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Agricultural Plant Genetic Resources Management and Agriculture in Nepal

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Agricultural Biodiversity and Climatic Variation

Nepal is rich in agricultural biodiversity (BPP 1995, HMG/MFSC 2002, Upadhaya and Joshi 2003). The nation holds less than 0.1% of earth's land mass, however, supports 2.2% of flowering plants, 1.4% of reptiles, 2.2% of fish, 8.5% of birds, 4.2% of butterflies and 4% of mammals (Figure 1). Estimated number of angiosperm species endemic to Nepal is 246 (Figure 2). Among the total angiosperm families in the world, almost 50% are represented in Nepal. The Biodiversity Profiles Project (BPP 1995) ranked Nepal as having the tenth richest flowering plant diversity in Asia and 31st in world. Diversity in edible genetic resources indicates availability of 599 species, of which 225 indigenous species are under cultivation (Figure 3).

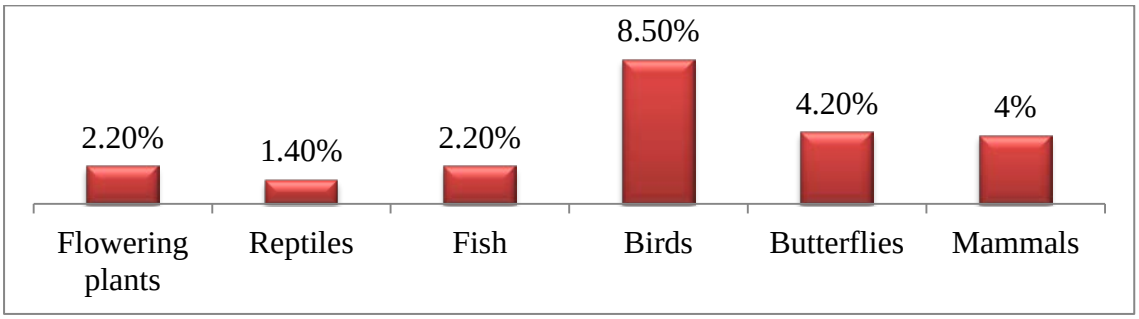

Figure 1. Representative percentage of total biodiversity of the world in Nepal (Land share of Nepal in earth is 0.1%).

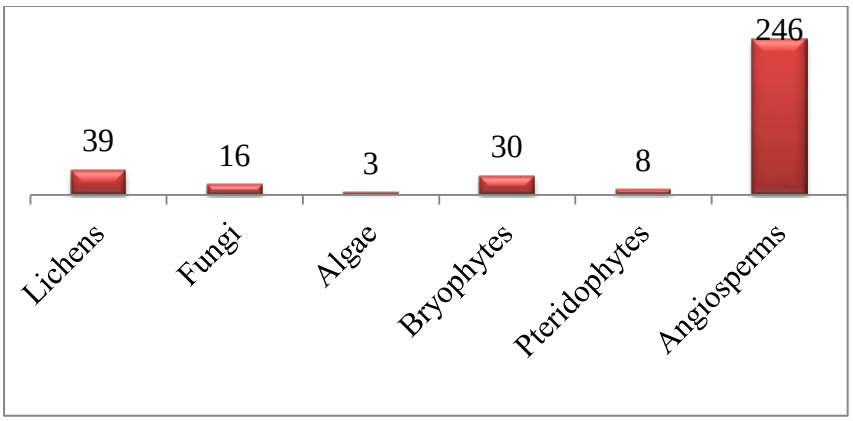

Figure 2. Estimated number of endemic species to Nepal.

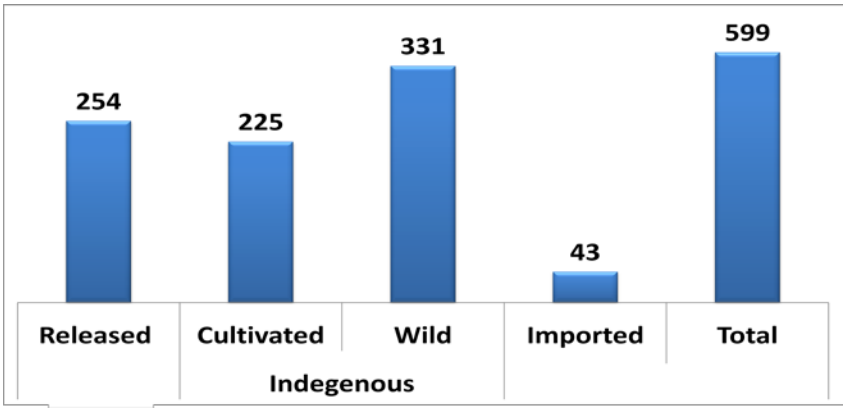

Figure 3. Estimated number of food plant species in Nepal.

Agro-biodiversity in Nepal is mainly due to diverse climatic variation (Figure 4) and diverse culture. Three agro-ecological zones ie Tarai, Mid Hill and High Hill experience a wide range of climate from tropical to temperate and arctic. The variation is mainly attributed to immense changes in elevation with the greatest range of altitude on Earth, from 60 to 8848 masl. However, large degree of genetic erosion is evident in major food crops that are the basis of food and nutrition security and livelihood of Nepalese people. It is estimated that 50% of traditional varieties have disappeared from farmers' field and existing landraces could be in an endangered condition (Joshi et al 2004, Joshi et al 2005). Therefore, priority is given to conservation and sustainable utilization of the plant genetic resources for food and agriculture (PGRFA) in the country. Genebank activities are now being systematically carried out considering the following conditions in the country (Bhatta 2012).

- Most of old collections (collections before 2010) need to regenerate
- Necessary to recollect from the old collection sites due to non-viability of most of the old collections
- Existence of landraces in most of the farming communities in Mid and High Hills of Nepal
- Poor utilization of genetic resources due to limited information on plant genetic resources (need to characterize)
- Poor governance mechanism of PGR
- Limited traits information both at phenotypic and genotypic levels
- Need to conserve all kinds of PGR eg orthodox types, recalcitrant types and vegetatively propagated crop species

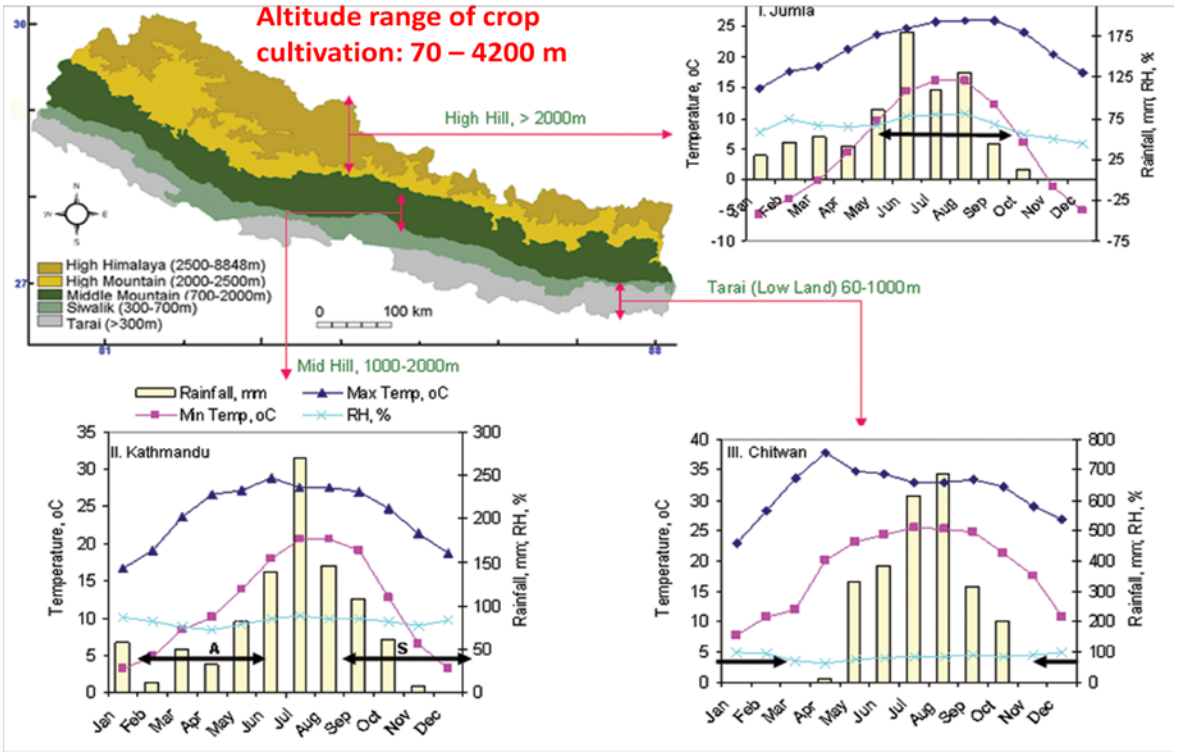

Figure 4. Three agro-ecozones in Nepal and their representative site with climate (Joshi 2008).

