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# Good Practices for Agrobiodiversity Management

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# 1. On-farm Agrobiodiversity Measurement and Conservation Approaches

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## A. Introduction

Total agrobiodiversity of any area is necessary to plan the implementation of agricultural and environmental projects and activities. Diversity is most for advancing agriculture development, however, modern agriculture has accelerated the replacement of old age crop diversity. Agrobiodiversity index and measures are commonly used and estimated for crop and animal species, landraces and sites. These are useful for locating sites, crops and custodians of agrobiodiversity. Agrobiodiversity includes crop and plant; livestock and fish, insect and microbial genetic resources that are cultivated, semi domesticated or wild. Diversity are necessary for a long-term basis to secure the food and nutrition in the world. Among the three conservation strategies (ex-situ, on-farm and in-situ), on-farm conservation strategy is farmer led and least cost strategy to manage total agricultural genetic resources. Within on-farm conservation, there are many approaches and methods being applied in Nepal. Agrobiodiversity in any area should be estimated properly that leads to choose the conservation approaches effectively.

## B. Objectives

- To assess and measure diversity of agrobiodiversity on farm
- To examine the genetic variation and trend on genetic erosion
- To conserve and utilize native genetic diversity following different approaches on farm

## C. Methods and Process

### On-farm Agrobiodiversity Measurement

Different types of data are generated or collected for the measurement of agrobiodiversity on-farm (**Figure** 1). Primary and secondary data are used. Both quantitative and qualitative data are collected through different methods (**Table** 1). The information for measuring agrobiodiversity comes from different levels. The levels of information are the genes, traits, genetic markers, variety, the crop, the parcel or plot, the household (farmer), the village, the community, the ethnicity, the municipality, the landscape or region, district, province, country, region.

