Rebuilding Local Seed System of Native Crops in Earthquake Affected Areas of Nepal

Proceedings of a National Sharingshop
18 December 2017, Kathmandu

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Kathmandu, Nepal
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NAGRC (Khumaltar, Lalitpur; http://narc.gov.np)
The National Agriculture Genetic Resources Center (NAGRC) was established in 2010 under NARC for conservation and utilization of all agricultural genetic resources including domesticated, crop wild relatives and wild edible plants. Agricultural plant genetic resources (APGRs) have been managed through ex-situ, on-farm and in-situ conservation, and breeding strategies by establishing seed bank, tissue bank, DNA bank, field genebank and community genebank.

Bioversity International (Rome, Italy; https://www.bioversityinternational.org)
Bioversity International (BI) is a member of the CGIAR consortium. Its vision is that agricultural biodiversity nourishes people and sustains the planet. Bioversity International produces scientific evidence and develops management practices and policy options to safeguard agricultural and tree biodiversity and attain sustainable global food and nutrition security.

Crop Trust (Bonn, Germany; https://www.croptrust.org/)
The Crop Trust, formerly known as the Global Crop Diversity Trust, is an international nonprofit organization, established in October 2004 as an independent organization under international law. The mission of the Crop Trust is to ensure the conservation and availability of plant diversity essential for food and agriculture, forever.

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Cover photo*: Houses damaged by earthquake in Barpak, Gorkha (by S Khatiwada and KH Ghimire); Seeds rescuing from Bichaur, Lamjung (by S Sapkota) and Seed increase in NAGRC field.*

Contents

Acknowledgements

The major unfortunate natural events in Nepal are 1934 Nepal–Bihar earthquake, 2014 Nepal snowstorm, 2014 Mount Everest avalanche, 2014 Cyclonic Storm Hudhud, 2014 Sunkoshi blockage, April 2015 Nepal earthquake, 2015 Mount Everest avalanches and 2017 Nepal flood. Nepal is the 11th most earthquake-prone country in the world. Among the earthquakes that causes great damages and losses of life are 1505 Lo Mustang earthquake, 1934 Nepal–Bihar earthquake, 1980 Nepal earthquake, 1988 Nepal earthquake, 2011 Nepal earthquake and 2015 Nepal earthquake.

7.6 ML (Ritcher scale) earthquake of April 2015 in Nepal caused 8,790 casualties and 22,300 injuries. The lives of 8 million people, almost one-third of the population of Nepal, have been impacted by these earthquakes. Over half a million houses were destroyed. Among the 75 districts, 14 were declared 'crisis-hit' (severely affected) and 17 districts as moderately affected. Disaster effects on agriculture sector were very high causing heavy damages and losses. We express deep condolences and sympathy to all the people who have suffered due to this earthquake. We pray that their departed soul take rest in heaven and God give their families the strength to get through this time.

We feel happy that farmers who were at tragedy supported our mission and in part team could able to support farmers by providing seeds of different crops. In Nepal farmers generally save their seeds themselves over a long period of time, which could help to develop household specific landrace that might be different than other farmers even within a village. Team collected 921 accessions of 61 crops, many of them are household specific landrace. We express our special thanks to farmers and extension and development workers who contributed on achieving the project outputs. The hard works of the team (S Sapkota, K Paudyal, DMS Dongol, S Sharma, Niru KC, Rita Thapaliya and KH Ghimire from National Genebank; S Khatiwada from Bioversity International and S Sthapit, S Neupane, B Bhandari, S Gautam, N Pudasaine, M Gurung, M Gurung, B Linkha, N Acharya, P Sapkota, H Singh, S Jirel from LIBIRD) are highly appreciated.

We are pleased with all the authors who collected information, analyzed data and prepared scientific papers that made possible to publish on time. There are 13 papers in this proceedings and among them, one paper was of seed rescue project implemented by LI-BIRD in three districts. We have documented some new approaches for the management of agrobiodiversity. The proceedings will be very useful for future planning on exploration, collection, conservation and utilization of agrobiodiversity, particularly during rescue mission, as well as to find out the status of rescued germplasm.

Crop Trust and the GRPI-2 Project of the Bioversity International funded by the Netherlands supported financially the work activities in Nepal through two mini projects, commonly named germplasm rescue project and seed rescue project respectively. We are very much thankful to late Dr Bhuwon Sthapit, Bioversity International Nepal for his especial guidance and support. Sincere thanks go to Dr Ronnie Vernooy, Dr Ehsan Dulloo, Dr Balaram Thapa, Madan Bhatta and Dr Mina Nath Paudel for creating favorable environment and supporting in the implementation of this work in Nepal.

The Editors

Dedicated to
Dr Bhuwon Ratna Sthapit for his contribution on agrobiodiversity
&
Farmers who lost their lives due to April 2015 earthquake

Foreword

Mina Nath Paudel, PhD
Principal Scientist + Chief
Genebank, Khumaltar, Lalitpur

Nepal is rich in Agriculture Plant Genetic Resources (APGRs). She hosts a known number of APGRs which include 1506 plant species encompassing both cultivated and exotic species further diverging semi-domesticated, crop wild relatives, and edible plant species. Among these groups there is inclusion of cereal, horticultural and forage species of having many useful traits for the survival of human kind across the world. Internalizing the importance of these APGRS, Genebank, Khumaltar, has taken initiatives to document the outputs of germplasm rescue including strategy for agrobiodiversity conservation action plan in such a publishable form.

Agrobiodiversity broadly covers the field of APGRs pertaining to domesticated plants and crops, animal genetic resources, wild edible species, aquatic genetic resources, semi-domesticated species, associated genetic resources, and crop wild relative species. Due to dearth of expertise and information in the entire field of Agrobiodiversity, Genebank has not been fully equipped to address in a holistic manners in present level of facilities. However, we are trying our best to address whatever best matches to our efforts within the limit of resources available to us. As a result, we have come across to publish this documents which could be a resource materials for all who are concerned to the issue of Agrobiodiversity conservation so far as APGRs is concerned. Aside from this, Genebank has taken lead role to conserve, identify, utilize and management of APGRs in Nepal. A 20 point conservation action plan included in this publication is the sole effort of Genebank brought into action covering all research stations under NARC, DoA and DLS so that it will help conserve APGRs in Nepal to sustain food and nutritional security of country in days ahead. Because once APGRs are wiped out from their place of origin it is virtually impossible to retrieve them as before. It is already been delayed to bring into effective conservation of important APGRs which are endangered and many of them have already been extinct due to many reasons and some of them are introduction of modern varieties, breeds and disturbing natural habitat of APGRs. Emphasis has been given for pragmatic conservation methods of APGRs which is important for Nepal.

I would like to thank authors of this publication for documenting information with respect to APGRs that are rescued, assessed and conserved in genebank and repatriated some of them. I am pleased that NAGRC in partnership with Bioversity International played lead role in documentation of germplasm rescue and conservation work from earthquake affected areas of Nepal. Last but not the least I am confident that a series of publications like this are very vital and important so far as Agrobiodiversity conservation is concerned which include holistic aspects of APGRs conservation, action plan, strategy and management leading to their utilization for sustaining food and nutritional security of Nepal in coming days as well.

6 Dec 2017

Foreword

Stephan Weise, PhD
Deputy Director General Research
Bioversity International, Rome

Bioversity International (BI) formerly known as International Plant Genetic Resource Institute (IPGRI) is the global agricultural biodiversity research-for-development center. It is one of the 15 International Agricultural Research Centers of the CGIAR (Consultative Group on International Agricultural Research). The mission of Bioversity International is to reducing rural poverty, increasing food security, improving human health and nutrition and ensuring sustainable management of natural resources. Its main objective is to deliver scientific evidence, management practices and policy options to use and safeguard agricultural and tree biodiversity to attain sustainable global food and nutrition security (www.bioversityinternational.org).

Bioversity International has over 30 years of partnership with Nepal in agrobiodiversity management and use that started in the mid-1980s. The formal partnership development with the Nepal Agricultural Research Council (NARC) and Local Initiatives for Biodiversity Research and Development (LI-BIRD) paved the way for a number of new initiatives related to biodiversity conservation and use in the country. Bioversity International has identified and recognized Nepal as one of the priority partner countries in achieving its mission of safeguarding agricultural biodiversity to attain sustainable global food and nutrition security.

I am pleased to learn that Bioversity International in partnership with the National Agriculture Genetic Resources Centre (NAGRC), alias National Genebank of Nepal, has successfully implemented the project "Rebuilding Local Seed System: Rescue Collection, Conservation and Repatriation in earthquake affected areas of Nepal" from August 2015 to December 2017 with the funding support of the Global Crop Diversity Trust. The project has been able to document the outputs of the planned activities in a proceeding to share and communicate the progress made in rescue collection, conservation and revival of local seed systems. Despite being a small project, it has played an important role in rescuing endangered germplasm for safe conservation in the national genebank as well as in on-farm with communities and community seed banks. This is an excellent of example of how ex situ and in situ approaches can and need to complement each other. In addition, it has also provided an opportunity for piloting specific tools and methods for rescue collection, conservation and repatriation.

I would like to thank National Genbank of Nepal and Bioversity International Nepal office for their joint efforts in documenting the outputs of the project. I believe that these proceedings will be read widely and used as a valuable reference in the field of post-disaster revival of local seed systems, rescuing endangered germplasm after disasters and ensuring agrobiodiversity conservation, both within the country and outside.

Uncommon Abbreviations

Uncommon abbreviations and abbreviation not spelled out in the text

ABD	Agrobiodiversity
APGR	Agricultural plant genetic resource
BCDC	Biodiversity conservation and development committee
BI	Bioversity international
BS	Bikram sambat (Nepali calendar)
CAC	Collection acceptance committee
CAT	Climate analog tool
CBM	Community-based biodiversity management
DADO	District agriculture development office
DLSO	District livestock service office
FGD	Focus group discussion
GEF	Global environment facility
GI	Geographical indication
GR	Genetic resource
GRPI	Genetic resources policy initiative
HH	Household
IRD	Informal research and development
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
KIS	Key informant survey
LCP	Local crop project
LEC	Landrace enhancement and conservation
LN	Natural logarithm
NABIC	Nepal agribusiness innovation center
NAGRC	National agriculture genetic resources center
ADO	Agricultural development office
ANDES	Association for Nature and Sustainable Development
NPC	National planning commission
NPR	Nepali rupees
NUS	Neglected and underutilized crop species
OJT	On-the-job training
PRA	Participatory rural appraisal
PDNA	Post disaster need assessment
PSE	Participatory seed exchange
RFF	Rebuilding family farm
SI	Simpson index
sp	Species (singular)
spp	Species (plural)
SQCC	Seed quality control center
SRP	Seed rescue project
VDC	Village development committee
WCF	Ward citizens forum
WTLCP	Western Tarai landscape complex project

Glossary

Working definition of some words used in the proceedings. Nepali words are italicized in this glossary.