National Agriculture Genetic Resources Center (Genebank)

Realizing the significance role of agricultural genetic resources in food security and national economic development and to meet the national obligation of implementing international agreements (the Convention on Biological Diversity 1992 and International Treaty on Plant Genetic Resources for Food and Agriculture 2004), the Government of Nepal (GoN) and Nepal Agricultural Research Council (NARC) has established the National Agriculture Genetic Resources Center (Genebank) in 2010 for conservation and utilization of agro-biodiversity.

A total of 2.4 ha is allocated for this Center. Out of 2.4 ha, Genebank building has occupied 0.092 ha, 0.26 ha is allocated for Field Genebank and 0.83 ha for regeneration, multiplication, characterization, evaluation and post quarantine activities. The Centre has considered the diverse strategies ie ex-situ, on-farm and in-situ for management of agricultural genetic resources (Joshi et al 2012a).

In addition to these strategies, Genebank has encouraged other existing supplementary mechanisms for conserving agro-biodiversity in Nepal. Existing supplementary mechanisms are i. Ritual practices of Hindu with regards to some plants, ii. Culturally protected areas (temple and other religious places), iii. Leasehold, community and private forests, vi. Farmers seed network system and vii. Protection of some plant species.

With the financial support of GoN and RDA, Korea and other organizations, following facilities have been created in the Genebank (Joshi et al 2012a).

- **Short Term Storage**: Cold store room (called Active Collection Room, ACR) with 4-10^{o}C and 35-45% RH for storing about 50,000 accessions for 5-10 years.
- **In-vitro Culture Lab and Tissue Bank**: Facility for tissue culture and in-vitro cold storage.

- **Field Genebank**: Field plots within Khumaltar, at different NARC stations, and along the road and around the office buildings and premises.
- **Molecular Research Lab**: Facility for DNA works eg genotyping, genetic diversity assessing, identification (DNA fingerprinting, marker assisted selection), genes mapping and tagging.
- **Seed Testing and Processing Lab**: Facilities for seed cleaning, health testing, viability testing, drying and characterizing.
- **Experimental Plot**: Fields for diversity blocks, regeneration, multiplication, characterization and evaluation.
- **Database Management**: Facilities for passport, management, characterization, evaluation, pre-breeding, genotyping and utilization data.

1. Status of Plant Genetic Resources Management System

NAGRC has been following diverse strategies to manage the available agricultural plant genetic resources in the country. After the establishment of Genebank in 2010, following the strategies have been considered.

1.1a. Strategy: Conservation Method

1. Ex-situ conservation
   - Seed Bank, Tissue Bank, Cryo Bank, DNA Bank
   - Field Genebank, Botanical garden, Zoological gardens, Farms/Parks
2. On-farm conservation
   - Household Seed Bank, Kitchen Garden,
   - Community Seed Bank, Community Field Genebank
   - Landrace Enhancement
3. In-situ conservation
   - Protected areas (National parks, Conservation areas, Wildlife reserves, Hunting reserve)
   - World heritage sites, Ramsar sites and Religious places
4. Breeding strategies
   - Evolutionary vs non-evolutionary
   - Diversity vs uniformity
   - Specific vs wide adaptation

1.1b. Strategy: Conservation efforts at all levels

1. Local Level: Conservation should start from the grassroots. All local level communities should be involved in the management of genetic resources. Therefore, NAGRC has started to support Households, Community Seed Banks, Community Field Genebanks for conserving available local resources at the local level. We encourage the community to consider Religious Sites as an conservation site for wild edible plants.
2. National Level: Currently there are National Genebank for ex-situ conservation and Protected Areas, Ramsar, World Heritage Sites for in-situ conservation. Different farmers of Department of Agriculture and NARC have been considered to establish the Field Genebank.
3. International Level: Collaboration has been established with different international organizations for effectively conserving and utilizing the genetic resources. Regular interactions at international level, have strengthened the activities of NAGRC. As a safely duplicates, some accessions have been sent to CG banks.

1.1c. Strategy: Types and Groups of Genetic Resources

Genetic resources that are being considered for conservation are Landraces, Modern varieties, Obsolete varieties, Breeding lines, Recombinant inbred lines (RILs), Genetic stocks, Near isogenic lines (NILs), Differential lines, Exotic genetic resources, Wild and wild relatives and Wild edible plants. These genetic resources are grouped based on the economic values as Cereals, Millets, Pulses, Vegetables, Fruits, Fibers, Oil seeds, Spices and Beverages. Based on the conservation strategy, all agricultural genetic resources are grouped as i. Orthodox seeds (can dry up to 3-7% moisture depending upon crop species), ii. Recalcitrant seeds (can't dry lower than 12-31% moisture) and iii. Vegetatively propagated crops and apomictic plants.

1.2. Guiding Documents and Genebank Guidelines

Genebank follows the rules and regulations of the Government of Nepal and support to formulate the policy guidelines. Main guiding document are National Agriculture Policy 2004, National Agricultural Biodiversity Policy 2007, CBD 1993 and ITPGRFA 2009.

To run the activities smoothly, Genebank has developed its own guidelines. There are 5 units in the Genebank (Figure 5). Each Unit is responsible for different activities. Operational flow chart of the Genebank has been developed and published based on the Genebank Standard of different countries including FAO (Joshi and Bhatta 2012a). Majority of the activities are now effectively executed. During exploration and collections, there were many issues including sampling strategies and identifying the samples. Therefore, exploration and collection guidelines are developed (Figure 6). Other guidelines developed by the Genebank are regeneration and characterization guideline for old accessions, field genebank guidelines, crop calendar, prioritizing method of genetic resources and database management.