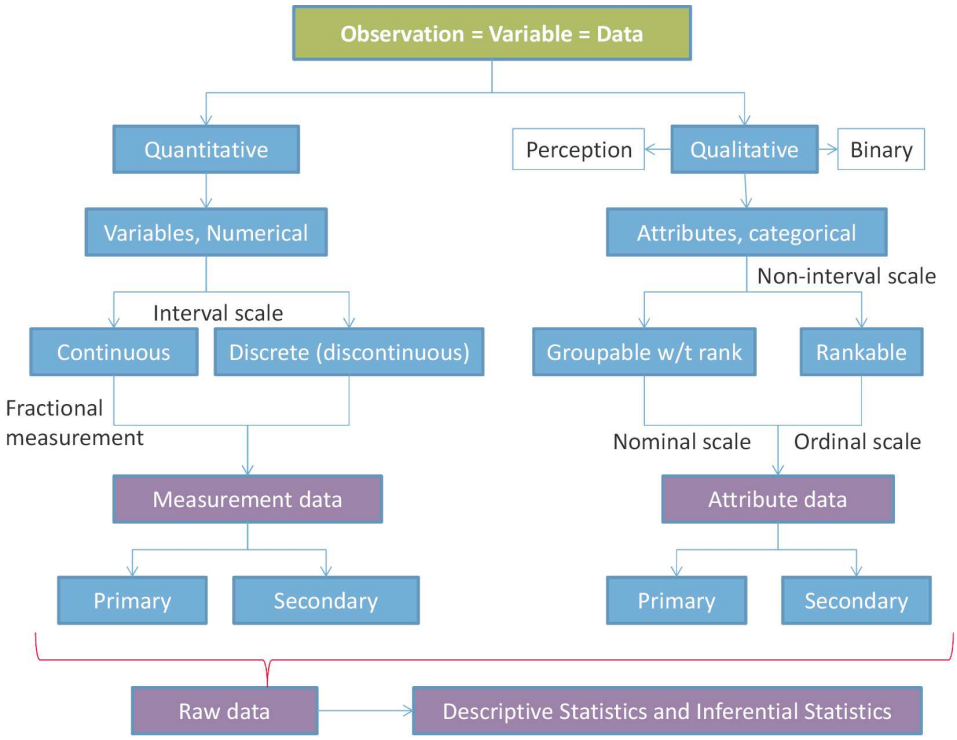


**Figure 1. Data types for measuring on-farm agrobiodiversity at ecosystem, species and cultivar levels.**

**Table 1. Methods of collecting data from on-farm for measuring agrobiodiversity**

| SN | Data Collection Method | Description | Remarks |
|---|---|---|---|
| 1. | Community biodiversity register review and community seed bank visit | Community Biodiversity Register (CBR) is maintained with detail of local agricultural genetic resources by community. Community seed bank (CSB) manage local crop diversity through germplasm flow among the farmers | Species, varieties, unique landraces and traits along with use value are collected |
| 2. | Diversity block | Growing and evaluating locally available crop landraces in easily accessible sites in small plots in farmers fields | Observation are recorded (inter and intra landrace level diversity, including population structure) |
| 3. | Diversity collection | Exploration and collection mission are launched for assessing diversity within landraces, sites. Seeds and information are collected. | Seed morphology and passport data are collected. Collection and diversity map are generated using GIS and analog sites using Climate |

| SN | Data Collection Method | Description | Remarks |
|---|---|---|---|
| 4. | Diversity fair | Exhibition of local seeds by all farmers in single spot | Useful for survey and diversity assessment and measurement including traditional knowledge |
| 5. | Field/ transect walk | Walk along the farming areas with custodian farmers and field staff | Team observe diversity and record data |
| 6. | Focus group discussion | Collecting of specific required information from the group of relevant farmers and stakeholders for discussion on agrobiodiversity | Check lists-based discussions help to collect and verify data. Pattern of landrace occurrence (growing areas and household), resource mapping, etc are done |
| 7. | Food fair | Exhibition and sale of local food made from local genetic resources | Assessment and survey of food diversity and traditional knowledge during food fair |
| 8. | Household survey | Questionnaire based structured collection of information from different sampling strategies | Assess different level of diversity by collecting both qualitative and quantitative data |
| 9. | Key informant survey | Knowledgeable person on agrobiodiversity are surveyed as per the checklists | Experiences are documented and data are validated along with resource mapping |
| 10. | Lab experiments | Includes molecular lab, seed lab, nutrition lab | Molecular level diversity, nutrition diversity are assessed along with image analysis |
| 11. | Literature review | Relevant literatures eg baseline survey report, annual report, project reports etc are reviewed | Secondary data are collected, verified and updated |
| 12. | Local market visit | Market near the site is visited and information are collected. Interview to seller is carried out | Diversity of target sites along with food items are assessed |
| 13. | On-farm trial | Diversity are further characterized and evaluated in farmers' fields following local practices | Data are recorded and verified based on descriptors and farmers' unit of descriptors |

| SN | Data Collection Method | Description | Remarks |
|---|---|---|---|
| 14. | On-station trial | Controlled experiment is conducted for diversity characterization, evaluation and screening | Data are recorded and verified based on descriptors |

The scientific community has developed a wide range of methods of measuring various dimensions of agrobiodiversity, which is often referred as agrobiodiversity index (Boversity International, 2017; Sthapit et al, 2017). Diversity is measured and explained at different levels eg ecosystem, species, landrace and gene levels. Within genotypic diversity, there are functional, molecular, use value and nutritional diversity (Figure 2). Based on the data types, objectives and objects, different measures are used to estimate and compare the diversity (Table 2). These are diversity indices and measures used to quantify the diversity in a particular site. Diversity indices can be used to allow comparisons within and between different populations at species, landraces and genetic levels. Some of these are further used to classify the landraces and species in different categories. For examples, areas and number of household are used in four cell analysis to group available landraces under four cells (patterns of landrace occurrence).