Accession	A distinct uniquely identifiable sample of seeds representing a cultivar (variety or landrace), breeding line or a population which is maintained in storage for conservation and use. Accessions of the same species or landraces may differ by collection sites, collection year, local name or donor
Achar	Generally sour and hot food items, serve with small amount
Agricultural plant genetic resources	All cultivated crop landraces and varieties, wild edible plants, and wild relatives of crops (agronomic, horticultural and forage species), cover kingdom Plantae
Agrobiodiversity index	A consistent, long-term monitoring tool to measure and manage agrobiodiversity across three dimensions: diets, production and genetic resources
Agrobiodiversity rich farmer	Farmers having higher number of different crop, plant, animal and other species and their landraces; farmer with conservation mind and maintaining high intra and inter species diversity, intra and inter varietal diversity; farmer having household genebank
Analogue site	Site with similar climates of reference site, can be temporal and/or spatial bases
Animal farm genebank	Rearing of domesticated local and indigenous animals as well as improved breeds on-farm maintaining different species and breeds available around the command areas of research station or public farms for conservation, use and research
Aqua pond genebank	Pond for domesticated local and indigenous plus improved aquatic plants and animals maintaining inter and intra species diversity available around the command areas of research station or public farms for conservation, use and research
Backward direction	Where can I find sites whose current climate is similar to the future modeled climate of my reference site? (Future to Present)
Bhatta	Soybean
Bhoj	Party
Climate smart landrace	Landrace identified from reference site suitable for climate analogue sites using climate analogue tool
Collection	Any planting materials collected following Genebank standard
Collection acceptance committee	Team for assessing the quality of newly arrived planting materials in the Genebank (to check with genebank standard, duplicates, characterize materials, to take image, etc).
Common landrace	Found in relatively large numbers, the most widespread, grown in large areas and by many farmers; not rare
Community genebank	A community storage facility for seeds of orthodox types and a one or more fields where farmer communities grow recalcitrant types of crops and maintain them over time, managed by community themselves
Conservation status	Any of five category of any cultivar based on the analysis of population size, distribution and values (red listing)
Crop	Cultivated angiosperm plant species (cover kingdom Plantae), either for sale or for subsistence
Crop specific park	Field genebank that cover only one crop with intra and inter-varietal diversity
Crop wild relative	A non cultivated species which is more or less closely related to a

	crop species (usually in the same genus) and occur in agro-ecosystems
Cultivar	Any distinct genotype under cultivation, including both landraces and varieties
Cultivar mixture	Growing two or more landraces/ varieties together in the same field
Custodian farmer	Agrobiodiversity rich farmer, who actively maintain, adapt, and disseminate agricultural biodiversity on-farm and at community level
Daal	Soup made of black gram or lentil or pigeon pea or beans
Dhindo	Thick porridge generally made from flour of finger millet, buckwheat or maize
Diversity block	Unreplicated small size but large number of plots with a numbers of different genotypes (varieties, landraces) of any crop
Diversity index	Different measures that explain variation among and within populations at varietal or specie levels
Diversity kit	Pack of planting materials consisting of more than 2 different cultivars
Elite line	Any genotype that possess at least one useful trait or superior line for at least one trait. In breeding phase, elite line is generally first identified, then promising and pipeline variety.
Endangered landrace	A landrace which has been categorized as likely to become extinct. Population size of that landrace is in decreasing order due to several factors
Endemic landrace	Landrace found only on particular geographical location and farming area
Evenness	The relative abundances of the different crops and landraces
Ex-situ conservation	The conservation of genetic resources maintained outside their natural habitat
Extinct or lost	Landraces not available now in a particular area where, it was grown in the past
Focus group discussion	A qualitative research method that gather together people from similar backgrounds or experiences to discuss a specific topic of interest. The topic of discussion is carried out in focused areas of interest. The group of participants is guided by a moderator (or group facilitator) who introduces topics for discussion and helps the group to participate in a lively and natural discussion amongst themselves
Forage	Grasses and other plants that are eaten by animals
Forward direction	Where will I find my current climate in modeled future climates? (Present to future)
Gap analysis	Analysis of existing collections in the Genebank to identify the locations from where germplasm are either not collected or poorly collected, generally done by generating collection maps, literature review and key informant survey
Genebank	Facility where germplasm is stored or maintained for research and use for long time eg seed bank, tissue bank, field genebank
Genebank standard	Criteria applied for storing germplasm in the Genbank maintaining diversity, viability and relevant information
Genetic erosion	Loss of genetic diversity (specific trait, particular cultivar) between and within populations of the same species over time or reduction of the genetic base of a species
Geographical indication	Quality in landrace that always linked with certain geo-location

Germplasm	Living genetic resources such as seeds or tissues that are maintained for the purpose of animal and plant breeding, preservation, and other research uses
Germplasm rescue	Collection of endangered and rare landraces and varieties from the red zone areas
Hattipau	Large size similar to elephant's foot
Household genebank	Maintenance and uses of APGRs in and around house, it consist of household seed bank and household field genebank
Image bank	Record of photos (printed or electronic form) of each accession of crops with some information that are used for identification and reference samples, similar to herbarium
Indigenous	Native, developed or created naturally within country, all APGRs that have been existed before 1950
Informal seed system	Flow and networks of seeds and planting materials among farmers without legal documentation and organizations
In-situ conservation	The conservation of genetic resources in their original ecosystem and natural habitat. In the context of agricultural genetic resources, conservation in the surroundings where they have developed their distinctive properties (with at least one allele originating there). Both active (growing) and dormancy (after seed matures) periods occur in the same place.
Kalo	Black
Key informant survey	Discussion with knowledgeable person who has very good expertise and experiences on a target subject
Kodo	Finger millet
Landrace	Genotype not altered by breeders but grown continuously by farmers over years. It may be local or introduced.
Latte	Amaranth
Local landrace	Crop landraces available before 1950 in Nepal and grown continuously in particular location for at least over 60 years in same location
Local seed system	Informal seed system covering only in a particular location and in action from very long time back (more than 100 years)
Local variety	Crop variety grown continuously in particular location for at least over 60 years in same location
Long term conservation	Storing germplasm in low temperature (-20^{o} for orthodox seeds and -196^{o}c for non-orthodox crops) and making available over 100 years
Lost landrace	Extinct
Maas	Black gram
Makai	Maize
Modern variety	Crop variety developed by educated plant breeders. Syn. High yielding variety
Multilateral system	Under the ITPGRFA, the multilateral system (MLS) comprises a pool of 64 selected crops (Annex 1) that are made accessible. On ratifying the treaty, countries agree to make their genetic diversity and related information about the crops stored in their genebanks available to all through the MLS
Native crop	Entity has always been in the place where they are, rather than being brought there from somewhere else. Native and indigenous are similar meaning words that refer to naturally growing plants, living animals, and even original inhabitants of a particular region
None direction	Where can I find sites that have a similar climate to my reference site concurrently? (currently or in the future) (same time period)

Not evaluated landrace	Landrace without any information of their population size, distribution or unique traits, not studied landrace of their red list status
On-farm conservation	The conservation of agrobiodiversity in farmers' fields and/or in community genebanks (seed bank and field genebank), where new traits or alleles have not originated, but have been cultivated over a period of time. Active life (growing period) remains in the field and dormancy period (after harvest) remains in the manmade structure nearby field
Pahenol	Yellow
Pani	Water
Passport	Information collected during germplasm collection, generally includes sources, origin and information from provider of germplasm
Plant	Uncultivated and wild flowering (angiosperm) plant species, cover kingdom Plantae
Raksi	Alcohol (distilled liquor) made from grains or fruits
Rare landrace	Not found in large numbers, grown by few farmers in small areas, localized landraces not commonly available, population size remain constant
Rayo	Broad leaf mustard
Red list status	Conservation status
Red listing	Process of determining the status category (red list status) of landraces or varieties
Red zone	Farming areas where population size of any genotypes are small and decreasing due to different factors
Regeneration	Growing of genebank accessions after decreasing their viability below 85%
Rejuvenation	Restoring vigor and appearance of very old non-orthodox crops, generally done by clonal propagation
Repatriation	The return of crop landraces to their original sites or climate analogue sites or similar areas of their original collection site
Rescue	Collection target of rare and endangered landraces from particular areas to save from danger or harm or loss
Reward call	Announcing with some kinds of support to providers of endangered or rare landraces
Richness	The number of varieties, landraces in a particular area or community
Roti	Flat bread, round, thin and single piece
Sattu	Flour made after roasting cereal grains
School field genebank	Conservation and utilization of locally available non-orthodox crops around the school areas, collection through students, use for study, income and beautifying the environment
Semi domesticated plant	A kind of plant species that is in between wild plants and domesticated crops, mostly in or around the farm and are under human intervention to care and maintain them
Sharingshop	Gathering of relevant people in the workshop to share findings of some works (sharing workshop)
Simi	Bean
Tarkari	Cooked vegetables
Threatened crop	Endangered crop
Traditional variety	Any landraces that have some traits associated with some tradition in a community

Trait distribution analysis	Analysis of frequency and distribution of any trait over the different landraces
Unique landrace	Landrace that possess very specific trait which is not commonly found in other varieties or landraces
Variety	Genotype developed by breeders. It may be under cultivation or in the process of development
Village level field genebank	A system of conserving and managing total diversity of a species through continue growing at least on landrace by each household by village members in their private land
Vulnerable	Landraces grown in large areas by few farmers or in small areas by many farmers. A vulnerable landrace is likely to become endangered unless the circumstances threatening its survival and reproduction improve. It is also called conservation dependent.
Wild edible plant	Wild plants that whole plants or its parts are used as food in fresh or after processed

Project Brief

Farmers' traditional seed stocks have been completely destroyed by 7.6 Richter scale earthquake (25 April 2015) and subsequent two major aftershocks (6.9 Richter scale in 26 April 2015 and 6.8 Richter scale on 12 May 2015). Official estimate of the Government of Nepal indicated that stored food grains and seed stocks amounting to more than NRs 8 billion (US$ 80 million) have been lost from the earthquake. Similarly, FAO's rapid assessment in 6 most earthquake affected districts showed that about 70% of the food and seed stocks of the households are destroyed by the devastating earthquake. The impact of this loss of household seed stocks on food security and agricultural livelihoods is expected to be very high as most of the households in these affected areas depend on own saving and local exchange of seeds of traditional varieties for the next planting seasons. Since, the affected areas are mostly remote, risk prone and mountainous, present varieties developed from formal breeding programme are either not available or not commonly adapted to local production systems. Moreover, private seed companies are not present in these areas as they do not see remote small holders as a potential market, given the small market size and high overhead cost of marketing.

Many agricultural plant genetic resources (APGRs) were at risk due to this natural disaster. APGRs are second most important after human, therefore there was urgent need of germplasm rescue. NAGRC, LI-BIRD and Bioversity International formulated agrobidiversity related projects to work on these earthquake affected districts. One project was 'Rebuilding local seed system: Collection, conservation and repatriation of native crop seeds in earthquake affected areas in Nepal', (commonly called germplasm rescue project) funded by Global Crop Diversity Trust (GCDT) and implemented in 7 districts by National Genebank and Bioversity International. This project was started from Aug 2015 and ended at Dec 2017. The second project was implemented by LI-BIRD in three districts which was funded by the Netherlands through GRPI-2 Project of the Bioversity International 'Strengthening National Capacities to implement the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)' (commonly called seed rescue project). The project period was from June 2015 to Dec 2015.