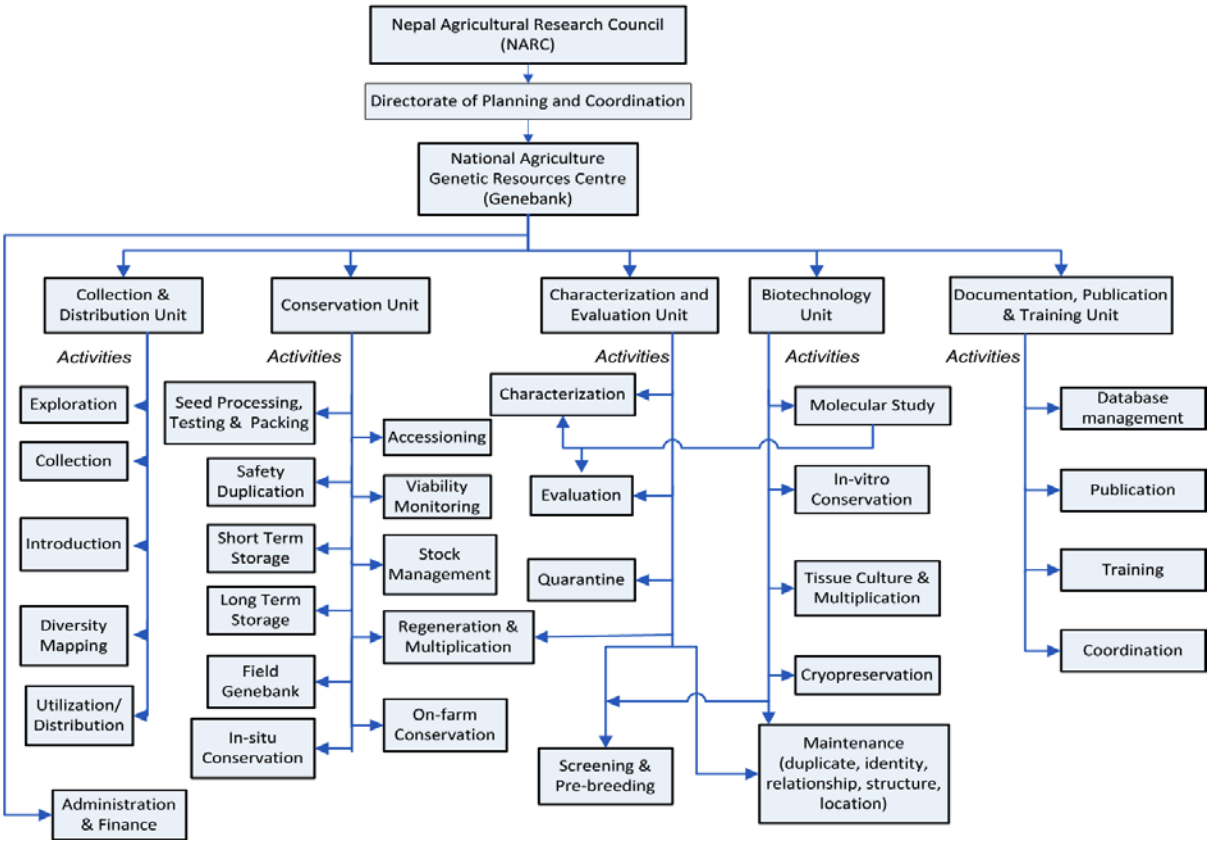

Figure 5. Structure of Genebank and major activities (Joshi et al 2012).

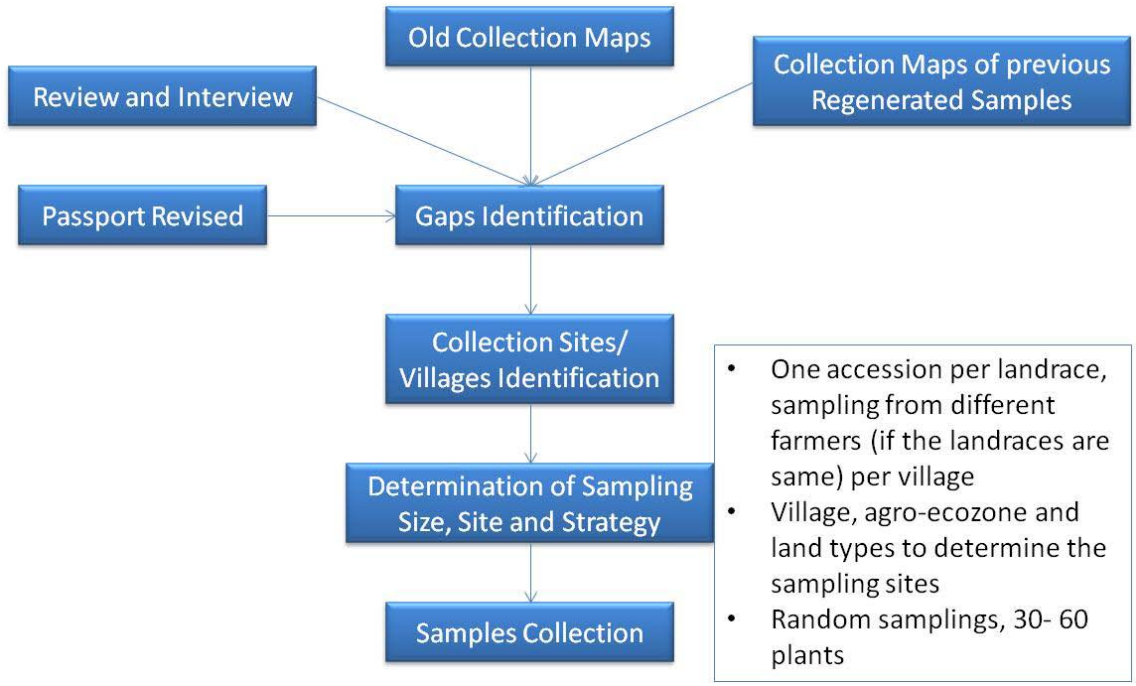

Figure 6. Steps followed during exploration and collections (Joshi et al 2013).

1.3. Conservation System and Status

Exploration and Collection: Collections before 2010 are mostly dead due to poor storage facility. Diversity and gap analyses were done based on the old as well as new collections and literature review. The common step followed for exploration and collection are given in Figure 6 (Joshi and Bhatta 2012b). Old collection sites as well new sites have been regularly explored and collected the PGR. After 2010, a total of 30 exploration and collection missions have been carried out in 218 village development committees of 37 districts from where, 85 species were collected including both orthodox and recalcitrant types. Genebank-NARC has requested to all NARC stations to collaborate during exploration and collections of PGR and requested to send all PGR available in the station.

1.3a. Seed Bank: Under the ex-situ conservation of orthodox seeds, more than 9,000 accessions are conserved in seed bank (Figure 7) along with their passport and characterization data. One of the seed rack is allocated for conserving breeders' materials as black box system. Breeder who has good materials and could not store for longer period and could not regenerate annually can use the space.

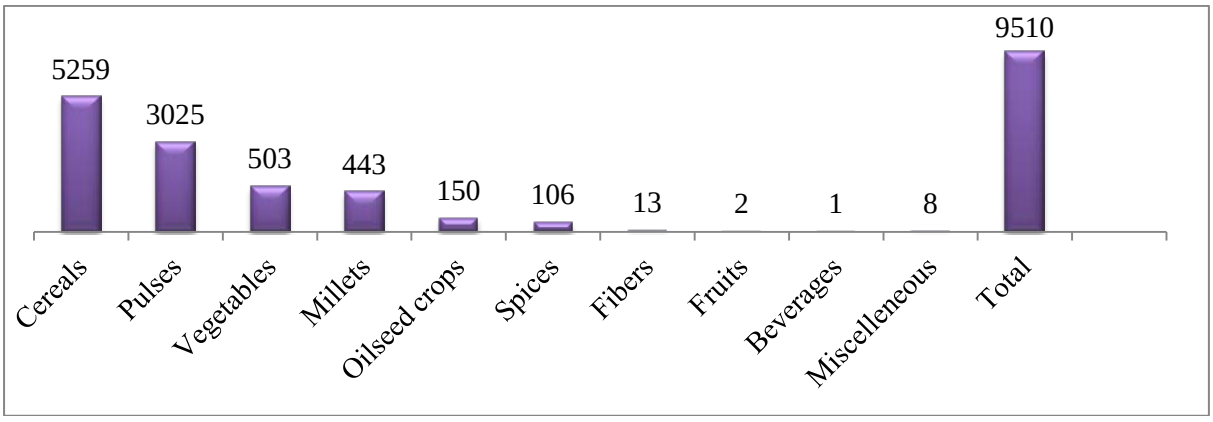

Figure 7. Total accessions of different crop species conserved in Genebank.

1.3b. Tissue Bank: To conserve the recalcitrant types of crop species and vegetatively propagated crop species, Tissue Bank has been established. Protocols for potato, sweet potato, banana, sugarcane, taro and cardamom have been verified. Currently 11 accessions of potato both local and improved are being conserved as plantlets in tube using MS media.

