Assessing Agrobiodiversity:

A Compendium of Methods

PAR

Assessing Agrobiodiversity: A Compendium of Methods has been prepared by Dunja Mijatović and Toby Hodgkin with contributions from Lukáš Pawera, Stella Beghini, Gennifer Meldrum, Mattia Manica, Barbara Smith, Devra Jarvis, Sajal Sthapit, Roba Bulga Jilo, Stanley Zira, Yasuyuki Morimoto, Patrick Maundu and assistance from (in alphabetical order): Alberto Tarraza Rodríguez, Alejandro González Álvarez, Annelie Bernhart, Epsha Palikhey, Ghanimat Azhdari, Helga Gruberg Cazón, Lal Kumara Wakkumbure, Maede Salimi, Mehdi Esmaeili, Natalia Estrada-Carmona, Reuben Mendakor Shabong and Sonthana Maneerattanachaiyong.

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Jhum rice fields in Arunachal Pradesh, India. Photo courtesy of Somnath Roy.

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PAR PLATFORM FOR AGROBIODIVERSITY RESEARCH

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DEDICATION

The Compendium is dedicated to the memory of our dear friend, colleague and mentor, Dr Bhuwon Sthapit, who passed away in August 2017 and whose ideas, like seeds, are planted in our work.

ACKNOWLEDGEMENTS

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INTRODUCTION

Sorghum varieties, Kenya.
Photo: Bioversity International/Y. Morimoto

INTRODUCTION

Agrobiodiversity is the diversity of crop species and varieties, livestock species and breeds, wild plants, pollinators, soil biota and other aquatic and terrestrial organisms that make agricultural and food production possible. Meeting the challenges of climate change, improving nutrition and health, and achieving a transformation towards more sustainable and equitable production systems will all require the restoration of agrobiodiversity and its improved conservation.

The growing interest in supporting agroecological ways of farming has created new opportunities to explore diversity-rich approaches with small-scale farmers, pastoralists, forest dwellers, urban gardeners and other communities. There is a great need to support these communities in their efforts to revive or maintain diversity and associated knowledge and practices.

In areas rich in agrobiodiversity, knowledge sharing and innovations arise through daily observation, experimentation and exchange. Both diversity and management practices are continuously changing and result in adaptive biocultural systems that emerge through an interplay between people and their environments. Such areas, where diversity and associated knowledge exist in dynamic forms, can benefit from scientific recognition and support. In the same way, science has much to learn from the communities who maintain diversity.

Drawing on experiences from projects around the world, this Compendium has been prepared by the Platform for Agrobiodiversity Research (PAR) to support the documentation, co-creation and sharing of knowledge about agrobiodiversity and its management. The Compendium seeks to encourage and support collaborative research that aims to help local communities to:

- Maintain and recover local crops, varieties and breeds
- Revive practices and knowledge associated with agrobiodiversity
- Diversify fields, farms and landscapes
- Protect and restore ecosystems.

Woman holding gourd bowls with white and purple hibiscus flowers, Boumboro village, Mali.
Photo: D. Mijatović

THE COMPENDIUM

The first steps in agrobiodiversity research include assessing the diversity present in an area and understanding its management and use. The Compendium provides guidelines for the collection and analysis of information about the diversity of crops, livestock, pollinators and harvested wild plants. The methods described have all been used and documented with communities around the world in landscapes with diverse environmental and cultural features. These methods can be adapted to specific research contexts and combined with many methods not covered in the Compendium.

Section 1 describes some general principles of agrobiodiversity research, including the approaches to be adopted and the ways in which the results can be used. Section 2 provides an overview of methods used in agrobiodiversity assessments together with some suggestions on how to obtain the data needed.

Sections 3 and 4 describe two of the key initial tools, transect walks and seasonal calendars, respectively, as these are usually some of the first activities carried out with the community.

Section 5 presents methods for carrying out household surveys. Section 6 describes the ‘four cell analysis’ approach for assessing the abundance and distribution of local crop and variety diversity in a farming community. This is followed by sections 7 and 8 on obtaining information on crop and variety traits, uses and values, and seed systems.

Section 9 explains methods for collecting information about the use of wild plants. Section 10 describes the process of obtaining information on animal and breed diversity and on the socioeconomic factors that are important to their maintenance and use. Section 11 presents two methods for assessing pollinator diversity.

Section 12 describes ways of finding out about the distribution of diversity and areas of importance for ecosystem services through participatory mapping and Section 13 covers community-based assessment of social-ecological resilience. Section 14 explains how to calculate richness, evenness and divergence for crops or crop varieties. Section 15 deals with some general aspects of data analysis.

This is the first version of the Compendium and PAR plans to add further sections to future versions, e.g. on assessing soil biodiversity. Your comments and suggestions for ways of improving the Compendium would be most welcome and should be sent to
platformcoordinator@agrobiodiversityplatform.org

1. ABOUT AGROBIODIVERSITY RESEARCH

Offerings to the spirits at the beginning of rice harvest in San Din Daeng Karen community, Thailand. *Photo: D. Mijatović*

1. ABOUT AGROBIODIVERSITY RESEARCH

1.1 WHAT IS AGROBIODIVERSITY?

Since the beginning of agriculture more than 10,000 years ago, hundreds of thousands of crop varieties and thousands of livestock breeds have been created through human and ecosystem interaction. These varieties and breeds are adapted to specific ecologies, climates and human needs, and they continue to evolve in unique environments and management systems.

AGROBIODIVERSITY includes all the variety and variability of animals, plants and microorganisms that are used directly or indirectly for food and agriculture, including crops, livestock, trees and fish. Created and managed by farmers, pastoralists, fishers and forest dwellers, it comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel and medicine. Agrobiodiversity also includes the diversity of non-harvested species that support production (soil microorganisms, predators, pollinators) and those in the wider environment that support agroecosystems (agricultural, pastoral, forest and aquatic) as well as the diversity of the agroecosystems (FAO and PAR 2011).

Common bean (*Phaseolus vulgaris*), Cuba. *Photo: G. Gullotta*

Crops and animals depend on countless organisms above and below ground that interact with each other in a complex web of ecological activities. Ecological processes that result from the interactions among species and between species and the environment provide a continuous flow of essential ecosystem services, including soil fertility maintenance, soil erosion control, pest and disease regulation and pollination.

- Thousands of species of plants and mushrooms have been cultivated or harvested.
- Countless varieties of cultivated species have been developed through adaptation to diverse natural and cultural environments.
- Thirty-eight species of animals and around 8,000 distinct breeds of livestock have been domesticated and bred by pastoralists and other livestock keepers.
- More than 20,000 species of wild bees and many species of butterflies, flies, moths, wasps, beetles, birds, bats and other animals contribute to the pollination of plants, many of which are food to people and animals.
- Millions of organisms, including vertebrate animals, earthworms, nematodes, insects, fungi and bacteria, are found in healthy soil.

Photo: D. Mijatović

Photo: FAO/D. Martins

Photo: G. Gullotta

Photo: G. Gullotta

1.2 THE CONTRIBUTION OF AGROBIODIVERSITY RESEARCH

In recent decades, great advances have been made in describing agrobiodiversity and understanding the cultural and biological forces that sustain and create that diversity. Substantial evidence has been generated on the important contribution of agrobiodiversity to resilience, livelihoods, health, nutrition and ecosystem services. Inspiring collaborative initiatives have emerged that have shown how research can assist or even instigate actions to maintain and increase agrobiodiversity through co-creation and sharing of knowledge.

DESCRIBING DIVERSITY

Assessment of the diversity of local varieties, breeds and wild plants and of their management and uses is a key first step in their improved conservation and use. Converting local knowledge into written documents, drawings, maps or audio and video recordings can help prevent loss of diversity. Documenting the use of wild plants, the diversity and abundance of insect pollinators and the number, distribution and characteristics of local crops, varieties and animal breeds can help local communities to assert, conserve and protect their traditional knowledge. Documentation of local knowledge about diversity can also facilitate the processes of knowledge sharing and transmission from elders to younger generations.

CO-CREATING KNOWLEDGE

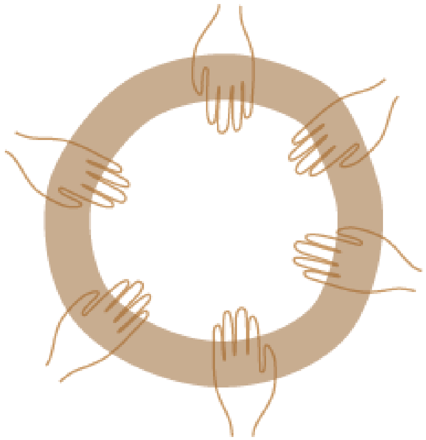
Agrobiodiversity management involves a dynamic interplay between conservation and innovation. Integration of traditional and scientific knowledge helps create strategies that harness agrobiodiversity to improve sustainability, resilience, nutrition, health and livelihoods. Collaborative research can support local processes of innovation without undermining the biological and cultural underpinnings of diversity-rich agricultural and pastoral systems. Participatory disease management strategies (Mulumba et al. 2012), participatory plant breeding (Ceccarelli and Grando 2009) and sustainable grazing plans (LPP and LIFE Network 2010) are examples of strategies combining local and scientific knowledge.

SHARING DIVERSITY

Conservation and innovation in agrobiodiversity depend on continued exchange of knowledge and experiences, seeds and cultivation techniques between generations, and between individuals and communities. In addition to traditional forms of knowledge sharing and transmission, different forms of exchange networks, institutions and activities are important for the conservation of and access to materials and knowledge that otherwise may be lost. Social networks and associations can help enable local communities to engage in collective management practices and strengthen the property rights of individuals or groups, as shown by community seed banks (Vernooy et al. 2017) and diversity fairs (Sthapit et al. 2006).

Different forms of exchange networks, institutions and activities, such as community seed banks and diversity fairs, have emerged as important for the conservation and access to diversity and knowledge that otherwise may be lost.

Community seedbank, India.
Photo: Bioversity International/P. Bordoni



1.3 THE RESEARCH PROCESS

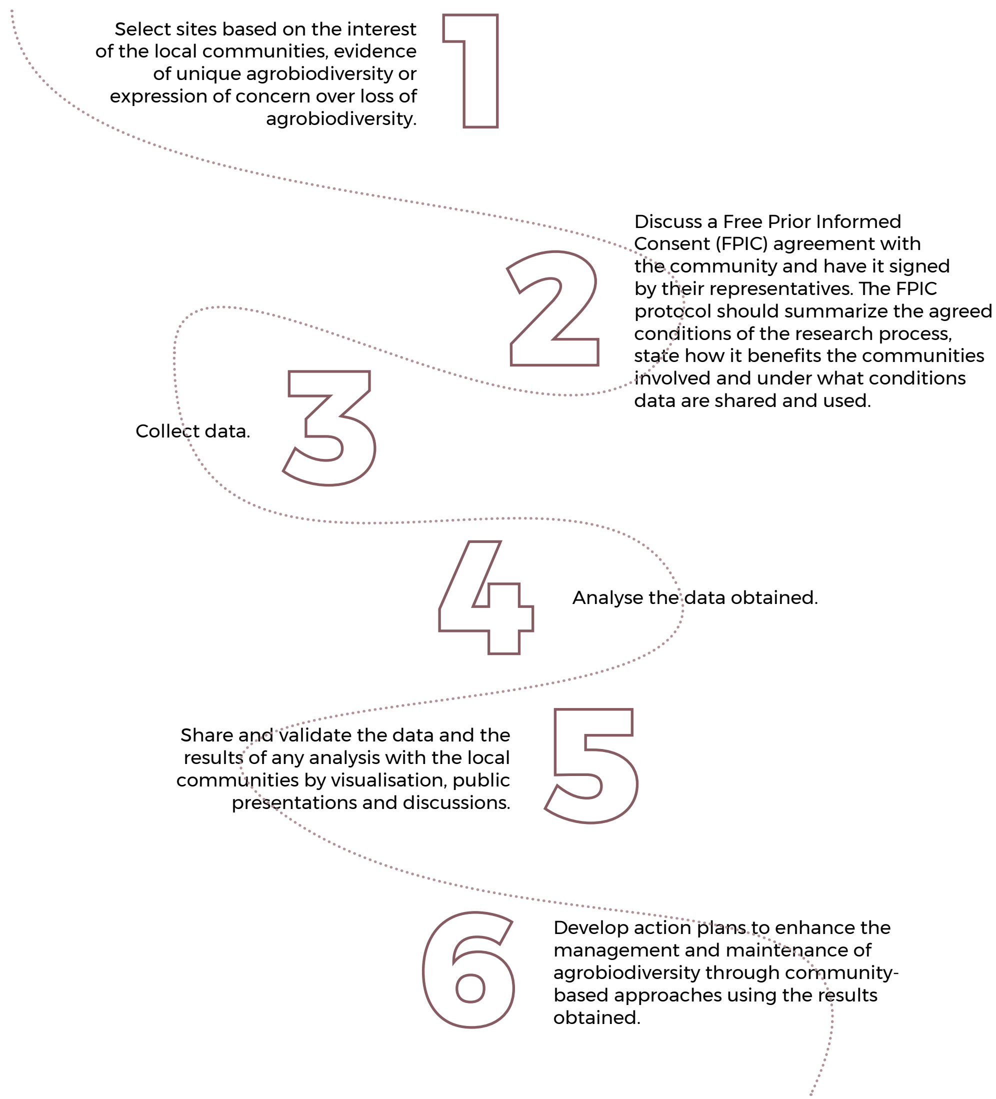
The diversity present in any landscape is the result of interactions between biological, ecological, environmental, social and cultural processes. Because of this, assessing agrobiodiversity and its management requires approaches that transcend single disciplinary perspectives. This is best done using a 'transdisciplinary' approach, which implies using a common language that all participants can understand, building joint visions and discussing choices and challenges. Transdisciplinary approaches include innovative participatory ways of working with local communities and engaging research practitioners from different disciplines, policymakers and other stakeholders.

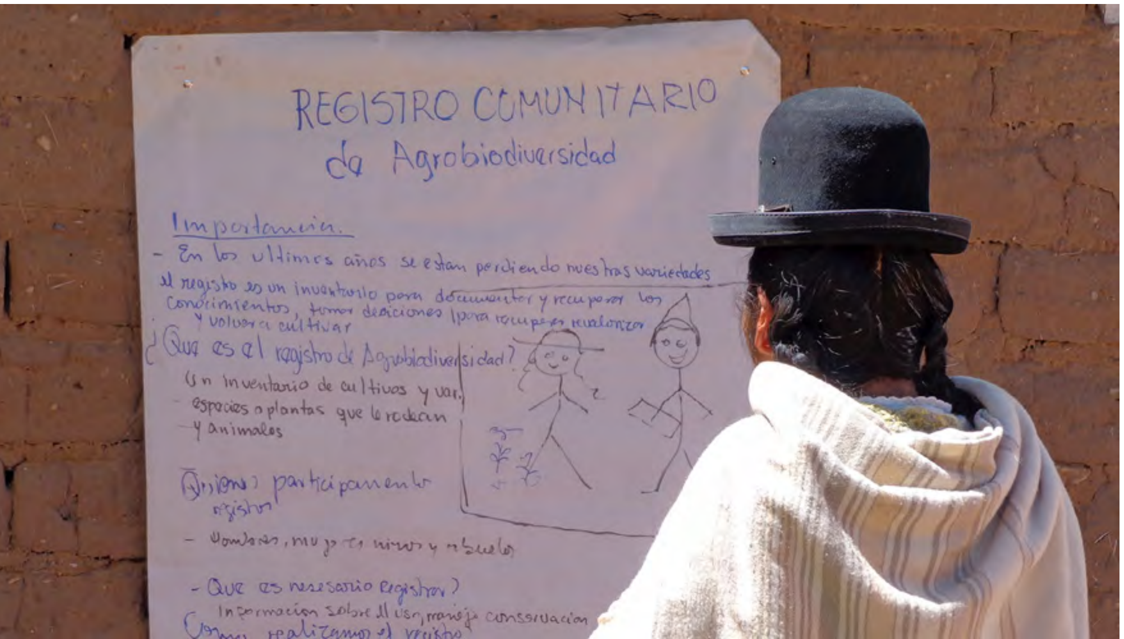
Studies of agrobiodiversity are best achieved through the process of participatory research (Figure 1.1). Participatory approaches focus on local perspectives, seeking to emphasize mutual learning. Participatory agrobiodiversity research requires a collaborative relationship between community members, local organizations and researchers.

Every aspect of the research process should be discussed and agreed with the community in order to develop a common understanding of the methods, the analysis and the purposes of the data collection. This will help avoid unreasonable expectations or extracting information that could go against potential benefits for the community.

The members of local communities where research is taking place play an important role in data collection, analysis, validation and sharing. It is essential that they are given an opportunity to use the research process and results to address their own questions, needs and challenges.

Figure 1.1 Participatory research process





Doña Viviana preparing a presentation on community biodiversity registers, Cachilaya, Bolivia.
Photo: H. Gruberg Cazón

Mlawula community garden, Swaziland. *Photo: S. Beghini*

FURTHER INFORMATION / REFERENCES

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2. OVERVIEW OF DATA COLLECTION

Data gathering with a Lyngngam community, Meghalaya, India.
Photo: D. Mijatović

2. OVERVIEW OF DATA COLLECTION

Agrobiodiversity research uses methods drawn from a range of disciplines (e.g. anthropology, ethnobotany, genetics, botany, biogeography, ecology). It requires approaches that integrate traditional and scientific knowledge and that can take account of different worldviews of diversity and the environment. Data collection procedures include commonly used methods such as household surveys and focus group discussions as well as specifically designed participatory methods such as the 'four cell analysis'. The methods presented here have been widely used to investigate the richness and distribution of species, varieties or breeds and their characteristics (traits), values and uses. Methods to study seed flows, land-use systems and the perceptions of the sources of resilience and ecosystem services are also described.

The choice of methods for data collection and analysis will depend on the specific questions that are being asked. For example, does the research focus on describing diversity (amount and distribution) or is it related to particular aspects of diversity management such as the revival of local seeds? Research questions can reflect the perspectives of specific disciplines (e.g. ethnobotany), or may be concerned with exploring various practical questions, such as how to conserve and increase diversity to improve productivity, resilience, livelihoods, nutrition and health.

The methods described in this Compendium provide information on:

- The amount and distribution of crop and livestock diversity at household and community level and the diversity of useful wild plants and pollinators
- Important characteristics (traits), management and uses of crops, crop varieties, livestock species and breeds and wild plants
- The ways in which seeds and planting materials are exchanged and affect diversity
- Changes in diversity over time
- Community perceptions of the landscape, and the importance of different land uses for the provision of ecosystem services and resilience
- Needs and opportunities for agrobiodiversity conservation and use.

2.1 DIVERSITY OF WHAT?

Agrobiodiversity encompasses both the differences among individual plants or animals, differences among crop varieties, between animal breeds or among wild plant populations, and the assortment of species, ecosystems and land uses. Most of the methods in this Compendium focus on assessing and describing variety, crop, breed or species diversity.

Crop species – plant species cultivated in agriculture or aquaculture. Crops and crop species are often but not always the same. For example, 'wheat' encompasses a number of species, including *Triticum aestivum* (bread wheat), *T. durum* (durum or pasta wheat) and *T. spelta* (spelt). In contrast, the species *Brassica oleracea* contains several crops, including kale, cabbage, cauliflower, broccoli and Brussels sprouts.

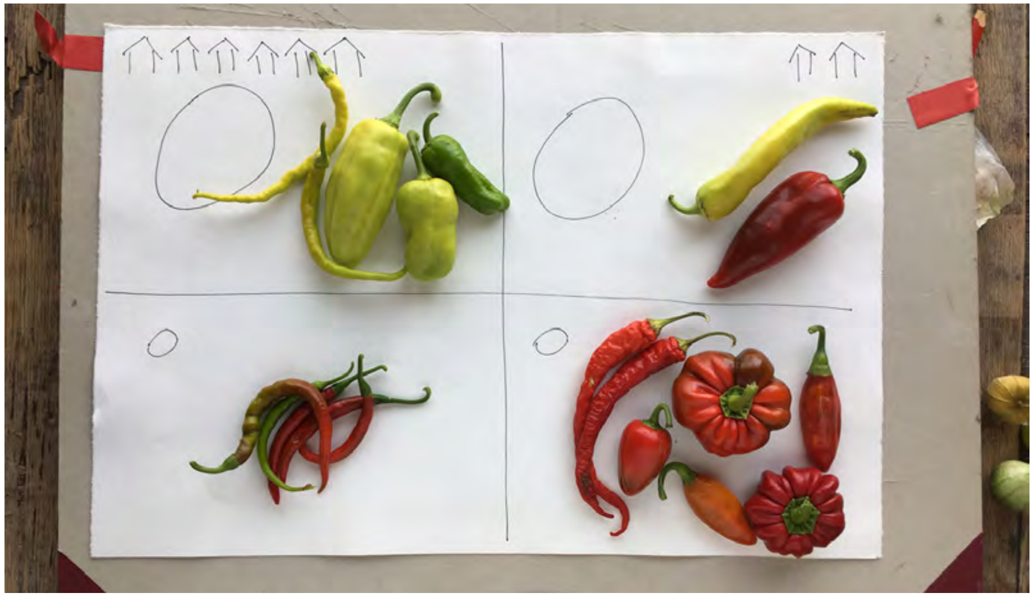
Local or traditional varieties (landraces) – dynamic populations of crops with certain characteristics selected by farmers. They have a distinct identity (phenotype) and are often genetically diverse and locally adapted. Modern varieties developed by plant breeding organizations are usually more uniform than traditional varieties.

Domesticated animal species – cattle, sheep, goat, pig, horse, donkey, buffalo, chicken and duck and some less-common species such as geese, llama, yak, camel and guinea pig.

Local breeds – groups within a domesticated animal species having common ancestors and identifiable external characteristics and appearance, homogeneous behaviour and/or other characteristics. Like local varieties, such breeds have evolved to suit local conditions.

Wild plants – wild species gathered for food, medicine, rituals, dyes, building material, etc.

Pollinators – animals, including insects, vertebrates and mammals, that pollinate plant species.



Demonstration of four cell analysis.
Photo: D. Mijatović

LANDSCAPE PERSPECTIVE

A landscape (or seascape) perspective allows a better understanding of the composition and patterns of agrobiodiversity, its management and uses at the community level.

Different crop varieties are cultivated on different types of soil, along elevation gradients and across different cultural groups. In addition to domestic crops and animals, local communities rely on wild species harvested along the continuum of land-use intensity in pastoral, rotational and other types of system.

Although information about the crop, animal and wild plant diversity is often collected separately, different components of agrobiodiversity depend on each other and should be seen as a part of a wider agroecological system managed by local communities. In such a system, practices for managing diversity, land and water are closely interrelated.

A landscape perspective allows a more complete understanding of the interactions between different components of diversity, e.g. the role of forests and sacred groves in providing food and medicine, maintaining pollinator populations and mitigating the effects of extreme weather events.

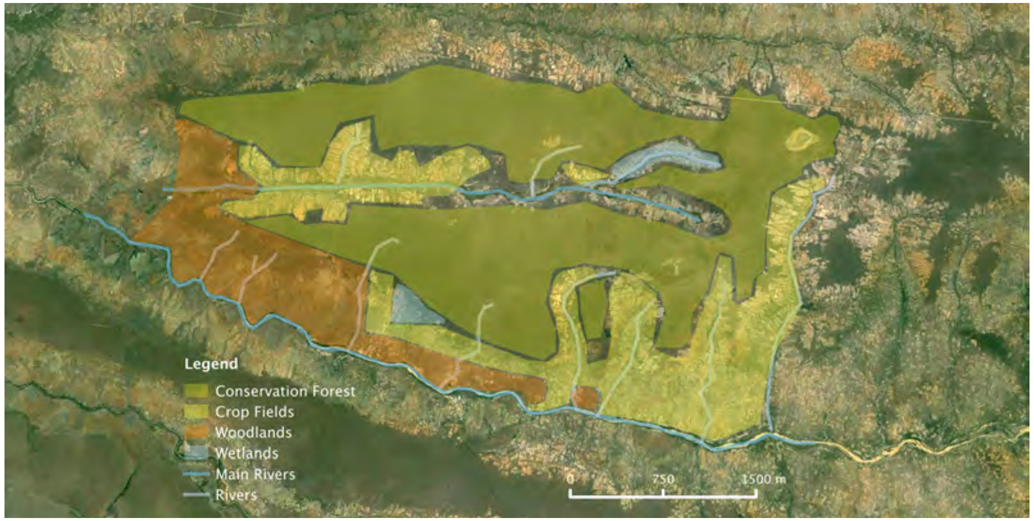


Figure 2.1 Community landscape map, Tshongogwe community, Zimbabwe. Source: Agrobiodiversity, Land and People Project, PAR and SAFIRE.

Sacred grove, Mali. *Photo: D. Mijatović*

2.2 LOCAL KNOWLEDGE

Agrobiodiversity and its management are intrinsically linked to local knowledge and cultural practices. Aspects of local or traditional knowledge that are important for agrobiodiversity research include the following:

Local classification systems (ethnotaxonomies) – Local names and classification systems for crops, animals, forest or pasture flora, soil types and ecosystems reveal important information about diversity and reflect the interactions between people, plants, animals and the environment.

Management practices and systems – Agrobiodiversity is a result of distinct management systems in diverse environments. Practices including seed selection and exchange and the management of animals, soil, water sources, forest and other ecosystems all influence the evolution, richness and conservation of agrobiodiversity.

Uses, values and beliefs – Wild species, crops, varieties, domestic animals and breeds are associated with a diversity of cultural uses, values and practices. Specific varieties, breeds or species may have a special place within traditional worldviews (or cosmovisions) or in local culture for their nutritional, culinary, medicinal or adaptive traits (e.g. adaptation to specific soil). Sacred groves and sacred woods have cultural and ecological importance.

Indigenous fishing practices, Qeshm Island, Iran. *Photo: M. Salimi*

GENDER AND AGROBIODIVERSITY

Agrobiodiversity knowledge and its acquisition are gender-differentiated. Knowledge arises out of experiences and daily acts and hence from gendered roles and responsibilities. Women and men have different roles in agricultural and pastoral production systems and consequently have different specialized knowledge about crops, animals, wild plants and the preparation of food, medicine and various crafts (e.g. weaving, natural dyes). Women have long been known for their specialized knowledge about seeds. The gender differences need to be taken into consideration to avoid gender-related bias in all stages of research.

Exploring local knowledge and preferences for shea (*Vitellaria paradoxa*) varieties, Burkina Faso. *Photo: B. Vinceti*

LOCAL NAMES AND CLASSIFICATION SYSTEMS

Agrobiodiversity research requires a good understanding of local names and classification systems for crops, animals, wild plants, soil, seasons, pests and diseases and other features of diversity and the environment. Local names and classification systems are specific to cultures.

One of the simplest and most-effective ways to understand local categorization is to use a 'freelisting' method. For example, asking interviewees or focus group participants to list all vegetables, fruits or wild food plants can help to understand categorization from a cultural-domain perspective.

Once local and common names have been identified, the next step is to link them with scientific or Latin names, which consists of genus and species (e.g. *Malus domestica* for apple). The identification of species of crops, pollinators and wild plants often requires collaboration with botanists, entomologist and other experts. Specimens or photos can be used to consult the botanists. The photos need to capture specific parts or characteristics of importance for species or varietal identification. For example, for the identification of the species (and variety) of cereals such as wheat, rice and millets, the photos need to show the structure of the spike or panicle and the shape and colour of the seed.

In many cases, the correspondence between local name and scientific name is one to one: one local name corresponds with one scientific name.

However, for certain plants the correspondence may not be one to one, and this results in:

- Overdifferentiation (several local names refer to only one Latin name) or
- Underdifferentiation (one local name refers to several Latin names) (Table 2.1).

One solution is to work with specimens or examples of crops, varieties or wild plants, and to ask the respondents or focus group participants to show or to bring the examples of species and varieties discussed. Photographs taken in advance can be helpful too.

Table 2.1 Correspondence of local names for wild food plants with scientific names (example from the White Carpathians, Czech Republic).