These two mini projects were implemented in 10 most severely earthquake affected districts of central and western regions of Nepal. The project aimed to revive and strengthen the local seed system and resilience of households through rescue collection missions of germplasm from affected and neighbouring areas of earthquake hit districts and repatriating the previously collected materials from both national and international genebanks in these affected local communities through multiplication and distribution. The priority crop cultivars collected were those that are native, high economic value and threatened by earthquake and other natural disasters (eg subsequent landslides after earthquake). The project targeted its collection routes and locations in new areas, where earlier collection missions had not been undertaken. The rescue collections were carried out employing existing networks of NARC, District Agriculture Development Offices, LI-BIRD and other local NGOs, CBOs and lead farmers in the earthquake affected districts. The collected genetic resources along with passport data are maintained in national genebank and local community seed system or banks to safeguard native crop diversity for further use. The collected seeds are also multiplied, characterized and maintained as a source for immediate use and in research.

Project Goal, Activities and Outputs

The main goal of the project was to rescue the germplasm, revive and strengthen local seed system and resilience of households, making access to crop diversity and repatriation of crop landraces in earthquake affected districts. The specific activities and outputs were:

Activity 1: Rescue collection mission of native crops from affected 10 districts
Output: Threatened native crops from earthquake affected areas conserved in National Genebank

Activity 2: Seed multiplication of native crop landraces in Khumaltar and GEF project sites
Output: Native crop landraces characterized and adequate quantity of their seeds increased for production in 10 affected districts, making access to farming communities and for conserving in National Genebank

Activity 3: Seed characterization and processing for storage in National Genebank
Output: Ensured the availability of collected germplasm to present and future generations

Activity 4: Repatriation of germplasm to affected areas from National and International Genebank
Output: Lost germplasm from the locality made available for integrating in the farming system

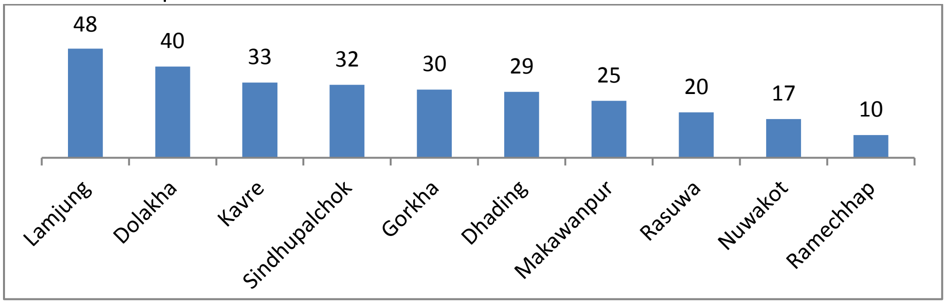
Project Implementation and Budget

The germplasm rescue project was implemented in 7 earthquake affected districts (Gorkha, Lamjung, Dhading, Nuwakot, Makawanpur, Kavre, Rasuwa) jointly by National Agriculture Genetic Resources Centre (National Genebank, NARC) and Bioversity International, Nepal which was funded through Global Crop Diversity Trust (GCDT). Two agriculture interns, staff from NAGRC, Bioversity International and DADOs were mobilized. Initially this project period was one year, later no cost extension was made for additional one year to accomplish the remaining work. Total budget for this project was US$ 30,000. The second project (seed rescue project) was implemented by LI-BIRD mobilizing their staff, technicians and field motivators in 3 earthquake affected districts (Sindhupalchowk, Dolakha and Ramechhap) in collaboration with Rebuilding Family Farm (RFF) project of the LI-BIRD and National Genebank. After collections, seeds were handed over to National Genebank. Fund for this project was from the Genetic Resource Policy Initiative (GRPI)-Phase 2 project of the Bioversity International, “Strengthening National Capacities to implement the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)”. The budget was US$ 30,000. Some part of this budget (US$ 8000) was used to lay foundation for establishing community seed bank in Jugu, Dolakha, which is one of the project sites of GEF UNEP Local Crop Project implemented in Nepal by Bioversity International in partnership with NARC, LI-BIRD and Department of Agriculture. The project developed synergy and collaboration with Local Crop Project sites in Jungu Dolakha and Ghanpokhara, Lamjung and with local NGO COPAADES in eastern Lamjung to implement some of the activities and follow-up of the work after completion of the project.

Major Project Achievements

- A total of 921 accessions of 61 crops were collected from 35 VDCs of 10 severally earthquake affected districts

- 284 rare and endangered crop landraces were rescued and conserved in National Genebank. See below figure for total collected rare and endangered crop landraces from 10 earthquake affected districts



- Passport data and seed image bank of these collections were maintained.

- Name list of 104 lost landraces were documented from 7 districts. 5-10% of total local crop diversity (based on the landraces) were lost due to earthquake in these 7 districts

- 173 collections of 11 crops were characterized and seeds multiplied.

- Collection acceptance committee (CAC) was established to check the quality of new collections

- Climate analogue sites and climate smart germplasm were identified for some of earthquake affected areas. Five landraces of four crops were repatriated.

- 200 diversity kits (containing 3 to 5 varieties) were provided to 200 farmers for reviving the local seed systems

- The awareness and capacity of 22 staff, 425 farmers and 35 extension and development workers were enhanced and increased, particularly on utilization and conservation of local crop diversity. Provided training to 75 farmers in east Lamjung

- One master student was supported for thesis research which was based on the information collected on agrobiodiversity from earthquake affected districts.

- Two community seed banks (one in eastern Lamjung managed by COPPADES a local NGO and second in Jugu, Dolakha managed by Local Crop Project) were strengthened through technical and financial supports.

- 15 i-buttons (weather data logger) were provided to Local Crop Project of GEF-UNEP. Digital balance and GPS were purchased for National Genebank.

Sharingshop

Crops diversity in agriculture is rapidly decreasing and the 2015 devastating earthquake have completely destroyed farmers' traditional seed stocks. To rescue the germplasm for long term conservation, National Genebank in partnership with Bioversity International has formulated the collection and conservation of germplasm from earthquake affected districts (called germplasm rescue project) with the funding support of Global Crop Diversity Trust (GCDT). In addition, LI-BIRD had also implemented seed rescue project in three districts from the funding support of GRPI-2 project of the Bioversity International for which original funding came from the Netherlands. The main aim was to revive and strengthen local seed system capacity and resilience of households through rescue collection, conservation, characterization, multiplication and repatriation of native and threatened crop seeds in the most severely affected districts. It was targeted to conserve and increase seed stock of threatened germplasm and distribute/re-introduce these germplasm to affected communities. Information on agrobiodiversity in relation to earthquake had been collected during field visits, through interaction with farmers, key informant, local communities and stakeholders. Many conservation and utilization initiatives have been implemented for long term security of APGRs and many partners have been involved for effective conservation and utilization. Progress and lessons learned from the projects need to be documented and shared for future smart conservation and utilization strategies. This sharingshop (sharing workshop), therefore is organized as a part of the project activity of Global Crop Diversity Trust (GCDT) of NAGRC and Bioversity International Nepal to share and communicate the recent progress made in rescue collection and conservation and widen the horizon of conservation efforts by inviting all relevant stakeholders.

Objectives

- Document and share progress on germplasm rescue from earthquake affected districts
- Create awareness on importance of local crops and landraces and encourage stakeholders to involve on conservation
- Share and validate tools and approaches of seed rescue collection, conservation and repatriation in disaster prone areas
- Help on building future conservation and sustainable utilization of APGRs for rebuilding local seed system in Nepal

Organizers: National Genebank and Bioversity International with support from Crop Trust
Venue: Entrance Cafe, Bakhundol, Lalitpur **Date**: 18 Dec 2017

List of Organization invited in the Sharingshop

1.	Bioversity International	2.	Department of Agriculture
3.	Nepal Agricultural Research Council	4.	International Rice Research Institute
5.	CIMMYT	6.	IAAS
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9.	Nepal Academy of Science and Technology	10.	World Food Program
11.	LI-BIRD	12.	IWMI
13.	Food and Agriculture Organization	14.	CARE Nepal
15.	IUCN	16.	CEAPRED
17.	International Centre for Integrated Mountain Development	18.	German Society for International Cooperation

Rebuilding Local Seed System of Native Crops in Earthquake Affected Areas of Nepal (Bal K. Joshi and Devendra Gauchan, eds). Proceedings of Sharingshop, 18 Dec 2017, Kathmandu; NAGRC, BI and Crop Trust; Nepal

Impact of 2015 Earthquake on Economy, Agriculture and Agrobiodiversity in Nepal

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Abstract

The April 25 earthquake (with 7.6 Richter scale) and its subsequent aftershocks have had both direct and indirect impact on people's livelihoods, agriculture and agrobiodiversity. The major effect of disaster was in remote hills and mountains where production system was rainfed, risk-prone, subsistence and people's livelihoods depended on agriculture and biodiversity of traditional crops. According to the estimates of the Post Disaster Need Assessment (PDNA) of the Government of Nepal, the total value of direct and indirect impact of the earthquake to Nepalese economy was close to USD 7 billion, equivalent to one-third of country's GDP. The agriculture sector suffered total damage and loss of USD 255 million, with maximum losses (86%) in mountainous and hilly areas of affected areas. The earthquake had also secondary effects triggering human and nature induced landslides, land degradation, flooding, drying up of water sources, avalanches and disease epidemics. It also have had long-term negative impact on agricultural and national development through the loss of productive labor force, infrastructure, forced outmigration and disruption in supply chains and earning potentials of people. The disaster had significant effect on the agriculture and agrobiodiversity due to destruction of storage structures, burial of stored seeds and damage of agricultural lands. An assessment of rescue collection mission carried out jointly by Bioversity International and National Genebank in 7 earthquake affected districts (Gorkha, Dhanding, Lamjung, Kavre, Nuwakot, Makawanpur, Rasuwa), revealed the loss of 104 landraces of different crops and 68 crop landraces becoming endangered from earthquake effect. Similarly a declining community and farm level richness and evenness of crop biodiversity was found in the affected areas. Increased investment in scientific agriculture and post-disaster revival of local seed system suited to affected areas of mountain agriculture and ecology is needed for rebuilding agriculture and revival of economy based on local biodiversity based livelihoods.

Keywords: Agriculture, Direct and indirect impact, Earthquake, Rescue mission, Loss of crop biodiversity

Introduction

The April 2015 earthquake was the most powerful disaster (7.6 Richter scale, Gorkha epicenter) to strike Nepal since the 1934 Nepal-Bihar earthquake (8.4 Richter scale) Indian Express 27 April 2015). The earthquake and its subsequent aftershocks have had huge impacts for Nepal with the official death toll of 9,000, with another 23,000 injured and more than 785,000 homes damaged or destroyed, and about 2.8 million people displaced (NPC 2015). Some casualties were also reported in the adjoining areas of India, China, and Bangladesh. The earthquake triggered an avalanche on Mount Everest, killing at least 19 and triggered another huge avalanche in Langtang valley, where 250 were reported missing, making it the deadliest day on the mountain in history (Wikipedia 2015). Centuries-old buildings were destroyed at UNESCO World Heritage sites in the Kathmandu Valley, including some at the Kathmandu Durbar Square, the Patan Durbar Square and the Bhaktapur Durbar Square (NPC 2015). Geophysicists and other experts had warned for decades that Nepal was vulnerable to a deadly earthquake, particularly because of its geology, urbanization, and architecture.

