management_of_agricultural_biodiversity_in_Nepal_Good_Practices_revised_edition_2012_1222_.pdf).

*This revised and updated handbook contains 17 tools and methods (“good practices”) for carrying out on-farm management, including conservation of agricultural biodiversity. Tools and methods are described in clear language and illustrated with figures, diagrams, and photos. An introductory chapter sets the stage and provides a conceptual overview of on-farm conservation of local crop diversity.*

## More on the subject

■ Jaramillo, S., Baena, M., 2007. *Ex situ* conservation of plant genetic resources: training module. International Plant Genetic Resources Institute, Cali, Colombia. Available: <http://www.biodiversityinternational.org/e-library/publications/detail/ex-situ-conservation-of-plant-genetic-resources/>.

*This richly illustrated handbook describes a step-by-step method for carrying out ex situ conservation. Annexes include the International Code of Conduct for Germplasm Collecting and Transfer and a Checklist for Preparing Collecting Missions.*

■ Shrestha, P., Shrestha, P., Subedi, A., Peroni, N., de Boef, W.S., 2013. Community biodiversity management: defined and contextualized. In: de Boef, W.S., Subedi, A., Peroni, N., Thijsen, M., O’Keeffe, E. (editors), *Community biodiversity management: promoting resilience and the conservation of plant genetic resources*. Routledge, Milton Park, UK, pp. 19–25. Available: <http://www.biodiversityinternational.org/e-library/publications/detail/community-biodiversity-management/>.

*This chapter defines community biodiversity management and describes the key components for putting it into practice. Other chapters in the book give practical examples of these components from countries around the world.*

## Custodian farmers

Custodian farmers are men and women farmers who actively maintain, adapt, and disseminate agricultural biodiversity and related knowledge, over time and space, at farm and community levels and are recognized by community members for their efforts. They are the champions of *in situ* conservation. Custodian farmers are often actively supported in their efforts by family or household members. Although custodian farmers have been around since the beginning of agriculture, they seem to have been largely neglected by science and policy until recent years when a number of researchers have begun to pay more attention and tribute to them.

One such example of proper recognition comes from Bolivia. Through the Instituto Nacional de Innovación Agropecuaria y Forestal (INIAF: the National Institute of Agricultural and Forestry Innovation), the Bolivian Government declared that, within the framework of the Network of Germplasm Banks of the National System of Genetic Resources, custodian farmers are important and complementary contributors to *ex situ* conservation of biodiversity. The recognition was formalized in the Manifesto of Gratitude to the “Custodian Farmers of Agrobiodiversity.” Identifying and rewarding custodian farmers by governments (from national to local levels) is one way to implement farmers’ rights. This can be complemented by other community-based methods that are responsive to local conditions and build on traditional knowledge and practices of farming communities, such as farmer biodiversity schools and community seed banks.

Custodian farmers are often active members of community gene and seed banks or are involved in other local efforts to conserve agricultural biodiversity. Local conservation efforts can be greatly enhanced by timely identification of custodian farmers and observing their methods of engagement with the wider community. Biodiversity International has developed a participatory, six-step methodology to identify and recognize the importance of custodian farmers.

## Recommended readings

■ Byrnes, A., Sthapit, B., 2016. A guide to the identification and importance of custodian farmers. Bioversity International, Rome, Italy. Available: <https://www.bioversityinternational.org/e-library/publications/detail/a-guide-to-the-identification-and-importance-of-custodian-farmers/>.

*This guide aims to help practitioners identify and document such farmers in a systematic manner for better understanding and to enable targeted support towards custodian farmers.*

■ Grunberg, H., Meldrum, J., Padulosi, S., Rojas, W., Pinto, M., Crane, T.A., 2013. Towards a better understanding of custodian farmers and their roles: insights from a case study in Cachilaya, Bolivia. Bioversity International, Rome, Italy, and Fundación PROINPA, La Paz, Bolivia. Available: <https://www.bioversityinternational.org/e-library/publications/detail/towards-a-better-understanding-of-custodian-farmers-and-their-roles-insights-from-a-case-study-in-c/>.

*This short document (33 pages) presents the findings of a unique research project that aimed to develop a better understanding of the attributes, roles, and responsibilities of custodian farmers in the Peruvian highlands. The concluding chapter offers some critical reflections on the method used, which is still in its infancy. It includes three custodian farmer stories and numerous illustrations.*

■ Sthapit, B., 2013. Custodian farmers of agricultural biodiversity: selected profiles from South and South East Asia. In: Lamers, H., Rao, R. (editors), Proceedings of the Workshop on Custodian Farmers of Agricultural Biodiversity, 11–12 February 2013, New Delhi, India. Bioversity International, New Delhi, India. Available: <https://www.bioversityinternational.org/e-library/publications/detail/custodian-farmers-of-agricultural-biodiversity-selected-profiles-from-south-and-south-east-asia/>.

*This report introduces the concept of custodian farmers, a typology of custodian farmers, and their main characteristics based on a review of the literature.*

## More on the subject

■ Negri, V., 2013. On-farm conservation of neglected and underutilized species: status, trends and novel approaches to cope with climate change. In: Padulosi, S., Bergamini, N., Lawrence, T. (editors), On-farm conservation of neglected and underutilized species: status, trends and novel approaches to cope with climate change. Proceedings of an international conference, Frankfurt, 14-16 June, 2011. Bioversity International, Rome, Italy, pp. 211–218. Available: <https://www.bioversityinternational.org/e-library/publications/detail/on-farm-conservation-of-neglected-and-underutilized-species-status-trends-and-novel-approaches-to/>.

*This chapter describes a number of policies and other measures that support the efforts of Italian custodian farmers and gardeners to maintain landraces, not only of major crops but also of neglected and underutilized species. Benefits derived from these policies and measures are analyzed and recommendations made to strengthen on-farm conservation of local diversity.*

■ Sthapit S., 2013. Strengthening the role of custodian farmers in the national conservation programme of Nepal. In: Meldrum, G., Stefano, P., Bergamini, N. (editors), Bioversity International, Rome, Italy, and Local Initiative for Biodiversity, Research and Development, Pokhara, Nepal. Available: [http://www.bioversityinternational.org/fileadmin/user\\_upload/online\\_library/publications/pdfs/Strengthening\\_the\\_role\\_of\\_custodian\\_farmers\\_in\\_the\\_national\\_conservation\\_1884.pdf](http://www.bioversityinternational.org/fileadmin/user_upload/online_library/publications/pdfs/Strengthening_the_role_of_custodian_farmers_in_the_national_conservation_1884.pdf)

*This workshop report documents presentations made and discussions held to deepen the understanding of the roles and contributions of custodian farmers, analyze the influence of social systems and gender on their motivations and efforts, and identify practical mechanisms to support custodian farmers.*



Photo: Hazaripara  
Community Seed Wealth  
Centre, Ishwardi, Pabna,  
Bangladesh.  
Credit: Bioversity  
International/R. Vernooy

## Community seed banks

Communities have been engaging in seed-saving initiatives for about 30 years. These efforts have taken various forms and names, including community genebank; farmer seed house; seed hut; seed wealth center; seed savers group, association or network; community seed reserve; seed library; and community seed bank. Broadly speaking, community seed banks are local institutions whose core function is to maintain seeds for local use. Most community seed banks are managed by a small group of dedicated farmers, but they usually serve a large number of farmers at the community or district level.

Community seed banks can have three main functions: conserving plant genetic resources, enhancing access to and availability of local crop diversity (this includes the repatriation of local varieties that have disappeared), and promoting seed and food sovereignty. In practice, most community seedbanks combine the first function with the second; in some cases, all three functions are combined.

Community seed banks generally store seeds of local varieties under *ex situ* conditions using a range of methods and equipment (except for roots and tubers which are kept in the field). They perform this conservation function with the aim of making seed available to the local community in the very short term — from one planting season to the next through mechanisms that usually require users to contribute to replenishing the stock each cycle. With regard to climate change adaptation, community seed banks can be instrumental in three important ways: by conserving a broad diversity of seeds of crops and crop varieties, by conserving seeds from plants that have a high capacity to survive under extreme weather conditions, and by accessing seeds from areas where plants have adapted to extreme weather conditions. Increasingly, these functions are gaining importance as farmer communities around the world are severely affected by the impact of climate change, leading to more seed and food insecurity.

In terms of seed and food sovereignty, community seed banks are seen primarily as a political mechanism allowing farmers to keep control over their own seeds, a condition that is considered the basis of conservation and sustainable use. The sustenance of rural livelihoods, local cultural,

and ethnic food traditions; the practical implementation of farmers' rights; and community empowerment are other key aspects of this function. Women are very active in most, if not all, community seed banks, often as the principal seed selectors and guardians and, in some cases, managers. However, their roles are not always recognized (let alone supported) in development policies, programs, and projects.

In recent years, the interest in and capacity to establish and support community seedbanks have grown. In Nepal, the national Association of Community Seed Banks of Nepal was formally established in the spring of 2019 with the aim of bringing the more than 40 active community seed banks in the country together. In South Africa, the National Plant Genetic Resources Center continues to set up and support new community seed banks as part of an effort to create a national network with at least one community seed bank in each province. New training materials have been developed. A number of young researchers researched sustainability and related novel issues of importance to community seed banks. In 2018, a proposal led by Bioversity International to establish a global community seed bank platform was finalized. It will support existing community seed banks as well as national and regional community seed bank networks around the world, scale out their activities and achievements, and contribute to their sustainability.

## Recommended readings

■ Vernooy, R., Sthapit, B., Tjikana, T., Dibiloane, A., Maluleke, N., Mukoma, T., 2013. Embracing diversity: inputs for a strategy to support community seedbanks in South Africa's smallholder farming areas. Report of field visits to Limpopo and Eastern Cape. Bioversity International, Rome, Italy, and Department of Agriculture, Forestry and Fisheries, Pretoria, South Africa. Available: <https://www.bioversityinternational.org/e-library/publications/detail/embracing-diversity-inputs-for-a-strategy-to-support-community-seedbanks-in-south-africas-smallhol/>.