Correspondence Type	Folk Name	Scientific Name
One-to-one	Kokoška	*Capsella bursa-pastoris*
Overdifferentiation	Kašičky, Kozičky, Černý bez, Hural	*Sambucus nigra*
Underdifferentiation	Štovík	*Rumex acetosa* *Rumex acetosella* *Rumex crispus*

LOCAL VARIETY AND BREED NAMES AS MEASURES OF DIVERSITY

In many parts of the world, local varieties and breeds are recognized through local names. They may be named after places of origin, morphological characteristics, phenology or other specific traits. Names of varieties and breeds may change over time or vary from community to community or even from household to household. Individual farmers in a community may call the same variety or breed by different names or different breeds or varieties by the same name. This identity problem may increase when working with different communities where other factors such as differences in pronunciation may complicate identification further. Focus group discussions and four cell analysis are ways of coping with this problem. Further studies using field trials or even molecular genetic methods can shed additional light on the similarities and differences between varieties that farmers recognize.

Local black awned wheat variety, Turkey.
Photo: D. Mijatović

Wild edible fruits, West Sumatra, Indonesia.
Photo: L. Pawera

2.3 DATA-GATHERING METHODS

Agrobiodiversity information is collected using a combination of quantitative (e.g. surveys) and qualitative (e.g. focus group discussions) methods. Field and participant observations, species inventories, field trials, nutritional composition analyses, pest and disease determination, remote sensing and molecular genetic studies are just some of the ways that can be used to obtain additional data. The Compendium describes some common data-gathering methods:

Household survey questionnaire is used to collect information from a sample of households in a community using a structured interview. Information collected includes land uses, management practices, characteristics of crops, varieties and breeds, seed sources and uses of wild plants. The household survey also provides information on demographics, socioeconomic status of households and other aspects to enable differentiation of the sample and analyses of changes over time. Further information is given in Section 5: Household surveys.

Mandailing respondent showing a wild vegetable fern (*Cyathea junghuhniana*), West Sumatra, Indonesia. *Photo: L. Pawera*

Focus group discussions (FGDs) are used to explore topics in more depth and from different perspectives within a community. FGDs are particularly useful to find out about diversity distribution, important characteristics, management practices, constraints and opportunities, and any other topic. FGDs are used to validate data from other sources and to reach a consensus at the community level, e.g. on variety identity and properties. Many methods in the Compendium draw on focus group methodology further described on page 15.

Key informant interviews are in-depth interviews with community members that have specialized knowledge about agrobiodiversity, e.g. medicinal plants, food or seed processing and beekeeping. These are conducted using semi-structured or structured interviews that consist of questions presented to all key informants in the same way. The Compendium gives examples of key informant interviews to collect information on animal diversity, wild plants and other aspects of diversity. Information obtained from key informants is complementary to information from household surveys and FGDs.

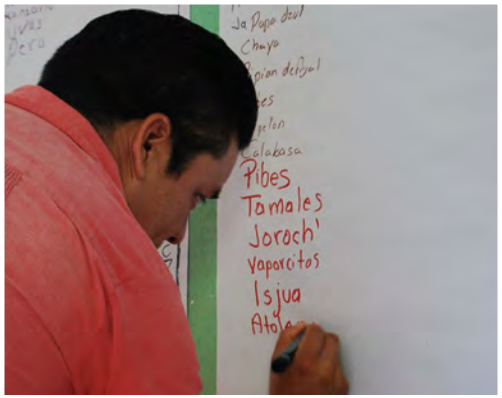
Identifying edible plant species and assessing their conservation status, Benin. *Photo: B. Vinceti*

PARTICIPATORY TECHNIQUES

Household survey questionnaire, FGDs and key informant interviews are the main methods to collect information about agrobiodiversity. There are a number of techniques for systematic collection of agrobiodiversity data that can be applied, modified and combined in surveys, FGDs and key informant interviews. Some of these techniques and methods described in the compendium can be deployed to facilitate empowerment and decision-making in relation to agrobiodiversity and other resources. Participatory data collection techniques can contribute to processes of shared learning, enabling ownership and mobilization of knowledge to address issues faced by local communities (e.g. loss of diversity, climate change and malnutrition).

- **Listing or freelisting** involves creating lists of items with individuals or groups about species or other items (e.g. fruits, animals, wild plants, varieties of a crop). See Section 9: Uses of wild plants for further information on the freelisting process.
- **Ranking, scoring or rating, pile sorting** and similar techniques elicit attributes, similarities and relations among items within a domain (which have been identified through freelisting or some other method). Two examples of ranking are given in Table 2.3 and Table 2.4. Another example is given in Figure 7.1, which shows the results of a scoring of rice varieties for different traits. Ranking, scoring, pile sorting and similar techniques can be applied and adapted in many different research contexts.
- **Diagrams** drawn by survey respondents, FGDs participants or key informants illustrate and explain processes, relationships and structures related to diversity, management practices or social institutions. An example is given in Figure 2.2, see Section 3: Transect walk for examples of transect diagrams.
- **Mapping** describes the location and distribution of resources, land uses and landscape features, their importance and changes over time. Landscape mapping is explained in Section 12, and mapping can be used to explore many other aspects of diversity and its management such as species distribution or migratory routes between dry- and wet-season pastures.
- **Calendars and timelines** show changes in uses, management and availability of diversity over time. While calendars show seasonal changes; timelines illustrate changes over a longer period of time, e.g. occurrence of droughts and floods, pest and disease outbreaks, introduction of commercial crop varieties or animal breeds. Examples of calendars are given in Section 4: Seasonal calendars; and an example of timeline is given in Section 13: Resilience assessment.

A farmer listing foods that have become less common in his community as part of a focus group, Yucatan, Mexico. *Photo: D. Sampson*



Researchers map a home garden with a farmer, Yucatan, Mexico.
Photo: D. Sampson

FGDs about the role played by formal and informal institutions. Men and women conducted the exercise separately and presented their results to the rest of the group and other community members, Burkina Faso.
Photos: B. Vinceti

FOCUS GROUP DISCUSSIONS

Many methods described in this Compendium make use of FGD techniques to explore a specific topic with a group of participants. The information collected in FGDs draws from local knowledge and from experiences, beliefs, perceptions and attitudes of the participants. An FGD is a moderated discussion between participants, and not between the researcher and the participants. FGDs are not only for the researcher or facilitator to get information, but also provide a chance for the participants to exchange information among themselves.

FGDs can be organized around a set of open-ended questions on a specific topic, but other techniques such as scoring, ranking and diagramming can be used to obtain information. During the FGD, the information is recorded on, for example, a large sheet of white paper or on cards. The recorded information is not just for the researcher, but also for the participants.

FGDs require good planning and organization during research design, preparation and data collection. An FGD is conducted by a team consisting of a facilitator and one or more assistants, note-takers or rapporteurs. The facilitator manages the discussion, and needs to create a comfortable environment for all participants. The assistants' role is to document the content of the discussion.

Designing FGDs

- Identify the main aim and the key research objectives
- Make a list of questions (schedule or script) as guidance for the FGD session
- Decide on the number of respondents (usually 4–15)
- Select the participants through purposive or convenience sampling
- Recruit the participants in advance
- Identify a venue for the discussion
- Prepare and organize material
- Organize refreshments for the participants
- Decide if to conduct a mixed or separate gender group according to the local socio-cultural context.

Conducting FGDs

Preparation – Make sure the research team gets familiar with the script, committing the questions to memory as much as possible.

Pre-session – Use the time before the FGD starts to become familiar with the group dynamics and make all participants comfortable.

Session- Introduction – before proceeding with the questions and discussion:

- The facilitator introduces the team and the topic and purpose of the FGD, and thanks the participants and organisers
- The participants introduce themselves (one option is randomized self-introduction instead sequential introductions)
- The facilitator initiates the discussion and proceeds with the script.

Facilitation

A successful FGD depends on a skilled facilitator to guide the group's discussion. The facilitator needs to encourage discussion by creating a warm and comfortable environment. It is essential that the facilitator respects participants' knowledge, experiences, opinions, perceptions and customs. Important facilitator skills include:

- Good speaking and listening skills
- Good observation of participants' body language and group dynamics
- Some knowledge of the topic of discussion
- Flexibility to adapt to the flow of the discussion
- Ability to remain impartial and maintain verbal and non-verbal objectivity
- A sense of humour to keep the discussion relaxed and encourage sharing of information (Nyumba et al. 2018).

Making a seasonal calendar, Mali.
Photo: D. Mijatović

2.4 AGROBIODIVERSITY DATA

During or after interviews and FGDs, the information collected is organized and processed to create data tables that can later be analyzed. For example, Figure 2.1 shows a diagram of seed sources drawn by a farmer during a household survey. Such a diagram can be processed to create a table (Table 2.2). To encode data on seed sources identified by farmers, the code ‘1’ is assigned to those sources from which there is an arrow pointing to the farmer, and the code ‘2’ to those for which the farmer is the source.

Figure 2.1 Diagram of a farmer’s response to questions about seed sources. Source: Jarvis and Campilan (2006)

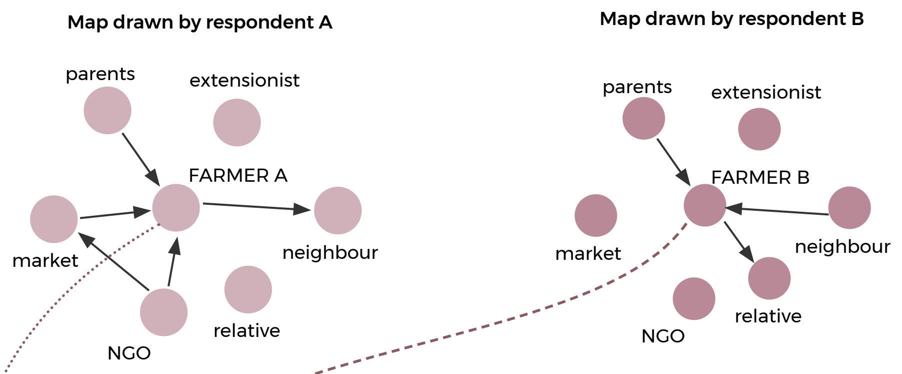


Table 2.2 Tabulated data from the farmer’s response to questions about seed sources from Figure 2.1.

Respondent	Parents	Neighbour	Market	Relative	Extensionist	NGO
A	1	2	1	0	0	1
B	1	1	0	2	0	0
C						
D						

While some of the information collected will be quantitative (How many varieties? What is the size of the field?), much will be semi-quantitative or qualitative (Which variety is better? Why?).

Quantitative data (numbers, also called numerical) are observations that can be counted (discrete data, e.g. trees in a field) or measured (continuous data, e.g. area of land). As such, this type of data should always be associated with a unit of measurement (e.g. number of trees, hectare).

Qualitative data (text) describe characteristics or properties of a subject. Qualitative data are also called categorical as they express a categorical measurement not in terms of numbers, but in terms of words. Qualitative data can be extracted from questionnaires, interview transcripts, FGDs, diagrams and any other participatory data-gathering technique. For many analyses, qualitative data need to be quantified, which involves turning the words into numbers (coding) (e.g. fruit colour: orange = 1, red = 2, purple = 3). Coding requires construction of a category system that allows all of the data to be categorized systematically. After coding, the data can be organized, interpreted and analyzed for frequencies and relationships between variables, means and variance.

Qualitative data can be gathered using techniques that allow easy transformation into quantitative data (freelisting, ranking, rating, pile sorting). Examples of such transformations and their uses include the following:

Characterization:

- Binary – the informant in a survey or focus group is asked to say ‘yes’ or ‘no’ (e.g. Is this variety resistant to a disease?), or to choose between two possible values (e.g. Is this variety resistant or susceptible to a particular disease?)
- Categories – the informant is asked to choose or give a description, e.g. white, red or black for the colour of grains in rice.

Comparative:

- Rating – the informant is asked to rate an item on a numerical scale between two or more alternatives, e.g. yield: low, medium, high
- Ranking – the informant is asked to rank a list of items in order, for example, according to preference or importance. Tables 2.3 and 2.4 provide examples of the results of ranking for traits and functions of fruits.

Belief statements:

- The informant is asked to assess the truth of a statement against a predetermined scale, e.g. this variety is good for feeding to nursing mothers: true, intermediate, false.

Table 2.3 Results of one-dimensional ranking of local fruits for taste. Four informants ranked each fruit on a scale of 1 to 5, in which higher values indicated better taste. After summing the values for the four informants for the different fruits, it appears that banana is considered the tastiest fruit among the informants.

Fruit	Informant 1	Informant 2	Informant 3	Informant 4	Total	Rank
Apple	3	4	5	4	15	4
Orange	3	4	4	3	14	5
Mandarin	4	4	4	4	16	3
Banana	4	5	5	5	19	1
Grape	5	4	4	4	17	2

Table 2.4 Results of multidimensional ranking of local fruits for different domains (taste, food security, income, tradition). One informant scored each fruit for different characteristics on a scale of 1 to 5 and the scores were summed across the domains. Durian had the highest final rank for the domains of interest.

Fruit	Taste	Food security	Income	Tradition	Total	Rank
Durian	4	4	4	4	16	1
Mango	4	3	4	4	15	2
Mangosteen	4	2	3	4	13	4
Banana	4	4	2	4	14	3
Guava	3	2	2	2	9	5

2.5 SAMPLING STRATEGIES

Choosing the participants and sample size are two important first steps in any study. The choice of sampling approach is directly linked to the study objectives. The sample should be able to represent the population that is of interest to the study and be large enough to have sufficient statistical power to answer the research questions.

The sampling strategy should consider both the selection of communities and the selection of participants within communities and households for data collection. In some cases, it is desirable to target specific people ('knowledge holders'). If the focus of the study is a specific region or district, then communities should be selected to ensure a balanced reflection of the different social and environmental conditions in the region. Often, the focus of study is a specific village or set of villages that have been selected based on particular criteria, such as established trust and willingness to engage with the researchers. For impact assessments, the sample should include villages and households that are not participating in any specific interventions to serve as a 'control'.

Young researcher in Lyngngam community, Meghalaya, India. *Photo: D. Mijatović*

The selection of participants should consider the variation of knowledge distribution among different age groups or social groups: certain knowledge can be held only by elders or specialist 'custodians of knowledge'. For example, knowledge about medicinal plants is commonly maintained by herbalists, traditional healers or shamans. It is important to keep in mind that knowledge is often gender-differentiated: women and men have different knowledge, preferences and concerns in relation to diversity. For example, in terms of preference for crop traits, traits important to women include qualities related to preparation and nutrition, while for men, important qualities are more likely to be related to productivity.

There are two main approaches to sampling: probability sampling and non-probability sampling. Probability sampling gives the best chance of obtaining a sample that is truly representative of a population. Non-probability sampling is used in specific cases, such as if the objective of the study is to document as much knowledge as possible in a short time or to document rapidly disappearing traditional knowledge. A summary of sampling strategies is provided below (based on Newing 2011).

PROBABILITY SAMPLING

Simple random sampling – Pick out individual cases (participants) from a sampling frame, using a random numbers table. For example, households can be randomly selected for inclusion in a survey by first preparing a list of households in the community, in consultation with local leaders, and then randomly selecting households from the list. In Microsoft Excel, the function =RANDBETWEEN(1,100) can be used to generate a random number for each household in the list, and then the households assigned the highest numbers can be selected for surveying.

Systematic sampling – Use a random numbers table to pick the first participant or household, and then select additional participants following a constant interval (***n = total population (P) / desired sample size (N)***). E.g. for a total population of 100 individuals or households, if the desired sample size is 20, the interval (n=P/N) will be calculated as n = 100/20 = *5*. If the random number (first participant) is 7, then the second participant is 12 (7+*5*), the third participant is 17 (12+*5*)... until 20 participants or households are selected.

Cluster sampling – Divide the population into 'clusters' (often, geographical areas), take a sample of clusters, and then take a sample of cases from each selected cluster. This approach is particularly useful for a large, dispersed population. To achieve probability sampling, a sampling frame is needed for each cluster that is sampled.

Stratified random sampling – Stratifying the population before applying random sampling methods involves developing criteria for stratification (e.g. socioeconomic subgroups). Divide the population into 'strata' (groups of cases with certain characteristics, such as men and women, rich and poor, large and small landowners), and then take a random sample of cases from each stratum.

NON-PROBABILITY SAMPLING

Convenience sampling – Interview anyone that you can find who fits your broad criteria.

Targeted sampling – Seek out individuals who are most relevant to study. Targeted sampling is used in studies that focus on a particular group (e.g. particular ethnic group, pregnant mothers between the ages of 25-30) or people with specialized knowledge (e.g. traditional healers).

Purposive sampling – (also known as judgmental, selective, or subjective sampling) – Select a sample based on personal judgment of their suitability for the study.

Quota sampling – Define two or more subgroups (e.g. men and women) and set the proportion you want in each category (e.g. 50:50). Interview anyone you can find in each subgroup until you have reached the target sample size.

Snowball sampling – (also known as chain sampling, chain-referral sampling or referral sampling) and respondent-driven sampling – Seek out individuals who are most relevant to the study, interview them and ask if they know of others you could interview or who are linked to them in a specific way (e.g. in studying seed systems). Then interview those individuals suggested by already interviewed respondents.

Sample size is a key consideration in planning your research and different methods may require different sample sizes to give the amount of information needed. The sample size depends on the study design, and the methods for data collection and statistical analysis you are planning to use. In general, a sample size of at least 30 individuals is desirable for crop and variety diversity information from a household survey. Economists, social scientists and others who want to have a more robust dataset tend to use larger sample sizes (50–100 households).

In bigger research projects, sample size should take into consideration the total population size, the magnitude of difference in specific indicators that will be assessed statistically and the resources available (time, people and funds). A good practice is to conduct a power analysis (McDonald 2014) to determine the necessary sample size to detect a significant difference in an indicator of interest.

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3. TRANSECT WALKS

Farmer harvesting semi-wild tuber-bearing plant '*Talas hitam*' (*Xanthosoma sagittifolium*), West Sumatra, Indonesia.
Photo: L. Pawera

3. TRANSECT WALKS

A transect walk is a walk along a defined path (transect) across the study area, together with key informants, to create a diagram that shows a cross-sectional view of the landscape. Transect walks are usually a starting point for other investigations and provide a useful preliminary to most of the other activities in this Compendium. They can also be used after the first exercises of participatory mapping in order to validate the information collected during the mapping exercises and can be used with seasonal calendars, timelines and other methods. During the walk, the following information can be collected:

- Topography and altitude (preferably using a global positioning system [GPS])
- Soil characteristics
- Cropping systems and major crops or crop types (e.g. orchards, arable fields)
- Livestock species and occurrence
- Type of wild vegetation (woods, marshes, shrubs)
- Population (houses, schools, community areas)
- Activities (grazing, foraging for wild edibles).

The discussions during the walk can cover any relevant topic, such as crop or livestock diversity, land management, land ownership, pollution problems, resource limitations and illegal cultivation or logging activities.

The data collected provide an overview of the main crops and animals in the landscape and of the availability of key resources. They provide an idea of the number of households and their location that can be helpful for conducting the household survey. The data collected will help in the formulation of hypotheses to be tested through the other methods described in the Compendium and provide some idea of the major problems faced by the community.

CONDUCTING A TRANSECT WALK

A transect walk is conducted by a facilitator or interviewer, note-taker and key informants.

Participants

The key informants should be knowledgeable about the environment, land uses and different activities in the landscape. Where possible, participants should include women and men and older and younger community members to provide different perspectives on the questions and issues raised.

Choosing a path

The facilitator should ask the local informants to suggest the most suitable path for the transect walk. The path chosen should cover the greatest diversity of the area, and can be drawn on a rough map. If the path is very long, more than one walk will be needed.

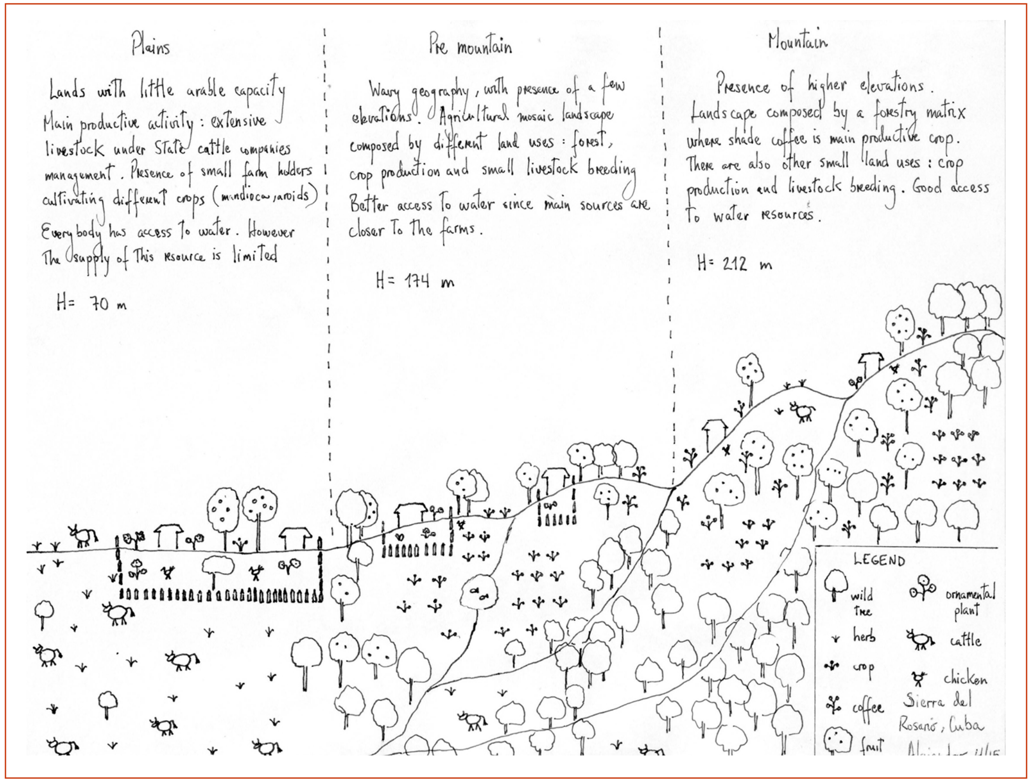

Figure 3.1 Example of a diagram produced from a transect walk in Sierra del Rosario, Cuba. Source: INIFAT, Agrobiodiversity, Land and People Project, PAR.

Process

Before starting the walk, the facilitator asks the informants to name and list all the land uses ('zones') in the area, making clear that the exercise aims to collect information not only on farming systems but also on grazing areas, wild zones and other land uses.

As the walk progresses, the team should stop at every key feature and at the beginning of a new zone (such as residential, topographic, land use, cropping system) and record the distance from the last feature or zone. As an alternative, stop every 50 or 100 paces (or other suitable interval) and take note of whether the land-use pattern has changed.

The facilitator asks participants to describe features encountered along the path and to explain the key characteristics of the areas that they see. The discussion can be facilitated by asking questions about the details and by making observations. The note-taker makes notes of all information gathered and takes photographs or draws sketches.

The key questions that have to be asked when stopping in each zone are:

- What is this zone called?
- What are the main characteristics of this zone?
- What crops or animals are here?
- What activities are carried out in this zone? By whom?
- What is the land ownership – private, collective or state-owned?

After the transect walk has been completed, discuss and check the information and data collected. Where more than one transect walk has been completed, results can be combined and compared. The final results are a diagram (see example in Figure 3.1 and Figure 3.2) and table (see example in Table 3.1).

In the table, the column heads list the different zones encountered, with information on altitude if available. In the left-hand column, list the topics of interest (plants, land use, problems, drainage system and so on) and then fill in the details of what was observed in each zone.

FURTHER INFORMATION

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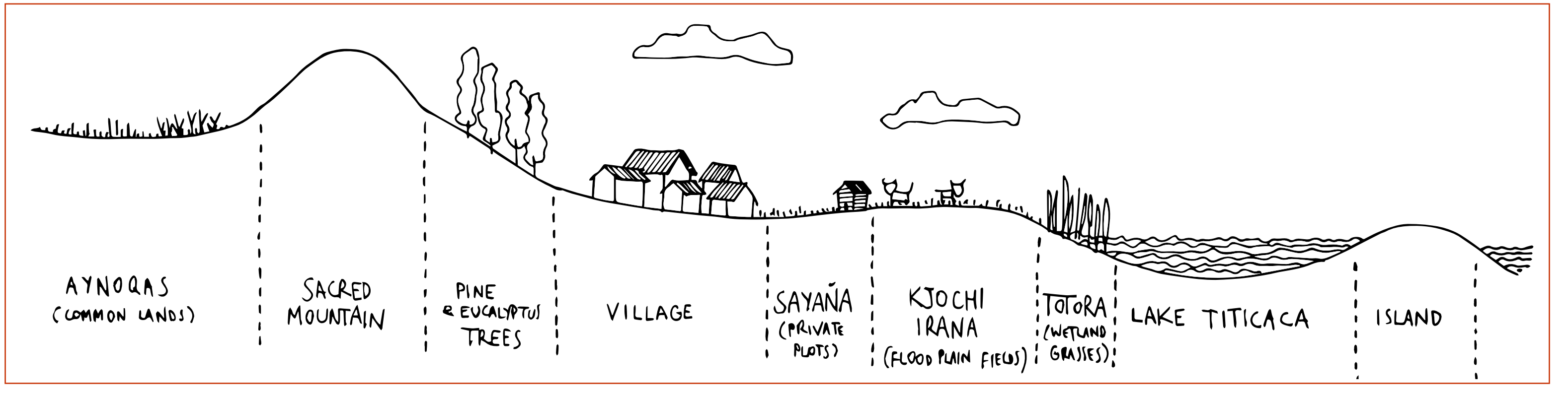
Transect walk in Huay Hin Lad Nai, Thailand.
Photo: D. Mijatović

Table 3.1 Example of a table used to capture information gathered during a transect walk

Zones	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Soil type					
Water availability					
Trees					
Crops					
Vegetation					
Animals					
Management					
Problems					
Opportunities					

Figure 3.2 Diagram produced from a transect walk in Cachilaya, Bolivia. Source: Agrobiodiversity, Land and People Project, PAR. *Illustration: F. Pasta*



4. SEASONAL CALENDARS

FGD facilitator recording participatory ranking and monthly availability of food plants in Minangkabau community, Simpang village, West Sumatra, Indonesia.
Photo: L. Pawera

4. SEASONAL CALENDARS

Seasonal changes have a big influence on the management and use of agrobiodiversity. Any study exploring agrobiodiversity and different aspects of local livelihoods has to take into account how seasonal variations affect agricultural activities, livestock management or the availability and collection of wild plants. This can be done using a seasonal calendar to collect information on:

- Seasons (most often related to rainfall and temperature)
- Activities related to crop production (preparing land, sowing, harvesting, etc.), animal husbandry or collection of wild plants
- Food availability
- Season-specific local knowledge about the environment and agrobiodiversity management, such as environmental and biological indicators
- Other activities and practices, such as collecting honey, seasonal work outside the farm, holidays, festivals and other cultural events.

Seasonal calendars can be created in focus group discussions or workshops with mixed or separate groups for women and men. It is desirable to have a facilitator and a note-taker at these events.

The information collected depends on the aims of the exercise.

The calendar can be drawn on big sheets of paper either as a grid or as a circle. The facilitator and participants draw a grid on a large sheet of paper (Table 4.1). Information can be written directly in the grid or on sticky notes and then attached to the paper.

Creating a calendar may begin with adding the main characteristics of the seasons by asking participants a series of questions, starting with:

- What are the different seasons? When does it rain? (Continue with other questions about temperature regime etc., as necessary)

Then the facilitator asks questions about the main crops and the different agricultural activities people perform during the year and adds them to the calendar. Examples of such questions include the following:

- What is the first activity you perform in the farming year (e.g. preparing the soil; in rotational agriculture, this may be through burning crop residues on the land)? When do you carry out this activity?
- When do you sow seeds of the different crops?
- When do you harvest each crop?

Ask the group to name the different activities that are important and add when they are carried out. In the case of animals, this is likely to include moving to new grazing areas, mating seasons and the main times for offspring production.

Seasonal calendars can also provide important information about food availability, using questions such as:

- In which month do you have the most food available from your own production?
- In which months do you have to buy food from the market?