The disaster had huge impacts for Nepal with overall economic impact on production and service sectors, such as in agriculture, industry and tourism and trade. It had both direct and indirect impact on people's livelihoods, agriculture and agrobiodiversity. The major effect of disaster was in remote hills and mountainous areas where production system was rainfed risk prone, subsistence and people's livelihoods depended on agriculture and biodiversity of traditional crops (Rasul et al 2015, Gauchan et al 2016). This paper provides broad overview of overall impact of earthquake on economy, agriculture and agrobiodiversity based on literature review and primary information generated from the field surveys.

Impact of Disaster on Economy

The earthquake has affected the overall economic situation in the production and service sectors, such as agriculture, livestock, tourism, trade, and industry and has put roughly 3.5 million people in need of food assistance (FAO 2015). It affected the livelihoods of over 2.28 million households and 8 million people with total damage and loss to livelihoods of NPR 28.4 billion (USD 284 million) in 31 districts (NPC 2015). The list of 31 districts with their severity of damage (severe, crisis hit and hit with heavy losses and slightly affected etc.) is presented in **Figure** 1. The impact of disaster on economy was very high resulting in low GDP growth, loss of employment opportunities and increased food insecurity (Sharma 2015). According to estimate of the Post Disaster Need Assessment (PDNA) of the Government of Nepal (NPC 2015), the total value of direct and indirect impact of the earthquake to Nepalese economy was close of USD 7 billion, equivalent to one-third of country's GDP. The earthquake also caused heavy loss and damage to productive human resource base (agricultural labour), draft animals and agricultural infrastructure. It also affected 180,000 people engaged in tourism, which were extremely vulnerable. The study also showed that about 0.7 million people fell on below poverty line due to negative consequences of earthquake (NPC 2015). Over 5 million workers have been affected, with about 150 million work days lost, 69% of which are in the agriculture sector. Livelihoods of small farmers and those of daily agricultural and non-agricultural labor have been severely affected, with income losses of over 75% reported in several areas (FAO 2015).

The average value of per capita disaster effect was highest in the mountains (USD 2,195) and the lowest in Inner Tarai (USD 508), with an average of NPR 130,115 (USD 1,301) in the 14 most affected districts (NPC 2015).The per capita disaster effect is positively correlated with poverty (0.46), indicating that less developed and poor communities, many of which are in mountain areas, endured a larger portion of disaster impacts (Rasul et al 2015). Poor women and disadvantaged groups particularly in remote hills and mountainous regions suffered more in terms of death, person years of life lost, injury, displacement, and impacts on other livelihood assets. The International Labor Organization (ILO) has estimated that 150 million work days were lost in 31 districts in the first few weeks following the earthquake.

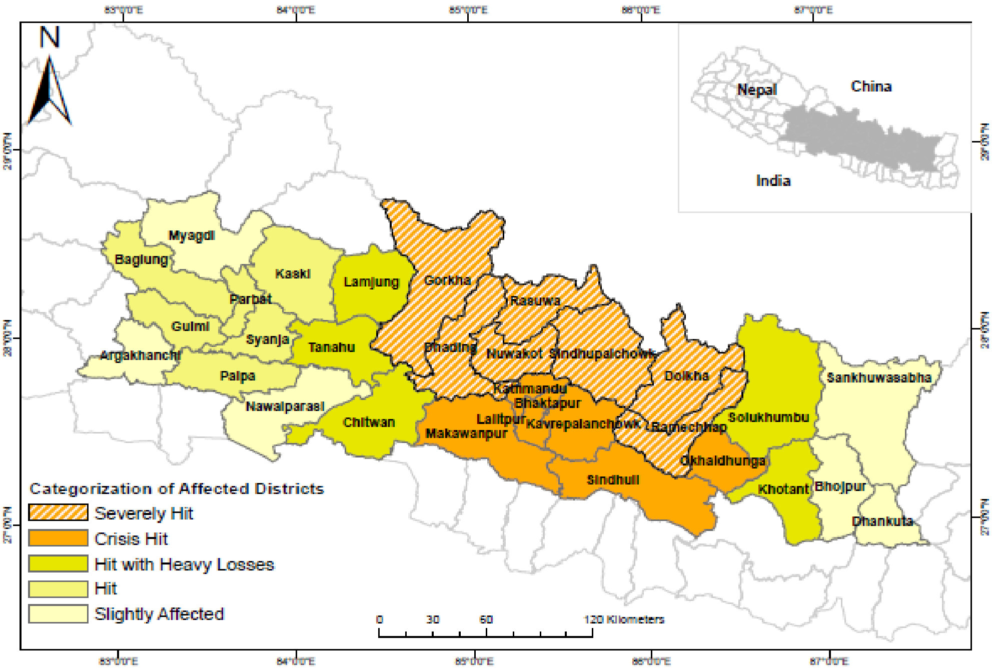

Figure 1. Thirty-one affected districts based on severity.
Source: NPC 2015.

Impact on Agriculture

Estimates of PDNA (NPC 2015) indicate that about 70% of agricultural households have lost their food and seed stock, livestock (draft animals), household assets (eg farm equipment, seed and food stores, cattle sheds) owned and maintained including agricultural infrastructure (irrigation canals, roads, rural power, communication) in worst affected 14 districts. About 135,200 tonnes of foodstuff, 16,399 large livestock, 36,819 small livestock, and 60,762 poultry animals have been lost. The agriculture sector suffered total damage and loss of NPR 25.5 billion (USD 255 million), with maximum losses (86%) in mountainous and hilly areas of central, eastern and western regions (NPC 2015, Rasul et al 2015). In agricultural sector, production losses occurred specially for different food and cash crops, animal fodder, fruit, potatoes, mushroom and vegetables, livestock, poultry, fish production and fingerlings, stock for seed and animal feed, egg and honey production, and stored food grains. The production loss also includes the value of production of the lost crops, increased costs of production and estimated production loss in subsequent seasons. The PDNA (NPC 2015) and FAO study (2015) indicate that rice and millet grains harvested in November and stored inside the house as food stock were mostly damaged when houses collapsed. Some maize is being recovered however it is hardly suitable for human consumption. Some areas with standing wheat and vegetables have been affected by landslides. Further losses of wheat were caused by hailstorms as household were too busy in managing their family members and the crop was left over-maturing. The **Figure** 2 below provides proportion of store crops and seed losses in affected six districts of Nepal (FAO 2015). The larger proportion of total losses was observed on rice, maize and millet.

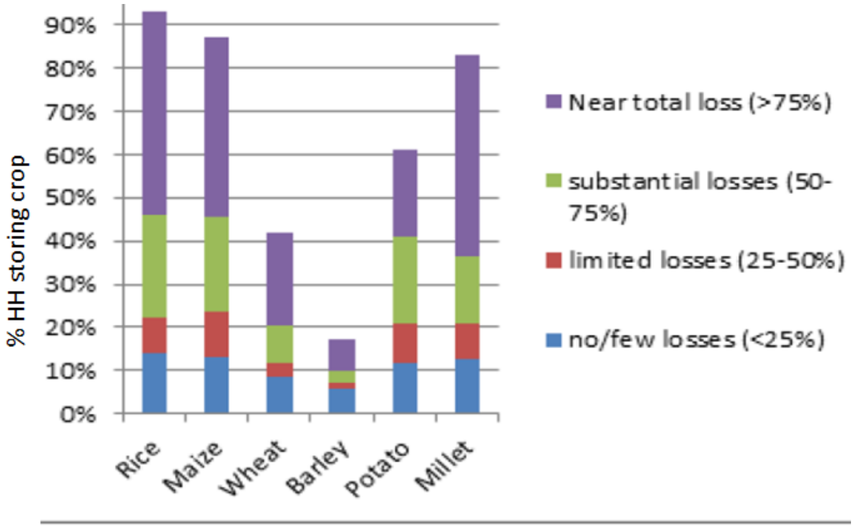

Figure 2. Proportion of stored seed stocks and food lost from affected areas.
Source: FAO 2015.

Impact on Agrobiodiversity

The 2015 earthquake had significant effect on the biodiversity of food crops especially in affected areas of remote hills and mountains where 90% of the farmers depended on informal seed system of traditional crops (Gauchan et al 2016). The earthquake led a major loss of diversity of local crop varieties due to destruction of storage structures, burial of stored seeds and damage of agricultural lands. In order to reduce further loss of seed stocks and diversity of native crops from the earthquake affected areas, Bioversity International in partnership with NAGRC (NARC) and LI-BIRD initiated rescue collection mission and assessed the crop diversity immediately after disaster which revealed that some unique traditional crop landraces were lost while some became at endangered state due to the impact of the earthquake (Gauchan et al 2017). From the 511 seed samples collected from the 7 affected districts (Gorkha, Dhanding, Lamjung, Kavre, Nuwakot, Makawanpur, Rasuwa) in 2016 funded through Crop Trust, the assessment showed that a total of 104 landraces of different crops had been lost and 68 crop landraces became at endangered state by the effect of earthquake, while 26 crop landraces were found rare in the affected areas (**Figure** 3). Endangered native landraces in affected areas were observed for various food crops in most parts of the mid hills and high hills (mountains) of the affected areas due to direct and indirect consequences of earthquake and other subsequent secondary effects of disasters. Furthermore, supplementary survey carried out during rescue mission revealed declining community and farm level richness and evenness of crop biodiversity of rice, maize and finger millet in most of the surveyed households in four severely affected districts (Poudyal et al 2017). The major perceived causes of genetic erosions occurring in the surveyed areas and germplasm at risk are due to the *ad hoc* distribution of large amounts of improved, hybrids and untested seeds as relief material from external agencies, the sudden migration of farmers after the disaster and attraction of rural farm households towards other alternative income generating options (Gauchan et al 2016, Sapkota et al 2017).

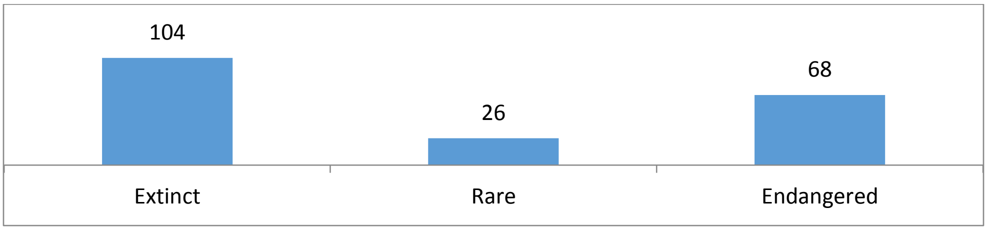

Figure 3. Impact of 2015 earthquake on status of crop biodiversity in 7 affected districts.