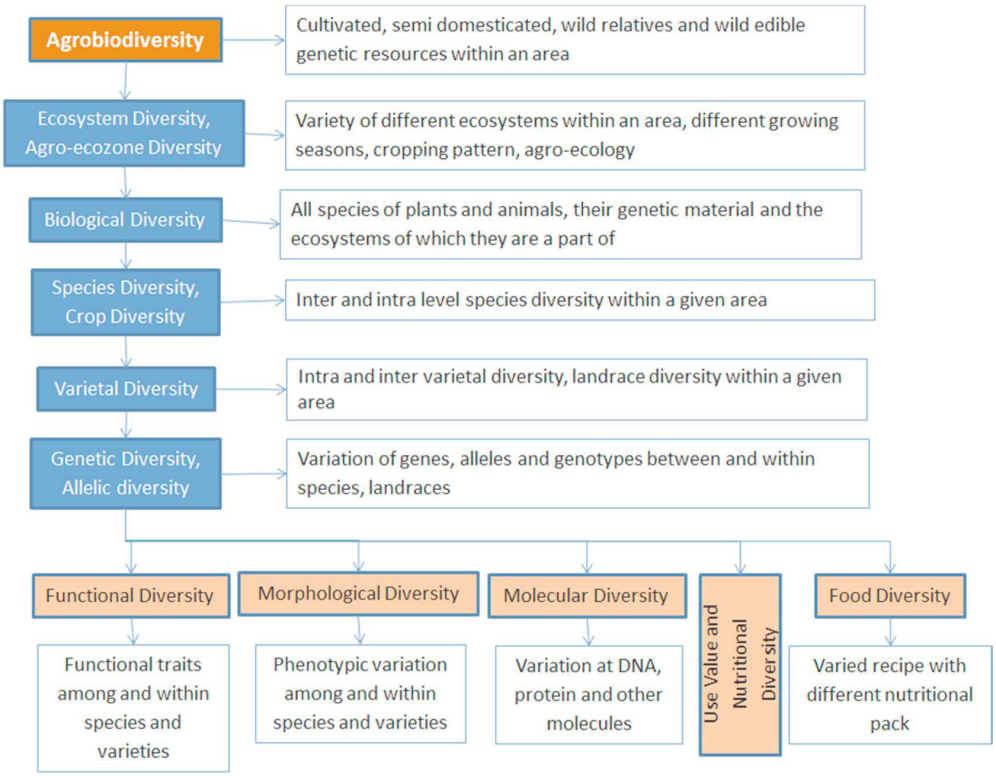


**Figure 2. Levels and types of diversity within agricultural genetic resources.**

Measuring patterns of landrace occurrence is the simplest basis for measuring the population structure of a particular species. Classification of landraces is common and easy based on growing areas and number of growing household. These two measures classify each landrace according to whether or not it is widespread (occurs in more than a few fields) versus localized (restricted to a few fields), and secondly whether it is common (here defined as grown at least on some farms, in large numbers, in above-average field sizes) versus rare (in small fields only).

Diversity changes over time and space are also estimated using different diversity measures. Both spatial and temporal changes are important for monitoring and applying appropriate methods of conservation.

**Table 2. Different measures for on-farm agrobiodiversity measurement**

| SN | Diversity Measure | Description | Remarks |
|---|---|---|---|
| 1. | Chi square ($?^2$) | Tests for comparing two sets of data, for example comparing two varieties or two populations for disease resistance classes, or comparing observed phenotypic classes in one population with the expected series | Comparison of a local population to a known established variety for a qualitative trait distributed according to classes such as flower color |
| 2. | Cluster analysis | Group entities with similar characteristics into categories. Methods may be hierarchical, resulting in a dendrogram, or non-hierarchical, resulting simply in groups of similar samples | There are numerous different clustering algorithms, which often lead to quite different results with the same data set |
| 3. | Crop groups | Number of crop groups based on different criteria eg use value base, economic importance base national list base, habitat base, red list base, growing season base, national priority base, etc. higher the number of such groups, indicate higher diversity, | Examples are cereals, vegetables fruits, released variety, registered variety, major, minor, primary, secondary, staple, commodity, high value, commercial, industrial, food crops, feed crops, manuring crops, pesticidal plants, cash crops, cover crops, trap crops, catch crop, , cultivated, semi domesticated, wild edible, field crops, garden crops, aquatic plants, common, rare, endangered, extinct, localized, vulnerable, winter crops, summer crops, off-season |