1.3c. DNA Bank and Molecular Research Lab: With the financial support form Korea, facility is created for molecular research and tissue culture. The extracted DNA samples have been started to keep in deep fridge at -40^{o}C as a DNA bank. DNA work is focused on diversity assessment, identification and genes tagging and mapping. DNA works has been initiated in sugarcane and large cardamom with RAPD and SSR markers. Some of research works in the lab are linked with the master thesis of University students. Currently there are now four students.

1.3d. Field Genebank: There are about 45 accessions in field genebank in Khumaltar. Field genebank is eessential for those crop species having recalcitrant seeds and vegetatively propagated and apomictic crop species for conservation, characterization, evaluation and utilization. NARC has therefore, started establishing sub field genebanks in its all research stations across the country (Figure 8). As a sub field genebank, there are 29 accessions of taro in Agricultural Research Station, Pokhara.

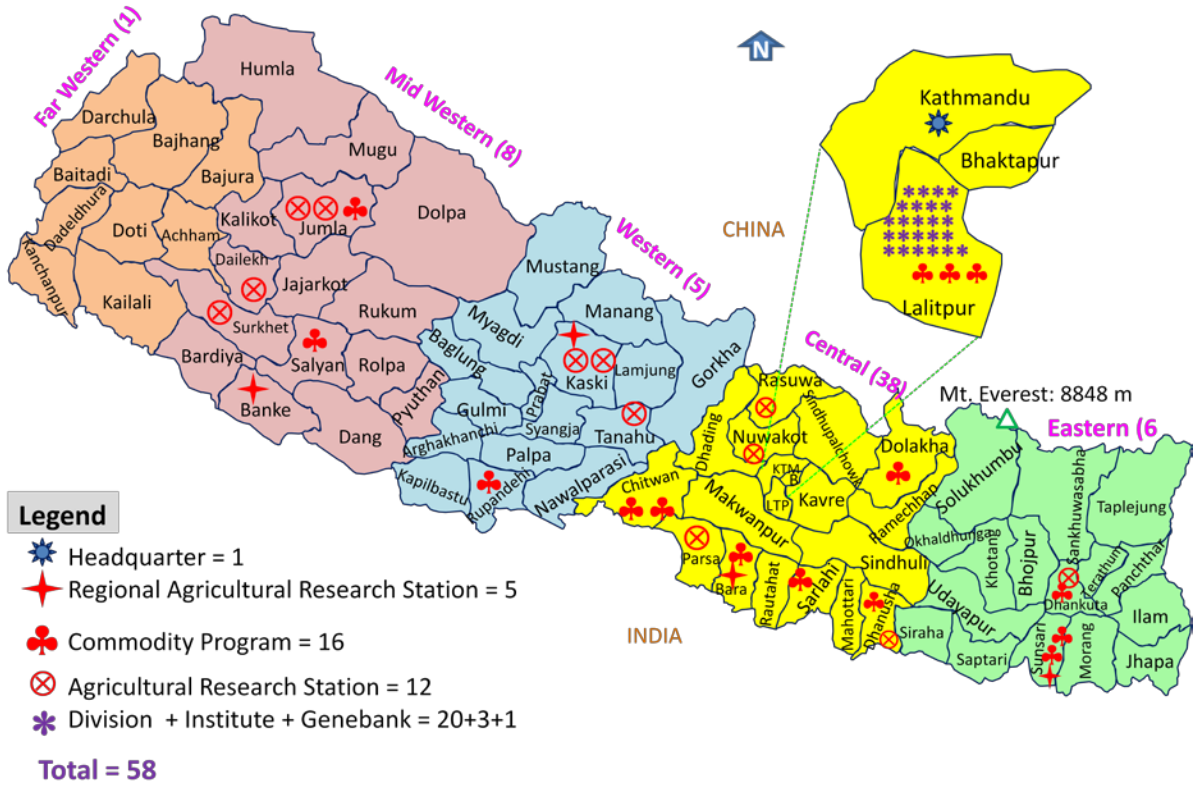

Figure 8. Country map showing NARC stations where Field Genebank is planned to established.

1.3e. On-Farm Conservation: It is a dynamic conservation of local and important crop varieties in farming community. Local landraces are being conserved through supporting community seed bank (CSB) and community field genebank (CFGB), by promoting kitchen garden, by strengthening household seed bank, by enhancing genetics of landraces, by recognizing diversity rich farmers and by strengthening seed networks. Among more than

115 community seed banks in the country (Figure 9), four CSBs (Dalchowki CSB, Kachowra CSB, Simariya CSB and Gadhariya CSB) have been strengthened for conservation and sustainable utilization of local genetic resources. Collections of these four CSBs have been conserved in the Genebank. Diversity fairs and diversity blocks are the major activities to collect and maintain the varieties in CSB. Guidelines for CSB and CFGB have been developed and given to the community. The community in Gadhariya, Kailali has established CFGB with 76 accessions of mango in 5.5 ha of land. Similar kind of work has also been started in Kachorwa and Dalchowki.

Figure 9. Location of community seed bank in the country (Joshi 2012).

1.3f. Nepalese Germplasm under Global Crop Gene Pools: After the establishment of NAGRC, a total of 1727 accessions of 8 crop species have been safely duplicated in different CG banks (Figure 10).

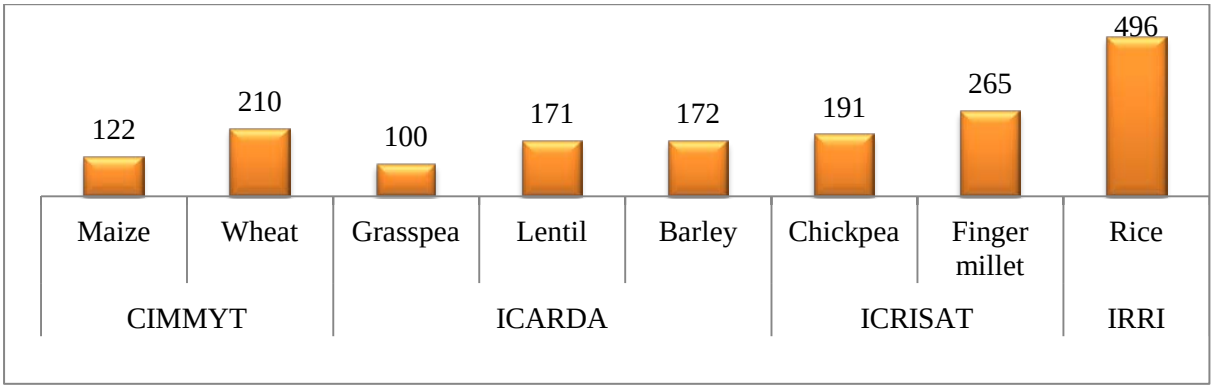

Figure 10. Total accessions of 8 crop species safely duplicated in CG banks after becoming Nepal party to the ITPGRFA.

1.3g. Documentation and Database Management: Passport descriptors for multiple crops have been standardized after two-day workshop. Data format for passport and

characterization have been developed based on the field experiences. A system of data checking is also established so that further analysis could be more effective and accurate. Passport data of 9559 accessions and characterization data of 3498 accessions are in excel. These data will be available in www.genebank-narc.gov.np. Genebank is planning to document all kinds of data associated with PGR as given in Figure 11 (Joshi et al 2012a).