Indirect and Secondary Impact

The disaster has also indirect, secondary and tertiary impact. The indirect impact of earthquake was substantial in the agricultural sector, commerce, industry and tourism sector (Sharma 2015). It triggered human and nature induced landslides, land degradation, flooding, drying up of water sources, avalanches and disease epidemics which are expected to potentially bring more infrastructural and agricultural damages and human causalities during upcoming seasons and years. The earthquake also have had long-term negative impact on agricultural and national development through the loss of productive labor force, infrastructure, forced outmigration and disruption in supply chains and earning potentials of people (NPC 2015). The earthquake has added work burden, especially of women, both at home and on farm. Loss of seeds and agricultural infrastructure also caused risks of potential loss in subsequent production seasons (FAO 2015). In farmlands, removal of debris and replenishment of soil needed additional burden to the routine jobs. The affected areas are also suffering from chronic labor scarcity and high cost of production as a result of loss of labor force by direct earthquake damage, youth migration and high input costs in agriculture. Consequently, long term productivity and profitability in agriculture is affected with negative attraction and incentives for youth and innovative people in agriculture production, value addition and business entrepreneurship.

Conclusion and Way Forward

The earthquake have had major impact on the livelihoods of poor small holder farmers located in remote mountainous parts due to chronic poverty, food insecurity and illiteracy. A significant negative impact has been observed in economy, agriculture and agrobiodiversity. The earthquake had also secondary effects triggering human and nature induced landslides, land degradation, flooding, drying up of water sources, avalanches and disease epidemics. It also have had long-term negative impact on agricultural and national development through the loss of productive labor force, infrastructure, forced outmigration and disruption in supply chains and earning potentials of people. The disaster had also significant effect on the biodiversity of food crops especially in affected areas due to destruction of storage structures, burial of stored seeds and damage of agricultural lands.

Despite several efforts made by national and international agencies in the relief operations to rebuild agriculture and revive economy, there were no efforts made on revival and rebuilding local seed system lost by earthquake effects through rescuing native seeds that are important for food security, safeguarding biodiversity and livelihood of smallholder farmers in affected areas. Lack of understanding the value of local agrobiodiversity in rebuilding local seed system and improving the food security and livelihood of people in marginal areas was the major reason. Furthermore, lack of adequate research and investment for traditional crops including remoteness, lack of disaster preparedness, political instability and poor coordination among international, national, and local actors were other reasons to address the seed and food security issues in the remote hills and mountains.

Agriculture is to be used as a unique instrument for growth, revival of economy and poverty reduction by reversing years of policy neglect, mis-investment and pervasive underinvestment in agriculture research and development. The focus should be on scientific research for developing locally adapted seeds, technologies and ecofriendly practices targeted to marginal and risk-prone areas where effect of disaster and people's vulnerability is high (Gauchan 2015). Increased investment in scientific agriculture and post-disaster revival of local seed system suited to affected areas of mountain agriculture and ecology is needed for sustainable modernization, commercialization and diversification of agriculture based on local biodiversity based livelihoods. Adequate efforts are needed to promote diversity rich solutions including cost reducing and resource conserving technologies and practices to address labor scarcity and landscapes of fragile mountainous environments. The focus of rebuilding should be on scientific land use planning and zoning based on suitability of biodiverse agriculture in mountain landscape affected by earthquake. Efforts are needed to diversify farmers' livelihoods options and create alternative income generating activities through sustainable farm production, value addition and marketing based traditional crops and commodities. Priority should be given to adapted varieties and quality seeds of the local crops that perform well in farmers' existing management systems and changing climate conditions. Promotion of traditional crops and their adapted seeds enhance not only sustainability of local agricultural system but also promote conservation and use of biodiversity of traditional crops. Finally, there is a need to rebuild human resource, institutional capacity and governance in agriculture and agrobiodiversity conservation linked to disaster risk reduction through massive training and capacity building of youth in agriculture and agrobiodiversity conservation.

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Agrobiodiversity: Conservation Strategies, Methods and Action Plans

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Abstract

Agricultural plant genetic resources (APGRs) are the main component of agrobiodiversity. It includes 1506 plant species consisting of 484 cultivated crops, 93 introduced species, 35 semi-domesticated plants, 224 crop wild relatives and 670 wild edible plant species in Nepal. APGRs are of three types, agronomical, horticultural and forages species. Among the 484 crop species, 64 are agronomical, 145 are horticultural and 275 are forages species. Four strategies for conserving these APGRs are ex-situ, on-farm, in-situ and breeding, under which, 20 different conservation methods are in practice in Nepal. National Genebank has suggested twenty action plans to manage agrobiodiversity and all stakeholders need collaborate for implementation of these action plans. One of them is to rescue germplasm regularly and to assess the status of crop landraces through grouping them under common, vulnerable, endangered, extinct and not evaluated.

Keywords: Agrobiodiversity, Action plan, Conservation, Species, Strategy

Agrobiodiversity

Agrobiodiversity is the most economically important component of biodiversity in the universe. It includes different forms of living organisms and broadly they can be grouped in four categories, ie plant and crop genetic resources (agricultural plant genetic resources, APGRs), animal genetic resources, aqua genetic resources and associated genetic resources (**Figure** 1, MoAD 2017, Genebank 2016, MoFSC 2014). Species of these groups may be domesticated, wild or semi-domesticated (Joshi et al 2017).

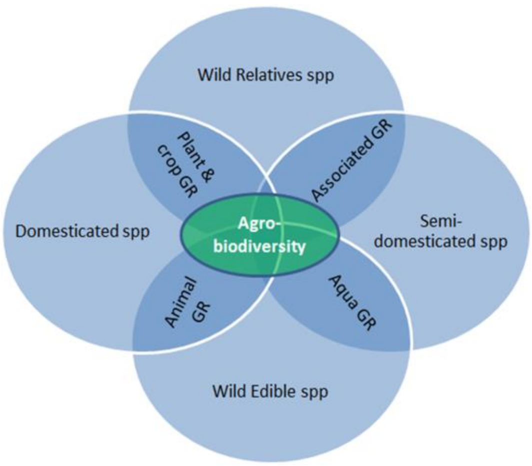

Figure 1. Scope of agrobiodiversity (GR, Genetic resources). *Source: Joshi 2017*

Due to high level of climatic variation in Nepal, a total of 1506 species of agricultural plant genetic resources have been reported (**Figure** 2, Upadhyay and Joshi 2003, MoAD 2017, Joshi et al 2017). Out of these APGRs, 93 are introduced species, 670 are wild edible plants, 224 are crop wild relatives, 35 are semi-domesticated and 484 cultivated crop species. Among 484 cultivated species, 64 are agronomical, 145 are horticultural and 275 are forages species (**Figure** 3). The working subgroups of APGRs in National Genebank are given in **Figure** 4.

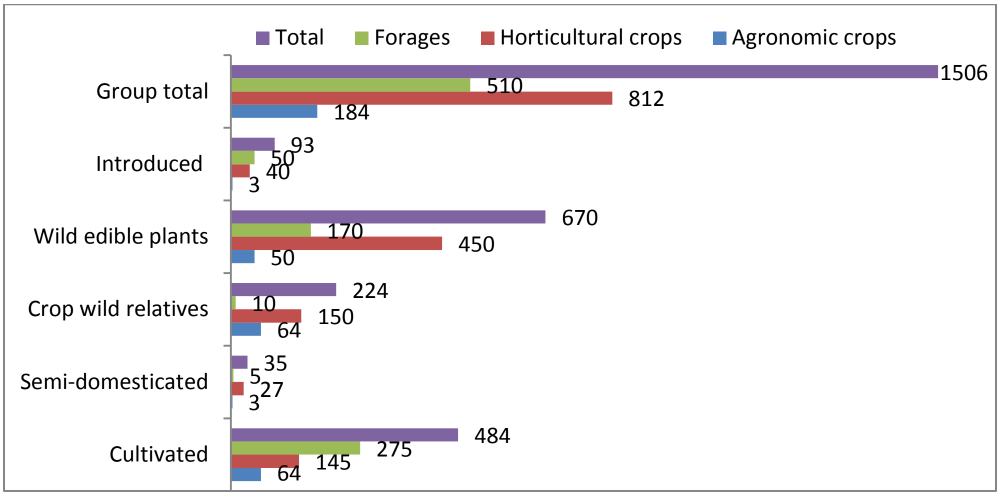

Figure 2. Total species of agricultural plant genetic resources in Nepal.
Source: Joshi 2017

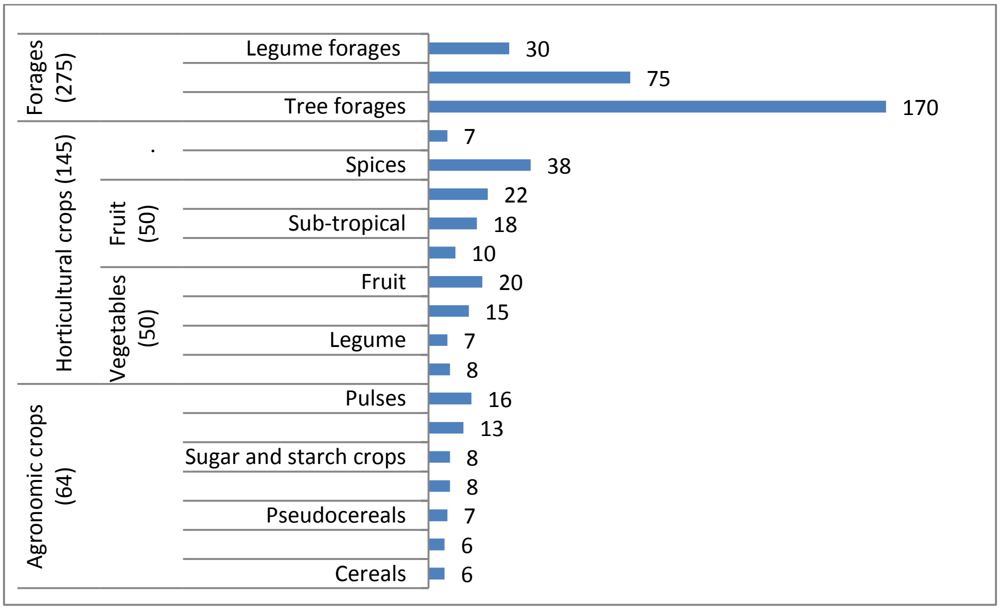

Figure 3. Total crop (cultivated) species under different economical plant groups in Nepal.
Source: Joshi 2017, Joshi et al 2017