*This report presents the findings of research in South Africa to answer the questions: To what extent are farmers still engaged in growing landraces? What are the main factors influencing the choice of crops and crop varieties? Is loss of diversity occurring? Are farmers experiencing the impact of climate change? If so, how are they responding? Are farmers saving seed on farm or at the community level? Are farmers exchanging seeds? With whom, when, and how? Are these practices changing and how? What do they think about a community seed bank? The report includes a novel framework for assessing the viability of establishing a community seed bank.*

■ Vernooy, R., Sthapit, B., Galluzzi, G., Shrestha, P., 2014. The multiple functions and services of community seed banks. *Resources* 3(4), pp. 636–656. Available: <http://www.mdpi.com/2079-9276/3/4/636>.

*Based on a literature review and field research, this article presents a novel comprehensive conceptual framework that focuses on the multiple functions and services provided by community-based seed-saving efforts, in particular community seed banks. The framework identifies three core functions: conserving genetic resources, enhancing access to and availability of diverse local crops, and ensuring seed and food sovereignty. It can be used for analysis of existing seed-saving initiatives and serve as a guide for the establishment of new community seed banks. It can also inform the development or revision of national policies or strategies to support community seed banks. The framework's utility is illustrated by three case studies of community seed banks in Bangladesh, Guatemala, and Nepal.*

## More on the subject

■ Vernooy, R., Shrestha P., Sthapit, B. (editors), 2015. Community seed banks: origins, evolution, prospects. Earthscan for Routledge, Oxon, UK. Available: <https://cgspace.cgiar.org/handle/10568/68708>.

*This is the first comprehensive scientific book about community seed banks based on contributions from researchers and from supporters and managers of community seed banks from around the world. The book includes 35 case studies and a comparison of the key elements of these cases: history and evolution, functions and activities, governance and management, technical issues, support and networking, policy and legal environment, and sustainability. (Also available in Spanish: <https://cgspace.cgiar.org/handle/10568/96304>.)*

■ Vernooy, R., Sthapit, B., Bessette, G., 2017. Community seed banks: concept and practice. Facilitator handbook. Bioersivity International, Rome, Italy, and the Department of Agriculture, Forestry and Fisheries, Pretoria, South Africa. Available:

In English: <https://cgspace.cgiar.org/handle/10568/81286>.

In French: <https://cgspace.cgiar.org/handle/10568/96299>.

In Spanish: <https://hdl.handle.net/10568/96304>.

*This handbook is organized as a guide for facilitators — people who work in the field with farmers and their organizations on issues of seed conservation and sustainable use. The publication “Community seed banks: origins, evolution, and prospects,” edited by Vernooy, R., Shrestha, P., Sthapit B., 2015, which offers a global overview of diverse community seed banks around the world, provided the foundation for the content of the handbook, and parts of that publication have been updated and integrated into it.*

■ Vernooy, R., Bessette, G., Sthapit, S., et al., 2018. How to develop and manage your own community seed bank. Farmers’ handbook. Bioersivity International, Rome, Italy, and the Department of Agriculture, Forestry and Fisheries, Pretoria, South Africa.

*The farmers’ handbook (three booklets; URLs listed below) is a companion to Community seed banks: concept and practice: facilitator handbook by Ronnie Vernooy, Bhuwon Sthapit and Guy Bessette (Bioersivity International 2017). The three booklets making up this handbook were written and designed for rural producers who are interested in establishing, supporting and managing a community seed bank. Each booklet focuses on a theme presented by the members of a community seed bank in Africa, Asia and Latin America.*

Booklet 1: Establishing a community seed bank. Available:

In English <https://cgspace.cgiar.org/handle/10568/92000>.

In French: <https://cgspace.cgiar.org/handle/10568/92875>.

In Spanish: <https://cgspace.cgiar.org/handle/10568/93189>.

Booklet 2: Technical issues (Vernooy, R., Bessette, G., Sthapit, B, Gupta, A.) Available:

In English: <https://cgspace.cgiar.org/handle/10568/92001>.

In French: <https://cgspace.cgiar.org/handle/10568/92874>.

In Spanish: <https://cgspace.cgiar.org/handle/10568/93154>.

Booklet 3: Management, networking, policies and a final checklist (Vernooy, R., Bessette, G., Sthapit, B., Porcuna Ferrer, A.) Available:

In English: <https://cgspace.cgiar.org/handle/10568/92002>.

In French: <https://cgspace.cgiar.org/handle/10568/92873>.

In Spanish: <https://cgspace.cgiar.org/handle/10568/93153>.

## Testing your knowledge

Here is a quiz that will help you test your newly acquired knowledge. Once you have covered the content sections and completed the assigned readings, please answer the Germplasm-conservation quiz.

1. Which of these statements about *ex situ* and *in situ* conservation are true?
  - a. *In situ* takes place in natural habitats
  - b. *In situ* takes place in protected areas
  - c. *Ex situ* conservation takes place in genebanks
  - d. *Ex situ* conservation can also take place in botanical gardens.
  
2. Community seed banks maintain an *ex situ* collection, but turn-over periods are usually short. Some community seed banks maintain an *in situ* collection, for example, of root and tuber crops. Which of these answers represents the major constraint to *ex situ* conservation?
  - a. The process of natural evolution is halted.
  - b. The storage of seeds in *ex situ* conservation is complex and expensive.
  - c. Germplasm is not easily accessible.
  - d. Farmers lose their rights on the seeds that are stored *ex situ*.
  
3. Which farmers can be characterized as custodian farmers?
  - a. Farmers in an area where there is a community seed bank.
  - b. Farmers who have special knowledge and skills to practice seed conservation and are recognized by the community for this special trait.
  - c. Members of community seed savers groups.
  - d. Farmers who breed new varieties on their farms.
  
4. The main function of a community seed bank is to:
  - a. Maintain seeds for local use
  - b. Distribute seeds to a large number of farmers
  - c. Conserve genetic resources
  - d. Enhance access and availability of crop diversity
  - e. Ensure seed and food sovereignty
  
5. How do community seed banks conserve seeds of local varieties?
  - a. Under *in situ* conditions
  - b. Under *ex situ* conditions
  - c. Under both *in situ* and *ex situ* conditions

## Applying your knowledge

Now that you are able to conserve germplasm, it is time to apply your new knowledge. In the previous step, you field-tested newly acquired germplasm and selected the best materials. Now it is time to establish and maintain an effective conservation system to keep that germplasm alive and in good hands.

Please document this step of the research process by identifying the following:

1. At the end of an earlier module, which new germplasm did you select as the best?
2. What are the major features of *ex situ* and *in situ* conservation, and how do they complement each other?
3. What hands-on experience with establishing and maintaining a community seed bank do you have and what are the new elements to use?
4. What are your recommendations for conserving the germplasm you selected in the previous step of the research process? (Please justify.) Will you establish a community seed bank? If so, what will the planning process look like?



# MODULE 8

# Participatory evaluation

*Ronnie Vernooy*



## PARTICIPATORY EVALUATION

*Photo: Women farmers assess a new technology using a scorecard, Vietnam.  
Credit: Bioversity International/ R. Vernooy*

### Introduction

In the previous modules, you learned how to prepare, design, and conduct participatory research around resilient seed systems and climate change. You followed seven steps to understand the local context and analyze how best to develop an adaptation strategy, together with farmers, that is focused on the acquisition and evaluation in the field of new crop varieties. Now that you have almost completed the research cycle, it is time to ask what has been achieved and what has been learned.

In keeping with the overall approach of the resource box, answers to these questions can be found using a participatory method in which researchers and farmers and possibly other stakeholders work together to assess the achievements, reflect on problems and challenges encountered, and identify lessons learned about the research process itself.

In this module, you will learn how to conduct participatory evaluation with regard to the resilient seed systems research cycle. The key questions are: When should evaluation questions be defined? Who should be involved? What are the key aspects of the research that participatory evaluation questions can usefully address? What types of tools can be used for what purpose? Where can the tools be found? What are core tasks or steps in conducting an effective participatory evaluation? What factors can have an influence on the process and the results?

At the end of the module you will be able to prepare a comprehensive participatory evaluation plan.

## What is participatory evaluation?

Research evaluation is the analysis of the effectiveness and direction of a particular research activity or project and involves judging progress and outcomes. Research for development often aims to bring about change in how people behave and do things. Evaluation in this sense focuses on if and how such change has happened as a result of the research.

Participatory evaluation is a joint effort or a partnership between researchers and other stakeholders, such as farmers, government officials, or extension workers, to evaluate, systematically, the research carried out. By participatory we mean various types and degrees of involvement in, control over, and decision making in an activity or the whole research process.

Two important reasons for using a participatory process are to increase the relevance and effectiveness of the research to stakeholders and to contribute to empowerment and social transformation. Combining these two reasons, participation can be seen as both a means and an end to strengthen local people's capacity to make decisions, shape their future adaptation choices, and enhance their ability to create an environment for change. Participatory evaluation can also increase the accountability of everyone involved in the research process because it is constructed as a collective effort to learn from successes and failures. Last but not least, participatory evaluation can help identify gaps in the research process and suggest how these gaps can be filled through possible follow-up activities.

Participatory evaluation has emerged because of a recognition of limitations in conventional evaluation, which mainly serves the needs of project implementers and donors/investors. It tends to focus on an assessment of the degree to which value for money was achieved and often ignores the interests of other groups involved in research and development efforts, especially local people. Such evaluations are normally carried out by outside experts, which can result in a gap between the experts' perception of the project and its results and that of the people who are directly involved or who are expected to benefit from the project. Participatory evaluation gives priority to learning about the results of research and if and how it has contributed to change. One comprehensive methodology for tracking and assessing results over time is outcome mapping, developed by the International Development Research Centre of Canada and used by organizations around the world.