| SN | Diversity Measure | Description | Remarks |
|---|---|---|---|
| 4. | Cropping patterns | Number of different cropping pattern | Indicates number of species, variation in growing seasons |
| 2. | Cluster analysis | Group entities with similar characteristics into categories. Methods may be hierarchical, resulting in a dendrogram, or non-hierarchical, resulting simply in groups of similar samples | There are numerous different clustering algorithms, which often lead to quite different results with the same data set |
| 5. | Coefficient of Variation (CV) | Quantifying diversity using quantitative agromorphological data. Expresses sample variability relative to the mean of the sample –it is also called a measure of relative variability or relative dispersion | For comparing diversity across groups |
| 6. | Dissimilarity coefficients | Measure the degree to which two populations or individuals are different in composition | Examples are Euclidean distances, Mahalanobis' generalized distance |
| 7. | Distinctness | Not identical | The range of variation found |
| 8. | Evenness (species, cultivar) | The frequency of occurrence, observations distributed evenly among categories result in high diversity | Distribution of the different classes (eg % area covered by each variety of a crop in a given village) |
| 9. | F-test and ANOVA | Quantifying diversity using quantitative data | Used to estimate genetic variance between entities (varieties, populations, regions, sites |
| 10. | Growing season | Number of crop growing time and seasonal variation | Higher number of growing seasons indicates higher varietal and species diversity |
| 11. | Household Diversity Index (HDI) | Estimate following Shannon-Weaver Index method | Total diversity maintained by each farmers, considering either species of different categories or varietal traits categories |
| 12. | Land type and habitat | Different types of land and habitat in an area | As number of different number of land type increase, diversity at varietal and species level increased |
| 13. | Mean | Average of all values of the a variable | Compare mean of different samples |

| SN | Diversity Measure | Description | Remarks |
|---|---|---|---|
| 14. | Minimum, maximum value | Largest and smallest value | Compare among species and landraces |
| 15. | Morpho type | Groping of species or landraces based on their outlook | Consider all traits at a time to define morpho type |
| 16. | Percentage and frequency | A display of data that specifies the percentage of observations that exist for each data point or grouping of data points | Useful method of expressing the relative frequency of survey responses and other data |
| 17. | Principal component analysis | Similarity or dissimilarity coefficients based ordination method, scatter plotting of observations based on their diversity values | Explain the variance-covariance structure of a set of variables through linear combinations. It is often used as a dimensionality-reduction technique |
| 18. | Range | The difference between the lowest and highest values | Shows how much the numbers in a set vary |
| 19. | Red list | Name list of genetic resources (at genotype, landrace, variety, strain and breed levels) under different groups based on the analysis of distribution and population size (also called five cell analysis), and trait distribution | Conservation status group eg common, vulnerable, rare, endangered, localized, unique |
| 20. | Richness (species, cultivar) | Take into account the number of species, landraces, any functional unit or objects | Number of types (eg crops, varieties, traits, genes), species richness, varietal richness |
| 21. | Shannon Diversity Index (H') | Take into account the number of species (the richness) and their relative contribution (the evenness) | Diversity index for qualitative data |
| 22. | Similarity coefficients | Measure the degree to which the populations of samples are alike | Simple matching coefficients, Jaccard's coefficient |
| 23. | Simpson's index (D) | Take into account the number of species (the richness) and their relative contribution (the evenness) | Quantifying diversity using qualitative data, diversity index |
| 24. | Species density | Take into account the number of species in an area, landrace density may also be estimated | Number of species in a sample area |
| 25. | Trend analysis | Temporal and spatial analysis on status and changes in agrobiodiversity | Regular estimate of different diversity measures over time and space, useful for monitoring diversity status |

| SN | Diversity Measure | Description | Remarks |
|---|---|---|---|
| 26. | Center of diversity | Presence of crop wild relatives near to site | Indicates areas with wild relatives a higher diversity for this species |
| 27. | Use value (food items | Types of different local food items and other cultural and social values made from locally available agricultural genetic resources | Higher agrobiodiversity means more number of different types of foods and use values |
| 28. | Variation and standard deviation | The average of the squared differences from the mean. the average difference between the arithmetic mean and the value of each observation in a data set | Measures of spread |

### On-farm Conservation Approaches

Three strategies ie breeding, in-situ and on-farm are considered at local level for overall conservation and utilization of agrobiodiversity. Different methods and approaches for on-farm conservation are given in Figure 2. All or any of these are applied and among them community seed bank is very common for management of crop diversity. In all these approaches, local and native genetic resources are considered. Farmers, communities, farmer groups and local stakeholders need to actively participate.