The facilitator can also ask about the use of wild plants for food and medicine, e.g.:

- When do you gather wild food plants?

The facilitator can also ask about off-farm activities:

- What other activities do you have to carry out (e.g. working in a local processing factory)?

Festivals and other cultural events can also be added to the calendar.

- What festivals do you celebrate during the year? When?

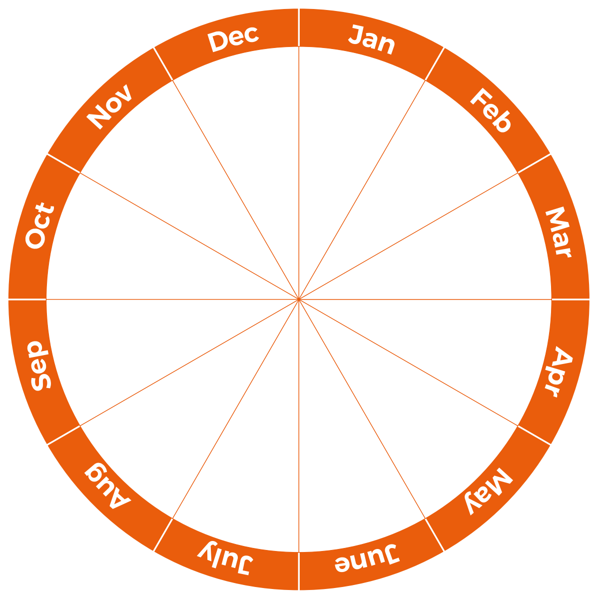


Figure 4.1 Circular seasonal calendar

Table 4.1 A table for seasonal calendar

Months	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Seasons												
Farming activities*												
Food availability												
Wild plant harvesting												
Off farm activities												
Cultural events												

* Activities related to soil, crop or animal management or other activities of importance to the participants. Add rows to capture different timing of activities with major crops and varieties or animal species and their breeds.

FURTHER INFORMATION

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Figure 4.2 Seasonal availability calendar of wild and cultivated leafy vegetables in local language Bamanakan, Ségou region, Mali. Source: Bioversity International and Institut d'Economie Rurale, IFAD-EU NUS Project.

5. HOUSEHOLD SURVEYS

Young men next to purple yam (*Dioscorea alata*) locally known as "*hingurala*", Milleniya, Sri Lanka. *Photo: D. Mijatović*

5. HOUSEHOLD SURVEYS

Household surveys are used to collect information on agrobiodiversity from a sample of households in a community or larger area using a questionnaire. The households sampled are usually from diverse socioeconomic backgrounds and are selected using stratified random sampling (see 'Probability sampling' under Section 2.5: Sampling strategies and sample size).

Annex 5.1 provides an example of an agrobiodiversity survey questionnaire that can be adapted to meet different research objectives. This questionnaire was designed to collect basic information about households, farming systems, the amount of crop and animal diversity, and use of wild plants. Surveys can also provide more detailed information about livelihoods, diets and consumption, climate-change adaptation or any other topic of interest. The objective is to generate data and statistics about diversity and production practices and to identify some of the constraints to, and opportunities for, increasing diversity.

The survey takes the form of a structured interview that involves asking a set of simple short-answer questions. Each question is asked in the same way to each informant and may be open-ended or fixed choice or may ask for some kind of scoring or ranking. While most of the questions will involve a verbal response, diagrams can also be used to obtain information where this is easier for the respondent (e.g. on seed supply in part D). The household questionnaire should be designed to enable the answers to be easily recorded and to allow sound analysis and interpretation of the data. It should be translated into the local language with precise, brief, simple and culturally appropriate wording. Unless otherwise stated, all questions concern the current production season or year, not previous years.

Note: *In many parts of the world there are two cropping seasons per year. During the survey you should ask only about the current cropping season; a second survey may be needed to capture all the information about what is grown in the other cropping season.*

Owita garden, Milleniya, Sri Lanka. *Photo: J. Prasad*

5.1 CONDUCTING THE HOUSEHOLD SURVEY

Inform the community well ahead of time about the planned survey and discuss the best timing with them in detail (e.g. month, week, day, time of day). The research team should test the questionnaire by completing it ahead of time to make sure there are no problems with any of the questions. Make plenty of copies of the questionnaire available in the local language and share them with those who are interested. Jarvis and Campilan (2006) provide general advice on individual interviews for crop diversity. It is best to have two people carry out the survey so that one can continue a conversation with the respondent while the other records the answers. Farmers will be giving up quite a lot of time to help with completing the questionnaire and their concerns and the other demands on their time should be respected.

At the end of each day, check the completed questionnaires to make sure they have been filled in correctly, that there are no major gaps and that different interviewers have used the same approach.

The example questionnaire in Annex 5.1 consists of the following parts:

A – Identification and validation information

B – General information

C – Land-use diversity and practices

D – Crop diversity (species and varietal)

E – Livestock diversity

F – Use of wild plants

Parts A and B should be included in all such questionnaires, while the precise content and inclusion of other sections will depend on the research questions.

A – IDENTIFICATION AND VALIDATION INFORMATION

Record the number of the questionnaire in the field 'Questionnaire ID' to keep track of the number of interviews conducted at each site. Fill in the site name, surveyor identity and survey date. Record the identity of the person who checked the survey and date when the questionnaire was checked.

B – GENERAL INFORMATION

Use this part of the questionnaire to collect the information about the household. This should include the name, gender and age of the informant and some basic information on the household (e.g. number of household members, gender, children and involvement in farm work). This can be expanded to collect additional socioeconomic data where needed.

C – LAND-USE DIVERSITY AND PRACTICES

This part of the questionnaire gathers information on the household's land use and practices. These might include home gardens, irrigated and non-irrigated fields, pasture, agroforestry areas, orchards and fishponds. Other production systems identified during the transect walk (e.g. rotational fields) should also be included. For each land-use type, record 'yes' or 'no' and whether it is privately owned, rented or community owned.

The results can be used to determine the total number of production types available to the community, the most commonly available and used production types and the extent to which different households use the same production types or different ones.

Farmers show sweet potato (*Ipomoea batatas*) tubers grown in their home garden, Yucatan, Mexico.
Photo: D. Sampson

D – CROP DIVERSITY (SPECIES AND VARIETAL)

This part of the questionnaire gathers the information needed to determine the amount and distribution of crop and varietal diversity used by households and communities. It is essential to record the identity of each crop and (where known) variety grown and the areas planted with each crop and each variety. In the case of tree crops, it is often better to ask questions about the number of trees being grown rather than the area they occupy. Questions about the area under production are often quite difficult for informants to answer and it is often necessary to ask follow-up questions that provide good estimates (e.g. Do you grow more than this area here or less? How much more?). In some cases, it may be easier for the farmer to draw an outline map of the land they cultivate and fill in the different fields with their crops and varieties on the map. Answers to the questions in this section can be used to calculate richness, evenness and divergence (see Section 14: Richness, evenness and divergence for crop species and varieties).

Start by asking what crops are cultivated by the informant, making sure that all the different crop types are covered (cereals, tuber and root crops, vegetables, fruit, oilseeds, legumes and pulses).

The questions might be as follows:

- What crops do you grow?

For each crop:

- Do you grow different varieties of the crop?

For each named variety, ask:

- Is the variety local or commercial?
- What is the source of the seed? (see Section 8 for categories of seed sources and further questions)
- What is the area planted of the variety?
- What is the total production?
- What are the most important reasons for choosing this species or variety (e.g. high yield, adapted to local soil, medicinal properties)?

Not all crops will have named varieties and it is often possible to obtain variety-level information for only a few of the major crops. Note also that individual farmers often have their own names for varieties and the four cell analysis process (Section 6: Four cell analysis) will help in developing an agreed list of varieties. Where there is more than one cropping season per year, ask about the current one and remember that different varieties might be grown in the other cropping seasons.

Note on crop classification: *Farmers may have their own classification of crops that differs from the scientific one. For example, in northeast India, people group potatoes, sweet potatoes and taro under one large group. The interviewer should use these local terms during the interview and, wherever possible, take photos or make notes on the different types discussed.*

Note on units of area and production: *Use the same measures for the area under cultivation and for production for all informants. Use local measures of areas and production during the interviews and then convert these to international units when transferring the data.*

Additional questions: Past status of crop and varietal diversity

To understand changes in cultivation and production, ask about the crops and varieties grown in previous years. Ask the same questions as for crop and varietal diversity but in past tense.

- What crops and varieties did you grow last year?
- What was the area under cultivation?
- What was the total production?

E – LIVESTOCK DIVERSITY

This part of the questionnaire gathers information on the number of households that keep animals, what these are and how many breeds of each there are in the community and households. Section 10: Diversity of domesticated animals and breeds provides ways of obtaining more information on the importance of animal diversity in a community.

Ask the following questions:

- What animal species do you keep?

For each species, ask:

- How many different breeds do you have?

For each breed, ask:

- What do you use this breed for (e.g. eggs, milk, meat, leather, manure, etc.)?
- How many females and males are of reproductive age?
- Is the number of female animals stable, increasing or decreasing?
- Is the number of male animals stable, increasing or decreasing?

Determining the identity of breeds is often quite difficult. Informants may not make much distinction between different breeds and just regard their animals as local or exotic.

Knowing the numbers of female and male animals in a population allows one to calculate the effective population size at household and community levels.

F – USE OF WILD PLANTS

This part of the questionnaire gathers information on the use of non-cultivated plants, asking informants which wild plants they use and for what purpose. Ask the informant:

- Which wild plants do you use?

After they have listed the plants they use, ask each of the following questions about each plant:

- Where do you gather it (e.g. near the river, in the forest, in fallow land, other)?
- What do you use them for (food, medicine, fodder, firewood, building material, other)?
- What part(s) of the plant do you use (leaves, roots, shoots, bark, flowers, fruits, seeds)?

Note: *List options for responses in the questionnaire to facilitate consistent recording.*

Where possible, take photographs of wild plants that respondents identify as useful, these can help confirm the identity of the different plant species and check that the same local names are used by all informants.

The data provide information on the general use of wild plants by a community. Combine these data with the information on wild plants obtained through the key informant interviews to complete the identification and analysis of information on the use of wild plants (see Section 9: Uses of wild plants).

Man holding African black plum (*Vitex doniana*), Boumboro village, Mali.
Photo: D. Mijatović

5.2 DATA ANALYSIS

Transfer the information on the individual record sheets to an electronic version, preferably an Excel spreadsheet, as soon as possible. The way in which the data are organized is important and will affect how they can be analyzed (see Section 15: Data organization and analysis). Some helpful guidance can be found in Jarvis and Campilan (2006), Broman and Woo (2017) and Ellis and Leek (2017).

Where diagrams have been used to answer questions, you will need to have developed agreed ways of converting the information to data sheets (see Section 2.4: Agrobiodiversity data).

The data provide an overview of agrobiodiversity in a community. The data can be used to explore the extent and distribution of agrobiodiversity as follows:

C – number of land uses and access to production options

D – richness and evenness of crop and variety diversity (Section 14)

E – richness and effective population size of animal species and breeds (Section 10)

F – richness of wild species and their uses (Section 9).

The data can also be combined for further analysis of relationships between different components of diversity and between diversity and household or land-use features using, for example, multiple regression and multiple factorial analysis. An example of this would be the relation between animal diversity (richness and effective population size) and household numbers or respondents sex. See Section 15 for further suggestions.

MARKET SURVEYS

Surveys can also be conducted in local food markets. Such surveys can help explore local food diversity as well as market systems including supply and value-chains. Every individual household is likely to consume a mix of foods grown by themselves, gathered from the wild and procured from markets. Visiting a few local markets (main as well as small farmers' markets) can help understand plant and animal resources such as foods consumed in an area and import/export movements of the key food items and groups.

During market visits one can record what is sold, sources of food items, price per unit, etc. These are not only observations, but data are collected through interviews and conversations. An informal market visit is recommended before carrying out a formal survey.

Market visits and surveys provide a quick overview of foods in each season and give an understanding of how important each food is. Information to record includes:

- Names of food items sold
- Food groups
- Price per unit
- Sources
- Type of sellers (see Annex 5.2).

Recording each food item by taking photos is an effective way of clarifying the information with key local informants after the market visit. Regular observations and measures will capture the patterns in seasonal availability of food diversity.

FURTHER INFORMATION / REFERENCES

Broman KW, Woo KH (2017) Data organization in spreadsheets. *The American Statistician* 72(1):2–10.

Ellis SE, Leek JT (2017) How to share data for collaboration. *PeerJ Preprints* 5:e3139v5

Jarvis DI, Campilan DM (2006) Crop genetic diversity to reduce pests and diseases on-farm: Participatory diagnosis guidelines. Version I. Bioversity Technical Bulletin No. 12. Bioversity International, Rome, Italy.

Maundu P, Bosibori E, Kibet S, Morimoto Y et al. (2013) *Safeguarding Intangible Cultural Heritage: a practical guide to documenting traditional foodways. Using lessons from the Isukha and Pokot communities of Kenya* (UNESCO).

Newing H (2011) *Conducting Research in Conservation: Social Science Methods and Practice* (Routledge, Abingdon, UK).

Another way of collecting information about diversity from households is through the documentation of local 'foodways' (Maundu et al. 2013). In this method, local community members are invited to document their foodways in order to capture food diversity within local food systems over the seasons, and also the cultural aspects of food: its uses and symbolic meanings and its relationship to health and nutrition.

Foodways include the knowledge, practices, beliefs and other cultural aspects related to how a community acquires, stores, prepares and uses its food. They also include describing gender aspects and seasonal dynamics. Documenting foodways provides an understanding of how people acquire food (e.g. market, cultivation, hunting, gathering), how it is prepared and processed, who prepares it, what tools are used, when it is prepared, and who eats it.

Foodway documentation in Gumuz region, Ethiopia. *Photo: Bioversity International / Y. Morimoto*

ANNEX 5.1 A SAMPLE HOUSEHOLD SURVEY QUESTIONNAIRE

SECTION A: IDENTIFICATION AND VALIDATION INFORMATION

Questionnaire ID:____
Site name:____
Survey conducted by: ___________________________________
Survey date:____
Survey checker: _____________________________________
Data of check: ______________________________________

SECTION B: GENERAL INFORMATION

1. Village name:
2. Respondent's name(s):
3. Respondent's sex: Male/Female
4. Age (in years):
5. Number of family members:

   Male_____ Female_____ Children, under 15 years_____
6. Number of family members involved in farm work:

   Male_____ Female_____ Children, under 15 years_____

SECTION C: LAND-USE DIVERSITY AND PRACTICES

7. Land use type *(add extra rows as necessary)*

Homegarden (Yes / No)	*Pasture*	*Agro-forestry*	*Fruit orchard*	*Fishpond*	*Irrigated fields*	*Non-irrigated fields*	*Are the fields in different parts of the landscape?*	*Which wild areas are used (forest, wetland, meadows, fishing grounds) and for which purposes?*

SECTION D: CROP DIVERSITY INFORMATION (SPECIES AND VARIETAL)

8. What cereal crops do you grow? *(add extra rows as necessary)*

Species	*Variety name*	*Local or commercial*	*Source of seed**	*Area planted*	*Unit for area*	*Total production*	*Unit for production*	*Reasons for choosing this variety?**List all that apply*

9. What root/tuber crops do you grow? (add extra rows as necessary)

Species	*Variety name*	*Local or commercial*	*Source of seed**	*Area planted*	*Unit for area*	*Total production*	*Unit for production*	*Reasons for choosing this variety?**List all that apply*

10. What vegetables do you grow? *(add extra rows as necessary)*

Species	*Variety name*	*Local or commercial*	*Source of seed**	*Area planted*	*Unit for area*	*Total production*	*Unit for production*	*Reasons for choosing this variety?**List all that apply*

11. What fruit do you grow? *(add extra rows as necessary)*

Species	*Variety name*	*Local or commercial*	*Source of seed**	*Area planted*	*Unit for area*	*Total production*	*Unit for production*	*Reasons for choosing this variety?**List all that apply*

12. What oilseed crops do you grow? *(add extra rows as necessary)*

Species	*Variety name*	*Local or commercial*	*Source of seed**	*Area planted*	*Unit for area*	*Total production*	*Unit for production*	*Reasons for choosing this variety?**List all that apply*

13. What legumes and pulses do you grow? *(add extra rows as necessary)*

Species	*Variety name*	*Local or commercial*	*Source of seed**	*Area planted*	*Unit for area*	*Total production*	*Unit for production*	*Reasons for choosing this variety?**List all that apply*

14. What other crops do you grow? *(add extra rows as necessary)*

Species	*Variety name*	*Local or commercial*	*Source of seed**	*Area planted*	*Unit for area*	*Total production*	*Unit for production*	*Reasons for choosing this variety?**List all that apply*

*Source of seed: Maintained by yourself; obtained from a relative or neighbour in same community; obtained from a relative or contact from another community; obtained from market / commercial seed seller; obtained from extension service or government agency; obtained from NGO or from a seed fair
**Reasons: High yield (Y), adapted to local soil (S), medicinal properties (M), cooking properties (C), drought-tolerance (D), etc.

E – LIVESTOCK DIVERSITY

15. What type of livestock do you keep? *(add extra rows as necessary)*

Species	*Breed name*	*Uses: milk (1), meat (2), manure (3), and other specify*	*Number of females of reproductive age*	*Number of males of reproductive age*	*Is the number of female animals stable, increasing or decreasing?*	*Is the number of male animals stable, increasing or decreasing?*

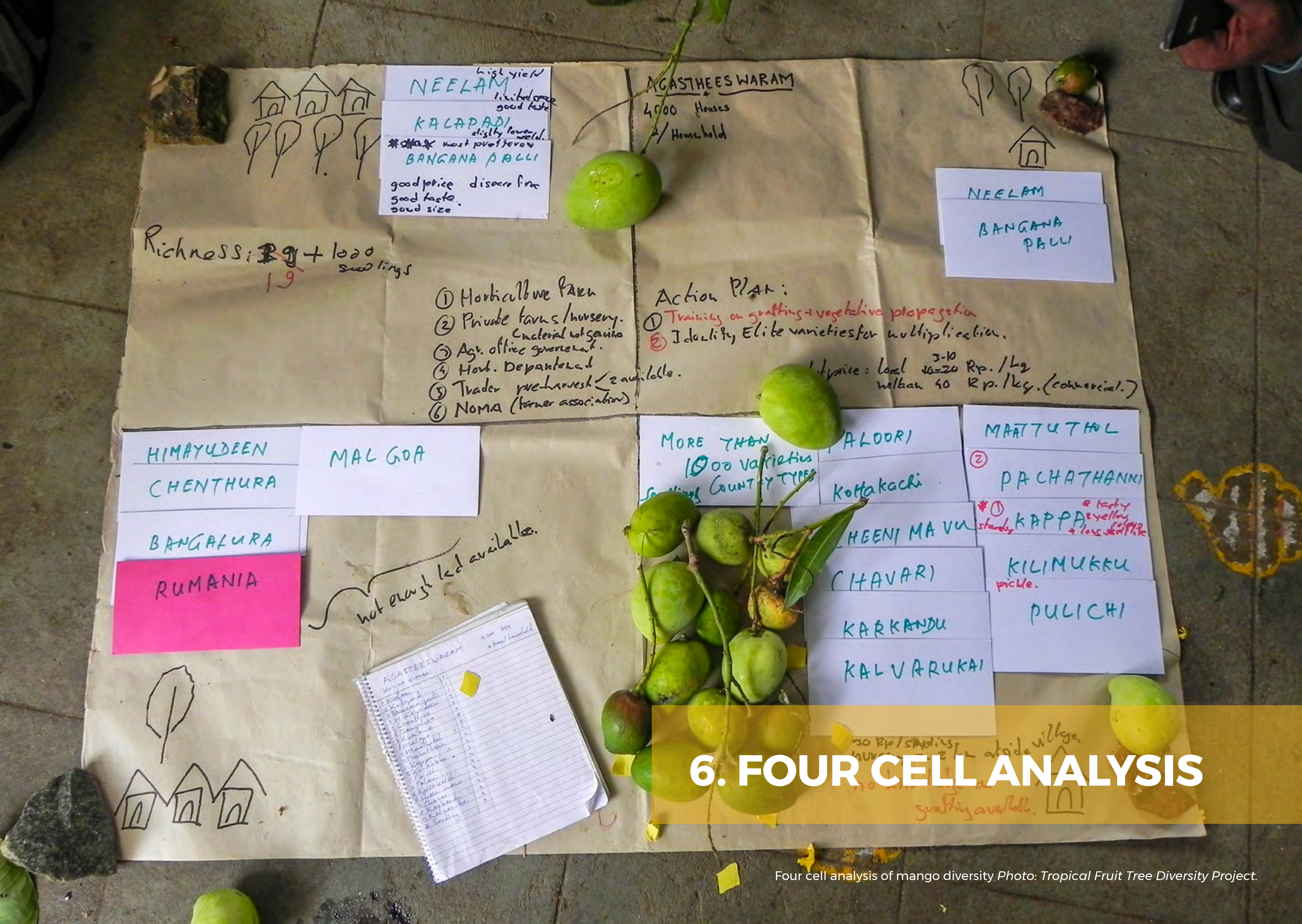
F – USE OF WILD PLANTS

16. What wild plants do you use? *(add extra rows as necessary)*

Species (local name)	*Habitat (forest, meadow, near water)*	*Main uses (food, medicine, fodder, firewood, building materials)*	*Part(s) used (leaves, roots, shoots, bark, flowers, fruits, seeds)*

ANNEX 5.2 A SAMPLE MARKET SURVEY QUESTIONNAIRE

Name of food item (species variety/breed)	*Food groups(grains, vegetables, fruits, meat/poultry/seafood, dairy, beans, eggs, nuts, processed foods)*	*Cost/Unit*	*Source within or outside of the community*	*Type of vendor (whole sale, small retailer, permanent vendor)*	*Gender of the vendor (M or F)*	*Photo number*



6. FOUR CELL ANALYSIS

Four cell analysis of mango diversity *Photo: Tropical Fruit Tree Diversity Project.*

6. FOUR CELL ANALYSIS

Four cell analysis (FCA) is a method for assessing the abundance and distribution of crop and varietal diversity in a community or landscape. It is used to gather information about species and varietal diversity of crops or trees on farms and in home gardens or orchards. FCA is based on focus group discussions with community members. The groups can be mixed or separated by gender or age or according to other criteria of interest. When repeated over time, the analysis can give an insight into changes in diversity in a specific area and can be used to explore the reasons for any change from the perspective of the farmer. With suitable modifications, the FCA could probably be used also for animals or other components of agrobiodiversity.

FCA provides a way of assessing:

- The amount and distribution of diversity of local crop or of varieties within a crop
- Which crops or varieties are common, unique, rare or endangered
- The characteristics (traits) of crops or varieties that provide reasons for the observed distribution
- Other factors encouraging or discouraging farmers to grow a certain crop or variety.

While FCA can be used for both crops and for varieties of specific crops, these should be done in separate exercises. Where varieties are the focus of interest, only one crop should be discussed at one time.

During the focus group discussion, the participants develop a description of the importance or frequency of the crop or variety by initially by stating how many farmers grow it. They then state whether a crop or variety is grown on large areas (or, in the case of trees, in large numbers, if this is more appropriate) or whether it is grown on small areas. This creates the four cells of the analysis (Figure 6.1).

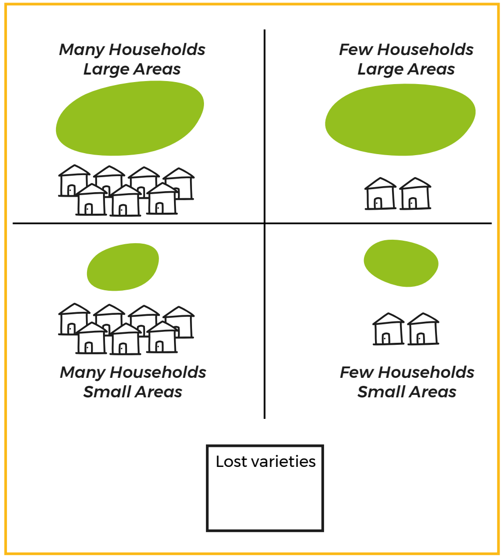


Figure 6.1 The four cell analysis approach to assessing crop or varietal diversity

During the focus group discussion, a fifth cell is often added that lists lost crops or lost varieties of a specific crop. This allows the group to identify crops or varieties that used to be grown in the area but that for some reason are no longer grown. The group can discuss whether these could or should be reintroduced.

Note: *Experience shows that when conducting an FCA it is best to first draw one axis (many households/few households) and obtain the results for this before proceeding to the second axis (large area/small area).*

The cut-off point between many and few households or between large and small areas is based upon the judgement of the participants in the focus group discussion. As each crop or variety is discussed and placed in a particular cell, there should be some additional discussion as to why it is put there. This discussion will identify the particular traits that it has and consider any other reasons that may affect how widely it is grown (e.g. seed availability, marketability, labour requirements).

FCAs may appear to provide similar information to the crop and variety section of the household survey (Section 5: Household surveys) but there are important differences. These include the following:

- The FCA is a participatory exercise that develops a consensus on how the group sees a crop or variety. It does not provide an accurate measure of richness or evenness as done by the household survey, but only a general idea. However, an FCA with knowledgeable participants can unearth information about rare and lost varieties that may not be discovered through household surveys.
- The FCA allows the group to reach a consensus on the identity of particular varieties. This helps solve one of the problems of the household survey – the relationship between variety names used by informants and their actual identity.
- The FCA allows for a discussion of the reasons why a particular crop or variety has the distribution that it does.
- The results of an FCA may be influenced by a few dominant participants in the focus group discussion. In contrast, the household survey allows individuals to provide information uninfluenced by the views of others, or to share information that they might not share in a public discussion.

6.1 CONDUCTING A FOUR CELL ANALYSIS

The FCA is conducted by a facilitator and a note-taker together with a mixed group of farmers.

Participants: Invite 10–15 participants of different genders, ages and diverse socioeconomic strata. Alternatively, conduct the exercise with separate female and male groups.

Materials: Drawing the four cell chart requires large sheets of paper, marker pens of different colours, stick-on papers (sticky notes) or cards of different colours. Alternatively, the analysis can be carried out by marking out the axes of the cells on the ground and placing the crops, varieties or symbols representing them in the different cells as the discussion continues.

Ask participants to bring specimens of the different crops or varieties to the venue where the exercise is to be conducted, or organize a walk through the field sites where target crops or varieties are found before the focus group meeting. During the walk, specimens can be collected and placed in the different cells during the exercise.

Note: *Before starting this exercise, the participants in the focus group must decide what is meant by the categories 'many households', 'few households', 'large area' and 'small area.' Generally, the category 'few households' is likely to mean fewer than 10% of the households in an area.*

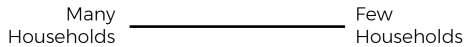
Four cell analysis of potato varieties grown in Coromata Media, the Lake Titicaca region, Bolivia.
Photo: PROINPA and Bioversity International, IFAD-NUS Project

Step 1: Make a list of crops or varieties

Ask participants about all the different crops or varieties and write each name on a different card or sticky note.

Step 2: Draw the first axis (many households/few households)

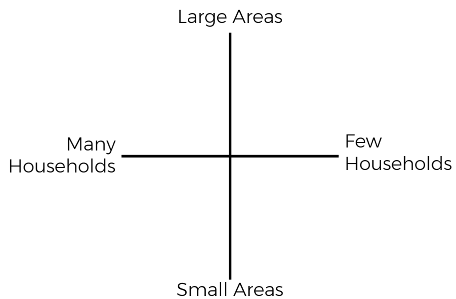
First, draw the vertical axis separating 'many households' from 'few households'. Do not draw both axes in the beginning – this is important because drawing both axes at the beginning leads to confusion and poor information gathering.



For each card or specimen representing a crop or variety, ask the participants on which side of the axis the crop or variety should be placed, i.e. grown by many households or grown by few households.

Step 3: Draw the second axis (small area/large area)

Draw the horizontal axis separating 'small area' from 'large area' and ask the participants into which cell each crop or variety falls. For each crop or variety, give the participants plenty of time to discuss before they make a final decision.