In this module, we introduce the concept and practice of participatory evaluation. Using such an approach will allow you to do more than just write a report for the donor agency or the agency that supports your work technically; it will allow others to put your results to good use as well.

## Learning objectives

At the end of the module you will be able to:

- Develop sound questions about participatory evaluation
- Choose appropriate evaluation tools
- Identify the core tasks or steps in conducting an effective participatory evaluation
- Know what factors can have an influence on the evaluation process and the results

## What do you already know?

- Do you have any previous experience with conducting research evaluations? With conducting participatory evaluations? What have you learned from these experiences?
- How familiar are you with the theory that informs participatory evaluation?
- Do you know which tools are available, which ones to select for what purpose, and how to use them effectively?
- Are you able to identify some of the challenges and conduct a participatory evaluation in an efficient and effective way?
- How have you used the results of previous (participatory) evaluations?
- How were they used by others?
- Was that a satisfactory experience?

### Content summary

- Defining sound questions about participatory evaluation
- Choosing tools for participatory evaluation
- Conducting an efficient and effective participatory evaluation

## Defining sound questions about participatory evaluation

This part of the module will help you answer the following questions: When should evaluation questions be defined? Who should be involved? What are the key aspects of the research that participatory evaluation questions can usefully address?

Participatory evaluation emphasizes participation of the stakeholders in deciding how project progress should be measured and the results acted on. Broadening the involvement of the various stakeholders in identifying and analyzing change can create a clearer picture of what is really happening on the ground according to the perspectives of both women and men of various ages, classes, and ethnic groups in the community. It allows people involved in the research to share successes and learn from each other.

At the same time, it is potentially empowering as it puts local people in charge, helps develop their skills, shows that their views count, and provides an opportunity for joint learning. Scientists can also use results from participatory evaluation to learn from and redesign their interventions.

Well-designed participatory evaluation starts with evaluation questions, which are relevant and of practical use to the research team and others involved in the research process. They must also be effectively answered within a reasonable time frame and with the amount of resources available. To integrate participatory evaluation into the whole research cycle and plan adequately for its execution, one or more evaluation questions should be defined during the initial stages of the cycle. They may be based on the objectives of the research, which are established before

research begins, then later refined or adjusted. In this way, the risk that participatory evaluation becomes a last-minute and, thus, largely futile activity can be avoided. The development of a clear and concise theory of change or impact pathway can be very useful for formulating evaluation questions that address different dimensions and stages of the research process.

Useful evaluation questions usually address three aspects of the research:

- **Design and planning.** This can include aspects of the situational analysis carried out in step 1 of the resilient seed systems research cycle (Module 1. Situational analysis and planning) and the analyses carried out in steps 2 (Module 2. Data preparation and software selection) and 3 (Module 3. Climate change analysis and identification of germplasm). How useful was the situational analysis to the research team? Did the team use the results of the analysis to respond to farmers' interests and needs and was this done in a participatory manner? How did farmers take part in the subsequent research design and planning steps? Which farmers? Did the research team spend enough time and did it have enough resources to carry out these steps? Were the research team and others trained and well prepared to take on the situational analysis and the use of the software?
- **Research implementation.** This can include aspects of the other modules (4–7). How well was the research carried out? Did the research team actually do what they intended to do? Who was involved and how? Were some farmers left out? Why? How useful were the tools used? Did activities proceed as planned, given available time and resources? Did new ideas emerge? Why and how? How did farmers contribute?
- **The research outputs<sup>1</sup> and outcomes.** What did the research team actually achieve? Were useful outputs produced and for whom? What were the main outcomes and for whom? Were there any unforeseen results, positive or negative, and for whom? To what degree can the outcomes be attributed to the research activities? Did other factors have an influence? What did the research team, farmers and other stakeholders learn from the overall process? Do we know why the results were obtained as happened? What could be adjusted in future research based on the lessons learned?

The specific evaluation questions should be introduced by the rationale (why carry out a participatory evaluation?) and address what will be evaluated and for whom. In the following steps in the preparation of the evaluation plan, the remaining questions of who will carry out, how to carry out, and when to carry out can then be dealt with. A sound strategy requires paying attention to the six key questions: Why? For whom? What? Who? How? When?

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<sup>1</sup> Evaluation of the immediate research outputs in the form of novel varieties takes place in step 5 of the research cycle (Module 5. Field-testing).

## Recommended readings

■ Bellon, M.R., Gotor, E., Carraciolo, F., 2015. Conserving landraces and improving livelihoods: how to assess the success of on-farm conservation projects? *International Journal of Agricultural Sustainability*, 13:2, 167-182. Available: [https://cgspace.cgiar.org/bitstream/handle/10568/69241/BELLON\\_ConservingLandraces.pdf;sequence=1](https://cgspace.cgiar.org/bitstream/handle/10568/69241/BELLON_ConservingLandraces.pdf;sequence=1).

*This paper presents a conceptual framework for analyzing on-farm projects and the trade-offs involved, as well as assessing their success in a more systematic way.*

■ Guijt, I., 2014. Participatory approaches. *Methodological Briefs: Impact Evaluation 5*. UNICEF Office of Research, Florence, Italy. Available: [https://www.participatorymethods.org/sites/participatorymethods.org/files/Participatory\\_Approaches\\_ENG%20Irene%20Guijt.pdf](https://www.participatorymethods.org/sites/participatorymethods.org/files/Participatory_Approaches_ENG%20Irene%20Guijt.pdf).

*This is a useful guide to participatory evaluation (organized by the key evaluation questions listed in the introduction to this module).*

■ Sette, C., n.d. Participatory evaluation. *Better Evaluation.org*. Available: [https://www.betterevaluation.org/en/plan/approach/participatory\\_evaluation](https://www.betterevaluation.org/en/plan/approach/participatory_evaluation).

*This is a very useful overview of the key elements of participatory evaluation.*

■ Workgroup for Community Health and Development, 2008. *The community toolbox: participatory evaluation*. Chapter 36: Introduction to evaluation, section 6: participatory evaluation. Work Group for Community Health and Development, University of Kansas, Lawrence, Kansas, USA. Available: <http://ctb.ku.edu/en/table-of-contents/evaluate/evaluation/participatory-evaluation/main>.

*This is an excellent, concise overview of participatory evaluation covering rationale, theory, and practice.*

■ Vernooy, R., 2005. Monitoring and evaluating participatory research and development: some key elements. In: Gonsalves, J., Becker, T., Braun, A., et al. (editors), *Participatory research and development for sustainable agriculture and natural resource management: a sourcebook*. CIP-UPWARD, Los Baños, Philippines, and International Development Research Centre, Ottawa, Canada, pp. 104–112. Available: <https://www.idrc.ca/en/book/participatory-research-and-development-sustainable-agriculture-and-natural-resource-1>.

*This chapter provides practical guidance for the formulation of a participatory evaluation-monitoring plan, including evaluation questions.*

## More on the subject

■ Chevalier, J.M., Buckles, D.J., 2019. *Handbook for participatory action research, planning and evaluation tools*. SAS2 Dialogue, Ottawa, Canada. Available: <https://www.participatoryactionresearch.net/tools>. (Requires registration with SAS2 Dialogue.)

*This comprehensive handbook offers theoretical and practical insights about participatory action research, including evaluation. Following registration with SAS2 Dialogue, you can download the handbook for free. The handbook is based on Chevalier, J.M., Buckles, D.J., 2019. *Participatory action research: theory and methods for engaged inquiry*. Routledge, London, UK.*

■ Estrella, M., Blauert, J., Campilan, D., et al. (editors), 2000. *Learning from change: issues and experiences in participatory monitoring and evaluation*. Intermediate Technology Press, London, UK, and International Development Research Centre, Ottawa, Canada. Available: <https://www.idrc.ca/en/book/learning-change-issues-and-experiences-participatory-monitoring-and-evaluation>.

*One of the first books about the participatory approach, it provides an overview of common themes and experiences in participatory monitoring and evaluation across different institutions and sectors as well as case studies. Chapter 1, *Learning from change* (pages 1–14), introduces key concepts and synthesizes four major steps for implementation.*



*Photo: Group work to evaluate research results, Mongolia.  
Credit: JASIL/H. Ykhanbai*

## Choosing tools for participatory evaluation

This part of the module will help you answer the following questions: What types of tools can be used for what purpose? Where can these tools be found?

To find answers to the evaluation questions, one or more tools must be selected. There is no blueprint for selecting tools. Usually, a mix of complementary tools will allow you to obtain the required information and provide some basis for triangulation or cross-checking of validity. Tools from conventional social science research, such as interviews and surveys, can be combined with tools from participatory research, such as participatory ranking and mapping.

In recent years, a large set of tools has been developed by researchers with various academic backgrounds, but a common interest in participatory evaluation. Among them are oral histories and testimonials, key informant interviews, brainstorming, focus groups, surveys, network analysis, various rating and ranking exercises, mapping, diagramming, community photography and video, theatre, and role playing.

The nature of the evaluation questions will be the best guide for identifying the most appropriate tool or tools. For the three types of questions related to design and planning, implementation, and outcomes, it would be useful to combine tools that capture the individual perspectives of participants in the research as well as their collective perspective (e.g., how the community has benefited from the research in terms of improved crops and cropping practices; what the community has learned beyond the introduction of new crop diversity). Data should be collected and analyzed rigorously in a manner similar to nonparticipatory approaches, methods and tools. It is important to keep the process doable while obtaining useful information. The readings below include lists of tools and how to use them. Numerous resources are available online.