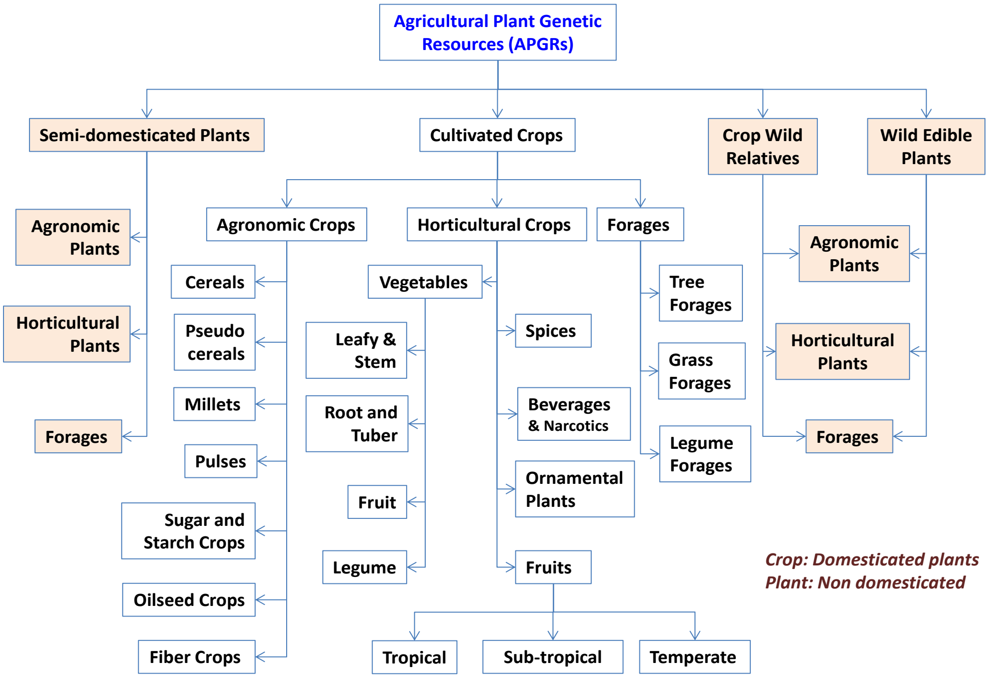

Figure 4. Classification of APGRs based on the management and conservation aspects.
Source: Joshi and Shrestha 2017

Conservation Strategy

Strategies adopted for APGRs conservation are ex-situ, in-situ, on-farm and use for breeding in Nepal. Comparative differences among three strategies are given in **Table** 1. In general, on-farm strategy is mostly applicable for farming areas and in-situ strategy for natural forest areas. In recent years, plant breeding strategy has been integrated in agriculture R&D for conservation through use. Some activities under the breeding strategy are landrace enhancement, evolutionary plant breeding, development of site specific varieties (focus group varieties), broad genetic base and cultivars mixture (**Figure** 5).

Table 1. Comparative analysis of conservation strategies

SN	Feature	Ex-situ	In-situ	On-farm
1.	Origin of collections	Other than storage site	Same place (at least one allele should be evolved)	Other than cultivation site. Traits/ landraces not evolved but continue cultivation of landraces in farm
2.	Site for plant life cycle	Mostly kept in dormant condition, field and store	Whole (active and dormant) period in same place	Active period in field and dormant period in nearby field ie farm store (household)
3.	Approach	Static storage, conservation through management	Dynamic, nature protection	Continue cultivation of landraces, conservation through use
4.	Evolution process,	Stop (arrested), variation in new	Continue	Continue. Completely adopted stage in a farm (more than 30

SN	Feature	Ex-situ	In-situ	On-farm
	creation of variation	location		years), relatively more diversity within landrace
5.	Storage condition	Controlled, managed	Natural	Normal and room temperature
6.	Seed container	Need air tight, normal container	No need of container	Normal container
7.	Seed moisture	Lowered to 3-7%, normal	Natural	Sun dried
8.	Regeneration	At 5-10 years interval, annual	Naturally	Annually
9.	Example	National Genebank, Field Genebank, Botanical Garden	National Park, Protected Area, Cultivation farm for crops where at least one trait evolved	Household Genebank, Community genebank, Cultivation farm

Source: Joshi and Upadhya 2017

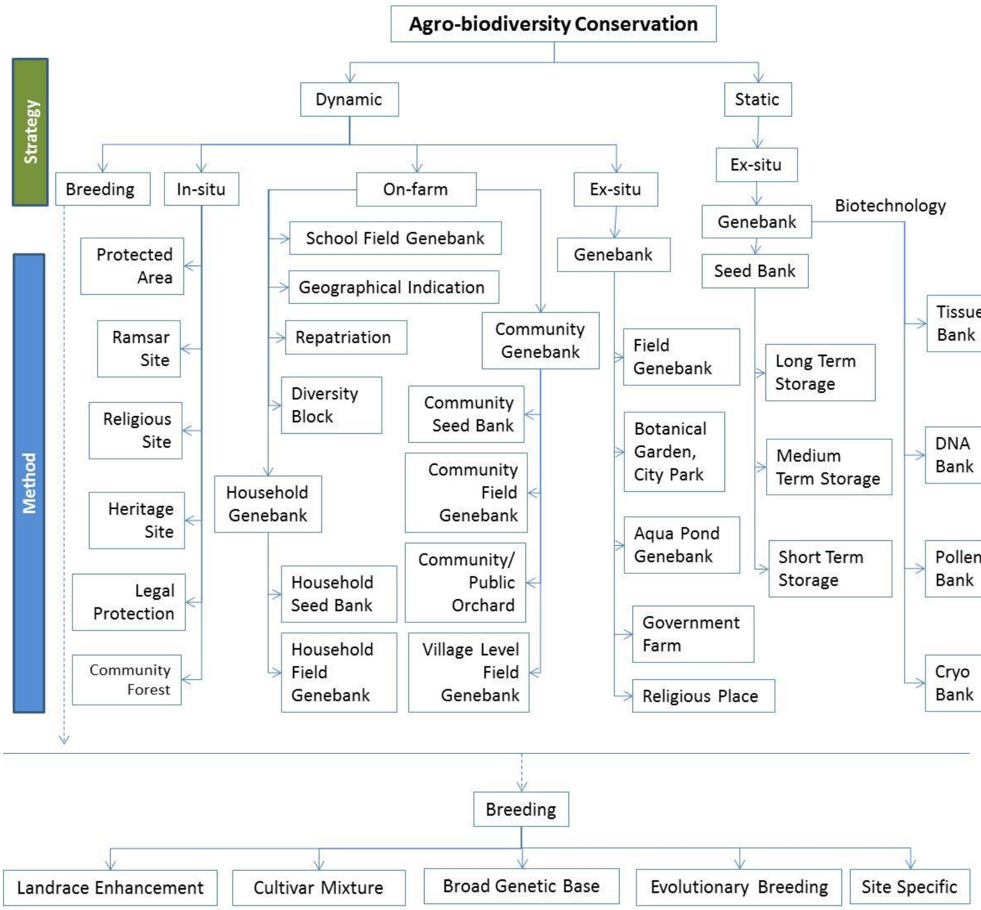

Figure 5. Four conservation strategies and different methods of conservation of APGRs under these strategies.

Source: Joshi 2017, Joshi et al 2016, Genebank 2016

Conservation Methods

Under three conservation strategies, 20 different conservation methods have been in practice in Nepal to manage APGRs (**Figure** 5). Most of them are developed by National Genebank and have been implemented in collaboration with different stakeholders in Nepal. For example field genebanks have been established in different research stations of Nepal Agricultural Research Council and in different resource centers of the government including farms, office periphery and other areas. Most recent technique of conservation is aqua pond genebank, which conserve all agricultural genetic resources that inhabit in water. Aqua pond genebank is established in Khajura, Nepalgunj under NARC.

Conservation Action Plans

Followings are the action plans (for details see Joshi et al 2016) that need to be initiated at local, regional and national levels for conservation of APGRs by relevant stakeholders.

1. Listing of local crops and cultivars and development of landraces catalogue
2. Identification of rare and unique landraces and potential landraces for large scale production (grouping of landraces under common, vulnerable, endangered, extinct, not evaluated, Joshi et al 2004)
3. Diversity mapping in terms of name given by farmers, intra and inter species of crops as well as diversity of functional traits of the given crops
4. Organization of diversity fairs of local crops
5. Establishment and maintenance of diversity blocks
6. Deploying diversity through distribution of diversity kits of rare crops and landraces to farmers and local community, and repatriation
7. Establishment of on-farm conservation village
8. Organization of diversity field school for the management and promotion of diversity rich solutions
9. Organization of exploration and collection missions and conservation program
10. Organization of rescue mission for rare and endangered landraces
11. Establishment and maintenance of different types of field genebank (community field genebank, community mango orchard, school field genebank, DADO field genebank, village level field genebank)
12. Establishing crop specific parks of local crops and cultivars
13. Establishment and strengthening community gene banks (community seed bank and community field genebank) and local seed networks
14. Establishing and strengthening household genebank (household seed bank and household field genebank)
15. Characterization and naming local landraces based on their specific traits and values
16. Initiation of landraces enhancement and conservation (LEC)
17. Collaboration with relevant stakeholders for crop wild relatives and wild edible plants conservation
18. Establishment of herbarium, museum and image bank
19. Study and identification of landraces that have specific geographic origins and use values which can be geographical indicators
20. Development of ownership documents for important landraces

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Process of Rebuilding Local Seed System after 2015 Nepal Earthquake: Rescue Collection, Conservation and Repatriation

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Abstract

A study was conducted from July 2015 - Dec 2017 to recue endangered crop landraces of native crops from 10 earthquake affected districts and promote their conservation for rebuilding local seed system and resilience of the households. The study employed several methods, approaches and processes combining rescue missions for collection, conservation and repatriation wiith both qualitative and quantitative assessment techniques and tools. The process helped to assess status of diversity of traditional crops, identify endangered, extinct and rare crop landraces, document and characterize their unique agronomic traits and develop and validate methodology for conservation of native crops by linking on-farm and ex-situ approaches. The process has rescued 284 rare and endangered crop landraces and conserved in Genebank from 10 earthquake affected districts, out of which some of the farmer demanded ones are repatriated back to local communities. The rescue collected seeds are processed, regenerated and stored in national Genebank and partly in community seed banks of the affected areas for conservation, local access and use for future food security. It has also helped to restore lost diversity, revive and strengthen the local seed system and safeguard biodiversity of native crops to adapt to more extreme and changing climatic conditions. The work has helped building national capacity and resilience to cope with future disasters and laying a foundation for community seed banks. Future priority in relief and rebuilding agriculture therefore should be given to rescue collection, conservation and repatriation of native crops in disaster prone areas by building national and local capacity in agriculture and agrobiodiversity conservation.

Keywords: Adapted seeds, Capacity building, Conservation, Rescue collection, Repatriation

Introduction

Seed is at the heart of restoring food security for farmers and their families in Nepal. Farmers in rural and remote hills and mountains have high dependence on food security from self-saved and locally exchanged seeds and biodiversity of traditional crops. The devastating earthquake that hit Nepal on 25 April 2015 and subsequent aftershocks was most severe in rural farm households particularly in remote and risk-prone hills and mountains where 90% of the farm households depended on self-saved and locally exchanged seeds of traditional crops (Gauchan et al 2016). The majority of the affected families were smallholder farmers, with low capacity to respond and recover from shocks. The country's vulnerable areas had been most affected, leaving over 3.5 million people in need of food, water, shelter and medical assistance (FAO 2015). Therefore, rescue collection of native and endangered seeds was important after disasters in order to revive local seed system, restore lost diversity and safeguard local crop biodiversity for future generation.