Step 4: Ask about lost varieties

After all the crops or varieties have been placed into one of the cells, ask participants to name those varieties that are no longer cultivated in the community, and place these varieties into a separate cell (See Figure 6.1).

Step 5: Collect descriptors of each crop or variety

For each crop or variety, ask the participants what its main distinguishing traits are and what they like and dislike about it. Ask:

- Why is this crop/variety in this cell and not another one?
- What are the characteristics of this crop/variety?
- What do you like about this crop/variety? What is special about it?
- What do you dislike about this crop/variety?

Some of this discussion will probably be part of Steps 1 and 2 when the crops or varieties are first listed and their distinguishing characteristic described.

Step 6: Discussion

Discuss with participants how they feel about crops being placed in their respective cells and if they would like to undertake measures to increase the cultivation of rare varieties or crops. This can give important information about existing conservation efforts and the reasons for changes in diversity patterns within a community.

Figure 6.2 Results of four cell analysis conducted in Coromata Media community, Bolivia. Source: PROINPA and Bioversity International, IFAD-NUS Project.

Many Households - Large Areas

2 varieties:
Huayacha, Wila Imilla

Few Households - Large Areas

4 varieties:
Chiji Pala, Janqu Pala, Pala Morado, Wila Pala

Many Households - Small Areas

9 varieties:
Ayawiri, Chiyara Surimana, Chiyara Imilla, Chiri Luki, Janqu Chuquipitu, Cuchi Callu, Muruku, Pitikilla Rojo, Piñu Blanco

Few Households - Small Areas

62 varieties:
Amajayu, Camara, Chiji Pala/Chixi, Chiji Pitikilla/Chixi, Chiji Yurima, Chinito, Chiyara Isla, Chiyara Surimana Largo, Chiyara Taraco, Choclito, Chuquipitu Nairan Morado, Condor Piqui, Cuchi Jipilla, Garri Blanco, Garri Rojo, Holandes, Sapallu, Holandesa, Huancu Callu, Janqu, Janqu Ajahuiri, Janqu Imilla, Janqu Pala, Janqu Piticalla, Janqu Polo, Janqu Sicha, Janqu Yurima, Kaisalla, Kaka Surimana, Kalla Pitikilla, Kealla, Koyu/Q óyu, Leke Cayu, Loka, Luki Taraco, Manzana Imilla, Morado Chuqipitu, Morado Kaisalla, Pala Morado, Pepino, Peruanito, Pureja Blanco, Queta, Sacampaya/Zaqampaya, Sacampaya Negro, Saitu Luki, Sani Imilla, Sapallu, Tonko Puya, Tonko Puya Blanco, Wila Koyu, Wila Nairan Peruano, Wila pala, Wila Piñu/Phinu, Wila Surimana, Wila Taraco, Wila Wislla, Wislla Paqui, Wislla Wislla, Yurima

Lost varieties
Papa Milagro
Papa Criolla
Morado Kullo

6.2 DATA ANALYSIS

Once transcribed, the data can be tabulated to provide an estimate of the numbers of varieties in each category, as, for example, in Figure 6.2. This shows the distribution of potato varieties grown by the Coromata Media community in Bolivian Altiplano. The relatively large number of varieties grown by a few families in small areas is a common finding, especially where the overall number of varieties of a crop is high.

Information from a group of villages can be combined to explore particular questions such as the local availability of alternative sources of seed of varieties that have been lost in some villages, as in the example for different millet crops in the Kolli Hills of India (Table 6.2). Here, the little millet variety '*Malliyasamai*' has been lost in all villages except *Puliyampatti*, which still grows a large area, while the foxtail millet '*Koranthinai*' is threatened throughout the area. A number of varieties are found only in small areas grown by a few households and might therefore be considered threatened.

Mandailing women assessing diversity and extent of collecting wild vegetables in four cell analysis, Sontang village, West Sumatra, Indonesia.
Photo: L. Pawera

Table 6.2 Distributions of local varieties of minor millets in villages surveyed in Kolli Hills, India. Source: M.S. Swaminathan Research Foundation and Bioversity International, IFAD-NUS Project.

MH=Many households

LA=Large area

FH=Few households

SA=Small area

VARIETY	VILLAGE					
	Padasolai	Sempoothu valavu	Thirupuli Oorpuram	Puliyampatti	Thuvarapallam	Valukulipatti
Kodo Millet *(Paspalum scrobiculatum)*						
Illangkelvaragu	MH/LA	MH/LA	FH/SA	-	MH/LA	-
Panivaragu	-	-	-	-	-	FH/SA
Perunkelvaragu	FH/SA	MH/LA	MH/LA	FH/LA	Lost	-
Sattaikelvaragu	-	-	Lost	FH/LA	-	FH/SA
Thirivaragu	-	-	-	-	-	Lost
Little Millet *(Panicum sumatrense)*						
Karumsamai	-	-	-	-	-	Lost
Kattavettisamai	-	-	Lost	Lost	-	FH/LA
Malliyasamai	Lost	Lost	Lost	MH/LA	Lost	FH/SA
Perumsamai	FH/SA	MH/LA	Lost	-	-	FH/SA
Sadanjsamai	MH/LA	FH/SA	-	-	-	Lost
Foxtail Millet *(Setaria italica)*						
Koranthinai	-	-	-	FH/SA	FH/SA	-
Mookanthinai	-	-	-	-	-	Lost
Palanthinai	FH/SA	FH / LA	FH/SA	-	-	Lost
Senthinai	-	-	-	-	MH/LA	Lost

Foxtail millet, Nepal.
Photo: LI-BIRD/E. Palikhey

7. CHARACTERIZING CROPS AND CROP VARIETIES

Rice varieties in a Karen community, San Din Daeng, Thailand.
Photo: D. Mijatović

7. CHARACTERIZING CROPS AND CROP VARIETIES

Crops and their varieties differ in appearance, taste and fragrance, tolerance to pests or resistance to diseases, adaptation to soil type, time of seeding, date of maturity, height and other properties – these make up their characteristics or traits. Each crop species and variety has some unique traits, uses and values for farmers, and these are sometimes reflected in their local names. One of the best ways of describing and exploring these traits and uses is through a focus group discussion. This can be carried out as part of a four cell analysis (Section 6: Four cell analysis) or may be done separately.

Collecting information about local names, uses and traits of crops and crop varieties is important to gaining an understanding of their agroecological, cultural, nutritional, economic and other values and functions. Assessments of traits in a crop or varietal portfolio can also help identify which important traits are missing and could be (re)introduced. For example, if all varieties of a crop are vulnerable to drought, there may be a need to (re)introduce or improve access to varieties that are drought tolerant.

Common categories for uses of crops and their varieties are food, fodder, material for building or other specific uses such as dyes, cultural use in specific ceremonies or festivals, and medicinal. There are also important agroecological uses such as green manure, erosion control, windbreak, firebreak and shade.

Characteristics or traits of crops and varieties vary depending on the crop – traits of importance for a rice variety are not the same as those that are important for a fruit or vegetable variety. Examples of crop and variety traits:

- **Morphological:** colour, size, height
- **Agronomic:** maturation time/earliness, competitiveness with weeds, yield
- **Quality:** storability, processability, market value
- **Resistance to or tolerance of biotic and abiotic stress:** pest tolerance, disease resistance, tolerance of drought or waterlogging, adaptation to poor soil
- **Use related traits:** flavour, nutritional qualities, smell

This list is not exhaustive; rather it is a guide of the kind of traits that are likely to be important to farmers that can be raised in a focus group discussion.

CONDUCTING A FOCUS GROUP DISCUSSION ON CHARACTERISTICS OF CROP VARIETIES

The aims of a focus group discussion (FGD) on characterizing crops and their varieties are to:

- Create an overview of the level of diversity of crops or varieties of major crops
- Describe the characteristics of local varieties, including size, colours and yield
- Characterize local varieties in terms of uses, values and traits
- Identify the positive and negative traits of particular crops or varieties.

In addition to these aims, other questions can be discussed and more data can be collected, depending on research questions.

The FGD is conducted with a facilitator, a note-taker and a mixed group of farmers (see 'Focus group discussions' under Section 2.3: Data-gathering methods).

Participants: Invite 10–15 people of different genders, ages and socioeconomic strata to participate. Alternatively, conduct the exercise with separate female and male groups. Women and men are known to have different preferences for crop traits. For example, women are often more interested in the cooking and processing properties of crops and varieties than men.

Materials: Recording the information gathered requires a large sheet of paper (chart paper or brown paper), marker pens of different colours, and stick-on papers (sticky notes) or cards of different colours.

Ask participants to bring specimens of the different crops or varieties to the venue where the exercise is to be conducted or organize a walk through the field sites where target crops or varieties are found and collect specimens for later discussion.

Farmer holding a variety of common bean (*Phaseolus vulgaris*), Sierra del Rosario, Cuba. *Photo: G. Gullotta*

Step 1: Draw a table on a big sheet of paper (see the example in Table 7.1). Start with crops that have the largest number of varieties. For example, rice. Then ask the participants to list all rice varieties and add them to the table. Then, ask the participants to describe each variety. Add the information provided by the participants to the table. See Table 7.3 for an example of a completed table.

Table 7.1 An example of data collection sheet

Crop	Variety	Local / Commercial	Meaning of local name	Description	Uses	Positive traits	Negative traits	Other notes
Crop 1	Variety 1							
	Variety 2							
	Variety 3							
	Variety 4							
Crop 2	Variety 1							
	Variety 2							
	Variety 3							
Crop 3	Variety 1							
	Variety 2							

Sorghum varieties, Kenya. *Photo: Bioversity International/Y. Morimoto*

Step 2: Draw another table on a large sheet of paper with one column for each trait identified in the previous step, and any other traits that the participants find important or that should be assessed for the research (see Table 7.2).

Table 7.2 An example of table for scoring traits of varieties

Crop	Variety	Traits							
		Earliness	Drought tolerance	Flood tolerance	Resistance to disease	Resistance to insects	Good storage	Yield	Other traits
Crop 1	Variety 1								
	Variety 2								
	Variety 3								
	Variety 4								
Crop 2	Variety 1								
	Variety 2								
	Variety 3								
	Variety 4								
Crop 3	Variety 1								

Leave blank columns for traits that might be added during the discussion. Then ask the participants to rate each variety for each trait. The easiest procedure is to use a scoring scale of poor, moderate or good (1-3 scale), but more-complex approaches may be useful for important traits or when the focus group wants to make clearer distinctions.

For each variety, the facilitator asks

- Is this an early maturing variety? On a scale 1 to 3, how would you describe the earliness of this variety?
- Is this variety tolerant of drought? On a scale 1 to 3, how would you score the tolerance of drought of this variety?

Step 3: Discuss further the importance of different traits.

- Which traits are the most important for the crop, variety or community?

See Figure 7.1 for an example of the results of a scoring of rice varieties for different traits. The figure shows that the varieties have different traits. For example, some varieties are more drought tolerant than others. Overall, many varieties have low pest tolerance and disease resistance.

DATA ANALYSIS

Transfer the data collected from the discussions to an Excel sheet. Information can be organized and analyzed to:

- Describe uses and trait composition in farming systems
- Understand which traits are important, and which traits encourage or discourage farmers to grow a variety
- Identify crops, varieties and traits of importance for specific problems (e.g. for climate-change adaptation).

See Section 15: Data organization and analysis for more information on the analysis of traits and uses.

Figure 7.1 Example of scoring for different traits of rice varieties in Sarawak, Malaysia.Source: Climate Change and Indigenous Communities Project, PAR.

0 – very poor; 1 – poor; 2 – moderate; 3 – good.

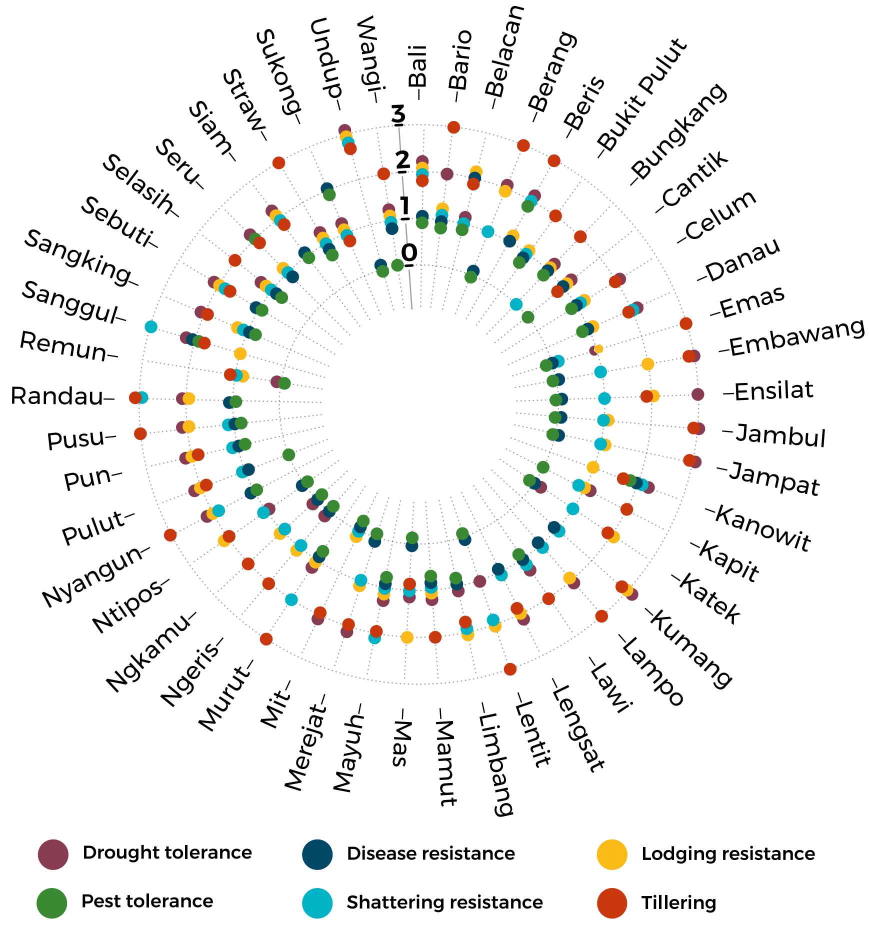


Table 7.3 List of rice varieties, their uses and characteristics in San Din Daeng, Thailand.
Type: paddy (P), hill rice cultivated in rotational fields (R)

Variety Name	Type	Meaning Of Local Name	Characteristics	Uses	Positive Traits	Negative Traits
Bu taj baux	R		Grown in fallow land 3-5 years	Food, income, Hmong people like to buy	Soft peel, good taste,	Cannot be stored longer than 1 year
Bu htau laj	R		Long leaf, long stem, long spike	Family consumption	Strong stem, no insects, easy to thresh	Hard seed, need more time to cook
Piv iv soo	R	Black sticky rice	Black seed	Used to heal diarrhoea in animals, special sweet made for children, given to pregnant women and thin people, natural dye	Resistant to pests and diseases	Each family grows not more than 1 bag of black rice
Bu nemoo	R	Good smell	Good smell	Family consumption	Tasty, easy to thresh, good smell	Hard seed, need more time to cook
Bu pox lox	P	Circle rice	Seed is round	Family consumption	Easy to thresh	Risks of insects
Bu kweiv	R	Zebra	Spike is black and white colour	Family consumption	Soft, large seeds	Risk of disease, heavy spike that breaks easily
Bu ha	P		Dirty rice, spike darkish outside white inside	Family eating, feed to pigs and chickens	No diseases, tasty, strong stem	

8. SEED SOURCES AND SEED NETWORKS

Seed granaries, Mali. *Photo: D. Mijatović*

8. SEED SOURCES AND SEED NETWORKS

This section describes how to collect and analyse information on seed sources, access and exchange.[1] The aim is to understand the local seed system – how farmers obtain and maintain the seeds and other planting materials of the crop varieties that they use.

The information obtained answers questions about:

- The overall availability of seed and the different sources of supply that farmers use
- The relative importance of different sources of supply for different crops and varieties
- The extent and importance of local seed exchange networks
- The identity of key individuals – sometimes called nodal farmers or custodian farmers – in maintaining crop and varietal diversity.

Information on seed sources, maintenance, access and exchange can be used to:

- Describe the types of exchange mechanisms that occur – who is involved and whether these are gifts, sales or exchanges
- Identify crops and varieties for which exchange between different actors is an important part of their evolution and management
- Explore whether the exchange of seed between individuals within a community constitutes a network
- Identify varieties that are private (maintained by individual farmers and never exchanged) and why this is (practical, cultural or other reason)
- Investigate whether there are differences in the ways that men and women or wealthy and poor farmers access seed for different crops
- Find out who is important in maintaining seed flows or in supplying a range of varieties
- Assess rates of turnover of seed stocks and thus how much the system is changing over time
- Identify the main constraints to seed availability and ways of strengthening access to diverse varieties or new materials.

The information collected should take account of age, gender and other relevant factors that may affect access to or provision of seeds.

Note: *Questions about seed management may be sensitive. Individual farmers may not want to be completely open about seed sources for cultural or other reasons.*

8.1 CONDUCTING A SURVEY OF SEED SUPPLY PRACTICES

Describing seed supply and seed networks is time consuming. Thus, it is best carried out on only one or two major staple crops. The survey may be carried out as part of the larger household survey (see Section 5: Household surveys).

For the selected crop, ask about the seed source of each variety named by the farmer during the household survey and about the original source of seed.

- What is the source of the seed you have planted?
  - ☐ Maintained by yourself from a crop you have grown in the past (self)
  - ☐ Relative or neighbour in the same community (gift, exchange, purchase)
  - ☐ Relative or contact from another community (gift, exchange, purchase)
  - ☐ Market/commercial seed seller
  - ☐ Extension service or government agency (gift, purchase)
  - ☐ NGO (gift, purchase)
  - ☐ Seed fair
- If maintained by yourself, what was the original source of the seed you are using?
  - ☐ Always yourself
  - ☐ Relative or neighbour in the same community (gift, exchange, purchase)
  - ☐ Relative or contact from another community (gift, exchange, purchase)
  - ☐ Market/commercial seed seller
  - ☐ Extension service or government agency (gift, purchase)
  - ☐ NGO (gift, purchase)
  - ☐ Seed fair
- When did you obtain the seed?
  - ☐ You always had it
  - ☐ This year
  - ☐ Last year
  - ☐ In the last two to five years
  - ☐ More than five years ago

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[1] The term 'seed' is used throughout to refer both to true seed and to other types of planting materials such as tubers, offsets or cuttings.

DATA ANALYSIS

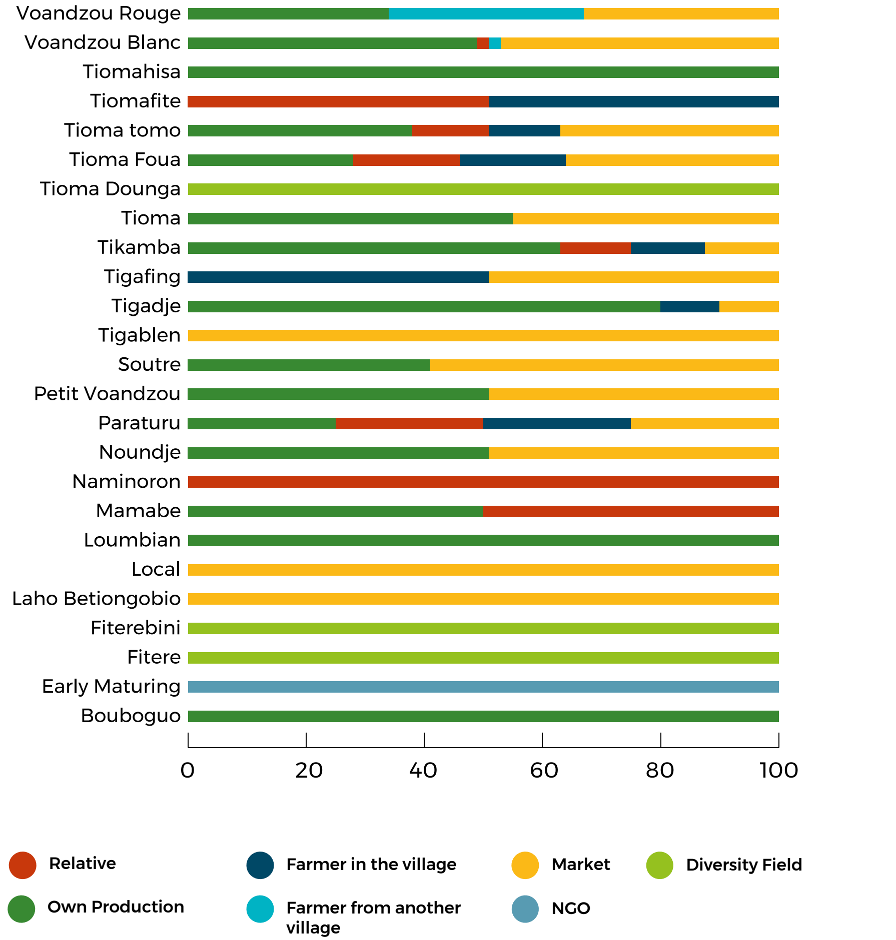
After transferring the answers from the household survey to an Excel spreadsheet the data can be analysed in various ways. For example, the results can be compiled to determine the ways in which seed of each variety is accessed by the community as in Figure 8.1 for Bambara groundnut (note: in this example, the investigators added a category for seeds obtained from relatives). Some varieties were maintained entirely by the farmers that grew them, others were always obtained from markets, while still others were obtained from a number of different sources. The proportion of farmers using the different seed sources can also be calculated as in Table 8.1. Other analyses can be carried out to explore differences between gender or age with respect to seed sources, or turnover (e.g. how often has a variety been exchanged or obtained from a market over the last five years).

Table 8.1 Seed sources for fonio (*Digitaria exilis*) reported by farmers surveyed in Sikasso and Segou regions of Mali. Source: Institut d'Economie Rurale and Bioversity International, IFAD-EU NUS Project.

Seed source	Number of farmers with seed source
Own production	85
Relative	28
Other villages	24
Market	34

Fonio (*Digitaria exilis*) seeds.
Photo: Bioversity International NUS Community

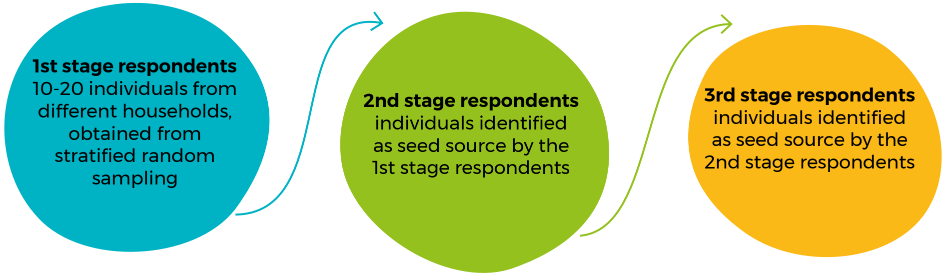
Figure 8.1 Seed sources for different Bambara groundnut (*Vigna subterranea*) varieties reported by farmers surveyed in Sikasso and Segou regions of Mali. Source: Institut d'Economie Rurale and Bioversity International, IFAD-EU NUS Project.



8.2 DESCRIBING LOCAL SEED NETWORKS

Seed network studies provide information on the flow of seeds within a community and on the importance of specific individuals in the community as sources of seeds. The information can be obtained through a three-stage interview process illustrated in Figure 8.2 and explained below.

Figure 8.2 Respondents for a three-stage interview process to identify seed flows



Step 1: First-stage interview

Identify 10–20 first-stage respondents through stratified random sampling (see 'Probability sampling' under Section 2.5: Sampling strategies and sample size).

Ask each first-stage respondent the following questions for each variety they have sown this season:

- From whom did you receive the seeds of this variety for this season?
- Was it as a gift, exchange or purchase?
- Now ask the same questions for the seed of each variety sown in the previous season.

List seed sources for each respondent and each variety in a table like Table 8.2.

Step 2: Second-stage interview

Interview farmers who were named as a seed source by the first-stage informants. Ask each of them from whom (s)he took seeds of the variety identified in the first-stage interview. Repeat the questions for the previous season and enter the information separately (see table 8.2).

Step 3: Third-stage interview

Ask the same questions of farmers who were named as seed source by the second-stage informants.

DATA ANALYSIS

Data about seed sources and modes of exchange can be used to draw maps that show the seed flows (Figure 8.3). Combine all the information on the different varieties and map the connections. Before starting to draw the map, identify the **nodal farmers**. These are the individuals who were named most frequently as seed sources. Decide on a minimum number of times a farmer must be mentioned in order to qualify as a nodal farmer.

This visual seed network representation shows how many seed sources and different modes of exchange are present for each variety, who are the nodal farmers, whether there are many exchange points and how diverse the modes of exchange are (e.g. a variety may only be sold, or may be both sold and exchanged for other goods).

Comparing seed networks

These maps can be used to compare seed networks between communities, for different crop species or varieties and between past and present seasons for a particular crop/variety. For example, Figure 8.3 shows seed networks for rice in two different communities in Nepal, Kaski and Begnas. In Kaski, an upland community with large numbers of traditional rice varieties, exchanges are frequent and there is a rich and highly developed network creating constant flows of seed of important varieties within the community. In Begnas, a community with fewer traditional varieties, there are fewer exchanges and the networks are poorly developed. This may be the result of a greater use of modern varieties obtained from commercial sources. For more information on how to analyze the results of seed network studies, see Ricciardi (2015), Subedi et al. (2003) and Thomas et al. (2015).

Table 8.2 Sources of seed for each variety sown by each first-stage respondent in the current season and previous season

Farmer	Variety	Traditional or modern	This Season		Previous Season	
			Source (farmer name or other source)	Made of exchange	Source (farmer name or other source)	Made of exchange

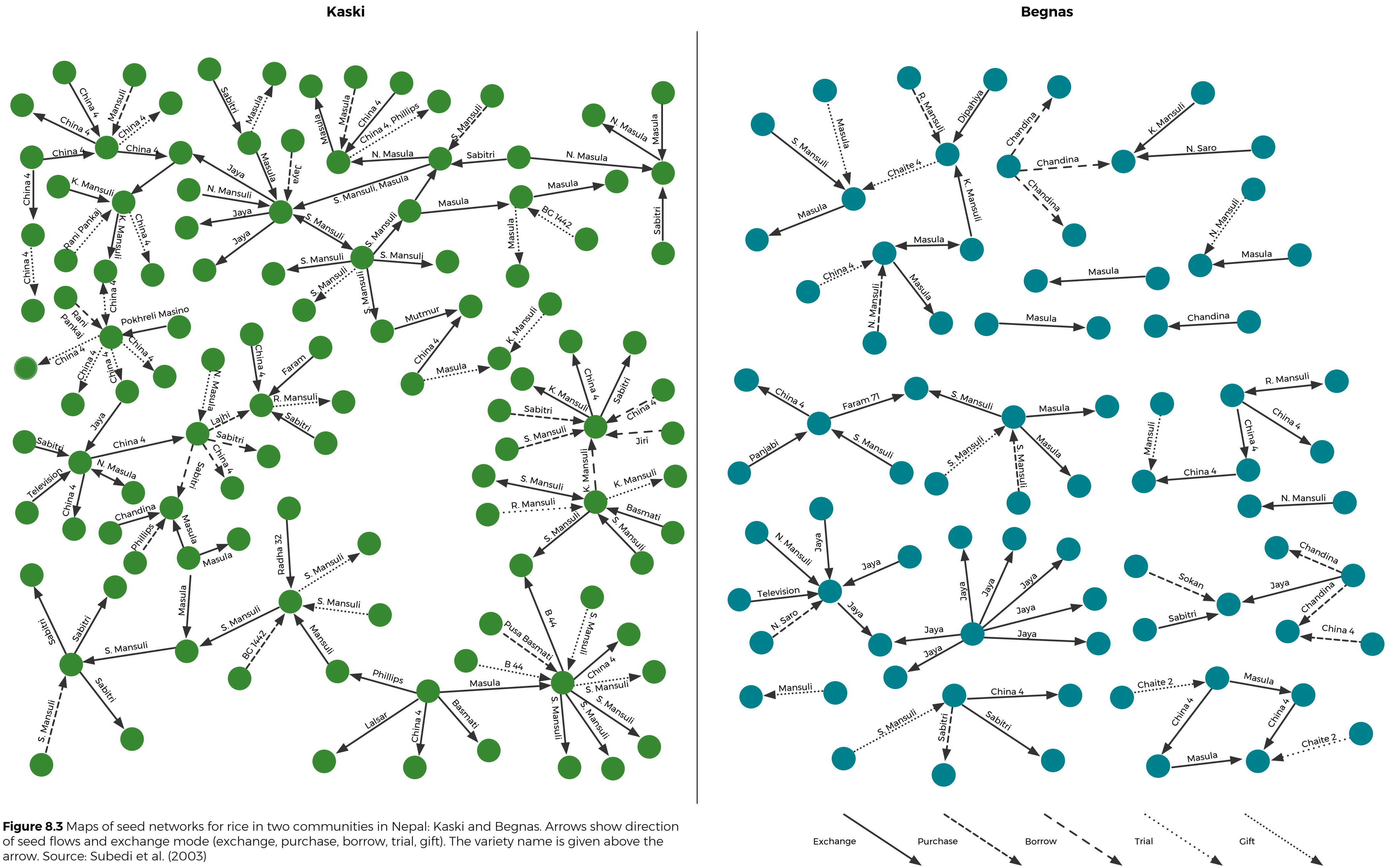


Figure 8.3 Maps of seed networks for rice in two communities in Nepal: Kaski and Begnas. Arrows show direction of seed flows and exchange mode (exchange, purchase, borrow, trial, gift). The variety name is given above the arrow. Source: Subedi et al. (2003)

8.3 FOCUS GROUP DISCUSSION ON SEED SUPPLY

A focus group discussion (FGD) provides an opportunity to obtain general information on seed availability and seed quality of different crops and varieties in the community and can be used when time is limited or a full-scale household survey is not undertaken.