## Recommended readings

■ Estrella, M., Blauert, J., Campilan, D., et al. (editors), 2000. Learning from change: issues and experiences in participatory monitoring and evaluation. Practical Action Publishing, IDRC, Ottawa, Canada. Available: <https://www.betterevaluation.org/en/approaches>.

*This is a very comprehensive overview of different approaches used in participatory evaluation.*

■ Gotor, E., 2012. Network analysis for evaluating on-farm conservation projects, fact sheet. Bioversity International, Rome, Italy and McKnight Foundation, Minneapolis, USA. Available: <https://www.bioversityinternational.org/e-library/publications/detail/network-analysis-for-evaluating-on-farm-conservation-projects-fact/>.

*This brief summarizes the use of social-network analysis in the project “Assessing the success of on-farm conservation projects in delivering conservation and livelihood outcomes: identifying best practices and decision support tools,” implemented in the High Andes of Ecuador, Bolivia and Peru, to evaluate, ex post, the effectiveness of the partnerships developed.*

■ Participatory methods, Useful methods and ideas. Institute of Development Studies, Brighton, UK. Available: <https://www.participatorymethods.org/methods>.

*This online document has a useful section on participatory methods.*

## More on the subject

■ Sustainability engagement evaluation toolbox. 2010. Tool selector. Available: [http://evaluationtoolbox.net.au/index.php?option=com\\_content&view=article&id=51&Itemid=131](http://evaluationtoolbox.net.au/index.php?option=com_content&view=article&id=51&Itemid=131)

*This list of monitoring and evaluation tools offers useful advice on the selection of tools according to type of data to collect (quantitative or qualitative) and category of outcome to measure (efficiency, effectiveness and outcomes).*

# Conducting an efficient and effective participatory evaluation

This part of the module will help you answer the following questions: What are the core tasks or steps in conducting an effective participatory evaluation? What factors can have an influence on the process and the results?

Careful planning of the evaluation process is as important as planning in the earlier stages of the research cycle, but, all too often, researchers only begin to think about evaluation once the research is nearly complete. At that point, energy and financial resources may have run out.

Participatory evaluation integrates the results of the previous steps, defining good questions and selecting appropriate tools, and provides answers to six key questions: Why? For whom? What? Who? How? and When?

If all goes well, answers to the evaluation questions will be found and put to good use. One way to do that is to synthesize them in the form of recommendations for further action to be undertaken by specific users. A sound recommendation includes not only the concrete action(s) to be undertaken, but also a feasible time frame and the actors who can take responsibility for the action(s). In Module 8, you will learn more about sharing the results of research.

The results generated by participatory research depend not only on asking sound questions,



using good tools, and having a feasible plan, but also on the context in which the research takes place. This includes the socioeconomic and political situation; local culture; resource access and rights; social identities and relationships along the lines of gender, class, kinship, ethnicity, and age; and the attitudes, interests, and abilities of the various stakeholders including, the researchers. In other words, as with all science, we need to be aware that knowledge is socially structured and that this implies a process of representation, discussion, and potential conflict and negotiation.

For example, in countries with a strong government system from national to local levels, politics usually play a key role in the process of rural change. Participatory evaluation can lead to greater transparency and accountability, but it should be introduced and practiced with prudence.

## Recommended readings

■ Bellon, M.R., Gotor, E., Caracciolo, F., 2012. Methodologies for evaluating on-farm conservation projects, fact sheet. Bioversity International, Rome, Italy and McKnight Foundation, Minneapolis, USA. Available: <https://www.bioversityinternational.org/e-library/publications/detail/methodologies-for-evaluating-on-farm-conservation-projects/>.

*This fact sheet reports on a project that developed a methodological and conceptual framework based on a critical review of the theoretical and empirical literature, with the aim of providing donors, practitioners and policymakers methodological tools to improve the evaluation of on-farm conservation projects.*

■ Hutchinson, K., 2017. A short primer on innovative evaluation reporting, Rome, Italy. Self-published. *This richly illustrated, inspiring booklet introduces four principles for communicating evaluation results effectively. It includes some simple tricks to make the final evaluation report more appealing to readers. Not freely available. For reviewers' comments, see <https://communitysolutions.ca/web/evaluation-reporting-guide/>.*

■ Manager's guide to evaluation. Better evaluation.org. Available: [https://www.betterevaluation.org/en/managers\\_guide](https://www.betterevaluation.org/en/managers_guide).

*The 9-step guide can be used for evaluations of different types of interventions, including research, projects, programs, policies and clusters of projects.*

■ Patton, M.Q., 2008. Utilization-focused evaluation. 4th edition. Sage Publications, Thousand Oaks, California, USA. Available: <https://us.sagepub.com/en-us/nam/utilization-focused-evaluation/book229324>.

*This classic book on utilization-focused evaluation is the source of the U-FE checklist.*

## More on the subject

■ Vernooy, R., Sun Qiu, Xu Jianchu (editors), 2003. Voices for change: participatory monitoring and evaluation in China. Yunnan Science and Technology Press, Kunming, China, and International Development Research Centre, Ottawa, Canada. Available: <https://www.idrc.ca/en/book/voices-change-participatory-monitoring-and-evaluation-china>.

*This book describes in detail how two Chinese research teams learned about and successfully integrated participatory monitoring and evaluation into their research projects in natural resource management. The two case studies also explain the context of the research, the challenges faced, and how they were dealt with. Of special interest are chapters 3, 4 and 5 (pp. 55–147), which describe the field experiences of the two teams.*

■ Patton, M.Q., 2013. Utilization-focused evaluation (U-FE) checklist. The Evaluation Center, Western Michigan University, Kalamazoo, MI, USA. Available: [http://www.wmich.edu/sites/default/files/attachments/u350/2014/UFE\\_checklist\\_2013.pdf](http://www.wmich.edu/sites/default/files/attachments/u350/2014/UFE_checklist_2013.pdf).

*A simple to follow checklist of 12 core tasks (or steps) and challenges for the facilitator of an evaluation.*

## Testing your knowledge

Here is a quiz that will help you test your newly acquired knowledge. Once you have covered the content sections and completed the assigned readings, please answer the Participatory evaluation quiz.

- 1.** Research evaluation involves making a judgment about research progress and outcomes, particularly in terms of bringing about change. What is participatory evaluation?
  - a. A joint evaluation done by researchers and evaluation experts
  - b. A process in which farmers evaluate the research themselves
  - c. A partnership between researchers, farmers and other stakeholders to evaluate the research carried out
  - d. An evaluation methodology that seeks to respond to the needs of project implementers
- 2.** Important reasons for using participatory evaluation are:
  - a. To increase the relevance and effectiveness of the research to stakeholders
  - b. To contribute to empowerment and social transformation
  - c. To create a clearer picture of what has happened according to the perspectives of women, men, and various age, class and ethnic groups in the community
- 3.** When should evaluation questions be defined?
  - a. At the start of the evaluation process
  - b. At the initial stages of the research cycle
  - c. During implementation
  - d. After approval of the evaluation design
  - e. After situational analysis
- 4.** What aspects of research do evaluation questions usually address?
  - a. Design and planning
  - b. Implementation
  - c. Outputs
  - d. Outcomes
  - e. Funding
- 5.** Which, in the following list, could be used as evaluation tools?
  - a. Interviews
  - b. Key informant interviews
  - c. Surveys
  - d. Oral histories
  - e. Testimonials
  - f. Brainstorming
  - g. Focus groups
  - h. Network analysis
  - i. Rating exercises

- j. Ranking exercises
  - k. Mapping
  - l. Diagramming
  - m. Community photography and video
  - n. Theatre and role plays
- 6.** What should an evaluation recommendation include?
- a. Concrete action(s) to be undertaken by specific users
  - b. Concrete results achieved
  - c. A feasible timeframe
  - d. The proposed actors for taking responsibility for the action(s)
  - e. A budget

## Applying your new knowledge

Document this step of the research process by summarizing your participatory evaluation plan. Please specify:

1. Your objectives
2. Your partners in the process
3. The tools you selected
4. Your work plan
5. Possible challenges that may occur
6. How you expect to put the results to good use



MODULE 9

# Knowledge-sharing and communication

*Guy Bessette*



## KNOWLEDGE-SHARING AND COMMUNICATION

*Photo: Farmers documenting their work and sharing their knowledge.  
Credit: FAO*

### Introduction

In the previous module, we learned how to plan and conduct participatory evaluation of the research process around resilient seed systems and climate change. We collected evidence-based information regarding appropriate germplasm and climate change in a given locality. What do we want to do with this information? Share it with colleagues or with a larger audience? Engage community members in a discussion of the results? Use it to influence policy? Or do we want farmers themselves to share their experiences?

In this module, you will learn about the concept of a communication strategy and some of its main elements, as well as its application to the field of agricultural research in view of communicating research results in an effective way. This module will help you undertake the following activities: develop a communication strategy, identify and involve various groups with whom to communicate, formulate communication objectives, and apply a strategy for communicating agricultural research results.

#### Learning objectives

At the end of the module, you will know how to design an effective communication strategy in the context of seed systems.

More specifically, you will be able to:

- Identify the goals, target groups, communication objectives, and key messages and activities of your communication strategy
- Compare various applications of communication strategies in the context of agricultural research and development

## Communicating research results

Often, in the context of a research process, communication refers to the dissemination of results. A report is usually prepared and sent to selected people, or a paper is written and sent to journals. However, there are more ways in which you can communicate your findings effectively.

Communication is more than dissemination. It is about making information available in different formats suitable to different groups of users. It is also about engaging them in a discussion about the research carried out and the results produced to reach specific communication objectives. Sometimes, it can be about how to support farmers and communities so that they can also tell their own stories.

In this module, we introduce the concept and elements of a communication strategy and its application to agriculture. Such a strategy will help you think about whom you want to communicate with, for what purposes, and how best to reach specific groups and get feedback in return.