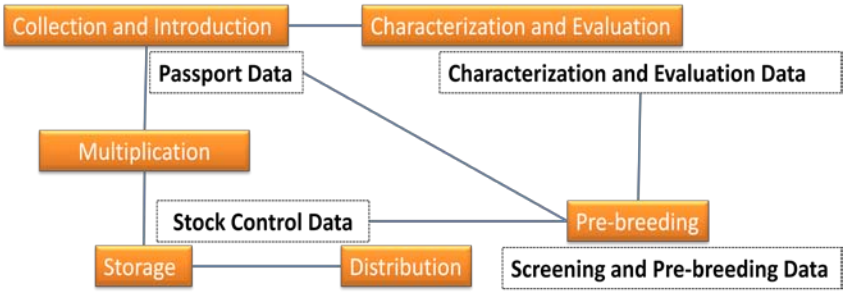

Figure 11. Types of data planned to document in the genebank.

1.4. Research Status

- **Diversity mapping and GIS application:** Before collections, gaps analysis has been done for major crops based on the old collection maps (Joshi 2004, Joshi et al 2006, Joshi et al 2008, Joshi 2008), regenerated old collections maps and review and interview using GIS software. Diversity map of rice, barley, buckwheat, wheat, wild rice, etc has been developed.

- **Characterization and evaluation:** There were a total of 10,781 old accessions. Among them, only 3126 accessions were regenerated and 5505 were found non-viable. Most of the accessions which went to regeneration and multiplication plots were characterized and evaluated using standard descriptors. For characterization, field books were prepared based on the descriptors developed by Bioversity International and national requirements. The ccharacterized and multiplied accessions were 3498 and 2604 respectively. The number of accessions characterized and evaluated in each crop is given in Figure 12. Both phenotypic and genotypic data will soon be available for most of the collections.

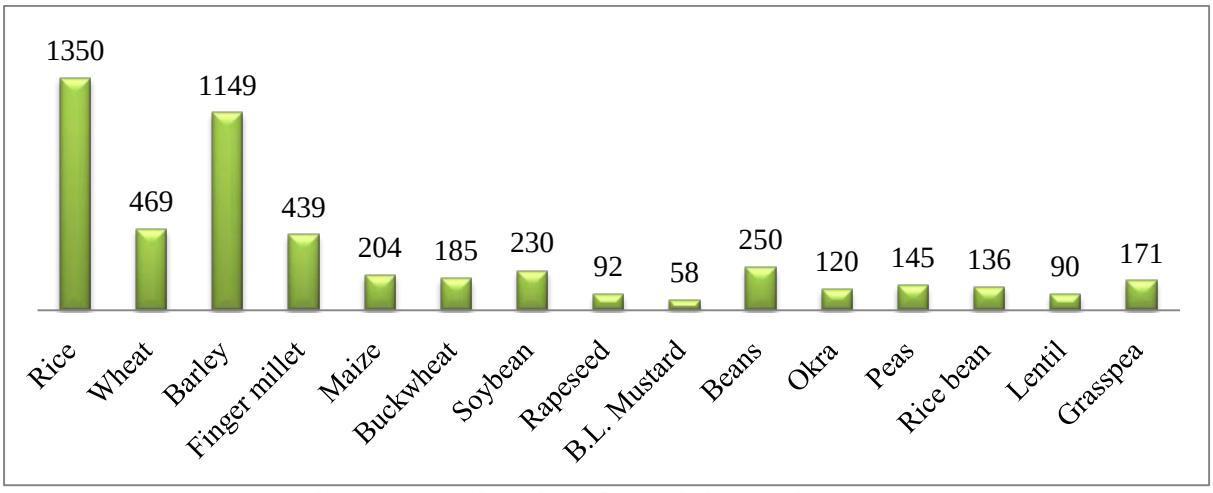

Figure 12. Accessions characterized and evaluated during last 3 years

- **Trait distribution study to identify unique genetic resources:** During characterization, trait distribution across the landraces is studied. If trait is found only in a particular landrace, this landrace is grouped as unique. There are many such types of landraces and some are given in Table 1.

Table 1. Some unique agricultural plant genetic resources (Upadhaya and Joshi 2003, Joshi 2008, Joshi 2005)

Crop	Landrace	Uniqueness
Rice	Gamadi	Panicle matured within flag leaf
	Mansara	Adopted to very marginalized land
	Bhati	Deep water rice
	Pakhe Masino, Makar Kandhu	Hiunde (winter) rice
	Ekle rice	Zn deficiency tolerance
	Jumli Marshi	Cold tolerance rice
	Amaghauj	Multiple spikelets per node
Wheat	Mudule	Very sweet wheat
	Dabde local	For low fertility and moisture deficient land
Finger millet	Dailekh local	High yielder, adapted to low fertility land
Cauliflower	Dalchwoki local (Garve Cauli)	Very large head, perennility gene
Chilly	Jire	All year round fruiting
	Ranga/ Akabare	Medicinal value
Sarsim	Gorlikhorka	Highest oil content
Buckwheat	Bhate Phaper	Loose husk
	Kagpani, Tatopani	Highest rutin content

- **Duplicates identification:** Duplication identification and merging them have been started. For this, passport descriptors of all subjected accessions are compared. Then team of Genebank visit field to look the similarity among accessions. Genebank has planned to use the following data for identification of duplicates.
  - Phenotypic and genotypic data
  - Standing crop inspection
  - Group discussion including farmers

- **Diversity study:** After generating the phenotypic and genotypic data including both quan-qualitative data, accessions are grouped using multivariate analysis technique specially cluster and principal component. Diversity was studied in rice, sugarcane, large cardamom, buckwheat and wheat. Diversity at on-farm level has also been studied (Joshi et al 2012b).

- **Pre-breeding, landrace enhancement and participatory varietal selection:** To facilitate the crop improvement work, genebank has started pre-breeding work, landrace enhancement (Joshi 2012) and participatory varietal selection in rice, wheat, broad leaf mustard and buckwheat. Such kinds of works will be expanded to other crops.

- **Developing documents for ownership:** Considering ITPGRFA and CBD, there is need of developing evidence of where the distinct form of landraces is developed. Many of the farmers and policy makers also raised issue about the ownership. Therefore, Genebank has planned to develop the following documents as an evidence of ownership for a particular landrace.
  - Archeological evidence and evolutionary history
  - Phenotypic and genotypic data
  - Distinct form developed site and its maintenance and use by locals
  - Values in relation to geo-location and culture

Utilization and Distribution: Genebank facilitates for utilization by providing easy access to PGR and databases, strengthens utilization with elite line development, collaborative marker assisted selection, tagging and mapping genes, screening germplasm, pre-breeding works and collaborations. The total accessions distributed are given in Figure 13.

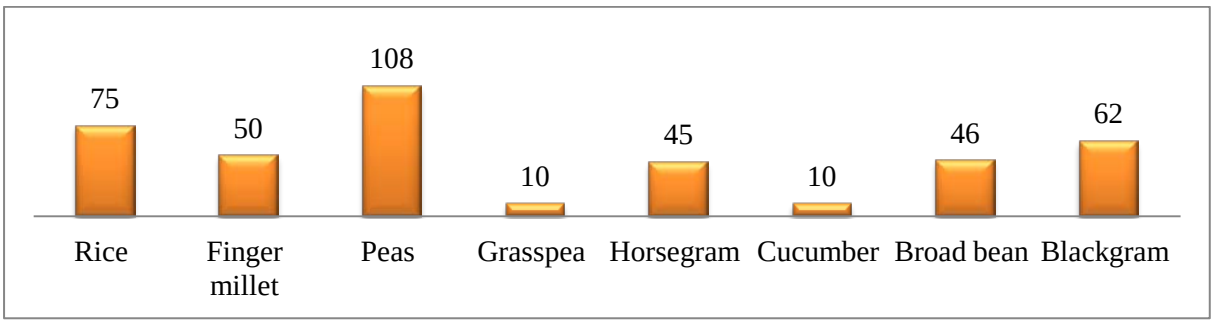

Figure 13. Accessions distributed for research.

1.5. Main Issues (or Challenges) in PGR Management

Farmers not interested to provide seed samples: During collections of seeds and associated information, farmers are requested to provide free of cost. Most of the farmers were found not willingness to provide seeds samples and associated knowledge.