The FGD on seed supply can be combined with the four cell analysis (Section 6). Once the varieties have all been identified and placed in the different cells, start with the common varieties grown in large areas and for each variety ask the following questions:

- Where can you get seed of this variety?
  - ☐ Maintained by yourself from a crop you have grown in the past (self)
  - ☐ Relative or neighbour in the same community (gift, exchange, purchase)
  - ☐ Relative or contact from another community (gift, exchange, purchase)
  - ☐ Market/commercial seed seller
  - ☐ Extension service or government agency (gift, purchase)
  - ☐ NGO (gift, purchase)
  - ☐ Seed fair
- Which farmers can supply seeds of this variety?
- Is it readily available, usually available or difficult to obtain?
- What are the limitations on availability (e.g. lack of seed, high cost)?
- Are there problems with seed of this variety (e.g. poor quality of seed, identity not reliable, not available when needed)?

Try to be as specific as possible and ask for individual farmers' opinions and then see if there is a consensus. Prepare a data sheet summarizing the information on each variety (Table 8.3).

Table 8.3 Table for recording farmers' opinions on aspects of seed supply in their community

Variety	Source	Farmer Sources	Availability	Problems With Seeds
Variety 1				
Variety 2				
Variety 3				
Variety 4				

An FGD can also create a diagram of seed supply practices using the following approach.

The facilitator draws squares representing the individuals participating in the FGD on a large sheet of paper and writes their names in each square. These squares are arranged in a big circle around the sheet of paper.

Each farmer then tells the group the total amount of seed (s)he used this season and writes that in their square.

The facilitator then asks each farmer to draw a set of circles around their square for each way in which they obtained the seed and indicate the amount they obtained from each source and varieties involved.

The facilitator can then ask for additional information to add to the picture, such as the identity of a known seed supplier in the community who is not at the FGD meeting.

Once these steps have been completed, the facilitator can annotate the diagram with lines and arrows connecting suppliers of seed to recipients.

FURTHER INFORMATION/ REFERENCES

On seed systems in general:

Almekinders C, de Boef W (2000) *Encouraging Diversity. The Conservation and Development of Plant Genetic Resources* (Practical Action Publishing, Rugby, UK).

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Jarvis DI, Sevilla-Panizo R, Chávez-Servia JL et al. eds (2005) *Seed Systems and Crop Genetic Diversity On-farm, Proceedings of a Workshop, 16–20 September 2003, Pucallpa, Peru* (IPGRI, Rome).

Pautasso M, Aistara G, Barnaud A et al. (2013) Seed exchange networks for agrobiodiversity conservation. A review. *Agronomy for Sustainable Development* 33:151–175.

On collection and analysis of seed system information:

Ricciardi V (2015) Social seed networks: identifying central farmers for equitable seed access. *Agricultural Systems* 139:110–121.

Subedi A, Chaudhary P, Baniya BK et al. (2003) Who maintains crop genetic diversity and how? Implications for on-farm conservation and utilization. *Culture and Agriculture* 25(2):41–50.

Thomas M, Verzelen N, Barbillon P et al. (2015) A network-based method to detect patterns of local crop biodiversity: Validation at the species and infra-species levels. *Advances in Ecological Research* 53:259–320.

9. USES OF WILD PLANTS

Local herbalists looking for medicinal plants in the Turkestan Range, Kyrgyzstan.
Photo: L. Pawera

9. USES OF WILD PLANTS

9.1 COLLECTION OF DATA ON THE USE OF WILD PLANTS

Wild plants continue to be an important part of the human diet, and have cultural, medicinal and economic values for local communities. Many wild species are actively managed to a greater or lesser extent. The use of wild plants is studied using ethnobotanical approaches – a combination of anthropological, ethnographic, botanical and ecological approaches (Martin 2004, Albuquerque and Alves 2016). Such studies can help to:

- Describe culturally important species and their uses
- Assess the sustainability of harvesting
- Identify species that could be domesticated or included in breeding programmes
- Identify underutilized species, or those with the potential to contribute to nutrition, climate-change resilience and other aspects of community well-being
- Determine changes and dynamics of traditional knowledge over time
- Enable intracultural and cross-cultural comparison of traditional knowledge.

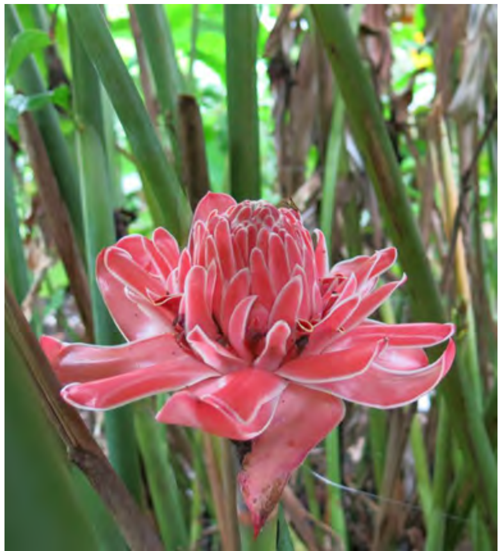
Information about the use of wild plants is most commonly collected through interviews with local people, but may also be collected through focus group discussions or household surveys. Because not everyone has the same knowledge of wild plants, their uses, locations and harvesting, it is important to identify key informants – those with knowledge of local wild plant resources and their uses. Interviewing key informants is the best approach when the objective of the study is to document as much knowledge as possible in a short time or to document rapidly disappearing traditional knowledge.

Often, certain knowledge is held by specialist 'custodians of knowledge'. For example, this is the case with medicinal plant knowledge, which is commonly maintained by herbalists, traditional healers or shamans. In this case, the method employed for selection of informants will be purposive (targeted) sampling or snowball (chain-referral) sampling (Tongco 2007; see also 'Non-probability sampling' in Section 2.5: Sampling strategies and sample size).

When study participants are chosen using purposive or snowball sampling, the results cannot be extrapolated as a finding for the whole community. If the study aims to assess knowledge and plant use across the whole community, use a household survey (Section 5: Household surveys) that uses a stratified random sample of informants.

FOLK CATEGORIZATION AND FOLK TAXONOMY

Communities often have specific terminologies and 'folk categories' for wild food plants, wild vegetables, forest medicines, etc. (see also Local names and classification systems in Section 2). One of the important decisions for the study will be whether to categorize plant uses according to folk categories (this would be a more emic and culturally-sensitive point of view) or to follow scientific categorization of plant uses, such as the Economic Botany Data Collection Standard (Cook 1995). The latter would be a more etic or scientific approach, and is more widely used in the international context and for comparative purposes. Emic perception is that of the community, while etic perception is an external (scientific) point of view.



Etlingera elatior (also known as torch ginger), Fiji.
Photo: D. Mijatović

FREELISTING

In freelisting, informants are asked to list, for example, all wild food plants that people in their community use and their answers are noted in the order in which they are given. It is a simple and effective method for capturing a large amount of traditional knowledge, and for quantifying plants' cultural importance (Quinlan 2005). The ease of freelist interviewing makes it ideal for collecting ethnobotanical data from a large sample.

The assumptions of the freelisting method:

- More commonly used items are cited by more people (frequency of citation)
- Informants tend to cite more important items earlier in the list (position in the list)
- A more knowledgeable person will give a longer list than a less knowledgeable person (number of listed plants)

Thus, freelisting will indicate:

- What items belong to a particular domain (folk categorization)
- What items are the most important in that domain (cultural importance)
- Who is most knowledgeable about the topic (number of items an individual informant lists).

Freelisting is conducted with the minimum of 30 informants, but gives better results with 50 or more informants. Individual informants are asked to list all plants they know (or use) in a particular category (e.g. wild food plants used, fruits consumed, medical plants used for gastrointestinal disorders).

For wild food plants, the interviewer asks:

- What wild food plants do you know? [2]

The freelist for one informant may look like this:

Kangkung air
Bayam liar
Daun kelor
Rimbang
Keladi
Mangga hutan
Kapunduang

Depending on study objectives, this would then be followed up with separate questions for other use categories, e.g.:

- What medicinal plants do you know?
- What wild fodder plants do you know?
- What wild plants do you know that can be used for firewood?
- What wild plants do you know that can be used for construction?

[2] *The list of plants given will depend on the exact question asked. For example, if informant is asked "Which wild food plants do you use?", the list of used plants will be shorter than if we ask for known plants.*

ETHNOBOTANICAL QUESTIONS

The freelisting method results in lists of plants known to or used by the community for different purposes. Additional questions are needed to find out about the different aspects of local knowledge and use.

Go back to the list of plants, and ask the following questions about each plant:

- Does the plant have other local names? If so, note down all plant names.
- What part(s) of the plant do you use (bark, root, flower, leaves...)?
- What is the mode of preparation or administration (infusion, decoction, raw, cooked...)?
- Where do you gather it (e.g. near to river, in forest, on fallow land, in home garden, in rice field)?
- How available is this plant (i.e. use a scale from 1 to 5, where 1 is rare and 5 is highly abundant)?
- Does the plant have some other uses beside the main use (medicine, spiritual use, technical material, and others)?

Additional questions can provide information on a plant's economic value, seasonal availability, time or distance to collection place, source of knowledge, quantity collected or frequency of use. The answers can be tabulated as in Table 9.1.

Table 9.1 Tabulation of basic ethnobotanical data

Scientific names	Local plant names	Food category	Plant part used	Main local uses	Other uses	Place of collection	Availability of plant
Cocos nucifera	**Kelapa**	Fruit	Fruit	Mature fruit eaten raw	Medicine for stomach ache	Forest	4
		Fruit	Fruit	Mature fruits pressed to obtain cooking oil			
		Vegetable	Leaf	Young leaves eaten raw	Material for making a brush		
Ipomea aquatica	**Kangkung liar, Lara**	Vegetable	Leaf and stem	Aerial part boiled or stir-fried	No	River	2

Pressing plant specimen of wild vegetable *Claoxylon longifolium* in Sontang village, West Sumatra, Indonesia. *Photo: L. Pawera*

9.2 DATA ANALYSIS

DIVERSITY OF USED WILD PLANTS

Information about wild plants is usually organized by species, indicating their uses and the number of informants who mentioned them. Basic analysis includes the organization of data into the botanical families, genera, and species they belong to, and some of the following calculations:

- The total number of useful species
- The number of species per botanical family
- The number of species per use category
- The most commonly used wild species based either on the number of times a species is cited in freelisting or on the percentage of informants who cited the species.

The data can be further analyzed to calculate quantitative ethnobotanical indices, such as use reports, salience index, use value or cultural importance index (see below). These indices show the importance of particular species in the community.

STATUS AND DISTRIBUTION OF PLANT KNOWLEDGE IN THE COMMUNITY

To understand the distribution of knowledge in the community and traditional knowledge richness, calculate:

- The average number of species mentioned per informant
- The average number of species mentioned in particular use categories per informant
- The total number of species known by the community.

USE REPORT

The most basic step towards quantification of ethnobotanical information is to convert the collected data on plant uses into use reports. Generally, one use report is when one informant mentions the use of one species in one use category. For example, in a study of wild food plants in the White Carpathians in the Czech Republic (Pawera et al. 2017), the first informant stated that they used elderberry (*Sambucus nigra*) as follows:

- Mature fruits for jams, preserves or marmalade (category 'Fruits')
- Flower for tea (category 'Recreational beverages')
- Flowers coated in batter and fried consumed as a snack (category 'Others').

This informant thus gave the species three use reports. In the whole study, which involved 65 informants, *Sambucus nigra* was referred to as being used in five different food categories and obtained a total of 71 use reports. The number and percentage of use reports for particular use categories or for botanical families indicate the importance of that use category or plant family. For instance, in the White Carpathians study, the highest share of use reports (31%) was recorded for the category 'Fruits'.

SALIENCE INDEX

The salience index is a value expressing the cultural significance of freelisted items. The salience index (of one item) is calculated using the following formula:

$$\text{Salience Index} = \frac{\text{inverted rank}}{\text{number of all items in the list}}$$

where rank is the position/order of the plant in the freelist.

The composite salience for all informants can be calculated by summing the individuals' salience scores and dividing the result by the number of informants (Table 9.3).

A free software (Anthropac; Analytic Technologies, Inc. *http://www.analytictech.com/anthropac/anthropac.htm*) is available for analysing large freelist datasets.

Table 9.2 Analysis of freelist from one informant

Fruit	Rank (order in the list)	Inverted rank/no. of all items	Salience index
Kangkung air	1	5/5	1
Bayam liar	2	4/5	0.8
Daun kelor	3	3/5	0.6
Rimbang	4	2/5	0.4
Keladi	5	1/5	0.2

Table 9.3 Analysis of freelists from two informants

Fruit	Informant 1	Informant 2	Total Salience	Composite Salience
Kangkung air	1	0.2	1.2	0.6
Bayam liar	0.8	0.6	1.2	0.6
Daun kelor	0.6	0.4	1	0.5
Rimbang	0.4	1	1.4	0.7
Keladi	0.2	0.8	1.0	0.5

Table 9.4 Example of final ethnobotanical table with wild food plants used traditionally in the White Carpathians, Czech Republic.
Source: Pawera et al. (2017)

Family, Species	Local Name	Habitat[a]	Food Category[b]	Parts Used And Mode Of Use	Use Report	Use Value	Actual Use[c]
Alliaceae							
Allium vineale	Planá pažitka	AN	VEG	Leaves eaten raw on the bread, added to soups, scrambled eggs	5	0.08	++
Allium scorodoprasum	Planý/divoký česnek	ME/AN	SEA	Bulbs as garlic substitution	2	0.03	
Allium ursinum	Medvědí česnek, Hadí česnek, Česnečica	FO	VEG	Leaves eaten raw, added to salads	27	0.54	++++
			SEA	Fresh/dried leaves added to sauces and soups	4		++++
			ALC	Fresh leaves with honey and wine for preparation of liqueur	1		+
Apiaceae							
Aegopidum podagraria	Bršlice	AN	VEG	Leaves stir-fried a few minutes as a spinach	2	0.03	-
Carum carvi	(Planý-) Kmín, Kmínek	ME	SEA	Seeds for seasoning dishes, soups and added to homemade saveloys	17	0.28	++
Asteraceae							
Bellis perennis	Sedmikráska, Chudobka	AN	VEG	Flowers and leaves eaten raw, on the bread or added to soups/salads	23	0.42	+++
			REC	Flowers for recreational tea	2		
Carlina acaulis	Myslivecký chléb, Pupava, Bodláček	ME	VEG	Receptacles eaten raw	11	0.18	+
Cichorium intybus	Čekanka	AN	REC	Dried grounded roots as a coffee substitution	6	0.12	-
			VEG	Flower buds loaded in oil	1		-
Matricaria discoidea	Heřmánek	AN	REC	Flowers for digestive herbal tea	3	0.05	+
Taraxacum sect. Ruderalia Kirschner, H.Øllg. & Štěpánek	Pampeliška, Půpava, Pléška	AN/ME	OTH	Flowers boiled with sugar to prepare honey	21	0.70	+++
			VEG	Leaves added to salads/eaten directly	18		++++
			REC	Dried grounded roots as a coffee substitution, flowers for tea	3		-
Tragopogon orientalis	Kozí brada	ME	CHS	Stem sucked/eaten for sweet sap	7	0.13	-
			VEG	Roots eaten boiled	1		-
Tussilago farfara	Podběl, Pupava	AN/AQ	REC	Flowers for recreational tea	2	0.03	+
Balsaminaceae							
Impatiens parviflora	Oříšky	AN/FO	FRU	Seeds eaten raw	2	0.03	+
Boraginaceae							
Pulmonaria officinalis	Medunica, Bednrica, Mednrica	FO	CHS	Flowers sucked	2	0.05	-
			VEG	Leaves eaten raw	1		-
Symphytum officinale	Kostival, Černý kořen, Černyj kořeň, Medunica	AN/MEA/AQ	CHS	Flowers sucked	2	0.03	-

[a] habitat-gathering environment: **AN**-Anthropic (villages/homegardens/crofts/orchards/fields/roads); **ME** - Meadows/pastures; **FO** - Forests (oak forest/oak-hornbeam/beach forest/spruce forest), **AQ**-Aquatic (swampy area on the pond/stream bank)

[b] food category: **FRU**-Fruits (including fruit kernels and seeds); **VEG**-Vegetables; **SEA**-Seasoning plants; **REC**-Recreational beverages; **ALC**-Alcoholic beverages; **CHS**–Children's snacks; **OTH**-Others

[c] actual use where: - expresses only historical use; + rare use; ++ occasional use; +++ common use; ++++ very frequent use

USE VALUE AND CULTURAL IMPORTANCE INDEX

To assess the cultural importance of particular plant species, one can calculate a quantitative ethnobotanical index such as use value (Phillips and Gentry 1993) or cultural importance index (Tardío and Pardo-de-Santayana 2008), which take into account frequency and diversity of species uses.

The use value (for one species) is calculated as:

Use value (UV)=U/N

Where U is the number of use reports cited by all informants for a given plant species, and N is the total number of informants interviewed. The plant species with high versatility of uses (use in more categories) and high frequency of citations will have a high use value.

The cultural importance index is calculated as:

$$CI_s = \sum_{u=u_1}^{u_{NC}} \sum_{i=i_1}^{i_{NC}} \frac{UR_{ui}}{N}$$

Where *u* is use, *i* is an informant, NC is the total number of use categories, N is the number of informants and UR is a user report.

***Note:** The difference between the composite salience index and the use value index or cultural importance index is that the first takes into account only listed plants while the other two also reflect the diversity of plant uses.*

Dried purple and white hibiscus flowers in gourd bowls, Mali.
Photo: D. Mijatović

Table 9.4 gives an example of a table with ethnobotanical information for food plants, which includes the number of use reports (UR) and use value (UV). The table shows 15 species that belong to five families. UV and UR values show that some species, such as dandelion (*Taraxacum*), are more used than other plants. In total, dandelion obtained 42 UR and it can be considered the most culturally important wild food plant species as demonstrated by the highest UV (0.70).

CROSS-GROUP COMPARISON

Where research aims to compare the diversity of useful plants or the similarity of plant uses across communities or ethnic groups or from different areas or sections of the community, an index such as the Jaccard index can be applied (González-Tejero et al. 2008).

Jaccard Index = [C/(A + B − C)] × 100

Where A is the number of species in sample A, B is the number of species in sample B and C is the number of species common to A and B. A high Jaccard index value indicates a similarity between the groups compared. Alternatively, a visual illustration of similarity can be made by using a Venn diagram that shows overlaps of plant species among the groups compared (Figure 9.1).

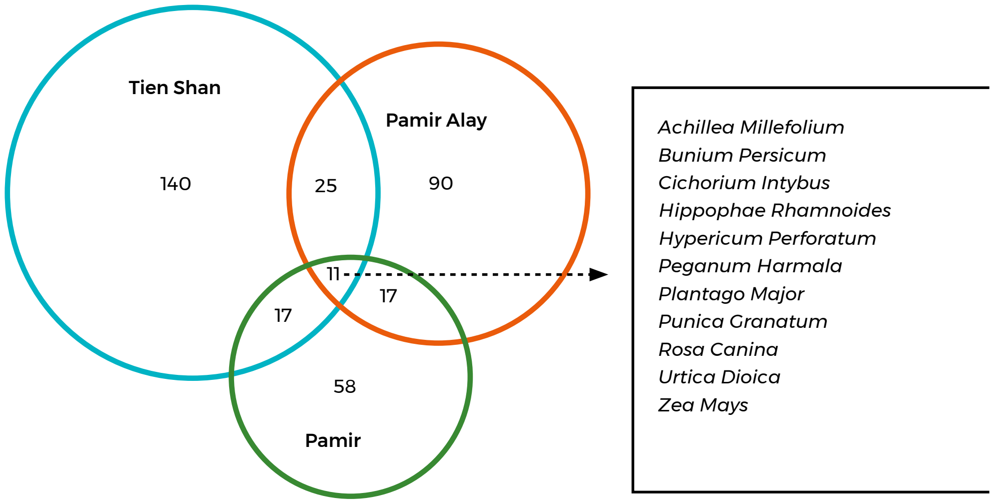


Figure 9.1 A Venn Diagram for medicinal plant species used in major Central Asian mountain systems. Source: Pawera et al. (2016)

NUMBER OF PREPARATION METHODS AND PLANT PARTS USED

In order to understand in more detail how local people use plants, it is common to assess the proportion of used plant parts (e.g. fruits, seeds, leaves, roots) (Figure 9.2), or by mode of preparation (e.g. use raw, dried, decoction, tincture) (Figure 9.2).

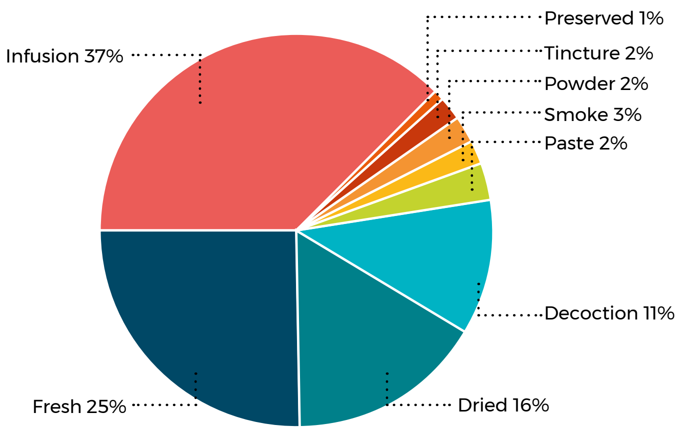


Figure 9.2 Example of medicinal species proportion according to the mode of preparation in Turkestan Range, Kyrgyzstan. Source: Pawera et al. (2016)

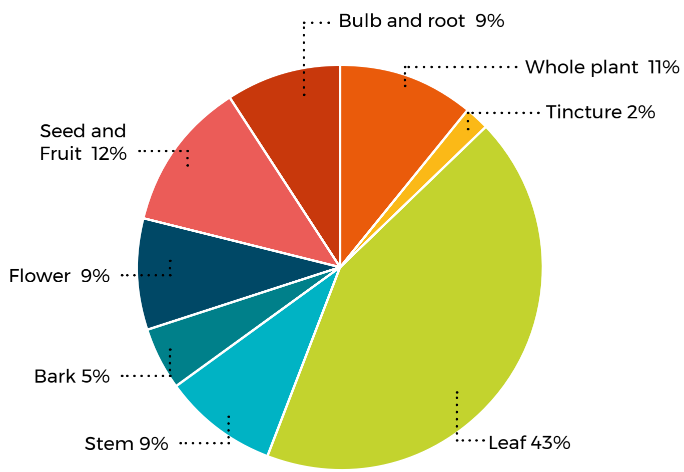


Figure 9.3 Example of proportion of medicinal plant uses according to the plant parts used in Zacatecas state, Mexico. Source: Reimers et al. (2018)

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10. DIVERSITY OF DOMESTICATED ANIMALS AND BREEDS

Seasonal water point on Hawas river where salty spring water mixes with fresh water, believed to have medicinal properties, Ethiopia. *Photo: P. Viesi*

10. DIVERSITY OF DOMESTICATED ANIMALS AND BREEDS

Thousands of breeds of domesticated animals exist in diverse pastoral, mixed crop–livestock and other production systems around the world. This high diversity of breeds is a result of interplay between biological, environmental and cultural factors. Local breeds have unique cultural, social and ecological values. They may have characteristics such as disease resistance and adaptation to local environments. The management of local breeds is linked to specific land-use or governance systems. Pastoralists have developed unique adaptation mechanisms to survive in harsh conditions, one of which is seasonal migration. They often have an extensive knowledge of local plants for such needs as ethnoveterinary medicine and for meeting the requirements of animals at different stages of their life cycles as well as knowledge of the environments they inhabit.

Cultural importance and adaptation to the local environment are among the most important reasons for the persistence of traditional breeds. In addition, these local breeds generate an array of benefits, including their contribution to social cohesion and identity, and their roles in nutrient cycling, nutrition and resilience.

Household surveys (see Section 5: Household surveys and Annex 5.1: A sample household survey questionnaire) can include questions that provide information on:

- The number and identities of animal species and breeds held by individuals and by the community
- The population sizes of the different breeds or species held by individuals and by the community.

The data obtained from this can be analysed to determine the effective population size of the different breeds and domestic animal species in the community (see 10.2: Data analysis).

Additional information on animal diversity is best obtained from key informants and through focus group discussions using the Local Livestock for Empowerment of Rural People (LIFE) protocol approach.[3] This protocol was developed to study aspects of local breeds beyond their population size and productive performance of individual animals.

The adapted version presented here is designed to gather information on:

- Characteristics of local breeds
- Social, cultural and ecological aspects of breed management
- Local knowledge associated with breed management
- Constraints and opportunities for conservation and sustainable use of local breeds.

[3] *The approach used for this section is adapted from Köhler-Rollefson I, Rathore HS (2005). The LIFE-method: A people centred conceptual and methodological approach to the documentation of animal genetic resources. Paper presented at Tropentag 2005, Conference on International Agricultural Research for Development, October 11–13, 2005, Stuttgart, Hohenheim, Germany.*

The Karrayyu-Oromo pastoralists reside in the fringes of upper Awash valley, Ethiopia. In Karrayyu-Oromo society, cattle are sacred to women, who care for them, milk the cows and make butter/ghee. The men take care of camels, including milking and herding them. Goats, sheep, donkeys and horses are taken care of by everyone, including the youth.

In the photo above, a Karrayyu boy is holding a *gorbo* milking container woven by Karrayyu women from the leaves of desert palm, straw and a specific mountain grass locally called *migira*. In the photo on the left, a young girl is holding goat kids.
Photo: P. Viesi

10.1 QUESTIONNAIRE FOR KEY INFORMANT INTERVIEWS OR FOCUS GROUP DISCUSSIONS

The livestock diversity questionnaire comprises two parts. Part 1 is a listing of local livestock breeds and species and their characteristics. Part 2 gathers information on the socioecological and cultural context and conservation opportunities for each breed separately. The example described here can be modified or expanded to reflect research questions or to suit the local context.

Select participants to ensure that there will be a diversity of experiences and knowledge. Include both men and women and younger and older members of the community. A focus group discussion should involve 5–15 participants; if necessary, separate ones can be held for men and women. The procedures should be similar to those described in 'Focus group discussions' under Section 2.3: Data-gathering methods and Section 6.1: Conducting a four cell analysis. Always record the main points in ways that all participants can see them and discuss them.