### What do you already know?

- How did you communicate your research results previously?
- Were you satisfied with the outcomes and feedback received? In what way?
- How do you apply the notions of communication objectives and target groups in your communication activities?
- What has been your previous experience in designing a strategy for reaching specific communication objectives?

### Content summary

- The elements of a communication strategy
- The application of communication strategies to agriculture

## The elements of a communication strategy

In this part of the module, you will learn how to develop a communication strategy, how to identify and involve various groups with whom you wish to communicate, and how to formulate communication objectives.

*A communication strategy is your road map to effective communication. It identifies the following elements:*

- Goal — Why do you want to communicate and share knowledge?
- Target groups — Which groups do you want to reach out to?
- Communication objectives — What do you want the target groups to know or be able to do after the communication activities?
- Messages and content — What research results do you want to share?
- Feedback — What kind of feedback would you like to receive after the communication activities and how will you obtain it?

- Communication tools and media — What communication tools, media or channels will you use, and what activities will you undertake to communicate your content and possibly obtain feedback?
- Evaluation — How will you know that the strategy has helped achieve your communication objectives?

It also includes an *implementation plan* that specifies:

- The resources at your disposal
- The timeline for implementing the strategy
- The roles and responsibilities of everyone involved in the communication effort.

As you can see, communicating goes far beyond sharing information through the use of media. It is a planned activity, based on participatory processes, as well as media and interpersonal communication. Its aim is to effectively reach stakeholders in order to share information and knowledge, facilitate dialogue and, in certain contexts, lead to consensus and action (see Acunzo et al. 2014 and Bessette 2004).

Communication planning requires a clearly defined strategy with specific objectives established in advance and an expected impact on intended stakeholders. Such a strategy includes four phases: analysis and design (selection of a goal, target group analysis, production of communication objectives, identification of expected feedback, messages and activities, and selection of communication tools), development and testing, implementation and monitoring, and evaluation and re-planning.

In this module, we will concentrate on the first four elements of a communication strategy: identification of a goal; target groups; communication objectives; and key messages, communication tools, and activities. Once you identify these, you will be able to develop the core of a communication strategy. You can then develop partnerships to select media and communication tools, produce and disseminate materials, and evaluate your strategy, as well as producing the required implementation plan.

#### **YOUR PERSONAL GOAL:**

Why do you want to share your research results?

You may have various goals in communicating your results:

- Expanding the scientific knowledge base — Increase the impact of the research on development and add to the body of scientific literature on resilient seed systems.
- Policy advocacy — Contribute to evidence-based policymaking and policy dialogue in support of more resilient seed systems.
- Community engagement — Engage communities in reflection on the research and development process (how best to adapt seed systems to climate change).
- Public information and knowledge sharing — Increase awareness and knowledge of the general public about issues related to the adaptation of seed systems to climate change.

#### **YOUR TARGET GROUPS:**

Which groups do you want to reach out to and how much do you know about them?

Depending on your goals, you will want to identify the groups you want to reach:

- *Scientific knowledge* — Managers working in the same organization or responsible for the project, colleagues working on the same project, colleagues working in the same area of research and development, academics and students, etc.



- *Policy advocacy* — Government, international agencies, policy and advocacy groups, environmental organizations, farmers' unions, etc.
- *Community engagement* — Farmers and community members engaged in the project, community members living in the same area, extension workers, nongovernmental organizations and community-based organizations, etc.
- *Public information and knowledge sharing* — The general public.

You can identify and learn more about your target groups by conducting a stakeholder analysis. This technique is explained in Module 1. Situational analysis.

You will also want to collect information on each target group: what they already know, their perceptions and attitudes, their level of influence, etc. This will help you establish communication objectives that target each specific group.

### **YOUR COMMUNICATION OBJECTIVES:**

What should your target groups know or do after the communication initiative?

In terms of communication, goals and objectives are different. Your goal is about what you want to do. Your communication objectives identify what you want your target groups to know or to do following the communication initiative.

For example, if you want to influence policymakers, you may want to have an objective stating that selected advocacy organizations will have the information they need to campaign in favor of resilient seed systems.

If you want communities to start using the new appropriate germplasm that was identified in the research, an objective might be: "Within one year, farmers in locality X will have the necessary knowledge and skills to use variety Y and report on its performance." Try not to be over ambitious.

Whenever possible, communication objectives should be "SMART" — Simple and clear, Measurable, Achievable, Reasonable, Time bound and location specific — because it makes them easier to monitor and evaluate.

### **YOUR KEY MESSAGES, COMMUNICATION TOOLS, AND ACTIVITIES:**

What will be the content and how will you share it?

You have a story to tell: your research process and your research results. You also know with whom you want to share this story and for what purpose.

You now have to:

- Develop your story — Select key messages to share, give examples, make it easy to understand, link your story with the objective you want to achieve.
- Prepare different presentations of your research results depending on whom you want to reach: a small information piece for the general public, a condensed and evidence-based presentation for policymakers, a report for your organization.
- Or will you help farmers tell their own story and share it with other stakeholders?
- Think of what is needed to address each specific group and reach the objective you have in mind.
- Identify the best way to reach your target groups and engage them, and pursue your communication objective.

You can then insert the different elements into a matrix:

Goal	Target Groups	Comm Objectives	Key Messages	Comm Tools & Activities

You will find examples in the readings below.

## Recommended readings

■ Acunzo, M., Pafumi, M., Torres, C., Tirol, M.S., 2014. Communication for rural development sourcebook. Food and Agriculture Organization of the United Nations, Rome, Italy. Available: <http://www.fao.org/3/a-i3492e.pdf>.

*This sourcebook presents the various steps in designing and implementing a rural communication strategy that combines participatory methods with communication processes, media, and tools best suited for a specific situation. Module 1, pp. 35–40, and Module 3, pp. 75–115, introduce the reader to the communication development process and the design of a communication strategy and plan.*

■ Bessette, G., 2004. Involving the community: a guide to participatory development communication. International Development Research Centre, Ottawa, Canada, and Southbound, Penang, Malaysia. Available: <http://www.idrc.ca/EN/Resources/Publications/Pages/IDRCBookDetails.aspx?PublicationID=204>.

*This practical guide for people working in research and development introduces participatory development communication concepts, discusses effective two-way communication approaches, and presents a method for planning, developing, and evaluating communication strategies.*

■ Mefalopulos, P., Kamlongera, C., 2004. Participatory communication strategy design: a handbook (2<sup>nd</sup> edition). Food and Agriculture Organization of the United Nations, Rome, Italy. Available: <http://www.fao.org/docrep/008/y5794e/y5794e00.HTM>.

*This guide presents the various elements in the design of a communication strategy. The reader will find concepts and tools used in identifying target audiences, establishing communication objectives and messages, using communication tools, applying a strategy, and evaluating results.*

## More on the subject

■ Graeff, J.A. (editor), 2008. Writing a communication strategy for development programs: a guideline for programme managers and communication officers. UNICEF, Dhaka, Bangladesh. Available: [http://www.unicef.org/cbsc/files/Writing\\_a\\_Comm\\_Strategy\\_for\\_Dev\\_Progs.pdf](http://www.unicef.org/cbsc/files/Writing_a_Comm_Strategy_for_Dev_Progs.pdf).

*Pages 12–63 cover the steps toward developing a communication strategy. Although presented in the context of UNICEF's health and development interventions, these tools and approaches can be integrated into other types of communication strategies.*

■ Oepen, M., Willner, S., 2006. Strategic communication for sustainable development: a conceptual overview. GTZ Rioplus-Environmental Policy and Promotion of Strategies for Sustainable Development, Bonn, Germany, pp. 36-46. Available: <https://www.cbd.int/cepa/toolkit/2008/doc/strategic%20communication%20for%20sustainable%20development.pdf>.

*Pages 36–46 present 10 steps for developing a communication strategy.*

■ Servaes, J., (editor), 2019. Handbook on communication for development and social change. Springer, Singapore.

*This handbook presents a collection of short chapters on the application of communication to different sectors of development. One chapter, "Participatory development communication and natural resources management" ([https://link.springer.com/referenceworkentry/10.1007/978-981-10-7035-8\\_71-1](https://link.springer.com/referenceworkentry/10.1007/978-981-10-7035-8_71-1)), discusses the application of participatory communication to agriculture.*



Photo:  
Sharing local knowledge  
through dance and  
songs, Zimbabwe.  
Credit: Bioversity  
International/R.Vernooij

## The application of communication strategies to agriculture

There are, of course, many examples of the application of communication strategies to agriculture. In this module we will look at four specific ones: disseminating new knowledge, scaling out agriculture innovations, empowering farmers, and influencing policies.

### Disseminating new knowledge

Disseminating new agricultural knowledge has traditionally been the field of extension. Researchers develop the knowledge, extension agents share it with the end-users, the farmers, and farmers are then expected to use it. As we now know, this model does not work very well. Effective extension now draws on sound participatory communication strategies that involve the farmers in the creation of knowledge through situational analysis, field experimentation, and participatory evaluation.

At the 9th United Nations roundtable on development communication, Niels Röling (2007) presented a paper that discusses three models for communicating agricultural innovations that have influenced practices. He suggested that communication strategies should focus on listening, exchanging ideas, building concerted action, and negotiating agreement with farmers around the learning and adoption of agricultural innovations.

Over the years, there has been a succession of initiatives that attempted to embed farmers' participation in concrete models designed to share agricultural knowledge, improve productivity, open markets and develop an enabling environment. In Africa, the Forum for Agricultural Research in Africa (FARA) has been championing the Integrated Agricultural Research for Development (IAR4D) multi-stakeholder processes using innovation platforms (IP) as a key tool

to enhance the impact of development initiatives and improve the livelihood of farmers and other partners through research for development projects.