Diversity not captured due to very few seeds from farmers: Collections are generally from farm store. Farmers generally provide few seeds especially of vegetable crop species and not interested to give enough seeds. We have to multiply the seeds from them. Due to the limited sample size, diversity within a landrace could not be captured during collections.

Collections not from standing crops: Collections are more effective from standing crops to capture diversity as much as possible, to identify the samples and to get enough seeds so that collections can be directly conserved in short and long term storage without seeds multiplication. However, most of the collections are from farm store.

Difficulty on identifying samples: Due to limited knowledge on taxonomy and local languages, collectors are frequently facing problems on recognizing the samples in the field as well as farmer's given samples. Sometime, farmers provide seeds sample with wrong name.

Difficulty on duplicates identification and possibility of collecting many duplicates: Names of same landrace may be different among and even within a village among different cast. In such condition, there remain to collect many duplicates. In some cases, donors and

recipients may place emphasis on increasing the number of accessions, which leads to collect many samples within limited areas and from few farmers.

Difficulty on marking sampling sites and sampling method: Due to the lack of clear guidelines applicable to different crop species and locations, collectors always face problem for identifying sampling sites and sampling methods.

Insect pest and disease problems in seeds: Seed health testing has not been started due to which there may be possibility to damage seeds and to get problems in regeneration.

Seed setting problem during regeneration: Many accessions of rice and grain legumes regenerated in Khumaltar-Kathmandu and Rampur-Chitwan could not set the seeds. This may be due to low or high temperature and short or long photoperiod. Appropriate locations need to identify for regeneration of different accessions. This can be done using the passport data and GIS but many of accessions of old collections do not have complete passport.

Non-viability of old collections: Many of the old collections are found non-viable. It needs to revisit the locations for collections.

Lack of glasshouse facility: Collections are from tropical to temperate areas, therefore, temperature adjustable glasshouse is necessary to regenerate these collections. Regeneration activity could not bet carried out effectively.

Lack of facility for base collections: Maintaining seed viability is a critical gene bank function that ensures germplasm is available to users and is genetically representative of the population from which it was acquired (ie the most-original-sample). A critical objective of seed drying and storage standards is to reduce the frequency of regeneration of the most-original-sample by maximizing seed longevity, thereby reducing the cost of gene banking and the risks of genetic erosion. For this purpose, long-term storage is required for all most-original samples and for safety duplication of the collection. Storage at -20^{o}C has been recommended for long-term storage as it is the lowest temperature that can be achieved with a single stage standard deep freezer compressor. Long-term storage conditions as recommended are expected to provide high seed quality for about 100 years for seed of most agronomic species. However, Genebank-NARC has deep-freezers for base collections preservation. Due to the frosting in deep freezers, seeds preserved in deep freezers are not considered safe. Due to the problems with deep freezers for handling seeds, storage room with temperature and RH adjustable is more effective. Therefore, long term storage room should be created.

Lack of systematic governance mechanism of PGR in the country: Information among organizations is lacking due to weak coordination. There is lack of systematic flow of germplasm and information. Due to the lacking of governance mechanism of PGRFA, germplasm flows outside and inside the country are not systematic and well documented. Many organizations collect, introduce and distribute PGRFA independently.

Poor utilization of indigenous PGR (lack of accessible database): Local plant genetic resources have been negligibly used in the breeding program. The impacts of local germplams on food security therefore, are minimum. This is mainly due to the unavailability of characterization and evaluation data of conserved germplasms and lack of elite-lines.

Limited technical manpower and financial resources: Due to the limited manpower and financial resources, all the activities envisioned in Genebank have not been become more effective and efficient.

Accessioning system of agricultural genetic resources not strong: All genetic resources that come in the Genebank are assigned a unique identity number, which is always used for further handling eg regeneration, characterization, distribution, etc. All data eg passport, characterization, evaluation, pre-breeding data, etc of each accession are linked with this accession number. Accession number is the only way to trace the genetics of any collections in presence and future. Genotypes are always identified with this number and any researchers can use this number from anywhere and at any time, to request seeds, information, to report its genetic status, to trace the research history, etc. However, accessioning (giving accession number to each collection) and doing research based on the accession number are not common in Nepal. Usually, each research station/ organization assigned their own number, and later, it could be difficult to get seeds and other information based on this temporarily assigned number.

1.6. Public and Private Research Organizations for PGR Management

A. Organizations

Followings are the public and private organizations for PGR management in Nepal.

1. National Genebanks
    a. NAGRC
    b. NAST Genebank
    c. Himalayan Seed Bank
2. Department of Agriculture under MoAD, other Departments and University
    a. Horticulture Farm, Solukhumbu
    b. Extensive Horticulture Farm, Sarlahi
    c. Horticulture Farm, Sindhuli
    d. Horticulture Farm, Panchkhal
    e. Horticulture farm, Godawari
    f. Horticulture Centre, Kirtipur
    g. Horticulture farm, Trishuli
    h. Horticulture Farm, Daman
    i. Horticulture Farm, Boch, Dolakha
    j. Horticulture Farm, Marpha, Mustang
    k. Horticulture Farm, Palpa
    l. Horticulture Farm, Jumla
    m. Horticulture Farm, Dadeldhura
    n. Horticulture Farm, Dailekh
    o. Horticulture Farm, Baitadi
    p. Horticulture Farm, Humla
    q. Root/ tubers crop development center, Sindhuli
    r. Vegetable Development Farm, Khumaltar
    s. Nucleus Potato Center, Nigale, Dolakha
    t. Vegetable Development Farm, Rukum
    u. Horticulture Farm, Yagyapuri, Chitawan
    v. Pasture and Grasses Seed Production Farms, Janakpur; Ranjitpur, Sarlahi; Gaughat, Banke

w. Tissue Culture Laboratory, National Herbarium and Plant Laboratory, Godavari, Department of Plant Resources
x. Central Department of Botany, Tribuvan University, Kirtipur, Kathmandu
y. Himalayan Collage of Agricultural Science and Technology (HICAST), Purbanchal University, Kalanki, Kathmandu
z. AFU, Rampur, Chitwan
aa. IAAS, Lamjung, Paklihawa, TU
bb. Kathmandu University, Dhulikhel, Kavre
cc. National Academy of Science and Technology (NAST), Khumaltar, Lalitpur
dd. Seed Quality Control Center (SQCC), Hariharbhawan, Lalitpur
ee. National Spices Development Program, Khumaltar
ff. Agriculture Inputs Company (AIC) Ltd, Teku, Kathmandu
gg. National Seed Company Ltd, Kathmandu
hh. CTEVT, Thimi, Bhaktapur

3. Regional PGR and Crop Improvement Networks
    a. South Asia Network on Plant Genetic Resources (SANPGR)
    b. Asian Vegetable Research and Development Centre (AVRDC), Taiwan, China
    c. South Asian Association for Regional Cooperation (SAARC), Dhaka, Bangladesh
    d. Asian Network for Small Scale Agricultural Biotechnolgies, Lajimpat
    e. Asian Grain Legume Network
    f. Asia Network on Sweet Potato Genetic Resources (ANSWER)
    g. Taro Network for Southeast Asia and Oceania (TANSAO)
4. Community Genebanks
    a. Dalchowki Community Seed Bank, Lalitpur
    b. Kachorwa Community Seed Bank, Bara
    c. Simariya Community Seed Bank, Sunsari
    d. Gadhariya Community Seed Bank, Kailali
5. Plant Breeding Programs in the Public (NARC)
    a. National Rice Research Program (NRRP), Baniniya, Hardinath
    b. National Maize Research Program (NMRP), Rampur, Chitwan
    c. National Wheat Research Program (NWRP), Bhairahawa, Rupandehi
    d. National Potato Research Program (NPRP), Khumaltar, Lalitpur
    e. National Grain Legumes Research Program (NGLRP), Rampur, Chitwan
    f. National Oilseeds Research Program, Nawalpur, Sarlahi
    g. Hill Crops Research Program, Kavre, Dolakha
    h. Sugarcane Research Program, Jitpur, Bara
    i. Ginger Research Program, Salyan
    j. Citrus Research Program, Paripatle, Dhankuta
    k. Jute Research Program, Itahari, Sunsari
    l. Agriculture Botany Division, Khumaltar, Lalitpur
    m. Horticulture Research Division, Khumaltar, Kathmandu
    n. Commercial Crops Division, Khumaltar, Kathmandu
    o. Pasture and Grasses Research Division, Khumaltar, Kathmandu
    p. Regional Agricultural Research Center, Khajura, Nepalganj
    q. Agricultural Research Station, Surkhet
    r. Agricultural Research Station, Doti
    s. Agricultural Research Station, Jumla
    t. Agricultural Research Station, Dailekh
    u. Agricultural Research Station, Rajikot, Jumla