In the case of interviews with key informants, each interview should be carried out separately so that the informants do not influence each other. The procedure followed is that for the household survey (Section 5.1: Conducting the household survey).

PART 1: NUMBER OF ANIMAL SPECIES AND BREEDS

Ask the group or informant the following questions:

- What livestock species do you keep and how many breeds are there for each species?
- What are the local names of each breed?

For each breed, ask each participant or informant the following question:

- How many females and males are of reproductive age?

This will provide a freelist of all the livestock species and breeds kept by the group as a whole (in the case of a focus group discussion) or by each informant (in the case of key informant interviews).

PART 2: SOCIOECOLOGICAL AND CULTURAL CONTEXT AND CONSERVATION OPPORTUNITIES

This part of the interview is conducted separately for each breed. This consists of a series of questions aimed at understanding the characteristics, uses, management and conservation of the individual breeds.

Description of the breed

- What are the main characteristics (traits) of the breed? Points to record include:
  - Size
  - Colour
  - Important morphological features
  - Disease resistance or susceptibility
  - Product features (includes meat, milk, cheese, eggs, leather, wool)
  - Behaviour.
- What distinguishes this particular breed from other breeds? (Use the trait list above to help answer this)
- What is the origin of the breed?

Knowledge and management practices

- Who is the main caretaker of this breed (feeding, milking, taking to pasture, taking care of the animal when it is sick)?
- Do women have a specific role or traditional knowledge about this breed?
- How is the knowledge about that breed shared?

You may want to include questions to elucidate the local terminology (folk taxonomy) for the animals, for example, various age and sex classes as well as colour types. Examples of such questions include:

- What do you call young females and males of this breed?
- What do you call mature females and males of this breed?
- What do you call this coat colour or pattern?

Ecological and production context

- Which parts of the landscape or ecological zones are important to the animals and why?
- Do the animals graze in cropped areas? During which season? List periods in which animals graze in cropped areas.
- Do animals migrate seasonally? What is the migration route? Describe migration route with information on times of the year or season of migration
- Have seasonal migration routes changed in recent years? If yes, why do you think that happened?

Social context

- Is the breed associated with a particular community or cultural or social group? Name the group and provide information on their role(s).
- What is the social network that supports the management of the breed?
- Is there a producer organization?

Livelihood significance

- What products are obtained from the breed?
- Do you sell animals or their products? What is sold, when and how?
- Is the breed used for draught power? Do you use its manure (fertilizer, fuel, etc.)?

Breeding mechanisms and strategies

- Do you give or lend animals to anybody outside the community?
- Are any animals linked to deities?
- Which of the following strategies are used as part of the breeding strategy for the breed?
  - ☐ Selection (of either males or females or both)
  - ☐ Offspring testing
  - ☐ Oral or written record keeping of genealogies
  - ☐ Castration of unwanted male animals
  - ☐ Avoidance of inbreeding.
- What are the main breeding objectives for the breed? These might include:
  - ☐ Good yields (meat and milk)
  - ☐ Ability to walk long distances
  - ☐ Good mothering instincts
  - ☐ Need for social currency (acting as dowry or bride price)
  - ☐ Ability to survive in an unfavourable environment including low water availability, poor grazing or feed availability, mountainous terrain (as appropriate)
  - ☐ Good reproductive performance.

Chances for sustainable use and conservation

- What pressures does the breed face that threaten its survival or sustainable use?
  - ☐ Loss of grazing
  - ☐ Changes in agricultural production systems
  - ☐ Loss of traditional institutions
  - ☐ Lack of health care
  - ☐ Lack of market demand
  - ☐ Lack of interest by younger generation
  - ☐ Drought/floods or other natural catastrophes
  - ☐ Conflict/war
  - ☐ Other.

Interest in revival/conservation by the local community

- Is there interest in the local community in maintaining the breed? If yes, what are the reasons for maintaining the breed (livelihood, identity, cultural)?
- What are the existing local institutions that could be mobilized to support conservation efforts?
- What constraints need to be addressed?
- What are the suggestions of the local community for how the breed might be conserved?

Further questions about local knowledge, gender roles or migration routes can be developed as needed. The questions in the household survey (Section 5) or on the use of wild plants (Section 9) can be used to find out about the uses of wild plants as part of breed management.

Cows and piglets in rotational farming, San Din Daeng, Thailand. *Photos: D. Mijatović*

(a)

(b)

(c)

(d)

The Karrayyu-Oromo pastoralists are considered among the last Oromo tribes that still exercise the Gada system – an ancient form of democracy. Power among the communities alternates every eight years. One full Gada cycle lasts 40 years. Gada is a political as well as social institution which governs the life of individuals in Oromo society.

Following the Gada system, every eight years another community comes to live in a place shown on the photo. Each family has a house (a) and animal enclosure (b), which make a circular form around the common community space in the middle (c). Men and boys seasonally migrate with camels (d), while women stay home to take care of cattle, sheep and goats.

Photo: R. Bulga Jilo. Illustration: F. Pasta

10.2 DATA ANALYSIS

CALCULATING RICHNESS AND EFFECTIVE POPULATION SIZE

Data from the household survey and from key informants can be analyzed to:

- Calculate richness or number of livestock species and breeds
- Calculate the total population size and effective population size for each breed.

In most domesticated animal species, the numbers of breeding males and females is unequal, with few breeding males and large numbers of females. Just counting the total size of the population might not tell us much about the likely survival of a breed (imagine a population with only one male but many females). To deal with this problem we calculate the effective population size.

The effective population size is the number of individuals that a population with equal numbers of both sexes would have to have in order to produce similar numbers of offspring as the actual population of interest.

Effective population size (N_e) is calculated using the following equation:

$$N_e = (4 \times N_m N_f)/(N_m + N_f)$$

where N_m is the number of breeding males and N_f is the number of breeding females in the actual population.

For example, a community in Zimbabwe kept four breeds of cattle, five breeds of chicken, two breeds of goats and one breed of donkey (Table 10.1). Table 10.2 shows the total population size of the cattle breeds (survey data) and effective population size.

For example, the effective population size for the Tuli cattle breed in the community is:

$$N_e = (4(48 \times 594))/(48 + 594) = 177.6$$

The results suggest that the effective population size of the Brahman breed is low and this breed might be at risk of disappearing in the community but that other breeds are probably of sufficient size at present. FAO has suggested that an effective population size of 50 is the threshold for concern, and the Brahman breed is well below this in the community.

The same calculations for population size and effective population size can be done for each year for which data are available to track changes in the conservation status of the populations.

ANALYSIS OF OTHER DATA

Data from the household survey can be combined to explore associations between animal species and breed diversity (richness and effective population size) and household features such as gender or age and between livestock diversity and other diversity using multiple regression, multiple factorial analysis or principal component analysis (see Section 15). Similarly, information from the focus group meeting or key informant survey can be compared with other community or diversity data. Note that the focus group and key informant data are not a random sample as participants have been selected for the information they can give.

Table 10.1 List of animal species and breeds in one community in Zimbabwe in 2015. Source: SAFIRE, Agrobiodiversity, Land and People Project, PAR.

Species	Number of Breeds	Breed names	Trend
Cattle	4	Tuli	↑
		Nkone	↑
		Brahman	↑
		Mashona	↓
Chicken	5	Isikhova	↓
		Insingizi	↑
		Ithendele	↓
		Imbila	↓
		Indiya	↑
Goats	2	Mashona goat	↑
		Matabele	↑
Donkey	1	African	↑

Table 10.2 Numbers of breeding males and females in cattle breeds in one community in Zimbabwe and calculation of effective population size for each breed. Source: SAFIRE, Agrobiodiversity, Land and People Project, PAR.

Breed names	Effective Males(N_m)	Effective Females(N_f)	Effective Population Size(N_e)
Tuli	48	594	177.6
Nkone	15	156	54.7
Brahman	3	20	10.4
Mashona cattle	18	53	53.7

11. POLLINATOR DIVERSITY

Nomia sp. on flowers of eggplant.
Photo: FAO/D. Martins

11. POLLINATOR DIVERSITY

There is global concern about declining pollinator abundance and diversity. Insect pollinators are important for crop production and for maintaining wild plant populations, are sensitive to changes in the environment (such as changes in landscape composition and structure) and are an important indicator of wider ecosystem health. This section presents two methods for assessing pollinator diversity:

- Field surveys to establish which species of bees are present in the landscape
- Community surveys to understand document local knowledge about pollinators.

Information about which pollinators are present and which plants they pollinate is useful in agrobiodiversity assessment, and for making decisions about how to manage agrobiodiversity. This information is typically lacking. It is also important to know if there have been declines in pollinator numbers, in order to target management. Systematic field surveys can be used to assess pollinator presence and diversity and local communities can play an important role in gathering information about wild bee pollinators, by drawing on their observations over many years. Both field surveys and community surveys help us to understand the status of pollinators in a given area, two methods are outlined here.

Many species are pollinators, for example: birds pollinate some flowers such as hibiscus, bats play a role in the pollination of some fruits such as mango and guava and flies are important pollinators of cocoa (from where we derive chocolate). However, the majority of animal-mediated pollination is carried out by bees. Bees are specialists in pollination, they have formed symbiotic relationships with plants where they are dependent on the flower products (nectar provides them with sugar and pollen provides them with protein) for survival and in the process they provide essential pollination services.

There are approximately 20,000 known species of bees in the world and almost certainly many that have yet to be identified. Most people are familiar with honeybees but this group also includes other social bees such as bumblebees that live in colonies and solitary bees that live alone, such as carpenter bees and blue-banded bees. Bee nests can be found in a variety of habitats, from soil, to dead wood, live trees and old walls. Some bees are generalists and feed on a wide-range of species, where as some are specialists and are dependent on just one species of plant. They are crucial for food production, particularly of vegetables and fruit. So although other species do have a role in pollination, it is useful to focus on bees as they are the most important.

11.1 FIELD SURVEYS

Passive sampling of insect pollinators is used to establish which species of bees are present in the landscape. A common approach is to use water-based pan traps. The advantage of pan trapping is that the sampling method is simple and can be done by almost anyone; it collects a wide-range of bee species and can give a good indication of which bees are present. The data collected represents the background level of bees; it samples the local area rather than an individual field in an area as the bowls will attract bees from some distance. If done over several years this sampling will give an indication of whether bee diversity is declining. The disadvantage is that expertise in identification is necessary for processing the pan trap samples and the volume of traps collected means that the data processing can be lengthy.

Although not all bees are attracted to pan traps, it has been established that approximately 90% of common species are likely to be detected (Grundel et al. 2011). The frequency of trapping will depend on the aim of the sampling. Trapping can be carried out on a weekly basis if the aim is to intensively sample a season of pollinators, or a monthly basis to get a less detailed but broader picture of how the pollinator community changes across the seasons, or on one or two occasions annually to get a snap shot of pollinators over several years. It is important to remember that if years are to be compared, then sampling should take place on the same date each year. It is up to the researcher to tailor the sampling regime to the question being asked.

Pollinator visiting coffee flowers in the Kerio Valley, Kenya.
Photo: FAO/D. Martins

PAN TRAPS

Pan traps are small coloured bowls that are filled with water with a small amount of detergent to break the surface tension. Bees are attracted to the bowls and are trapped by the water. Three colours of bowls (ultraviolet blue, ultraviolet yellow and white) are used, which represent the three colours that attract bees. The bowls are painted with ultraviolet paints because bees see the ultraviolet spectrum.

It has been established that the minimum number of pan traps for sampling is approximately 20. Here we present a sampling layout used successfully in a participatory trial with farmers in India (Basu et al. 2016). It comprises a transect of 200m with 27 bowls, 9 of each colour. Figure 11.1 shows the layout. The transect is located randomly in the area that you wish to sample. Alternatively you can place 24 traps, 8 of each colour, at 5 m intervals along a transect of 100m. Bowls can be fixed to canes, set away from dense vegetation so that they are visible to bees. The photo on the right shows a farmer setting up a sampling station and illustrates how the traps can be set-up. Each bowl should be two thirds filled with water and a drop of unscented detergent added (washing up liquid for example). If possible, sampling should be carried out during dry conditions, however, if this is not possible, or there is a risk of rain, a small overflow hole should be made at the top of the bowl to allow excess liquid to drain away.

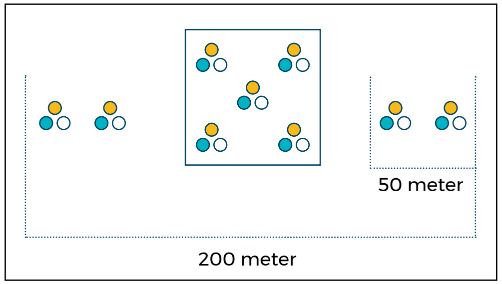


Figure 11.1 Schematic design of trapping station. Each group of three traps was placed at least 5m apart. The coloured circles represent different coloured traps. Source: Basu et al. 2016

Set traps early morning, before 9 am and collected after 24 hours. Make a clear record of the following information:

- Site location and description
- Date and time set
- Date and time collected
- Number of bowls set
- Number retrieved (some bowls may 'go missing' or fall over).

SAMPLE COLLECTION

Each bowl should be tipped into a small net such as an aquarium net or a large tea strainer. Bees from all the bowls can be combined. After collection carefully shake the bees into a plastic bag, such as a strong sandwich bag or ziplock bag, have a spatula or spoon ready to help you gently transfer the bees, being careful not to damage them. Add a data label to the bag. To do this use a small piece of white paper, and write using a pencil (which will not smudge as a pen would) recording: location, date, time of collection, name of collector. Protect the bag by placing into a box and take it back to your headquarters. Bees should be taken out of the bag as quickly as possible as they will quickly degrade in the bag. If you are setting more than one transect, do keep the bees from the different transects in separate bags. Providing you are not transporting the bees too far it's not necessary to put them in alcohol. If you need to keep the bees for any length of time before processing you may need to decant the bees into individual glass vials with 70% alcohol. In this case each bowl is likely to need its own vial. Label each vial separately, using card and pencil to write, slipping the label into the vial.

Setting up a pan trap station: the light-weight plastic bowls painted with UV paint and are attached to the canes with wire. *Photo: Centre for Pollination Studies, University of Calcutta, India.*

SAMPLE PROCESSING

The next step is to wash and dry the bees. Helpful instructions and videos for processing and storing bee specimens can be found on the Bee Wasp and Ant Recording Scheme website under the heading 'Additional helpful resources' (*www.bwars.com*) along with advice on identification. See also *http://www.fao.org/3/a-i5367e.pdf*.

PINNING AND LABELLING BEES

Bees should be pinned for and stored for identification on a styrofoam block using entomological pins. More details on pinning bees and labelling them can be found on *www.bwars.com*. Good labelling is important. Labels should be pinned close to the specimen so that it is clear which bee it refers to. Label each bee with the following information on thick archival quality paper (20mm x 8mm is a good size to use):

- A unique ID number
- Country
- Region
- Specific location
- Latitude and Longitude
- Date
- Name of collector.

The unique ID number will enable any researcher to find details of the bee in project database.

Now bees are ready for identification. Identification of species is a specialist task and must be carried out by a taxonomist. However, it is relatively straight forward to identify bees to family and training of keen individuals in parataxonomy (identification of insects by non-specialists) can be organised through local museums and universities. Guides and advice can also be found on *www.bwars.com*.

SAMPLE STORAGE

Over time bee specimens will degrade. This can be minimized by keeping the bees in insect proof strong boxes with a silica gel pouch to prevent moisture accumulating (bees can go mouldy quite quickly). Store the boxes in a dark cool place. Placing the boxes in a freezer for three days at -10c periodically will help to ensure any pests are killed.

DATA STORAGE

Build a database for the information. Data can be stored in a simple spreadsheet such as Excel. Any amount of information can be stored but the following are useful:

- Country
- Region
- Specific location
- Site Number
- Date and time when trap set
- Date and time when trap collected
- GPS coordinates
- Habitat it was collected from
- Type of trap used
- Collector's name
- Genus
- Species
- Name of person who identified the specimen
- Date the identification took place
- Who entered the record
- When the data were entered
- Notes field for weather, conditions, problems encountered, flowers blooming, etc.
- Unique ID number for the sampling event
- Unique ID number for the individual specimen.

Human error is inevitable. It is advisable to have more than one person entering and checking the data to ensure that data is entered correctly and matches the specimen.

DATA ANALYSIS

From the database it will be relatively easy to collate summary data for each site, and date, such as which bees are present or calculate species richness for the site. Further data analysis will depend on the aim of the sampling programme and a statistician should be consulted to ensure the analytical approach is appropriate.

Bees pinned and labelled in a pest resistant storage box.
Photo: Centre for Pollination Studies, University of Calcutta, India.

11.2 COMMUNITY SURVEYS

The local community will hold a certain amount of knowledge about local pollinator populations and the purpose of this exercise is to collate that information in a way that it can be used to make decisions about biodiversity. To ensure the dataset is robust, this method uses structured discussions, followed by a process of peer-to-peer validation to enable a consensus to be reached. In this way there is agreement among community members and error from unreliable observations is minimized. The method aims to gather information about:

- Which bees are present on local farms
- Whether there has been any change in bee numbers over time
- Which plants they visit and potentially pollinate.

This information can then be used to identify:

- Which bees are present and locally important
- Which bees, if any, should be targeted in local management plans.

Community survey participants looking at photos of pollinators, Northeast India. *Photo: P. Chakraborty*

Before the survey is carried out a series of photographs of bee species known to occur in the country / region should be printed ready for the exercise. This relies on local facilitators having some basic information about the nationally / regionally present bee community.

At each site identify at least 15 participants ensuring that there is no bias in terms of gender or age. Randomly allocate participants into three groups of five individuals. If it is possible to include more individuals in the survey, then the same process should be repeated (i.e. three groups of five). Experience has shown that five individuals is the optimum number for small group discussion in this case. At the start of the session explain the purpose, process and expected output of the exercise and give participants the opportunity to withdraw if they would like to. It is important that participation is voluntary.

The exercises consist of two stages. The first stage of the exercise is carried out separately with each group of five participants. In the second stage the participants of each group come together to share and review gathered information.

Stage 1

Carry out separately for each group of five.

Show the photographs to the participants and ask them whether they recognize the bees and if they can name them. Local names should be recorded along with the number of people who can recognize the bees.

Ask the participants the questions shown in Table 11.1. Encourage participants to expand on the questions and allow additional discussion. Make detailed notes of the discussions – it is easier if a note-taker is present so that the facilitator can focus on the conversation.

Invite the participants to disperse for sometime. During this time take the answers from the participants and turn them into a set of statements, keeping the statements from each group separate. Write these in a way that they can be discussed in peer groups. For example: "Blue-banded bees have declined by 50% in the last 10 years"; "carpenter bees visit aubergine and bottle gourd"; "Asian honey bees could be encouraged by planting more trees which will grow tall"; "bee numbers could increase if less pesticides were sprayed".

Stage 2

Bring the participants back into their groups and ask each group to review the statements from the two other groups. Ask participants to either accept, reject or modify the statement, encouraging discussion.

Bee hives on a baobab tree, Mali.
Photo: D. Mijatović

Table 11.1 Questions about pollinators for the community survey

Questions	Purpose
What do you understand by 'pollination'?	Establishing local knowledge about pollination
How do you know this?	Establishing the source of local knowledge
Please rank the insects in the picture book according to their value as crop pollinators. Please also indicate those that you do not think play a role.	Collating local knowledge about the importance of particular pollinators
How do you know that the insects you mention have a role?	Establishing the source of local knowledge
Are there other insect pollinators not shown here?	Adding local knowledge to existing knowledge about local pollinators
Which crops do you see each of these insects visiting?	Establishing local understanding of which insects visit which crops and are therefore likely to be pollinators
Have there been any changes in the abundance of any of these pollinators in the last 5, 10, 20 years? By what percentage do you think they have increased or declined?	Gathering local knowledge on pollinator declines or increases and the time scale over which these have occurred.
How do you know there has been a change?	Establishing the source of local knowledge
Why do you think this change has occurred?	Scoping reasons for pollinator abundance change
In your opinion, how could their abundance be increased?	Gathering local expertise on managing pollinators
Would it be useful to have more pollinators?	Establishing how important the community thinks that pollinators are in their local context

Stingless bees (*Meliponini*) constitute a diverse group of highly eusocial insects that occur throughout the tropics. Eusociality is the highest level of organization of animal sociality. Eusocial species, any colonial animal species (e.g. ants, bees, some wasps, termites), live in multigenerational family groups. The majority of individuals cooperate to care for juveniles and relatively few (or even a single) reproductive group members.

Keeping of stingless honeybees is known as meliponiculture. Stingless bees store their flavoursome honey in clusters of small resin pots near the edges of the nest.

Stingless bees of Melipona genus, Cuba.
Photo: G. Gullotta

ANALYSIS

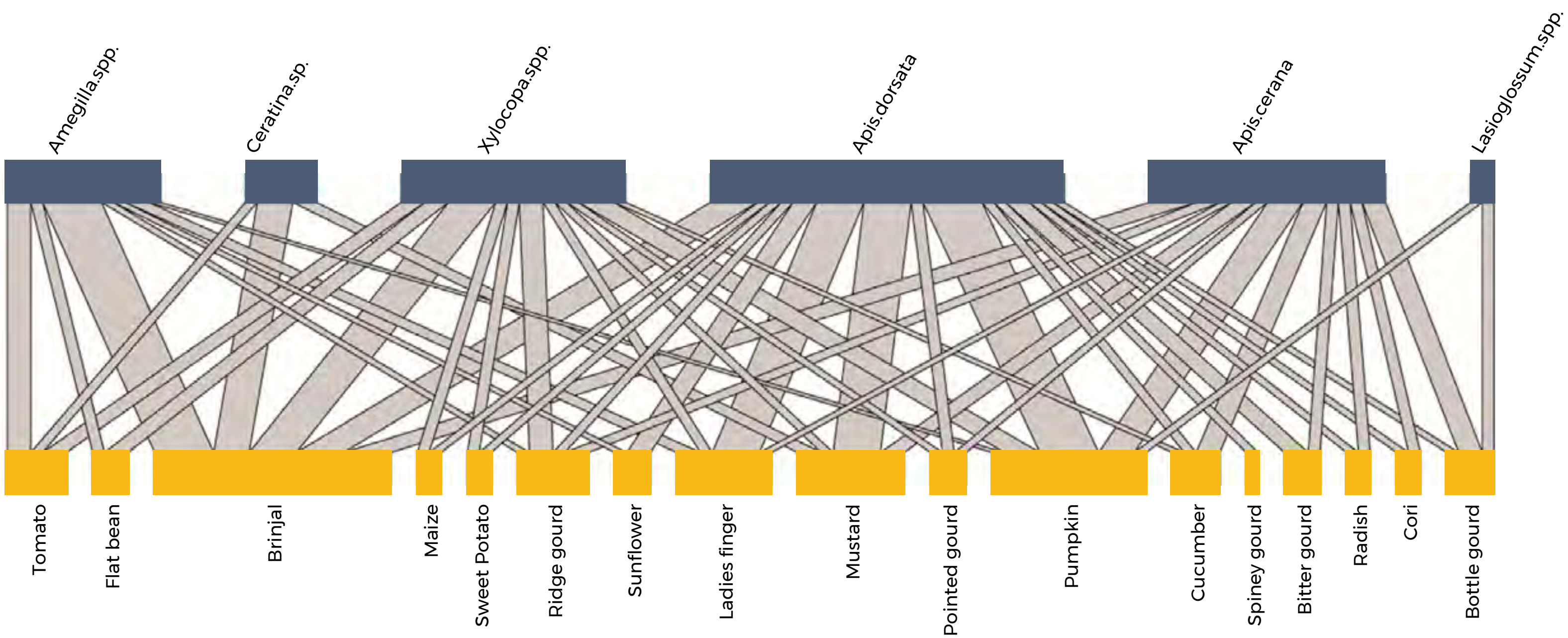
Keep the information from the three groups separate. At the end there may be consensus across groups but if this is not the case then it is useful to know how groups differ. It indicates uncertainty within the community. Data can then be summarized to establish:

- Which pollinators are well known
- Which are observed to be present
- Which are considered to be declining and why
- How the local community consider these pollinators could be managed.

A study in Northeast India used this approach to collate information about pollinator populations (Smith et al. 2017). In this study researchers took the data recording which bees had been seen visiting particular crops and constructed a visitation network based on participant observation (Figure 11.2). Network analysis was performed using "R" statistical software version 3.0.1(R_Core_Team, 2013) (R_Core_Team 2013) with "bipartite" (Dormann, 2013) and "SNA" (Butts 2006) used to construct the network with "ggplot2" (Kahle and Wickham 2013) and "igraph" (Csardi and Nepusz 2006) packages used to visualise data.

The information from the three study areas was pooled to form a single network describing crop-bee interactions based on farmer perceptions. In this network the width of the connecting lines shows the number of farmer groups that cited an interaction. The researchers assumed that the more farmers cited an interaction, the more confidence they could have that this interaction exists. In this way the line width represents a proxy for confidence in the information. The network shows that *Apis dorsata* (the Asian honey bee) visited the most crops and that *Lasioglossum spp.* (sweat bees) visited the least. Aubergine was the most visited crop and spiney gourd the least well visited. The network has some limitations; bigger bees are more likely to be spotted so there is some bias in the data. However this is a good basis for further research and in this case sparked a positive discussion around pollinators within the local community.

Figure 11.2 Visitation network describing crop-bee interactions based on farmer perceptions. Source: Smith et al. (2017)



The same study showed that the community perceived that blue-banded bees had declined by at least 60% in some areas and carpenter bees had declined by 75%. This provides an early warning sign for scientists. The participants recommended reducing chemical pesticides, conserving natural habitat and preserving big trees to encourage more bees. This gives the community an excellent starting place for participatory research.

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12. LANDSCAPE MAPPING

Participatory mapping, Udukumbura, Sri Lanka.
Photo: D. Mijatović

12. LANDSCAPE MAPPING

Participatory landscape mapping is a way of obtaining and documenting spatial information on land use, agrobiodiversity and landscape features. Participatory mapping taps into local knowledge, and provides a greater understanding of human–environment interactions, activities and processes in a landscape. It can be used to gather information on spatial distribution of landscape features such as forest, cropland, grassland and wetland; human activities such as farming, grazing, fishing and collecting wild plants; and importance of specific areas for ecosystem services. Participatory maps are also useful in identifying and locating the main challenges and hazards encountered at community level, such as soil erosion, desertification, pollution, deforestation, fire and hydrogeological risks (e.g. flooding, landslides, avalanches).

When information is updated over time, maps can show changes in land-use patterns and diversity. These can be analysed using the tools provided by most georeferencing software. For example, this can show how much forest cover has been lost due to deforestation and logging activities, or a change in land use from grazing to crop production.

The participatory process is, in itself, of central importance. Knowledge is shared within the community and can be used for developing land-management plans. Access to spatial knowledge can help clarify and support community demands on their landscape and become a negotiating tool for decision-making processes on landscape management and on development projects.

Common uses of participatory maps include:

- Gathering information about land and resource-use patterns, hazards and community values in relation to agrobiodiversity conservation
- Creating management plans, such as community-protected areas and buffer zones
- Sharing knowledge within and among local communities
- Promoting community engagement in decision-making processes concerning natural resource management
- Monitoring changes in land cover and practices over time
- Documenting the impacts of logging, mining and 'land grabs'.

12.1 CONDUCTING PARTICIPATORY LANDSCAPE MAPPING

Participatory landscape mapping is best carried out in a focus group discussion or workshop. Before the workshop, all community members should be informed about what the exercise is intended to achieve and how the community will benefit, and all community members should be invited to participate. Some of the participants will have extensive knowledge about different land uses and activities in the landscape (e.g. forestry, use of wild plants, sources of water, sacred sites) and can act as expert informants.

Mapping is usually best conducted with 10-20 participants. It can be carried out with a mixed group of men and women, or separately with men and women if that is more culturally appropriate. Information collected in separate groups sometimes provides a better understanding of the differences in land use and landscape perceptions between women and men. It is important that both older and younger members of the community participate in order to capture different perceptions of landscape features and allow for exchange of information between them. Depending on the research context and purpose, it may be desirable to include participants with expertise in different areas (e.g. animal herders, traditional healers, artisans, farmers, fishers).