Successful outcomes of this and other participatory approaches for extension and research for development depend on a number of issues that deserve special attention. These include the quality of participation, fruitful multi-directional relationships between the various stakeholders (producers, NGOs, private-sector operators, local/national authorities and researchers), modalities of knowledge sharing and use in the field, and the lag time between these iterative processes and the adoption of the improved traditional or modern technologies.

## **Scaling out agriculture innovation**

Likewise, scaling out new knowledge about on-farm experiments has proven to be a complex endeavor. This is illustrated by the Knowledge Sharing and Communication Strategy used by the Evergreen Agriculture Project.

In the context of scaling out Evergreen Agriculture innovations, a team of researchers developed a communication strategy to inform stakeholders about the new systems and to facilitate their mobilization to achieve the objectives of the project. The strategy was developed through stakeholders' workshops that included farmers, media personnel, local government representatives, community-based and nongovernmental organizations, researchers, and extension agents at the local and district levels.

The workshop took stakeholders through a number of steps, namely:

- Identification of stakeholders: farmers, extension agents, local government representatives, etc.
- Understanding each group's needs and potential for action
- Identification of the communication objective(s)
- Identification of key messages and appropriate communication tools for each target group
- Identification of, and collaboration with, partner organizations.

This is a good example of involving stakeholders in the design of a communication strategy. Doing so increases the chances that the strategy will be appropriate for each category of stakeholder.

## **Empowering farmers**

Using communication as a tool to empower farmers and support them in the role of educating their peers is a very effective application of communication in agriculture. In a case study on growing bananas in Uganda, researchers had developed technologies that could be of benefit to farmers, particularly in improving banana crops. However, farmers proved reluctant to use these new technologies, despite researchers' attempts to disseminate them.

Instead of sharing the information and conducting demonstrations, researchers decided to develop a communication strategy in which farmers would take the lead role. They asked them to prioritize the problems they faced for which they needed help. Farmers identified issues related to soil fertility, soil erosion, and soil moisture retention. With the help of the researchers, they then identified communication objectives for each of these problems, the activities that could be undertaken to alleviate them, and communication tools that could help them share their knew knowledge with other farmers.

During this process, the researchers discovered that some farmers had extensive indigenous knowledge related to these concerns, but it required validation. Moreover, farmers did not have a forum in which to share information; hence, the need for communication tools.

Researchers facilitated visits to sites where farmers were already using appropriate practices. Following the visits and discussions, farmers were more convinced than before of the new technologies' benefits. Field experiments were organized with those who were willing to participate, and farmers were amazed at the results: not only did they have high-yielding banana plots, but they were also making more money from their produce.

Participating farmers chose to use videos, photographs and posters to show other farmers how to implement these techniques. This farmer-to-farmer approach was effective in spreading appropriate soil management practices.

Through this process, they became closer as a group and started a farmers' association. They became proactive in tackling their own problems and approaching service providers regarding their community concerns. In this case, communication around new soil technologies became a channel for empowerment.

## Influencing policies

Influencing policies is a fourth application of communication strategies in agriculture. Engaging stakeholders in dialogue can lead to better policy design and implementation. It also ensures that a given policy takes into account the many dimensions at play and the various interests and perspectives of the stakeholders.

Communication with policymakers often requires the presentation of evidence in an intelligible way. In a short article published by ODI, Jones and Walsh (2008) discuss the use of "policy briefs" and the need for a communication strategy that is more integrative.

Policy briefs are a way to package research evidence for policymakers. They are short documents that present the findings and recommendations coming from research or a study (and more often from numerous sources) to a non-specialist readership with the intention of recommending some policy action.

The first step in a policy brief is to prioritize a policy issue. Once an issue has been prioritized, the focus turns to mobilizing the full range of research evidence relevant to the topic's various features. Drawing on studies, research reports and reviews makes feasible the process of mobilizing evidence and of using it to, consequently, recommend orienting policies.

However, briefs alone can do little. To foster uptake and implementation, face-to-face and/or electronic discussions and deliberations with policymakers about the evidence presented in the brief and policy guidance are critical. Active mediation and translation among knowledge producers, knowledge brokers, and end users are needed, as well as an integrated communications approach that takes into consideration individual, organizational, and systemic levels.

In the case of the implementation of the International Plant Treaty in Burkina Faso, specific workshops were organized for different categories of stakeholders, such as farmers' associations and NGOs, researchers, government representatives and the media, thus enabling a policy dialogue that recognized the interests and perspectives of each group, and which fed back to the elaboration of a draft law for protecting phylogenetic resources. This policy dialogue and consensus-building process was as important as the circulation of information to influence policy. To gain success, the presentation of evidence has to lead to a consensus among the different actors involved.

## Recommended readings

■ Bessette, G., 2019. Participatory Development communication and natural resources management. In: Servaes, J. (editor), Handbook on communication for development and social change. Springer, Singapore. Available: [https://link.springer.com/referenceworkentry/10.1007/978-981-10-7035-8\\_71-1](https://link.springer.com/referenceworkentry/10.1007/978-981-10-7035-8_71-1).

*This chapter suggests a participatory communication approach where the information is not transmitted from experts to end users, but where researchers and practitioners use communication to facilitate participation and the sharing of knowledge.*

■ Naboka Odoi, N., 2006. Growing bananas in Uganda: reaping the fruit of participatory development communication. In: Bessette, G. (editor), People, land and water: participatory development communication for natural resource management. International Development Research Centre, Ottawa, Canada, and Southbound, Penang, Malaysia, pp. 129–135. Available: <http://www.idrc.ca/EN/Resources/Publications/Pages/IDRCBookDetails.aspx?PublicationID=112>.

*This case study is an example of empowering farmers through communication.*

■ Masuki, K., Muriuki, J., Odhiambo, D., 2012. Knowledge sharing and communication strategy: Evergreen Agriculture Project. World Agroforestry Centre, Nairobi, Kenya. Available: <http://worldagroforestry.org/sites/default/files/Knowledge%20sharing%20and%20communication%20strategy.pdf>.

*A good example of involving stakeholders in the design of a communication strategy.*

■ Jones, N., Walsh, C., 2008. Policy briefs as a communication tool for development research. Background notes Overseas Development Institute, London, UK. Available: <http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/594.pdf>.

*Key ingredients of effective policy briefs. The article stresses that it is critical to foster close collaboration between researchers and policymakers from the outset, rather than disseminating research results at the end of a project; to reach consensus on the key questions to be addressed; and to promote understanding of research methods as well as ownership of findings.*

## More on the subject

■ Bessette, G. (editor), 2006. People, land and water: participatory development communication for natural resource management. International Development Research Centre, Ottawa, Canada, and Southbound, Penang, Malaysia. Available: [http://www.seedsresourcebox.org/recommended-readings/detail/?tx\\_news\\_pi1%5Bnews%5D=1081&cHash=b915e726e24afdd7efb625549e897b0f](http://www.seedsresourcebox.org/recommended-readings/detail/?tx_news_pi1%5Bnews%5D=1081&cHash=b915e726e24afdd7efb625549e897b0f).

*This is a collection of case studies in which communication was used in the context of agriculture and natural resource management. It also provides different cultural perspectives on communication for development.*

■ Lavis, N.J., Permanand, G., Oxman, A.D., Lewin, S., Fretheim, A., 2009. SUPPORT tools for evidence-informed health policymaking (STP) 13: Preparing and using policy briefs to support evidence-informed policymaking. *Health Res Policy Syst*, 2009; 7(Suppl 1): S13. Available: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3271824/>.

*In this article, the authors suggest questions that can be used to guide those preparing and using policy briefs to support evidence-informed policymaking.*

■ Rölöng, N., 2007. Communication for development, in research, extension and education. In: FAO 2007. Communication and sustainable development. Selected papers from the 9th UN roundtable on communication for development. Food and Agriculture Organization of the United Nations, Rome, Italy, pp. 57–77. Available: <http://www.fao.org/docrep/010/a1476e/a1476e00.htm>.

*This article argues that it is not useful to consider innovation as purely the outcome of transfer or delivery of results of scientific research to the “ultimate users” or farmers and that participation plays a major role in effective innovation.*

## Testing your knowledge

Here is a quiz that will help you test your newly acquired knowledge. Once you have covered the content sections and completed the assigned readings, please answer the Knowledge-sharing and communication quiz.

1. What is the most important factor in communicating research results effectively?
  - a. Simplifying and presenting the content in a clear and structured way
  - b. Identifying what is expected from the audience and preparing the content in different ways for different groups, with their input
  - c. Selecting interesting communication media that will spark interest from the audience
  - d. Doing an evaluation after the presentation of the research results
2. Which, among the following, are part of a communication strategy?
  - a. Goal
  - b. Target groups
  - c. Resources and timeline
  - d. Communication objectives
  - e. Key messages
  - f. Evaluation
  - g. Communication tools
  - h. Marketing
  - i. Roles and responsibilities
  - j. Communication activities
  - k. Communication champions
3. What are communication objectives?
  - a. The goals of the communication strategy
  - b. The outcomes of the activities in terms of what target groups should be able to understand or to do
  - c. The changes expected as a result of the communication activities
  - d. The milestones for each communication activity
4. What is the difference between dissemination of new agricultural knowledge and communication of new agricultural knowledge?
  - a. The two are the same
  - b. Communication is more than dissemination; it involves the design of a plan
  - c. Communication of new agricultural knowledge uses different types of media
  - d. Communication involves farmers in the production and sharing of knowledge
  - e. Dissemination also includes the application of the new agricultural knowledge
5. What is a policy brief?
  - a. A document recommending changes in policy as a result of a research effort
  - b. A document presenting different aspects of a given policy
  - c. Policy orientations in a given sector (e.g., agriculture)

## Applying your knowledge

Please, document this step of the research process by describing your communication strategy.