v. Regional Agricultural Research Center, Lumle
w. Agricultural Research Station, Malepatan, Pokhara
x. Regional Agricultural Research Center, Parwanipur
y. Agricultural Research Station, Rasuwa
z. Agricultural Research Station, Belachapi, Dhanusa
aa. Regional Agricultural Research Center, Tarahara
bb. Agricultural Research Station, Pakhribas, Dhankuta

6. I/NGOs and other Organizations
    a. FORWARD
    b. CEAPRED
    c. SEAN
    d. Action Aid Nepal
    e. LIBIRD
    f. Oxfam
    g. SAHAS
    h. Tissue Culture Factory, Godavari
    i. Nepal Biotech Nursery
    j. RLABB
    k. RRN
    l. Helvetas
    m. ICIMOD
    n. Nepal Permaculture Group
    o. International Corn Foundation
    p. Luthern World Federation
    q. Plan International
    r. Care Nepal
    s. Natural Resources and Agriculture Management Center
    t. Nepal Agricultural Technical Association
    u. Agriculture Enterprise Center
    v. COPP
    w. Lumbini Seed Company
    x. Universal Seed Company
    y. Anmol Biu
    z. Kalika Seed Company
    aa. Sidhartha Seed Company
    bb. Everest Seed Company
    cc. Global Agro Tech
    dd. NAF

B. Purpose and Main Activities of Organizations

- Public sector: Purpose of public sector is mainly to increase production. Main activities of public organization involved for PGR management are:
    - Ex-situ, in-situ and on-farm conservation
    - Crop improvement
    - Seed production and distribution
    - Policy formulation
    - Collaboration with national and international organizations
- Private sector: Purpose of private sector is generally to support for food security at local level and they focus mainly on the following activities.
    - Awareness and community mobilization

  - Seed production
  - Diversifying agriculture produce and marketing
- Education sector: Purpose is to develop manpower. Main activities related to PGR management under education sector are:
  - Curriculum development
  - Teaching
  - Research

C. Gaps in PGR Management between Public and Private Research Organizations

1. **Germplasm and information sharing not systematic:** Information among organizations is lacking due to weak coordination. There is lack of systematic flow of germplasm and information. One window system of germplasm flow and documentation should be considered for managing and advancing agriculture genetic resources and research effectively and efficiently. NGOs also do not consider documenting electronically.
2. **Accessioning based research not in practice**: Collections are assigned number by each organization and conduct research based on this number. Later, collections and data could not get accessed, which means every thing is temporary. Therefore, giving permanent number and then research based on this number is necessary to make the collections and data available any time and to advance the research.
3. **Lack of genebank standard**: Many NGOs and communities are working on management of agriculture genetic resources. Standards for managing diverse genetic resources have not been developed. Community Seed Bank has also collects and conserves local genetic resources without considering any standard.
4. **Independent collections**: Collection and research on agriculture genetic resources are carried out independently by many organizations.
5. **Limited knowledge on sampling strategies**: Exploration and collections guidelines have not been developed at local level. Generally collection is made without considering any sampling strategies and guidelines which could lead to collect same accessions many times and to capture narrow genetic base.
6. **Ignorance on passport and characterization data**: Database is not found well documented and managed. Even the passport form has been sent along with seed samples without filling form completely. Priority is also not given on characterization.
7. **Field genebank concept not commonly perceived**: There are many locations having fruit trees in public land as well as in government farms, which can be turned to field genebank. Awareness should be created to relevant persons on the concept of field genebank and its management.

2. General Agricultural Statistics

Nepal is agricultural based country. The number of farmers are 1,52,10,000 in the country which is 65.7% of total population. About 57% of the total households ie 32,33,800 are farm houses. Average family size in the farm household is 5. Majority of the farms produce agricultural products year round for home consumption.

The total area of Nepal is 1,47,18,000 ha. About 21% (ie 30,91,000 ha) of the total land is being cultivated (Figure 14). Additional 7% of the total area can be cultivated to increase the total production. Major crops in the country are rice, maize, wheat, millets, barley, buckwheat, sugarcane, jute, oilseeds, potato, pulses, vegetables and fruits. Rice is being cultivated in the largest area followed by maize and wheat (Figure 15). Rice occupies about 50% of the total area (Figure 16). Rice is generally grown in lower belt of the country called Tara. Maize is the dominant crop in Mid Hill where are buckwheat is the major crop in High Hill (Figure 17).

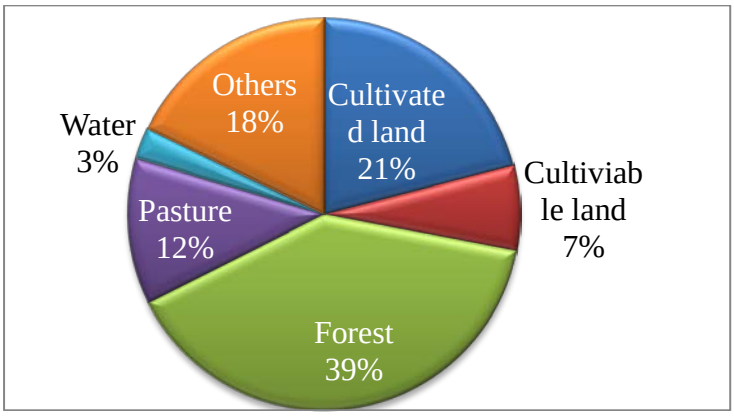

Figure 14. Land use pattern in Nepal (Total area = 1,47,181 sqkm) (ABPSD 2011).

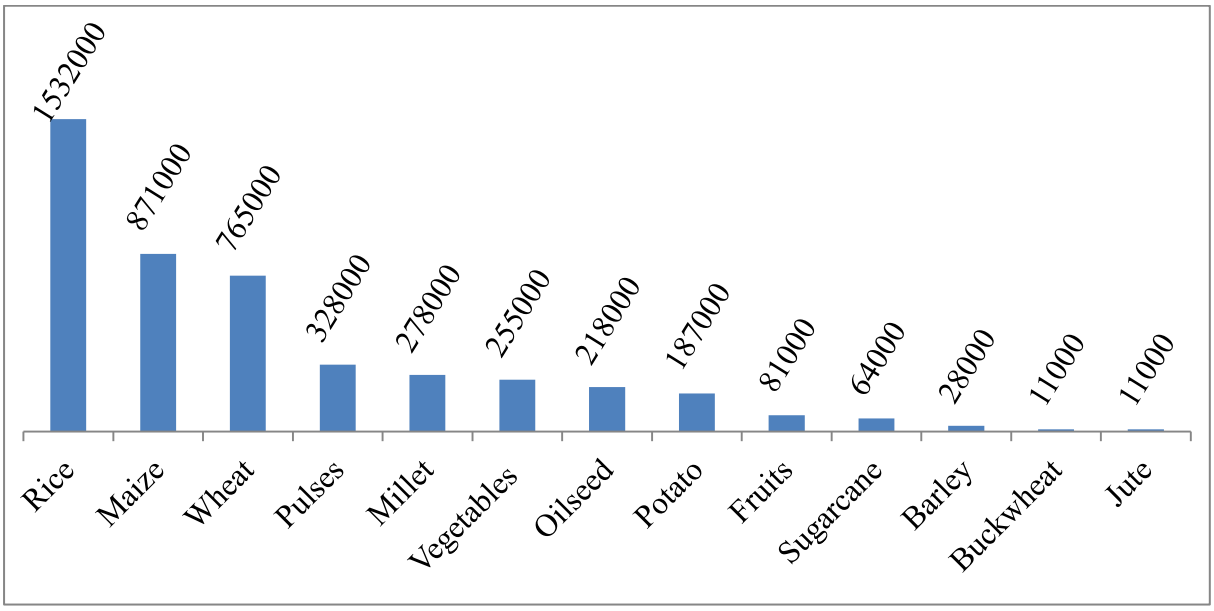

Figure 15. Main crops and cultivation area (ha) (ABPSD 2011).