Aftermath of the disaster, various national government and international relief agencies made efforts in Nepal to rescue human beings, livestock and valuable assets but no immediate initiatives were made to rescue endangered native crop seeds and varieties in the affected areas in Nepal (Gauchan et al 2016). Considering the critical role of local and native varieties in rebuilding local seed system, improving livelihoods of mountain communities and safeguarding crop biodiversity, Bioversity International jointly in partnership with National Genebank, NARC and LI-BIRD initiated a study from June 2015 to December 2017 on rescue seed collection, conservation and repatriation of local crop genetic resources that are endangered from earthquake areas. The main objective of the rescue collection was not only to rescue endangered crop seeds and native varieties for conservation but also develop and promote process and methodology of rescue collection for seed recovery, livelihood improvement and safeguarding biodiversity of native crops. The rescue collection, conservation and repatriation after disaster played important role in revival and rebuilding of local seed systems in the affected areas. This paper deals with the role, process, methodologies and achievement made in rebuilding local seed system through rescue collection, conservation and repatriation in earthquake affected areas.

Methodology and Approach

The study employed several methods and approaches combining both qualitative and quantitative methods for rescue collection, conservation and repatriation of native crops seeds in affected areas. Rescue collected seed sample data and information including methodology and findings were supplemented and validated through review of available national and international literature, field characterization and evaluation and consultation meetings and workshops. The brief outlines of specific methods and steps are presented below. The study covered altogether 35 VDCs of 10 districts that are severely affected from earthquake. The specific approaches employed are briefly outlined below.

1. Review of literature and secondary data collection on rescue collection, conservation and repatriation and identification of severely affected districts and village development committees (VDCs) for initiating rescue collection mission and identify specific earthquake affected areas where native seeds are in danger and need rescue collection is needed for rebuilding local seed system.
2. Prepare field survey checklists and household survey questionnaire as well as review and update existing passport data format to collect information from farmers where seed rescue collection is being done. Mapping of the existing gene bank collection to identify gaps in collections in earthquake affected

districts to initiate the rescue collection in those locations where previous collections are missing and endangered.

3. Consultation meeting and interaction programs with researchers, conservationists and local government offices (eg Agricultural Development Offices and District Natural Disaster Committee) including local NGOs and communities involved in seed relief operations for planning rescue mission and field survey.
4. Participatory rural appraisals focusing on key informant interviews, transect walks, focus group discussion (FGD), 4-cell analysis and passport data filling from selected farmers (men and women). FGD and 4-cell analysis was carried out in selected affected local communities to identify rare native crops and landraces that need rescue collection and repatriation in local communities.
5. Preparation and distribution of Diversity Kits of promising locally adapted materials from Genebank and those from other research stations and local sources to sample farmers from whom seeds have been rescued and collected. The objectives are to provide immediate access to locally available seed, re-introduce /repatriate some promising local crop seeds to sample farm households, and back up community seed bank collections in earthquake affected areas.

Agroecology, Farming Systems and Focus of Crop Groups

The collection covered from lower hills and river basins to mid hills and high mountains covering different altitudes, agroecozones and farming systems from 10 affected districts (Gorkha, Dhading, Lamjung, Makawanpur, Kavre, Nuwakot Ramechhap, Dolkaha, Sindhupalchowk and Rasuwa). The specific crop groups and cropping patterns where sampling was done is outline in Table 1.

Table 1. Target agroecology, crop species and cropping patterns in affected districts

Altitude range	Agroecozone	Taxa/ crop species/ groups	Major cropping patterns
500-1000 masl	Lower hills and river basin (Sub-tropical climate)	Cereals, legumes, oilseeds, spices and vegetables	-Rice–wheat/legumes in lowland -Rice–potato/vegetables in lowland -Maize–wheat /legumes in upland -Fruit and fodder trees and vegetables in home /kitchen garden
1000-2000 masl	Mid hills (Warm temperate climate)	Cereals, pseudo-cereals, legumes, oilseeds, spices and vegetables	-Rice–wheat/vegetables in lowland -Maize-/+millet in upland -Maize–potato /vegetables - Fruit and fodder trees and vegetables in home /kitchen garden
2000-3000 masl	High hills /mountains (Temperate climate)	Cereals, pseudo-cereals, legumes, oilseeds, spices and vegetables	-Potato- buckwheat/ beans -Millet- wheat/barley - Fruit and fodder trees and vegetables in home /kitchen garden

Role and Process of Rescue Collection, Conservation and Repatriation

Rescue collection, conservation and repatriation played important role in rebuilding local seed system by enhancing access of locally adapted seeds to smallholder farmers. Since, above 90% of the seeds upon which smallholder farmers depended in the remote earthquake affected hills and mountainous districts were farm-saved and obtained through informal channels of distribution and exchange, revival and rebuilding of local seed system was critical to enhance resilience of the households to future disasters. Since about 70% of agricultural households have lost their more than 60% of their seed stock and crop genetic resources stored in their household stores from earthquake damage (FAO 2015, NPC 2015), rescue collection, conservation and repatriation provided mechanism for rebuilding their local seed system and safeguarding conservation of globally important genetic diversity of local adapted crops. The processes in the study involve followings.

Assessment of Crop Diversity and their Status

The process of rescue collection played important role in assessing the crop diversity and identify crop landraces that are endangered, extinct, rare and abundance in 10 earthquake affected districts. The assessment revealed that a total of 104 crop landraces are lost, 26 are rare and unique and 258 seed types of different crops are at endangered state due to earthquake and various other factors, which needs immediate conservation measures (**Figure** 1). Endangered native landraces in affected areas were observed for various food crops in most parts of mid hills and high hills/mountains of the affected areas due to direct and indirect consequences of earthquake and other subsequent effects of disasters. Furthermore, supplementary survey of 131 households in 17 VDCs of severely affected four districts of Gorkha, Nuwakot, Kavre and Rasuwa carried out during rescue mission revealed declining community and farm level richness and evenness of crop biodiversity of rice, maize and finger millet in most of the surveyed households' four severely affected districts (Poudyal et al 2017). The major perceived causes of genetic erosion occurring in the surveyed areas and germplasm at risk are the *ad hoc* distribution of large amounts of improved, untested seeds as relief material from external agencies, the sudden migration of farmers after the disaster and attraction of rural farm households towards other alternative income generating options (Gauchan et al 2016, Sapkota 2017).

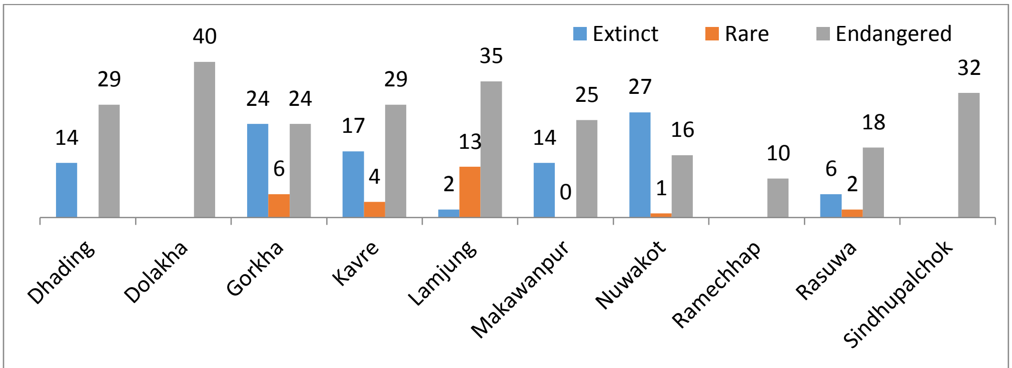

Figure 1. Role of rescue mission (number of landraces listed and collected) is assessing crop diversity from earthquake affected areas. Extinct and rare were not listed in Dolakha, Ramechhap and Sindhupalchowk.

Sensitizing Stakeholders on Rescue Collection, Conservation and Repatriation

Sensitization of local stakeholders and communities was key component of the process of rescue collection. This was carried out both for seeking local support in rescue collection and creating awareness for conservation of rare and endangered traditional crop seeds and safeguarding genetic diversity for food security. In the process, two major district level interaction workshops were carried out in 2015 and 2016 in Dolakha (Charikot) and Rasuwa (Dhunche) respectively to have interacting with local district government offices and communities in collection areas of ten affected districts. The study made significant efforts to organise district level awareness programme on Rescue Collection in Charikot, Dolakha in 22 Feb 2016 and in Dhunche, Rasuwa on 7 Dec 2016. The events were special not only sensitizing local stakeholders for rescue collection and conservation but also provided venue for official handover of rescue collected seeds for conservation in National Genebank of Nepal. There was a very good response from district level stakeholders and local communities on the role of rescue collection and conservation of native seeds for future generation. The work on revival of local seed system after disaster was communicated widely to stakeholders at the local, national and international level for creating awareness of the value of rescue collections through not only meetings and workshops (eg International Agrobiodiversity Workshop New Delhi, 6-9 Nov 2016 and International Mountain in Changing World Conference, Kathmandu 2-3 Oct 2016) but also through news media (FM Radio, TV), social media (facebook), research papers and news blogs in the websites (eg www.bioversityinternational.org; www.himalayancrops.org).

Developing and Validating Methodology

The study has played important role in developing and testing/ validating available methods for post-disaster revival of seed system and safeguarding biodiversity of traditional underutilized crops. The study has developed methods for analogue sites identification (Poudyal et al 2017); and red listing of crop genetic resources similar to forest and broader plant and animal biodiversity (Joshi et al 2017) and helped in identifying gaps in collections in Genebank and methods for repatriation methods (Dongol et al 2017). The process has helped in validating 4-cell analysis to identify endangered and rare crop genetic resources for rescue collection and conservation in Genebank (Sapkota et al 2017). It has also supported validation of methodology for participatory seed exchange (PSE) for rescue collection and revival of local seed system after disaster (Sthapit and Gautam 2016, Gauchan et al 2016) and testing and validation of climate analogue tools (CAT) for the suitability of rescue collected germplasm for repatriation in similar affected areas (Poudyal et al 2017). The study has helped in mapping of the existing genebank collections to identify gaps in earthquake affected districts to initiate the rescue in those locations where previous collections were missing and endangered crop seeds need to rescue.

Documentation and Characterizing Valuable and Unique Landraces

Documentation and characterization of rescued collected samples are essential for their protection, immediate use in cultivation and future use in crop improvement. The collected seeds are assessed in the processing (germination, drying) and regeneration through which data are captured. The collected samples which did not meet adequate Genebank standards (eg adequate quantity) are being used for seed increase and further processing. Some of them are in the cleaning and drying process for putting in Genebank for safe storage. Most of the collected samples are further evaluated, characterized and regenerated for their evaluation, multiplication and documentation of unique and rare traits. A total of 173 samples (accessions) of 11 crops are characterized in the fields for their agronomic traits (Sapkota et al 2017). The study has supported national genebank of

Nepal for characterization and documentation of unique and rare germplasms and traits from earthquake affected districts for future us in crop improvement.