For our purposes, we will leave aside for now the other elements of a communication strategy as well as the communication implementation plan, and concentrate on the following elements:

1. Your personal goal
2. Your target groups
3. Your communication objectives
4. Your key messages
5. Your communication tools and activities for each target group



# QUIZ ANSWERS

## MODULE 1

- **Question 1:** A situational analysis in the context of resilient seed systems and adaptation to climate change encompasses different steps of activities. Which step(s) is (are) missing in the following list: a) Community identification and profiling, b) Analyzing with farmers their perceptions on climate change, variability and adaptation, c) The assessment of a community's diversity and its vulnerability to climate change, d) Participatory adaptation planning.

**Possible answers:**

- a. Transect walk
- b. Participatory vulnerability assessment
- c. Participatory ranking of varieties
- d. Village resource mapping
- e. Seasonal calendar
- f. Stakeholder analysis

**Correct answers:** b) f)

- **Question 2:** Community profiling is a process that involves participatory analysis of a community. This is done through:

**Possible answers:**

- a. Identifying the socio-cultural aspects of a community
- b. Identifying land use characteristics and common resources within the community
- c. Discussing the local understanding of climate change and how it affects them
- d. Identifying adaptation mechanisms
- e. Identifying types of agricultural activities and economic livelihoods
- f. Mapping landscapes and diversity on farm and within the community
- g. Assessing the risks and vulnerability of the community to climate change

**Correct answers:** a) b) e) f)

- **Question 3:** Which of these tools are usually used to analyze with farmers their perceptions of climate change, variability and adaptation?

**Possible answers:**

- a. Transect walk
- b. Village resource mapping
- c. Seasonal calendar
- d. Participatory ranking
- e. Four cells
- f. Livelihood resource assessment

**Correct answer:** c)

■ **Question 4:** Participatory vulnerability analysis is usually done through:

**Possible answers:**

- a. A questionnaire distributed and discussed with farmers
- b. A survey of the area
- c. Focus-group discussions
- d. A community meeting
- e. The collection and analysis of secondary sources

**Correct answer:** c)

■ **Question 5:** The method of Four Cells Analysis is usually applied through:

**Possible answers:**

- a. The distribution of a questionnaire
- b. A survey of the area
- c. Focus-group discussions
- d. A community meeting
- e. Researching secondary sources
- f. Ranking

**Correct answers:** c) d) f)

■ **Question 6:** Stakeholder analysis is useful for:

**Possible answers:**

- a. Identifying the relationships between stakeholders that work in the communities and how these relationships present opportunities or threats to the adaptation process.
- b. Identifying the relationships between the community and the different existing organizations and institutions working in or influencing the community and the impact of these relationships on the community.
- c. Understanding the roles of other local actors and how their activities impact on shaping adaptation and the possibilities for improving capacities of local communities to adapt to climate change.

**Correct answers:** a) b) c)

■ **Question 7:** The main step in participatory adaptation planning is:

**Possible answers:**

- a. Analyzing information collected during each stage of the situation analysis.
- b. Developing an implementation plan based on the vulnerabilities identified, and targeting different intervention strategies while taking into consideration gender and social variables.
- c. Identifying who is doing what, where and how.

**Correct answers:** a) b) c)

## MODULE 2

■ **Question 1:** Which of the following statements are true?

**Possible answers:**

- a. Regional meteorological data can be obtained from national meteorological stations.
- b. These data must cover at least a span of ten years to be useful.
- c. This type of data can also be collected by field observations using environmental sensors.

**Correct answers:** a) c)

■ **Question 3:** Biodiversity and environmental data can also be obtained from the following sources:

**Possible answers:**

- a. Global or national genebanks
- b. Field observations
- c. Herbariums
- d. Global agencies
- e. Specialized data bases

**Correct answers:** all

■ **Question 3:** Which of these software tools can be used for data analysis?

**Possible answers:**

- a. Ecocrop
- b. ModEco
- c. openModeller
- d. DIVA-GIS
- e. MaxEnt
- f. Google Earth
- g. The Climate analogue tool

**Correct answers:** all

■ **Question 4:** What are the main prerequisites for importing data into DIVA-GIS and MaxEnt?

**Possible answers:**

- a. Data have to be entered or downloaded in an Excel file and converted into appropriate formats for spatial analysis.
- b. Data need to be accompanied by an identification code, a scientific or taxonomic name and coordinates (latitude and longitude).
- c. Coordinates need to be presented either in Degrees, Minutes and Seconds (DMS) format, Degrees, Minutes (DM) or Degree Decimal (DD).
- d. It is possible to assign coordinates manually to missing values.

**Correct answers:** a) b) d)

■ **Question 5:** Which of these statements are true?

**Possible answers:**

- a. In DIVA-GIS, you can download free spatial data for the whole world.
- b. The Ecocrop model is built in DIVA-GIS.
- c. It is possible to download climate data from WorldClim directly in DIVA-GIS.
- d. One of the main applications of DIVA-GIS is the prediction in population, ecology and biogeography.

**Correct answers:** a) b) c)

## MODULE 3

■ **Question 1:** How is germplasm related information usually recorded in a collection nowadays?

**Possible answers:**

- a. The location information of the collection site is noted through details like administrative units, presence of nearby town/village, distance from the road, etc.
- b. Passport data collection of accessions is recorded through standardized formats.
- c. Location information is recorded in the form of geographic coordinates.

**Correct answers:** b) c)

■ **Question 2:** Why is assigning geographic coordinates to germplasm important?

**Possible answers:**

- a. The location of each collecting site is critical to obtain other data about that accession, such as soil data.
- b. Assigning geographic coordinates is necessary to access georeferenced sites that can be used as reference.
- c. Once the accessions have been assigned geographic coordinates, the random dataset can then be classified according to climate, which will organize the collection in a more efficient manner and from which patterns can be easily deduced.

**Correct answers:** a) c)

■ **Question 3:** How can we identify locally adapted adaptation measures to climate change?

**Possible answers:**

- a. Develop climate models that simulate future conditions and provide a glimpse of a set of possibilities both spatially and temporally.
- b. Use General Circulation Models (GCMs), which provide the current and future scenarios (under different probable conditions) to gauge the vulnerability of a site to changing climate.
- c. Develop improved genotypes that are resilient to any number of stresses like extreme temperatures, flooding or drought.

**Correct answers:** a) b)

■ **Question 4:** What is the climate analogue technique?

**Possible answers:**

- a. A pre-emptive adaptation strategy
- b. A corrective adaptation strategy
- c. A technique consisting of finding out a reference site whose climate matches (with a degree of probability) the climate of the target site, although both may be separated both spatially or temporally.

**Correct answers:** a) c)

■ **Question 5:** What are the next steps after carrying out the assessment of a given site's vulnerability to climate change and identifying potential climate-matching sites?

**Possible answers:**

- a. Identify those genotypes that can be tested in the vulnerable site.
- b. Take into consideration other physical factors like soil conditions and topography and non-physical factors like socioeconomic conditions and the market.
- c. Test under different conditions for a few seasons.

**Correct answers:** all

## MODULE 4

- **Question 1:** In many cases, germplasm acquisition must follow formal rules and regulations. What do these rules cover?

**Possible answers:**

- a. The scientific aspects of seed production
- b. The phytosanitary aspects of seed production
- c. The protection of traditional knowledge
- d. Access to germplasm
- e. The phytosanitary aspects of seed distribution
- f. Benefit sharing of germplasm
- g. The protection of biodiversity

**Correct answers:** b) c) d) e) f)

- **Question 2:** In relation to the Convention on Biodiversity (CBD) and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), which of these answers is or are true?

**Possible answers:**

- a. The CBD is crafted on a bilateral system of access and benefit-sharing agreements.
- b. The ITPGRFA does not recognize national sovereign rights over plant genetic resources.
- c. The ITPGRFA represents a multilateral system for facilitated access to all agricultural crops related to food security.
- d. Many countries have national policies and laws that concern the acquisition and use of new germplasm, but the rules and regulations set by the CBD and ITPGRFA take precedence once they have been ratified.
- e. The ITPGRFA represents the application of the CBD to the domain of plant genetic resources for food and agriculture.

**Correct answer:** a)

- **Question 3:** How would you characterize the relation between the ITPGRFA and farmers' rights?

**Possible answers:**

- a. The Plant Treaty includes a special charter on farmers' rights.
- b. Protection of traditional knowledge is a key dimension of the Plant Treaty.
- c. Farmers' rights are addressed in the CBD, not in the Plant Treaty.
- d. The Plant Treaty regulates the acquisition of germplasm in terms of respect for and recognition of local agricultural practices.
- e. The Plant Treaty only regulates the acquisition of germplasm that has been accessed through legal arrangements.

**Correct answers:** b) d)



■ **Question 4:** What are access and benefit-sharing rules and regulations concerned with?

**Possible answers:**

- a. The access to new germplasm, its use, and conditions of sale
- b. The questions of who may have access to and make use of germplasm and under what conditions
- c. The intellectual property rights of breeders, and conditions of access of new germplasm
- d. All of the above

**Correct answer:** b)

■ **Question 5:** Who defines the phytosanitary regulations related to the exchange of germplasm?

**Possible answers:**

- a. The providers of germplasm
- b. Internationally agreed standards
- c. The national agency for phytosanitary regulations
- d. The national agency in each country implementing the ITPGRFA

**Correct answers:** a) b) c)

## MODULE 5

■ **Question 1:** Why did participatory crop improvement emerge as an alternative to conventional approaches to crop experimentation?