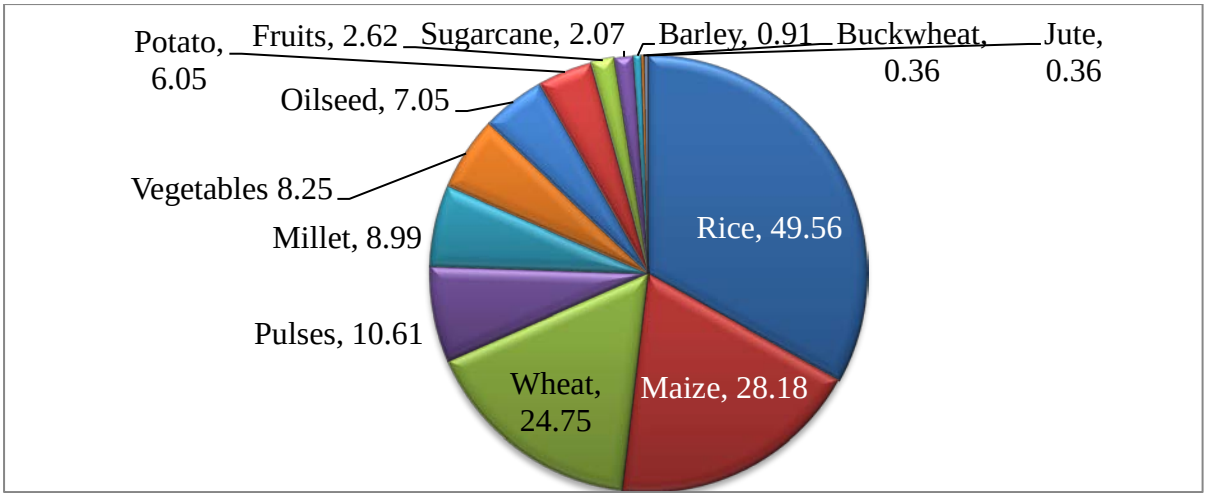

Figure 16. Area coverage in percentage of major crops (ABPSD 2011).

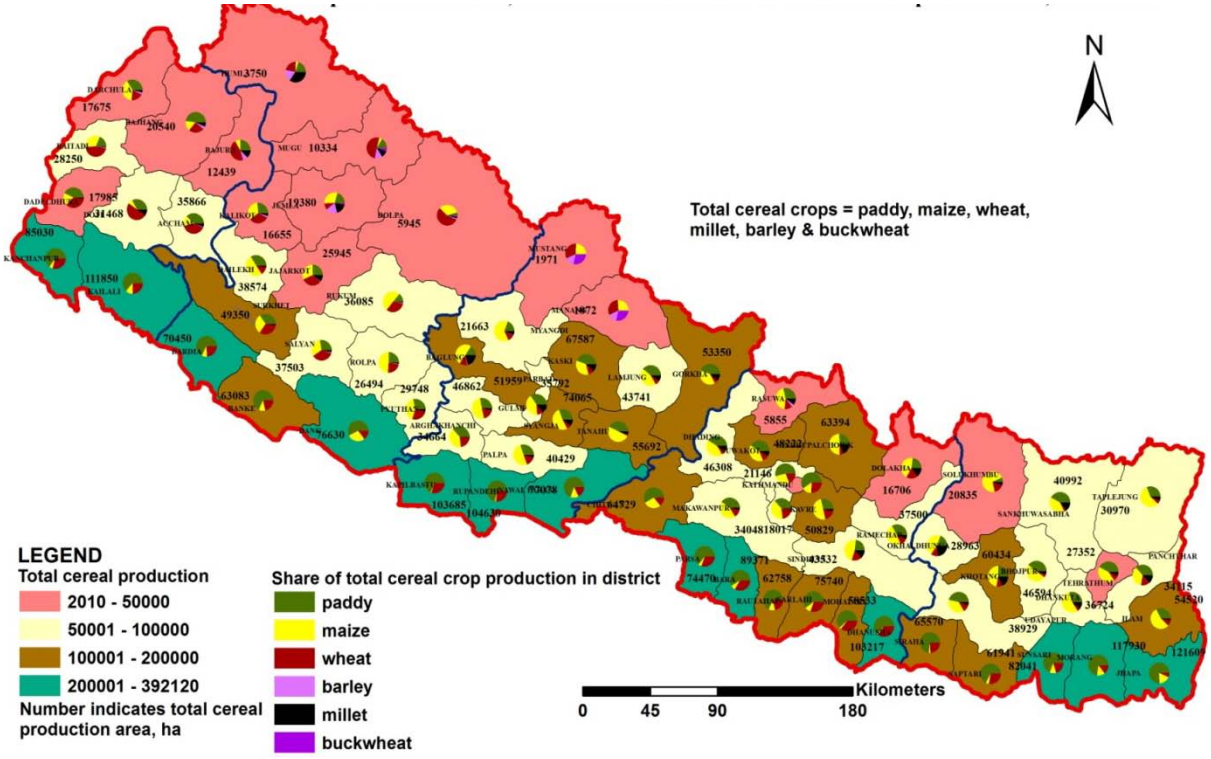

Figure 17. Distribution, production and share of total cereal crops production (ABPSD 2011).

3. Suggestion

- There is a need of extensive characterization, evaluation and tagging of economically important traits to facilitate and utilize the plant genetic resources.
- Many accessions in the collection may be duplicates. Duplicates identification mechanism should be developed and should be initiated to remove duplicates.
- Database sharing among Asian countries is very poor. Therefore, database sharing system should be established like (like EURISCO in Europe).

- Crop improvement utilizing local genetic resources in Nepal is negligible. Potential of landraces have not been studied. Therefore, pre-breeding program should be strengthened.
- Documents related to ownership of the landraces needs to develop. Study is necessary on where and how the landraces have developed their form on landraces. Evidence of association of landraces with geography and cultural value need to explore.
- Genebank has just started in-vitro conservation. There is limited technical manpower specially on in-vitro conservation, cryo-preservation, seed health testing. Therefore, there is need of improving capacity of the manpower in these areas.
- Genebank still does not have facility for base collection. Priority should be given to create facility for long term storage, cryo bank and glass house.
- Linkage should be established with relevant stakeholder to initiate the in-situ conservation across the country. There are many wild species and wild relatives of cultivated species distributed across the country. These are the reservoir for different important genes and evolution continuously takes places interacting with nature. Economical means of in-situ conservation is coordination with National Parks, religiously and culturally protected sites, heritage sites and community. In Nepal, there are Protected Areas (National Parks, Conservation Areas, Wildlife Reserves, Hunting Reserve), Ramsar Sites, World Heritage Sites and many Religious Places.
- Different NARC stations and community seed banks should be utilized for exploration and collection, regeneration and multiplication of local genetic resources.
- Each country might have a good expert on particular area. Regular visit program and experts exchange program should be organized.

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