## D. Advantages and Disadvantages

### Advantages

- Many options (simple to complex) to measure and monitor agrobiodiversity
- Any level (crop, plot, farmer, village, etc) can be considered for estimate
- Useful to compare diversity among crops, village and districts
- Farmers and agriculturist involve equally to estimate and assess the diversity
- Different farmers, group of farmers can choose any conservation approaches and these are simple and cost effective
- Easy access to diversity and accelerate the germplasm flow
- Conservation through use continue the evolutionary process

### Disadvantages

- Need to consider multiple approaches and dimension to estimate and collect data
- Take more time and human resources
- Information collected on native genetic resources might further be needed to verify

- Difficult to demark the areas for analysis of diversity. Area coverage is based on administrative rather than adaptation of genetic resources
- In some cases, technical expertise are needed
- Strong collaborations are needed.

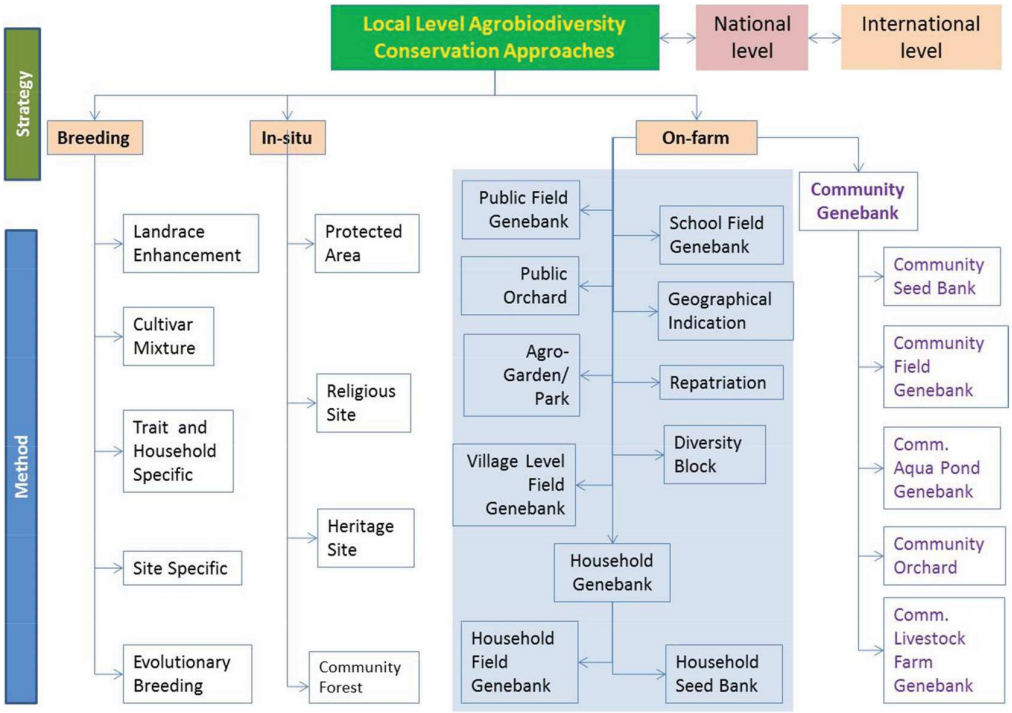


**Figure 3. Agrobiodiversity conservation approaches and methods at local level adopted in Nepal.**

*Source: Joshi and Upadhyay 2019*

## E. Success Cases

Many diversity measures and indices are estimated for different sites and crop species and landraces. Most commonly used measures are analysis of variance, mean, SD, multivariate analysis, and Shannon-Weaver index. Information is available from species to landraces to genes levels of rice, bean, proso millet, finger millet, amaranth, buckwheat, naked barley, foxtail millet, etc. Native and local crop genetic resources are being conserved through community seed bank in Humla, Jumla, Lamjung and Dolakha. Linkage among stakeholders is established for in-situ conservation. Local landraces have been genetically enhanced through participatory approaches. Some such landraces are got registered. Custodian farmers are identified and household genebank are established along with community field genebank.

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