**Possible answers:**

- a. While conventional crop research has contributed to substantial yield increases mainly in high-input agricultural production areas, smallholders with limited access to inputs or credit have enjoyed little benefit.
- b. Farmers often have different priorities than plant breeders that often were not taken into account.
- c. Women, men, and younger farmers have different needs, interests and preferences, which were not always recognized.
- d. Some researchers felt that farmers are the best placed to decide what varieties to develop and how to test them in their fields.
- e. Conventionally bred varieties often failed to respond to the specific requirements of marginal environments in which smallholder farmers operate.

**Correct answers:** a) b) c) e)

■ **Question 2:** How does participatory variety selection take place?

**Possible answers:**

- a. Organized farmer groups grow a set of promising varieties in experimental quantities on one or more plots that have been volunteered by one or more farmers in the group.
- b. Pre-selected, improved varieties at physiological maturity are presented to farmers by researchers at a breeding station. Farmers select a variety they would prefer to grow and then are offered small amounts of seed to test on farm.
- c. The cultivation of trials is completely under farmer management.
- d. The practice of “mother-baby trials” combines the benefits of trials at research stations with trials under farmer management. In “mother” trials, breeders and researchers assess a large range of varieties under controlled conditions and measure yield and other variables. The most promising materials are then given for no charge to interested farmers, who grow no more than two to three varieties, on their own land. These are the “baby” trials.

**Correct answers:** all

■ **Question 3:** What can be the main limits of participatory variety selection?

**Possible answers:**

- a. Researcher-biased questioning at the time of selection
- b. Incentivizing productivity in baby trials
- c. Selection based on snapshot impressions
- d. Knowledge gaps
- e. Lack of scientific validation

**Correct answers:** a) b) c) d)

■ **Question 4:** What is the crowdsourcing field trials approach?

**Possible answers:**

- a. An approach used to collect data by large numbers of specialized researchers and breeders.
- b. An approach used by scientists and companies worldwide to collect data by large numbers of volunteers.
- c. An approach enabling farmers to carry out large trials.
- d. An approach that usually focuses on many crops at the same time.

**Correct answer:** b)

■ **Question 5:** Which of these statements, regarding participatory plant breeding (PPB) is true?

**Possible answers:**

- a. Farmers are able to participate and take responsibility in all steps of a plant breeding program.
- b. Participatory, decentralized approaches are likely to lead to varieties that are adapted to the local environmental and economic conditions, higher yielding and socially accepted.
- c. PPB relies on lasting relationships between researchers and "custodian farmers."
- d. Although farmers cannot make choices that are as effective as trained researchers, they can supervise the trials and inform researchers of progress. Researchers will then decide what is best for farmers.

**Correct answers:** a) b) c)

## MODULE 6

■ **Question 1:** Which of the following statements are defining factors of a farmer-managed seed system?

**Possible answers:**

- a. It is not part of the commercial seed system
- b. It is usually defined as the informal seed system
- c. It combines components from both the formal and informal systems
- d. It contributes to maintaining crop diversity on the farm and in the community

**Correct answers:** a) c) d)

■ **Question 2:** Among the following practices, which contribute to produce and maintain good quality seed of a crop variety over time?

**Possible answers:**

- a. Seed sourcing
- b. Land/field selection
- c. Isolation of seed fields
- d. Agronomic management
- e. Rouging of off types
- f. Inspection before harvest
- g. Storage in a cool dry place
- h. Verifying seed quality regularly after storage.

**Correct answers:** all

■ **Question 3:** Once farmer-managed seed has been harvested, selected and stored,

**Possible answers:**

- a. It has to be certified
- b. It cannot be certified
- c. In some countries it can sometimes be certified or receive a quality guarantee label

**Correct answer:** c)

■ **Question 4:** Seed produced in farmer-managed seed systems

**Possible answers:**

- a. Can usually be labeled and distributed in the seed market throughout the country
- b. Can only be sold in the country if there is a shortage of seed from the formal seed system
- c. Can only be sold in a radius of 10 km from where it was grown
- d. The situation varies among countries.

**Correct answer:** d)

## MODULE 7

- **Question 1:** Which of these statements about *ex situ* and *in situ* conservation are true?

**Possible answers:**

- a. *In situ* conservation takes place in natural habitats.
- b. *In situ* conservation takes place in protected areas.
- c. *Ex situ* conservation takes place in genebanks.
- d. *Ex situ* conservation can also take place in botanical gardens.
- e. Community seed banks maintain an *ex situ* collection, but turnover periods are usually short. Some community seed banks maintain an *in situ* collection, for example, of root and tuber crops.

**Correct answers:** all

- **Question 2:** Which of these answers represents the major constraint to *ex situ* conservation?

**Possible answers:**

- a. The process of natural evolution is halted.
- b. The storage of seeds in *ex situ* conservation is complex and expensive.
- c. Germplasm is not easily accessible.
- d. Farmers lose their rights on the seeds that are stored *ex situ*.

**Correct answer:** a)

- **Question 3:** Which farmers can be characterized as custodian farmers?

**Possible answers:**

- a. Farmers in an area where there is a community seed bank.
- b. Farmers who have special knowledge and skills to practice seed conservation and are recognized by the community for this special trait.
- c. Members of community seed savers groups.
- d. Farmers who breed new varieties on their farms.

**Correct answer:** b)

- **Question 4:** The main function of a community seed bank is to:

**Possible answers:**

- a. Maintain seeds for local use
- b. Distribute seeds to a large number of farmers
- c. Conserve genetic resources
- d. Enhance access and availability of crop diversity
- e. Ensure seed and food sovereignty

**Correct answers:** all

■ **Question 5:** How do community seed banks conserve seeds of local varieties?

**Possible answers:**

- a. Under *in situ* conditions
- b. Under *ex situ* conditions
- c. Under both *in situ* and *ex situ* conditions

**Correct answer:** c)

## MODULE 8

■ **Question 1:** Research evaluation involves making a judgment about research progress and outcomes. What is participatory evaluation?

**Possible answers:**

- a. A joint evaluation done by researchers and evaluation experts
- b. A process in which farmers evaluate the research themselves
- c. A partnership between researchers, farmers and other stakeholders to evaluate the research carried out
- d. An evaluation methodology that seeks to respond to the needs of project implementers

**Correct answer:** c)

■ **Question 2:** Important reasons for using participatory evaluation are:

**Possible answers:**

- a. To increase the relevance and effectiveness of the research to stakeholders
- b. To contribute to empowerment and social transformation
- c. To create a clearer picture of what has happened according to the perspectives of women, men, and various age, class and ethnic groups in the community

**Correct answers:** all

■ **Question 3:** When should evaluation questions be defined?

**Possible answers:**

- a. At the start of the evaluation process
- b. At the initial stages of the research cycle
- c. During implementation
- d. After approval of the evaluation design
- e. After situational analysis

**Correct answer:** b)

■ **Question 4:** What aspects of research do evaluation questions usually address?

**Possible answers:**

- a. Design and planning
- b. Implementation
- c. Outputs
- d. Outcomes
- e. Funding

**Correct answers:** a) b) c) d)



■ **Question 5:** Which, in the following list, could be used as evaluation tools?

**Possible answers:**

- a. Interviews
- b. Key informant interviews
- c. Surveys
- d. Oral histories
- e. Testimonials
- f. Brainstorming
- g. Focus groups
- h. Network analysis
- i. Rating exercises
- j. Ranking exercises
- k. Mapping
- l. Diagramming
- m. Community photography and video
- n. Theatre and role plays

**Correct answers:** all

■ **Question 6:** What should an evaluation recommendation include?

**Possible answers:**

- a. Concrete action(s) to be undertaken by specific users
- b. Concrete results achieved
- c. A feasible timeframe
- d. The proposed actors for taking responsibility for the action(s)
- e. A budget

**Correct answers:** a) c) d)

## MODULE 9

■ **Question 1:** What is the most important factor in communicating research results effectively?

**Possible answers:**

- a. Simplifying and presenting the content in a clear and structured way.
- b. Identifying what is expected from the audience and preparing the content in different ways for different groups, with their input.
- c. Selecting interesting communication media that will spark interest from the audience.
- d. Doing an evaluation after the presentation of the research results.

**Correct answer:** b)

■ **Question 2:** Which, among the following, is or are part of a communication strategy?

**Possible answers:**

- a. Goal
- b. Target groups
- c. Resources and timeline
- d. Communication objectives
- e. Key messages
- f. Evaluation
- g. Communication tools
- h. Marketing
- i. Roles and responsibilities
- j. Communication activities
- k. Communication champions

**Correct answers:** all, except h and k

■ **Question 3:** What are communication objectives?

**Possible answers:**

- a. The goals of the communication strategy
- b. The outcomes of the activities in terms of what target groups should be able to understand or to do
- c. The changes expected as a result of the communication activities
- d. The milestones for each communication activity

**Correct answers:** b) c)

■ **Question 4:** What is the difference between dissemination of new agricultural knowledge and communication of new agricultural knowledge?

**Possible answers:**

- a. The two are the same.
- b. Communication is more than dissemination; it involves the design of a two-way communication strategy and plan.
- c. Communication of new agricultural knowledge uses different types of media.
- d. Communication involves farmers in the production and sharing of knowledge.
- e. Dissemination is about informing about the new agricultural knowledge and advocating its utilization.

**Correct answers:** b) d) e)

■ **Question 5:** What is a policy brief?

**Possible answers:**

- a. A document, based on research, for communicating knowledge and recommending specific actions to policy actors
- b. A document presenting different aspects of a given policy
- c. Policy orientations in a given sector (e.g., agriculture)

**Correct answer:** a)

## COMMENTS OR QUESTIONS

We would be happy to hear from you. Please send any question or comment to the following email address: [bio-policy@cgiar.org](mailto:bio-policy@cgiar.org)



## Alliance

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The Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT) delivers research-based solutions that harness agricultural biodiversity and sustainably transform food systems to improve people's lives. Bioversity International and CIAT are CGIAR Research Centres.

ISBN: 978-92-9255-138-4