Participatory mapping, Taveuni Island, Fiji. *Photo: D. Mijatović*

PREPARATION

1. Identify participants and venue for the workshop in discussions with members of the community. Keep in mind that the activity may well take a whole day and people will probably have to come and go to deal with other commitments. Make sure the activities are dynamic and that participants are provided with adequate refreshments.
2. Arrange for one or more facilitators (one for each working group). These will need to conduct transect walks and interviews with key informants before the workshop to get to know the local classification of land and land-use patterns.
3. Prepare and print maps and collect other materials such as large pieces of transparent plastic (blank transparent overlays), paper, coded cards (for the activity on ecosystem services) and pads of sticky notes. Printed maps can be prepared using a satellite base map. Participants can then draw landscape features on transparent overlays on the map.
   - Prepare and print the satellite map in advance. The map should be 1m x 1m or larger. Use Landsat or Google Earth images at a scale of 1:15,000–1:30,000, adjusting the scale depending on the area that the community manages. In the case of nomadic communities, the scale may need to be smaller than 1:30,000. When preparing the map in Landsat or Google Earth, add dots with coordinates along the edges of the map (see Figure 12.1a). Mark these also on the transparencies to permit georeferencing and digitizing the maps.
   - Prepare blank transparent overlays in advance. During mapping, make sure that every transparent overlay is firmly attached to the map in order to prevent movement between the two and ensure the accuracy. This can be done by lining up the dots with coordinates on map and transparent overlays (see Figure 12.1a).

THE MAPPING PROCESS

Mapping can be conducted in different ways, here we provide an example of activities for participatory mapping.

After the introduction and preliminary discussion, invite the participants to add the following items to the map:

Land features and land cover, such as rivers, roads, lakes, forests and villages.

This will help everyone to recognize and locate themselves on the map. The participants can start by marking their own homes and then marking natural and managed land cover/use types by drawing different areas (technically called polygons) for forest, crop production, grazing and fishing.

While conducting the mapping workshops, make a legend on the side of the map with all the components on the map. Use points, lines and different shapes to add features on the map. This will help in the process of transferring them to digital maps with georeferencing software.

Human activities, such as fishing, cropping, grazing, and collecting wild food, medicinal plants, fodder, timber, and building. Use different symbols for the different activities.

Challenges and hazards, such as threatened habitats or species, areas of soil erosion, soil and water pollution, deforestation, desertification, drought, plant diseases, flood risk or fire risk. These can be identified through discussions that start with questions such as:

- Are there places where the water is polluted?
- Are floods and mudslides happening in any particular place?

The importance of different land uses for ecosystem services, such as water regulation, soil quality, pollination and pest control. Ask participants to locate on the map the areas that provide different ecosystem services.

One way of doing this is by giving participants coded cards for different ecosystem services, which they can place on the parts of the landscape that are the most important for each ecosystem service. Since ecosystem services are fairly abstract terms, it is best to ask specific questions like those listed in Table 12.1.

Table 12.1 Questions about ecosystem services (these general questions should be followed up with more specific ones as appropriate).

Type of ecosystem service	Question
Provisioning	Where do you go to get water to drink or for use in cooking?
	From where do you get water for agriculture?
Cultural	Which areas are important for cultural reasons?
Regulating	Which areas are important to minimize flooding?
	Which areas are important to minimize the impact of droughts?
	Which areas are important to reduce soil erosion?
	Which areas are important to maintain soil fertility?
	Which areas are important for pollination?
	Which areas are important for pest control?
Supporting	Which areas are important for wildlife, for example, for mating season, forage, spawning, migration?

Another way to conduct this activity is by using signs for land cover/use types and coded cards for ecosystem services (see photo below right).

* Make signs for each land cover/use on sheets of paper. For example, the forest sign might consist of a sheet of paper with 'forest' written in local language. Place the signs on a table or on the ground. The signs represent land uses in the landscape.
* Prepare coded cards with a unique number and questions in English and local language. A unique number is assigned to each participant beforehand. For example, the participant with number 1 will get ten cards marked with the number 1, one card with each of the ten questions in Table 12.1). The farmer with number 2 will get ten cards with the number 2 on them, and so on.
* Ask each question, one at a time, and let the participants place their cards on the land-cover/use sign that best corresponds to the question. For example, ask the first question, "Where do you go to get water for human consumption?" After all participants have placed their cards on the sign, move on to the next question.

Assessing the importance of different land uses for ecosystem services, Meghalaya, India.
Photo: D. Mijatović

12.2 CONVERTING DRAWN MAPS INTO DIGITAL FORMAT

Geographical data from the maps can be digitized. The first step is to georeference the base map and transparent overlays. For this, the transparent overlays laid over the base map have to be photographed. Make sure the transparent overlays are well labelled, that the coordinates on the base map and transparencies match (Figure 12.1a) and that the transparent overlays are not wrinkled. Put the base map and the transparent overlays on a flat surface. Using a good camera that takes high-resolution images, take a photograph from above the centre of the map and perpendicular to the map (Figure 12.1b).

Georeferencing is the process of assigning coordinates to the participatory maps. The different steps involved in georeferencing are beyond these guidelines and, wherever possible, geographic information system (GIS) experts should be asked to support or do georeferencing.

Georeferencing tools are specific software that allows the creation and analysis of spatial data, based on information carrying geographical coordinates. Commercial GIS software includes ArcGIS and ArcMap. QGIS (Quantum GIS *http://www.qgis.org/en/site/*) is a user-friendly open-source tool for mapping and digitizing geographical information. The program allows the user to draw points, lines and polygons (also called 'shapefiles') over satellite or topographical bases (also called 'rasters').

Figure 12.1 Taking photos of the transparencies

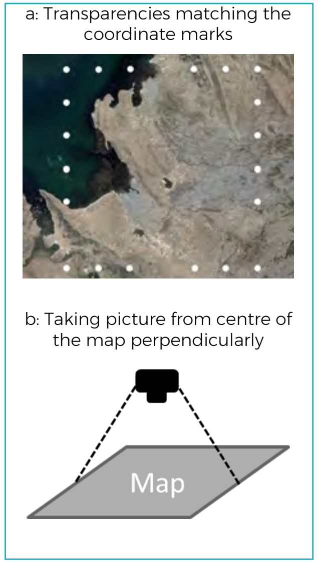
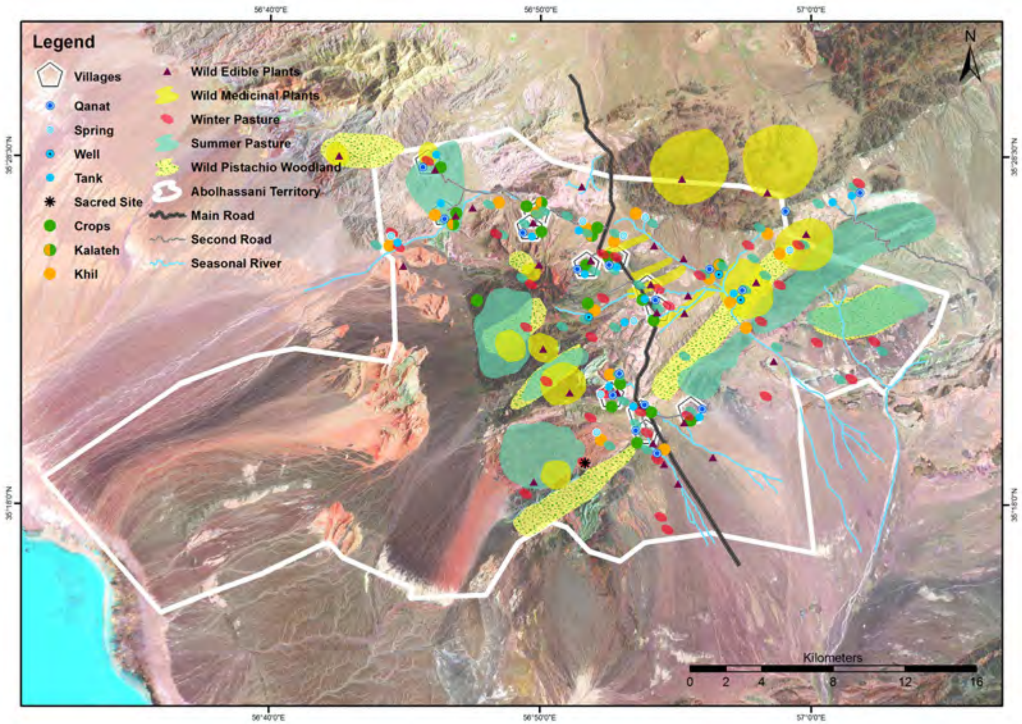


Figure 12.2 Map of the Abolhassani Indigenous Nomadic Tribal Confederacy, Iran.
Source: G. Azhdari, CENESTA



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13. RESILIENCE ASSESSMENT

Highland pastures, Naxçıvan, Azerbaijan.
Photo: D. Mijatović

13. RESILIENCE ASSESSMENT

Resilience in agricultural landscapes refers to their capacity to recover after stresses such as drought, flood or hurricane, and to adapt to changing conditions. The social-ecological resilience assessment aims to develop a better understanding of the factors that contribute to resilience to climate change. The results of the assessment provide a basis for developing plans to enhance resilience through better management of diversity, soil and water.

The assessment involves community members in a workshop, discussing and assessing their response to 20 questions (see Table 13.1) that provide the indicators of resilience.

The questions are divided into five groups:

- Landscape/seascape diversity and ecosystem protection
- Biodiversity (including agricultural biodiversity)
- Knowledge and innovation
- Governance and social equity
- Livelihoods and well-being.

During the assessment, the participants are asked to discuss each question and give an individual and a collective score of their current view and of their perception of the trend. They are also asked to explain the reasons for the scores and trends.

CONDUCTING A RESILIENCE ASSESSMENT

Participants: The resilience assessment is conducted in a workshop with ten community members of mixed age and gender. It also involves one or more facilitator(s), a note-taker and, if needed, a translator.

Facilitator: The facilitator is responsible for describing the purpose of the assessment to the participants and for making sure that all steps are taken in the right order and that all participants are involved. It is important that the facilitator ask the questions in a way that is easily understandable to all participants. He or she should practice asking each question beforehand and prepare supporting questions and local examples.

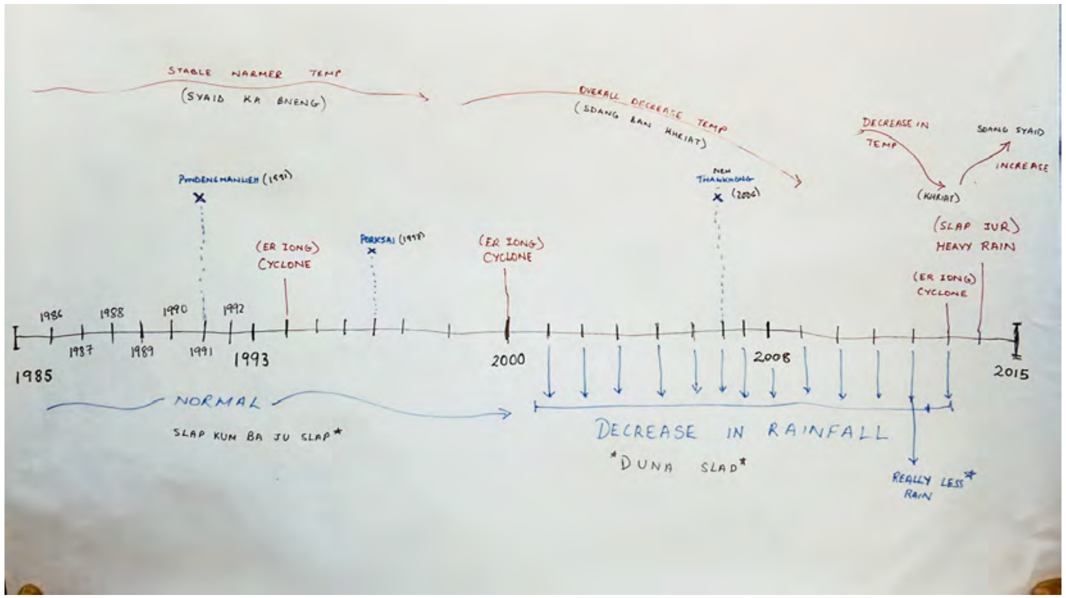
Translator: If the facilitator and note-taker do not speak the local language, a translator will be needed to translate the written list of indicators and questions and an interpreter will be needed to ask the questions and translate the answers and discussion during the assessment.

Note-taker: The trends and scores for the indicators (described later) do not capture the most important information – reasons, problems and possible solutions. The note-taker's job is to capture the discussions and explanations around each question. He or she should take notes during the entire workshop, including the introduction.

Preparation: Preparation includes planning and organizing the assessment workshop, identifying possible participants, fixing a date that is convenient to everyone and ensuring that there is a suitable venue available and adequate refreshments are provided. Preparation also includes other practical matters such as translating the indicators into the local language.

Materials: Materials needed for the day of the workshop include:

- A translated list of indicators, large sheets of paper, coloured pens for mapping, stickers, tape and other material you think will be helpful for the assessment
- Food and refreshments, as the workshop is likely to last an entire day.



Climate change timeline, Lyngngam community, Meghalaya, India.
Source: Agrobiodiversity, Land and People Project, PAR.

Table 13.1 Social-ecological resilience indicators

Domain	Indicator of social-ecological resilience to climate change	Very low (Score=1)	Very high (Score=5)
Landscape diversity and ecosystem protection	Landscape diversity: The landscape is composed of a diversity/mosaic of natural ecosystems and land use types.	One or very few natural ecosystems and land uses	High number of natural ecosystems and land uses
	Ecosystem protection: Areas within the landscape are protected for their ecological and/or cultural importance.	There are no areas under protection	Key resources are under some form of protection
	Landscape integration: Ecological interactions between different components of landscape are taken into consideration in natural resource management.	Ecological interactions are not considered	Ecological interactions are considered and harnessed
	Recovery and regeneration of the landscape: The landscape has the ability to recover and regenerate from environmental shocks and stresses.	Very low ability to recover and regenerate	Very high ability to recover and regenerate
Biodiversity (wild and agricultural)	Local food diversity: The community consumes a diversity of locally-produced food.	Very few or no locally-sourced foods	Very high diversity of local foods widely consumed
	Crop/animal diversity: Households and/or community groups maintain a diversity of local crop varieties and animal breeds.	Very few or no local crop varieties and animal breeds	Local crop varieties and animal breeds are widely conserved and used
	Sustainable management of common resources: Common resources are managed sustainably in order to avoid overexploitation and depletion.	Common resources are overexploited or depleted	Common resources are sustainably managed
Knowledge and innovation	Innovative practices: New sustainable practices in agriculture, fisheries and forestry are developed, adopted and improved, and/or traditional practices are revitalized.	Community is not receptive to change, no innovation	Community members receptive to change and adjust their practices
	Traditional knowledge related to biodiversity: Local knowledge and cultural traditions related to biodiversity are transmitted to young people in the community.	Local knowledge and cultural traditions are lost	Local knowledge and cultural traditions are transmitted to young people
	Documentation of traditional knowledge: Biodiversity in the landscape, including agricultural biodiversity, and knowledge associated with it is documented, stored and made available to community members.	Little or no documentation in the community	Traditional knowledge is documented
	Women's knowledge: Women's knowledge, experiences and skills are recognized and respected at household, community and landscape levels.	Women's knowledge, experiences and skills are not recognized and respected	Women's knowledge, experiences and skills are recognized and respected
Governance and social equity	Land/resource rights: Customary or formal rights over land/water and other natural resources are clearly defined and recognized.	Rights are not recognized and heavily disputed	Rights are fully recognized and not disputed
	Local governance: Accountable and transparent local institutions are in place for the effective governance of resources and local biodiversity.	There is no institution	Institutions exist and are capable of transparent, participatory and effective decision-making
	Social capital: Individuals within and between communities are connected and coordinated through networks that manage resources and exchange materials, skills and knowledge.	Little or no cooperation and coordination in natural resource management	Very high level of cooperation and coordination in natural resource management
	Social equity: Rights and access to resources and opportunities for education, information and decision-making are fair and equitable for all community members.	Access to resources and opportunities is not fair and equitable	Access to resources and opportunities is fair and equitable
Livelihoods and well-being	Infrastructure: Socioeconomic infrastructure is adequate for community needs.	Socioeconomic infrastructure does not meet community needs	Socioeconomic infrastructure meets all community needs
	Human and environmental health: The overall state of human health in the community taking into consideration the prevailing environmental conditions.	Health situation is bad	Health situation is satisfactory
	Income diversity: People in the landscape are involved in a variety of sustainable income-generating activities.	Households have no alternative economic activities	Households are involved in a variety of sustainable income-generating activities
	Biodiversity-based livelihoods: The community develops innovative use of the local biodiversity for its livelihoods.	Livelihoods are not related to local biodiversity	Livelihoods are being improved through sustainable use of biodiversity
	Socioecological mobility: People are able to move around to take advantage of shifts in production opportunities and avoid land degradation and overexploitation.	There are no opportunities for mobility	There are sufficient opportunities for mobility

The indicators are scored as: 1 = very low, 2 = low, 3 = medium, 4 = high, and 5 = very high; and given a decreasing, increasing or stable trend.

RESILIENCE ASSESSMENT WORKSHOP

The workshop consists of three parts:

1. Introduction
2. Scoring the 20 indicators
3. Conclusions

INTRODUCTION (2 HOURS)

During the introduction, the facilitator introduces and develops a common understanding of key concepts, such as the landscape, agrobiodiversity and resilience.

Explain what is a landscape

- Ask workshop participants to draw a map of their landscape with forest, rivers, water sources, lakes, fields, houses, roads, etc.
- Ask the participants for local words for the landscape and write these down on a big sheet of paper. For example, in Japan, traditional landscapes are called satoyama, which means forest-field. The word satoyama expresses the links between the cultivated (field) and uncultivated (forest) parts of the landscape.

Explain agrobiodiversity

Ask participants to list the most important agrobiodiversity elements in their landscape. These include:

- Landscape parts (fields, forest patches, rivers, pastures, water sources)
- Crops and varieties of the main crops
- Domesticated animal species and breeds
- Useful wild species
- Fish in streams, rivers and lakes
- Insects, etc.

Write their answers on a big piece of paper and stick it on the wall.

Explain resilience

- Ask participants to draw a timeline for the last 30 years with major events and changes (droughts, floods, etc.) (Figure 13.1).
- Describe 'resilience' by discussing examples from the timeline: recovering after stress (e.g. drought) and the ability to adapt to change.
- Ask the participants to explain resilience in their own words.
- Describe 'adaptation' by discussing, for example, how they cope with and adapt to drought or floods, and other extreme weather events, irregular rainfall, etc.

SCORING THE INDICATORS (6–8 HOURS)

Individual scores and trends: Participants answer 20 questions one by one. The answer to each question consists of a score and a trend:

Score: Participants give a score to each question on a 5-point scale. The facilitator will need to explain what each number means.

Trend: Participants give a trend for each question by using the following categories:

↑ Steep upward trend (e.g. getting better)

→ No change

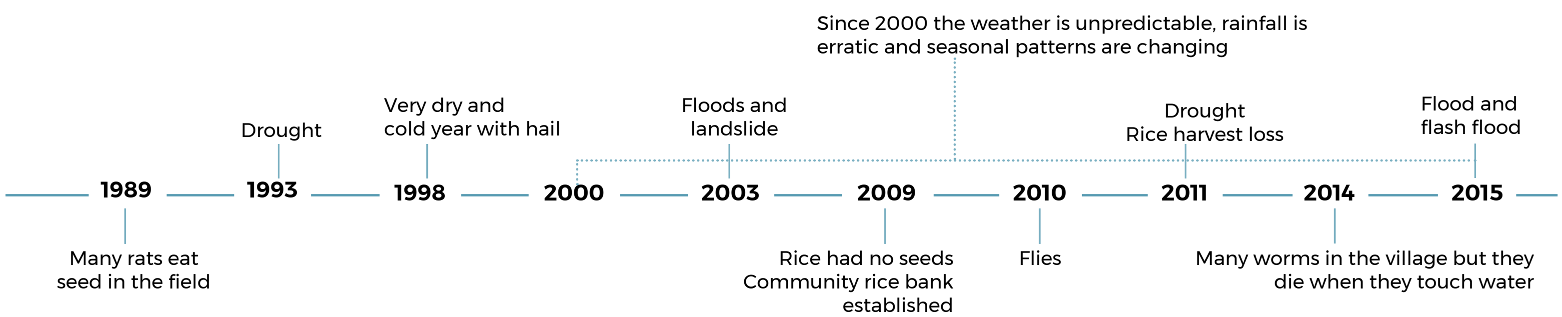
↓ Steep downward trend (e.g. deteriorating).

Draw a table on a big sheet of paper and add participants' names (Table 13.2). Record the scores and trends in this table.

After participants have given their scores and trends, the facilitator asks them to explain their answers. For example, if a participant gives a score of 3, the facilitator asks, "Why did you give to this question a score of 3?" The note-taker captures the explanations given by the participants and the main points of the discussion.

Consensus (group) score and trend: After all participants have given their score and trend for each question, ask for a consensus (group) answer. This creates a space for discussion and reaching a common agreement. Give the participants time to discuss and explain their answers to each other while working towards an agreement on the consensus score and trend as a group. During the discussion, the participants will share their ideas, views and problems. This helps reach a common understanding of the landscape, threats and solutions. When the group has reached a consensus answer, move on to the next question.

Figure 13.1 An example of climate change timeline in Pgaz K'Nyau, Thailand. Source: Agrobiodiversity, Land and People Project, PAR



CONCLUSIONS

The timeline and the answers to the 20 questions will reveal the main challenges faced by the community as well as possible solutions. For example, there may be problems with increasing frequency of droughts, the loss of diversity and traditional knowledge, or the lack coordination and social cohesion. The facilitator can summarise the problems and discuss possible solutions that emerged during the discussion of the 20 indicators. If the group identifies solutions, more-detailed follow-up steps and actions can be defined.

DATA ORGANIZATION AND ANALYSIS

Data organization and analysis can involve:

- Transcription of the timeline, notes, scores and trends
- Plotting of scores and trends, and calculation of the mean and standard deviation for scores
- Qualitative analysis to understand social-ecological processes in a community.

Table 13.2 A table for recording scores and trends during resilience assessment.

QUESTIONS	RESPONDENTS										
	A	B	C	D	E	F	G	H	I	J	K
1											
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Resilience assessment, Sierra del Rosario, Cuba. *Photo: H. Gruberg Cazón*

FURTHER INFORMATION

UNU-IAS, Bioversity International, IGES, UNDP (2014) *Toolkit for the Indicators of Resilience in Socio-Ecological Production Landscapes and Seascapes* (International Partnership for the Satoyama Initiative, Tokyo).

14. RICHNESS, EVENNESS AND DIVERGENCE FOR CROP SPECIES AND VARIETIES

Rice harvest, Hanku, Nepal.
Photo: LI-BIRD/E. Palikhey

14. RICHNESS, EVENNESS AND DIVERGENCE FOR CROP SPECIES AND VARIETIES

Richness is the number of distinct species, crops or varieties present on a farm, in a community or in a landscape.

Evenness measures the distribution or relative abundance of crops or varieties. It shows whether different types occur with similar or different frequencies. In the case of trees, it is usually based on differences in the numbers present while in the case of field crops it is measured as differences in the areas the different crops or varieties occupy.

Divergence indicates how different households are within or between communities or the extent to which different communities differ within a landscape with respect to the crops or varieties they grow. It measures how likely it is that two randomly chosen samples taken from any two farms or communities will be the same. The higher the divergence, the more different one farm is likely to be from another.

Calculating **richness**, **evenness** and **divergence** allows us to describe the amount of diversity within a farm, community or landscape and to look at the differences between them. Richness, evenness and divergence can be calculated for species, for crops or for the varieties present within a crop. The calculation of richness, evenness and divergence allows us to describe:

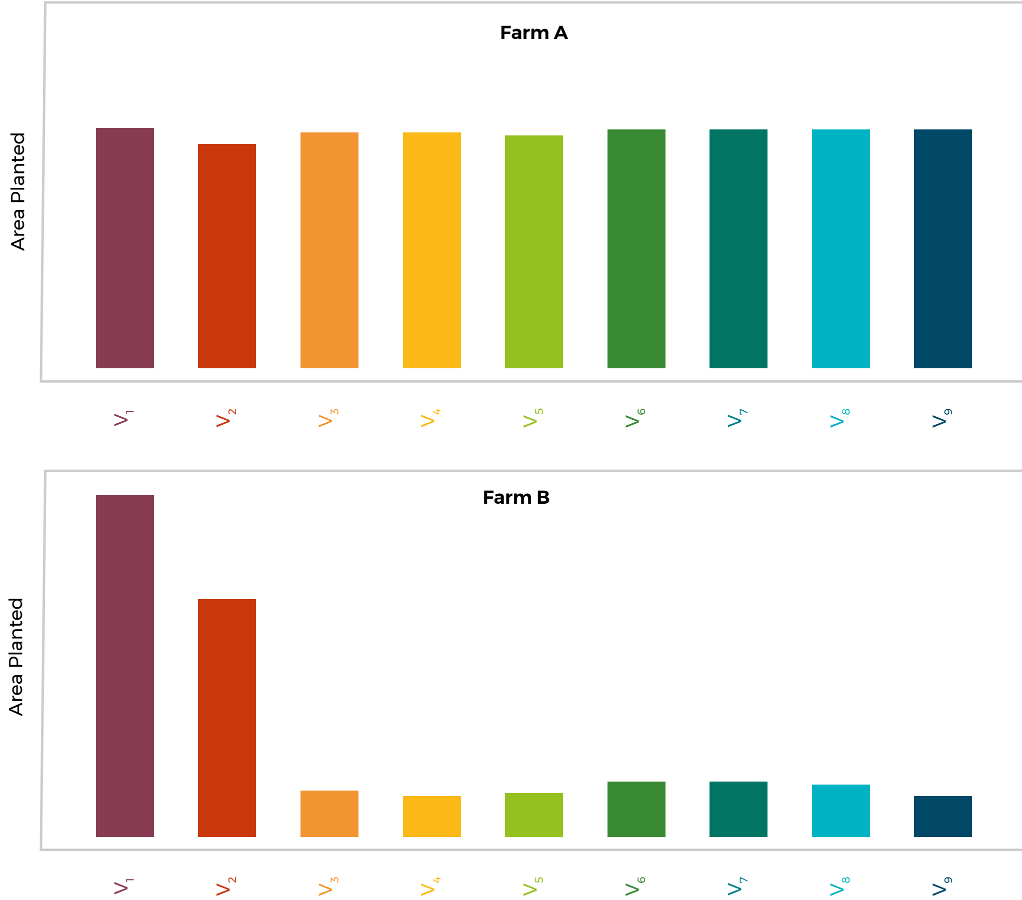
- The amount of crop or variety diversity (which may include all varieties in an area or only the traditional varieties)
- The way the diversity is distributed across fields, households, communities or villages
- The extent to which farmers (or communities within a landscape) differ with respect to the distribution of agrobiodiversity.

This information can be used to:

- Identify common and rare species, crops or varieties
- Identify any rare crops or varieties in need of particular conservation action
- Identify which farmers grow and maintain many crops or varieties
- Begin to identify patterns of distribution of diversity associated with particular sections of the community (e.g. men and women, rich and poor), specific environments (e.g. upland areas, valleys) or production areas (e.g. home gardens, irrigated or non-irrigated fields).

Figure 14.1 illustrates richness and evenness in two farms. Both Farm A and Farm B have nine varieties of a crop (illustrated through the vertical lines in different colours; v=variety) and therefore have the same richness (9). However, the varieties in Farm A are grown on approximately equal areas, whereas those on Farm B are grown on very different areas. Thus, Farm A has much greater evenness than Farm B.

Figure 14.1 Areas of different crop varieties grown on two farms.



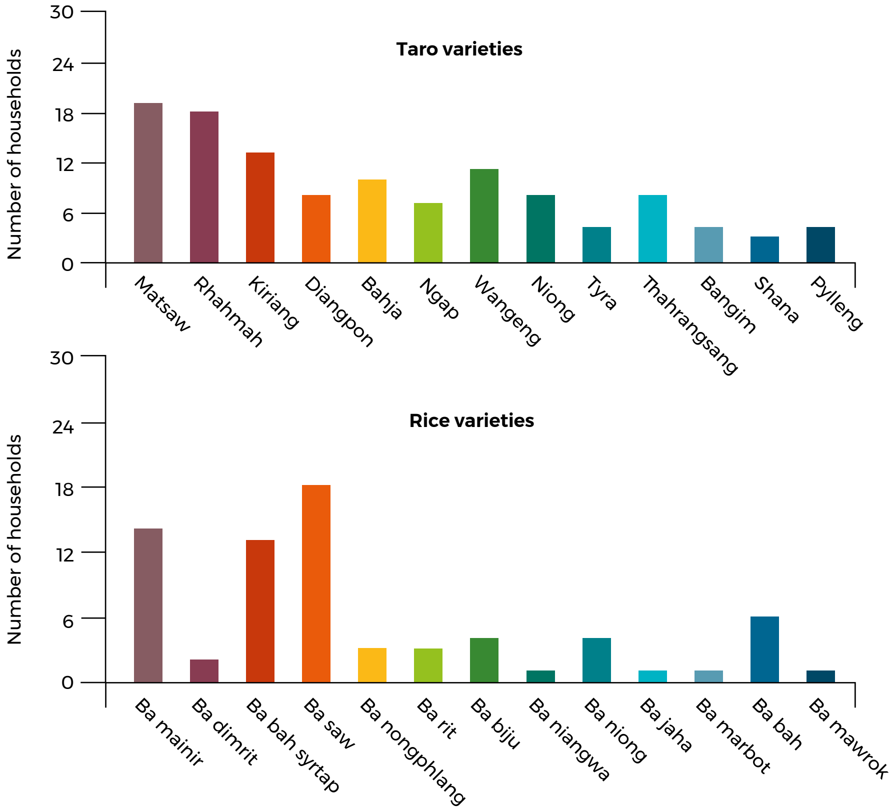
CALCULATING RICHNESS, EVENNESS AND DIVERGENCE

There are several ways to calculate richness, evenness and divergence of crops or varieties (see Magurran 2003). In this Compendium we use the Simpson Index (see Jarvis et al., 2008). It is worth remembering that all measures of evenness also reflect richness to some extent since their calculation involves calculating the frequencies of all the crops or varieties being investigated.

First, create an Excel sheet by transferring the data from the household questionnaire (household identifier, names of varieties and area under each variety in each household). In the case of tree crops, enter the number of trees of each type grown by a household instead of the area.

Table 14.1 gives an example of calculating evenness and divergence for varieties of Bambara groundnut grown by a sample of ten households in Tshongwe, Zimbabwe.

Figure 14.1 Richness and evenness of taro and rice varieties in a Lyngngam community, Meghalaya, India. Source: NESFAS, Agrobiodiversity, Land and People Project, PAR.



RICHNESS

To determine richness of varieties of one specific crop:

Count the number of different varieties grown by each household

Count the total number of different varieties in the community

Calculate the average number of varieties per household (average richness) and compare this with the total number in the community.

Calculate the frequencies of each variety in the community as a whole so as to identify those that are grown in only very small areas by a few farmers and have a low frequency, as these are at risk of being lost.

EVENNESS

The relative abundance of crops or varieties (evenness) can be calculated using the Simpson Index (Jarvis et al. 2008). It is relatively simple to calculate and depends to a substantial extent on the frequencies of the most common varieties, which means that it is less sensitive to situations where not all the rare varieties have been identified.

The Simpson Index is defined as:

$$h = \sum(p_i^2)$$

where p_i is the proportional representation of each species, crop or variety, i.e. the fraction of the total area of, for example, wheat grown on a farm that is occupied by a particular variety.

It can be thought of as the probability of any two individuals drawn at random from an infinitely large community belonging to the same variety (in the example given) and conveys information on the variance of the varietal abundance distribution.

In the case of a finite community) a more appropriate formula would be:

$$h = \sum((n_i[n_i-1])/(N[N-1]))$$

where n_i is the number of individuals in the ith species and N is the total number of individuals. From a probabilistic viewpoint, this is the probability of any two individuals being the same species if drawn at random from a population without replacement.

However, the Simpson Index is generally expressed as 1−h (or 1/h) because h increases as diversity decreases. The following example uses the notation 1−h to indicate the Simpson Index. As a consequence, it will be between 0 and 1 and increase as diversity increases. High values indicate low evenness while low values show that the frequencies of the different types are relatively even. The household Simpson Index tells us about the distribution of varieties or crops on each farm (do farmers grow the same amounts of each variety or do they grow different amounts). The community Simpson Index tells us about the distribution between varieties over the whole community.

1. Calculate the Simpson Index for each household (each row in Table 14.1)

$$1 - \frac{v_1^2 + v_2^2 + \dots + v_N^2}{(\sum_i^N v_i)}$$

Where v_1 is the area under variety 1 grown by that farmer, v_2 that under variety 2, and where the total area under the crop for the household is

$$v = (\sum_i^N v_i).$$

Calculate the mean evenness for the households, not forgetting to include households with a Simpson Index of 0.

2. Calculate the area under each variety at the community level by summing the areas for that variety over all households (each column in Table 14.1).

3. Calculate the community Simpson Index using the same formula with the values obtained from step 3 and the total area under the crop.

In Table 14.1, the individual-level Simpson Index values for the ten households ranges from 0 to 0.667 and the mean Simpson Index is 0.564. The community-level Simpson Index value is 0.694.

Divergence is the difference between the community evenness value and the average farm evenness value, divided by the community evenness value, i.e.:

$$\frac{\text{(Community Simpson - HH Simpson)}}{\text{Community Simpson}}$$

In the example in Table 14.1:

$$(0.694 - 0.564)/0.694 = 0.187$$

In the example used for Table 14.1, the community as whole grows four varieties of Bambara groundnut and each household grows between one and three varieties, although most farmers (seven out of ten) grow three varieties. The area under each variety on a farm ranges from 1000 to 2000m^2 and the area given to the crop ranges for 1000m^2–5000m^2, so the areas under each variety on each farm are quite similar although there is some range in the area allocated by each household to the crop as a whole. While one household grows only one variety (Simpson Index 0), the others have Simpson values of 0.500–0.667. At 0.693, the community Simpson Index is not too different from the average household Simpson Index (0.564) and thus the divergence (0.186) is relatively low compared with other examples you may find. This is a community where the households sampled have rather similar strategies. It might be interesting to explore further the unique variety grown by Household 1 (variety 4).

The previous analysis can be extended to assess any relationship between the selected indices (richness, evenness, diversity) and some explanatory variables. Among many other statistical methods, regression modelling could be used to explain the variation in univariate indices (defined as the dependent variable) as a function of some explanatory variables (defined as the independent variables). Linear regression or one of its extensions should be applied, depending on the characteristic of the response variable, the hypothesis underlying the sampling design and the relationship between dependent and independent variables. Useful resources to guide the researcher in choosing the appropriate regression technique include Faraway (2014, 2016) and Zuur, Ieno and Smith (2007).

Cleaning bambara groundnut (*Vigna subterranea*), Mali. *Photos: D. Mijatović*

Table 14.1 Richness and evenness (Simpson Index) for Bambara groundnut (*Vigna subterranean*) varieties from ten households in Tshongogwe, Lupane, Zimbabwe.
Source: SAFIRE, Agrobiodiversity, Land and People Project, PAR.

Household (HH)	Total Area	Estimated area of each VARIETY (m²)				Richness	HH Simson Index (or h)
		Var 1	Var 2	Var 3	Var 4		
HH 1	5000	0	2000	2000	1000	3	0.640
HH 2	3000	1000	1000	0	1000	3	0.667
HH 3	3000	1000	1000	0	1000	3	0.667
HH 4	3000	1000	1000	0	1000	3	0.667
HH 5	2000	0	1000	0	1000	2	0.500
HH 6	2000	0	1000	0	1000	2	0.500
HH 7	3000	1000	1000	0	1000	3	0.667
HH 8	3000	1000	1000	0	1000	3	0.667
HH 9	3000	1000	1000	0	1000	3	0.667
HH 10	1000	0	0	0	1000	1	0.000
TOTAL	28000	6000	10000	2000	10000	4	0.694
				Average richness		2.6	
Community Frequency	1000	0.214	0.357	0.071	0.357		
				Household Simpson Index		0.564	
				Community Simpson Index		0.694	
				Divergence		0.187	

FURTHER INFORMATION/ REFERENCES

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Jarvis DI, Brown AHD, Hung Cuong P (2008). A global perspective of the richness and evenness of traditional crop-variety diversity maintained by farming communities. *Proceedings of the National Academy of Sciences USA* 105:5326–5331

Magurran AE (2003) *Measuring Biological Diversity* (Blackwell Publishing, Oxford, UK).

Simpson E H (1949) Measurement of diversity. *Nature* 163:688.

Zuur A, Ieno EN, Smith GM (2007) *Analyzing Ecological Data* (Springer Science & Business Media, New York, USA).

For a more advanced approach to exploring richness and evenness, the following can be consulted:

Baselga A (2010) Partitioning the turnover and nestedness components of beta diversity. *Global Ecology and Biogeography* 19:134–143.

Baselga A (2017) Partitioning abundance-based multiple-site dissimilarity into components: Balanced variation in abundance and abundance gradients. *Methods in Ecology and Evolution* 8:799–808.

A statistical package is freely available on R see:

Baselga A, Orme CDL (2012) betapart: an R package for the study of beta diversity. *Methods in Ecology and Evolution* 3:808–812.

Mango varieties sold in the market, Mali. *Photo: D. Mijatović*

15. DATA ORGANIZATION AND ANALYSIS

Maize varieties, San Din Daeng, Thailand.
Photo: D. Mijatović

15. DATA ORGANIZATION AND ANALYSIS

This section describes good practices for working with data collected during different investigations and gives an overview of some techniques for the organization and analysis of data. It is intended to be only an introduction to some of the most important issues; information on where to find additional and more-detailed instructions are provided for the interested reader.

15.1 ORGANIZING DATA

Any information collected should be organised and stored in an appropriate way. The choice of where and how to store data should be based on the characteristics of data themselves and the 'audience' for whom the data are intended. Keep data in formats that are accessible to most people (i.e. in open formats and not in proprietary software formats). At present, Excel spreadsheets are one of the most commonly used tools for data entry and storage. Broman and Woo (2017) and Ellis et al. (2017) provide practical guidelines for data organization and sharing.

Simple rules that can improve spreadsheet data entry and subsequent analyses include the following:

- **Plan where and in what format data should be stored.** This will facilitate the identification of potential pitfalls in data collection and data entry.
- **Keep in mind that in the future your data might be shared with collaborators or the public.** Always keep track of the data-entry process and keep a record of all data transformations or computation actions. Ensure that shared files do not include sensitive personal information about respondents.
- **Human and computer readability.** Data should be formatted to be understandable by human eye but also to be easily processed by computer software. Later analysis might be carried out using statistical software and ease of processing data will reduce your workload.
- **Metadata are important.** Always include basic information about the author, purpose and description of data, version number and explanations of any codes or labels and formatting conventions. This information can be stored in a separate file.
- **Be consistent and tidy.**[4] When entering data in spreadsheets one should:
  - Label the top row with a header
  - Enter a single record in each subsequent row (avoid double-row headers or empty rows)
  - Store a single variable in each column. Do not use a single cell to store multiple pieces of information
  - Avoid using colours to convey meaning. It is better to add a column where the information could be stored
  - Avoid leaving cells empty; use a unique code to denote missing values.
- **Always double check.** Double check that dates, labels and numeric values are consistent and stored correctly.
- **Keep track of changes and have backups.** Sometime, somewhere, something will go wrong and you could lose your data. Always have backups.
- **Always keep original data-record sheets and note books** and store them in a safe place. They are your responsibility and keeping them safe may be a legal requirement as well as showing recognition and respect for the information providers.

[4] *Recommended readings are Broman and Woo (2017) and Wickham, (2014).*

Wild fruits, Naxçıvan, Azerbaijan.
Photo: D. Mijatović

15.2 GOOD PRACTICE FOR DATA ANALYSIS

Discuss the research design and analyses planned with a statistician ahead of time, if possible. The specific question that you wish to answer determines what data you should collect and how they are analysed. Always find out about and check the assumptions of the chosen analysis procedures. The following are some suggestions on data analysis approaches and good practices:

- **Know the question.** It is fundamental to have a clear research goal ('the question') in order to ensure that you collect the required data, organize it and then analyse it appropriately.
- **Research design.** Planning in advance the data collection process and the variables to be collected will improve the analysis and help in choosing the most suitable statistical techniques. Test your methods if possible to identify potential issues and to improve data coding and consistency.
- **Check the quality of data.** Identify and decide how to deal with missing values, check data consistency and resolve any miscoding. After this is done, the different indices to understand patterns of diversity and its management within and among communities can be calculated (see Sections 9.2, 10.2 and 14).

15.3 EXPLORATORY DATA ANALYSIS

The first step in any analysis is to look at the data patterns. In this phase, no specific hypothesis is tested. Rather, the goal is to have a preliminary understanding of the information collected, by, for example, creating graphs and calculating appropriate descriptive statistics that summarize the principal features of the data (such as mean, median and variance). Exploratory analysis can include the following:

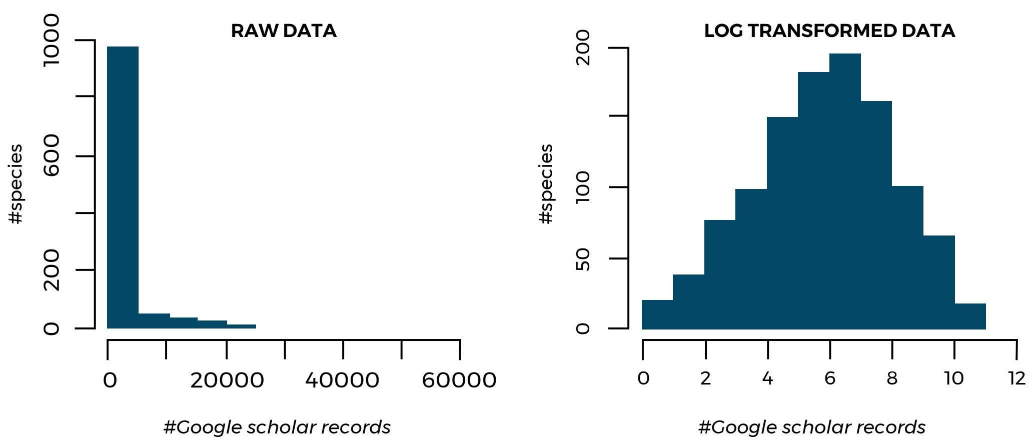
- **Prepare graphs.** Graphs are great tools to visualize and present patterns or general trends in data. Quantitative data might be graphed using histograms (to highlight data distribution), scatterplots (to highlight trends, patterns and relationships with other quantitative variables) and boxplots (to highlight clusters, groups and outliers), among other techniques. Qualitative data might be graphed using bar charts (to highlight frequencies) or a Likert-type scale (to highlight ratings).
- **Check for outliers in the data.** Double check the data for outliers (data values that are very different from all the others in a set). Consult the original data forms and attempt to find reasons for inconsistent values. Exclude outliers if there is good reason to believe the data are erroneous or that the sampled unit does not fit within the sample criteria (e.g. a survey of smallholder households that includes a farm with more than 100ha).
- **Calculate mean, median, range and standard deviation.** Descriptive statistics such as the mean or the median measure the overall tendency of the data. The range and standard deviation provide information about its spread (variance). The correlation coefficient can be calculated to assess the relationship between two quantitative variables to explore some preliminary relationships that may be important for subsequent analyses. In statistical techniques such as regression modelling, collinearity (when two variables are correlated) can result in non-significant parameter estimates.

15. 4 CHECKING ASSUMPTIONS FOR STATISTICAL TESTING

One can also check if assumptions required for applying a chosen analysis hold and, where needed, take corrective action or opt for other techniques, e.g. if the sample size is too small or if there are clear outliers. Checking assumptions can include:

- **Check the variance of the data.** One of the assumptions of analysis of variance (ANOVA) and related techniques (regression modelling, discriminant analysis) is homogeneity of variance. Homogeneity means that the variance of different groups that you want to examine is the same. This can be visually inspected using a boxplot, where the variation in the observations could be explored individually or subdivided into groups. If you are applying a regression model, this check should be applied to the residuals of the model (residuals being the difference between the observed and the estimated values).
- **Check the normality of the data.** A normal distribution of the data is a common assumption for many statistical techniques. This can be visually checked by plotting histograms. If the normality assumption is not met, consider transforming the data or using statistical techniques that do not require normality. Log transformation is a common way of transforming positive non-normal data (Figure 15.1). If you are using a regression model, this check should be applied to the residuals of the model (residuals being the difference between the observed and the estimated values).
- **Independence.** Many statistical techniques assume independence among observations. However, it is not always easy to identify deviations from independence and it is helpful to take the possibility into account in the experimental design phase. For example, soil samples taken at locations close to each other may have more similar characteristics than samples taken far from each other simply because they are close. This would be a deviation from an assumption of spatial independence and might affect soil-sampling plans.

Figure 15.1 Example of a log transformation of data to improve the conformity to a normal distribution. The histogram on the left shows the raw data and the histogram on the right shows the log transformed data Source: Meldrum et al. (2018)



15.5 STATISTICAL ANALYSIS

There are many resources on the internet that can be used for data analysis and appropriate statistical tools relevant for agrobiodiversity analysis. These include:

- The vegan packages for R – *https://cran.r-project.org/web/packages/vegan/index.html*
- Past3 – *https://folk.uio.no/ohammer/past/*
- Anthropac (Analytic Technologies, Inc.) free software for analysing freelists – *http://www.analytictech.com/anthropac/anthropac.htm*

Relatively simple analyses that are often used include test of independence (such as chi square), ANOVA and linear regression. ANOVA, linear regression and their extensions may be used to assess differences between groups and relationships between two or more variables. When there is more than one variable of interest (dependent variable in the linear regression framework), multivariate analysis should be considered rather than just analysing each variable separately. These different methods are described in most statistics manuals or text books (see 'Further reading' at the end of this section).

ANALYSIS OF VARIANCE

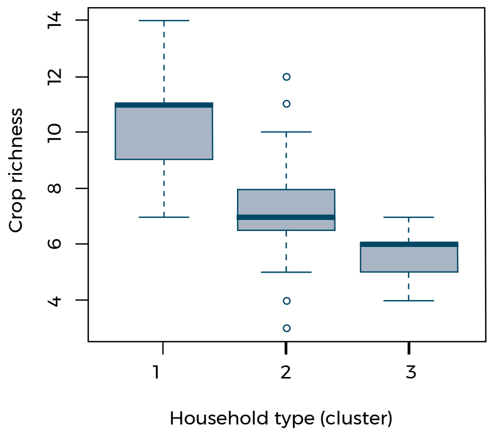
ANOVA is one of the most commonly used statistical techniques to test whether there are significant differences between two or more groups. The assumptions of ANOVA are:

- Independence of observations
- Normal distributions of the residuals
- Homogeneity of variances.

Example: Using ANOVA to investigate differences in crop richness by household type

Figure 15.2 shows the mean and variation of crop richness for different types of household that were identified through a cluster analysis (see 'Ordination and clustering'). The ANOVA test shows that the level of crop diversity is not the same for all types of household. The probability of the difference in crop richness occurring by chance alone is less than 1 in 20 ($p<0.05$). To determine which household type has significantly higher crop richness, a post hoc test is needed. Tukey's test of honest significant differences is commonly applied in such cases. From the graph, it can be seen that cluster 1 has the highest diversity, cluster 2 is in the middle and cluster 3 has lowest crop diversity.

Figure 15.2 Boxplot of crop richness by household type. Source: Bioversity International and Gene Campaign, IFAD-NUS Project.



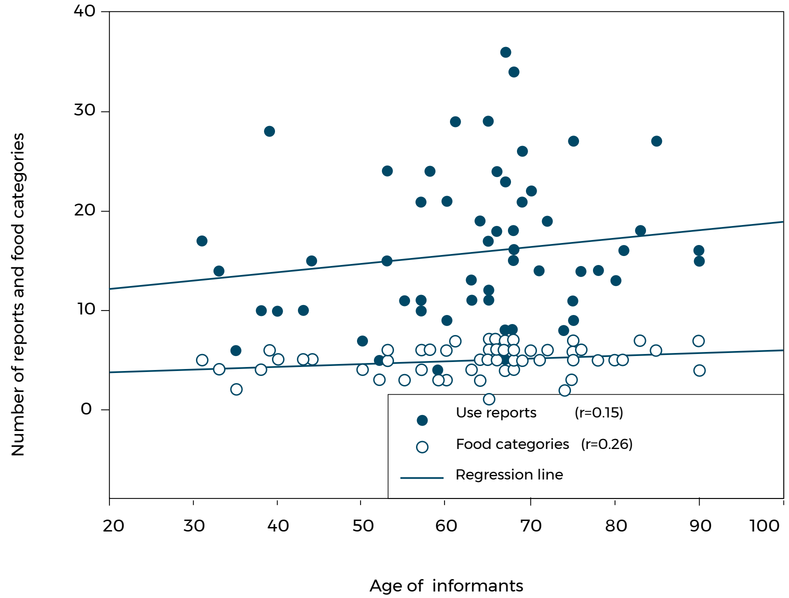
LINEAR REGRESSION

Linear regression can be applied if the main objective of the research is to understand the relationship between two variables.

Example: Using linear regression to investigate differences in knowledge of wild plants

Calculate and compare how many species are mentioned on average by different genders, occupations, ethnic groups or age groups. Figure 15.3 shows an example of the relationship between the age of informants and their knowledge on wild food plants. To conclude that this is a statistically significant trend, the regression analysis would need to show that the probability of the slope being different to zero is less than 1 in 20 ($p<0.05$). You should always check that the estimated effect of the independent variable (in this case, age) on the dependent variable (in this case, knowledge) is relevant and not just statistically significant, because a very small effect can be statistically significant given a large-enough sample size. Whenever possible, provide confidence intervals or standard errors for any estimates.

Figure 15.3 Relationship between the age of informant and number of use reports and number of wild food plant categories in the White Carpathians (Czech Republic). Source: Pawera et al. (2017)



MULTIVARIATE METHODS

Often, agrobiodiversity data include many variables, including the presence or level of production of many species, varieties and breeds and social and environmental data. It is possible to construct more-complex models using multiple ANOVA, multiple regression, general linear models, generalized linear models and a wide number of other possibilities.

ORDINATION AND CLUSTERING

Ordination and clustering are complementary methods that enable associations and groupings of variables to be recognized. These approaches can help reduce the complexity of the dataset and target key variables that can be subject to more-specific modelling and hypothesis testing. Common methods for ordination include:

- Principle components analysis, which is used for quantitative variables
- Multiple correspondence analysis, for qualitative variables
- Multiple factor analysis, for combinations of quantitative and qualitative variables
- Non-metric multidimensional scaling, which is well suited for species composition data.

Example: Clustering to define household typologies

A clustering of households in Uttaranchal India was made based on crop and livestock species maintained, irrigated area, income sources, farm size and income level. A geographic pattern in the household typologies was apparent when plotted on a map (Figure 15.4).

FURTHER INFORMATION/ REFERENCES

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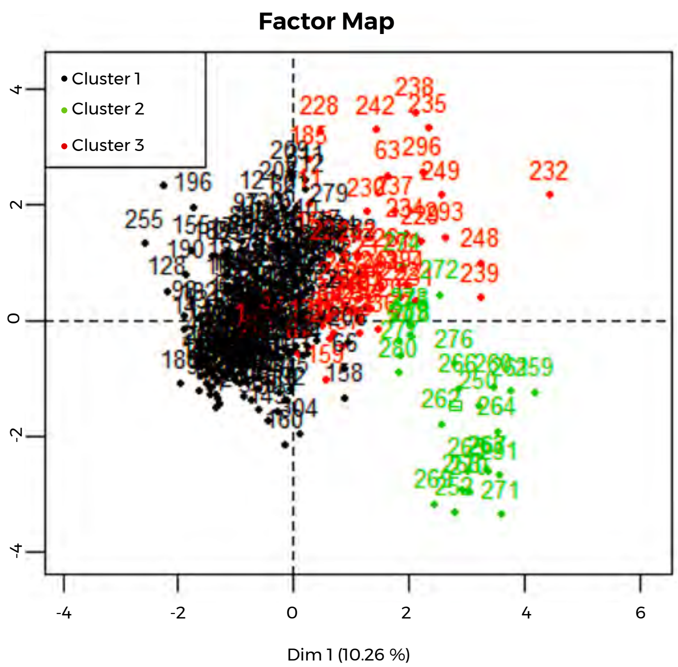
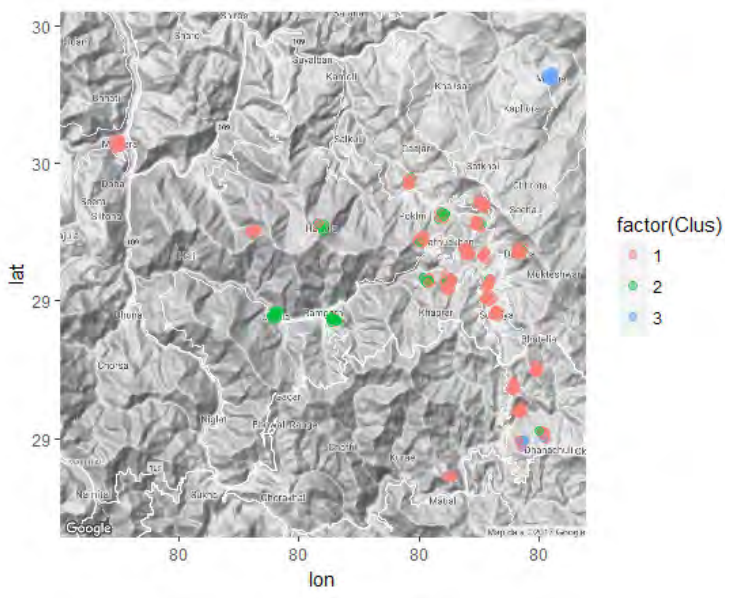
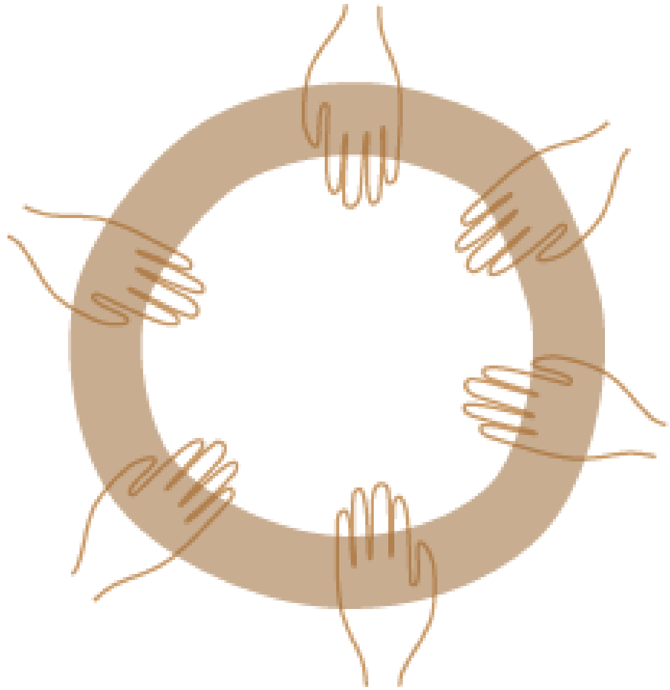
Figure 15.4 Clustering of households based on crop and livestock species maintained, irrigated area, income sources, farm size and income level using multifactor analysis and hierarchical clustering with the FactomineR package. A geographic pattern in the household typologies was apparent when plotted on a map.
Source: Bioversity International and Gene Campaign, IFAD-NUS Project.







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