Restoring Lost Diversity and Revival of Local Seed Systems

During rescue collection, a large proportion of native crop varieties were found in endangered state and some had already extinct in the study areas. The loss of diversity was not only from the impact of earthquake damage but also from the emergency *ad hoc* distribution of large amounts of improved, hybrids and untested seeds as relief material from external agencies, the sudden migration of farmers after the disaster and attraction of rural farm households towards other alternative income generating options (Gauchan et al 2016). The process has rescued 284 rare and endangered crop landraces and conserved in Genebank from 10 earthquake affected districts, out of which some of the farmer demanded ones are repatriated back to local communities. Therefore, the process of rescue collection, conservation and repatriation was important to restore lost diversity and revive local seed system of traditional underutilized crops particularly in remote and risk prone mountain regions where farmers had no or limited access of seeds from formal sources. The process of seed multiplication and conservation in both national genebank and community seed banks in the affected areas including diversity kit distribution and participatory seed exchanges during the process were important to enhance access of locally adapted crop seeds and varieties to smallholder farmers in the remote mountains that are not readily available in the market.

Strengthening Linkage between On-farm and Ex-situ Approaches

The process of rescue collection, conservation and repatriation has combined both ex-situ and on-farm approaches of conservation involving genebank scientists, NGO development professionals and local field staff of district extension agencies. Crop landraces rescued and collected from on-farm (farm households and fields) are processed and conserved in both National Genebank and partly in Community Seed banks located in earthquake affected areas. Farmer' preferred ones are multiplied and shared with disaster affected local communities through diversity kits distribution and organizing participatory seed exchange with local communities. Over 90% of the collected and shared seeds in the earthquake affected local communities were not in the official national notified list of crop varieties and of the national genebank collections (Gauchan et al 2016). The process of rescue collection, conservation and repatriation after disaster has helped linking national Genebank with community seed banks and farming communities in risk prone mountains areas. During the rescue collection and study process, Genebank scientists have provided training and orientation to farming communities and members of Community Seed Bank in east Lamjung for safe storage, conservation and methods of cultivation for their use. The work has helped building national capacity in rescue collection and holistic conservation by linking National Genebank with community seed banks for ensuring national and local food security.

Linkages and Synergies with On-going Initiatives

The study made significant efforts to link with on-going initiatives and develop synergies with on-going programmes and project of NARC and LI-BIRD. The rescue collection work carried out in the first phase in three districts (Ramechhap, Dolakha and Sindhupalchowk) was linked with LI-BIRD's Rebuilding Family Farm (RFF) programme (Sthapit and Gautam

2015). It is one programme supported by multiple development partners such as Swiss Development Cooperation (SDC) Switzerland; Development Fund (DF) Norway and Diakonie Katastrophenhilfe (DKH) Germany. The study was also linked with an existing GEF UNEP local crop project called "Integrating Traditional Crop Genetic Diversity for Mountain Food Security" in two of the affected districts (Dolakha and Lamjung), which is implemented jointly by NARC, LI-BIRD and DoA. GEF Nepal project has organized a Diversity (Seed) Fair in Jugu VDC of Dolakha district (one of the severely earthquake affected locations) on 2 April 2016 as part of on-going project activities, in which this activity was linked to generate supplemental information and validate the type of collected materials. The work has also supported on-going activities in other GEF project sites such as Lamjung, Jumla and Humla districts through on-farm testing of rescue collected seeds. The study helped to install i-Buttons (weather data loggers) to collect climate data (temperature and humidity) for linking with field trials and other on-farm experiments linking with on-going GEF project sites (Dolakha, Lamjung Jumla, Humla), Genebank crop fields, National Hill Crop Research Program, Kavre, Dolakha and Agricultural Research Station in Jumla for seed increase for generating climate data as well as to support for on-farm evaluation of farmer preferred rescue collected seeds. The work has also been linked with on-going programmes and projects of the National Genebank and those of NARC Research Programmes and Stations for collection, conservation and use of native crop landraces in crop breeding and research programme. In addition, the rescue collection was linked with the local NGO, COPPADES (Community for the Promotion of Public Awareness & Development Studies) that had initiated relief work and community seed bank activities in Rainash, eastern Lamjung, linking with its activities in earthquake affected eastern Lamjung villages. Similarly the rescue collection work of Ramechhap, Dolakha and Sindhupalchowk was linked very much with LI-BIRD's 3-phase response plan to rebuild faming farming in the earthquake affected areas. Collaboration with local stakeholders and DADOs also provided visibility and applicability of work to rescue endangered seeds and develop plan for repatriation to real target group of farmers who needed most

Strengthening Local and National Capacity on Rescue Collection & Conservation

The work has helped building national capacity in rescue collection and conservation and resilience to cope with future disasters and laying a foundation for community seed bank in Jungu Dolakha. The study was linked in building the capacity of researchers, local field staff and interns for collection missions with GEF UNEP project of NARC, DoA and LI-BIRD and "Rebuilding Family Farm (RFF)" project of the LI-BIRD. During the process, the capacity of researchers of NARC National Genebank, DADO and LI-BIRD that were engaged in GEF UNEP and RFF projects respectively were enhanced. In addition it also provided opportunity for building capacity of two young graduate students (interns) in carrying out research, where one of them accomplished MS thesis on the topic related to rescue collection and conservation of native crop seeds. The study also collaborated with COPPADES in eastern Lamjung to train local staff and farmers involved in community seed banks for rescue collection and safe conservation in community seed banks and use of collected seeds for ensuring local food security.

Local staff at the District Agriculture Development Offices (DADOs) and key informant farmers in earthquake affected districts have been consulted and engaged in the collection missions based on their availability in some affected areas of the districts. The collaboration provided opportunity to sensitize and enhance capacity of local district agricultural staff and local knowledgeable farmers in rescue collection and conservation. The work of rescue collection supported by GRPI-2 project of Bioversity International provided seed money of US $ 8000 to Jungu Community in Dolakha for laying foundation of Community Seed Bank (Sthapit and Gautam 2016). This seed money has very much helpful in initiating community seed bank and laying foundation for building structure for Community Seed Bank in Jungu, Dolakha where now the community seed bank is in operation with this initial support and other on-going support of local Cooperative, local Government and GEF UNEP project of NARC LI-BIRD and Department of Agriculture and Bioversity International.

Conclusions and Way Forward

The main outcome of the study was to rebuild local seed system and promote conservation through rescue seed collection missions from most severely affected villages of 10 earthquake affected mountainous districts. The collected information was analysed for diversity assessment, regeneration and processing for their safe storage in national genebank. The process helped to assess status of diversity of traditional crops, identify endangered, extinct and rare crop landraces, document and characterize their unique agronomic traits and develop and validate methodology for conservation of native crops. The process has also helped to store part of the collected seed samples in community seed banks in eastern Lamjung supported by COPPADES and in Jungu, Dolakha supported by GEF UNEP project for local access, availability and use. The most endangered and valuable local crop biodiversity based on farmers' demand are identified for repatriation to same communities and community seed banks for on-farm biodiversity conservation and strengthening local seed system. This strategy was useful to promote both ex-situ and on-farm agrobiodiversity conservation and help to safeguard native crop biodiversity for future generation in disaster affected areas. Many stakeholders have highly appreciated on-going work and outputs of this project and many landaraces that were endangered due to earthquake were rescued for conservation in national Genebank. The process of rescue collection, conservation and repatriation after disaster has helped linking national Genebank with community seed banks and farming communities in risk prone mountains areas. The study process has developed methods and tools and their scientific validations in rescue collection, conservation and repatriation and rebuilding local seed system in disaster affected areas. It has helped to restore lost diversity, revive and strengthen the local seed system and safeguard biodiversity of native crops to adapt to more extreme and changing climatic conditions. The work has helped building national capacity and resilience to cope with future disasters and laying a foundation for community seed banks.

Future priority in relief and rebuilding agriculture therefore should be given to rescue collection, conservation and repatriation in disaster prone areas. Focus should be on access and availability of locally adapted varieties and quality seeds of the local crops, that perform well in farmers' existing management systems and changing climate conditions, since locally adapted seeds are the heart of agriculture and food security of vulnerable people in fragile affected areas. Promotion of traditional crops and their adapted seeds enhance not only sustainability of local agricultural system but also promote conservation and use of biodiversity of traditional crops. Finally, there is a need to rebuild human resource, institutional capacity and governance in agrobiodiversity conservation and building local seed system linked to disaster risk reduction through massive training and capacity building of youth in agriculture and agrobiodiversity conservation.

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Germplasm Rescue: Why and How?

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Abstract

Germplasm rescue is the collection of endangered landraces from the red zone areas of farming areas and conservation of them either on-farm or ex-situ. It is necessary and very effective to protect the crop diversity from being extinction. Formal germplasm rescue mission was started since 2015 in Nepal. To organize the rescue mission, it is necessary to identify the endangered landraces, through the process called red listing. Red list status (also called conservation status) is determined either through survey, distribution and population size analysis, trait distribution analysis, red zoning farming areas and gap analysis. Rescue mission can be carried out after or before disasters. We organized one rescue mission for each district covering a total of 10 earthquake affected districts from 2015 July to 2017 June. Total 921 accessions of 61 crops have been rescued from 35 VDCs of the 10 affected districts. Rescue mission has helped to restore lost crop diversity, strengthen local seed system and safeguard biodiversity of agricultural crops. Rescue missions, therefore should be organized regularly in collaboration with relevant stakeholders following different rescue techniques for safeguarding crop biodiversity for the future.

Keywords: Endangered, Landrace, Natural calamities, Rare, Rescue mission

Germplasm Rescue

Crop diversity is most important factor for food and nutrition security in long term. However, there is always risk of extinction of crops landraces due to many factors eg disasters, abandon of agriculture, rapid expansion of modern varieties, etc. In Nepal about 50% of crop diversity has been lost in the past (Joshi et al 2017). Trend of genetic erosion is increasing in most of the farming areas. To protect the crop diversity, one of the effective strategies is to organize germplasm rescue mission. Germplasm rescue is the collection of germplasm, usually endangered ones from where there is a threat of genetic erosion (Engels et al 1995). First rescue mission was held in 2015 in Nepal targeting to rescue the Bhate Phaper (typical landrace of buckwheat) from Dolpa district (Joshi and Ghimire 2016, Genebank 2016, Joshi 2017). Rescue mission has been carried out for many crop species in different countries (Lima et al 2016, Paprstein et al 2016, Williams 2005, Joshi and Ghimire 2016, Genebank 2016). It is generally targeted to rescue endangered germplasm (Upadhyaya et al 2008) and collections are made for research purpose that is in immediate danger of genetic erosion or extinction (Williams 2005). Some of the achievements of rescue mission are given in **Table** 1 and further needs of mission are visualized in **Table** 2. National Genebank and other relevant stakeholders need to organize rescue mission when and where needed. After the massive earthquake of 2015 in Nepal, National Genebank with support from Bioversity International funded through Crop Trust implemented the germplasm rescue mission in 7 districts and LI-BIRD in partnership with the National Genebank and funding support of Bioversity International (GRPI-2 project) carried out in 3 districts. The processes and techniques of germplasm rescue mission carried out in the past and the germplasm that need rescue are described in Table 1 and Table 2 respectively.

Table 1. Rescued germplasm by NAGRC from different locations in the past

SN	Crop	Landrace	Rescued area	Rescued year	Status
1.	Amaranth	Seto Latte	Kavrepalanchowk	2016	Endangered
2.	Barley	Mudulejau	Nuwakot	2016	Endangered
3.	Barley	Bhote Jau	Lamjung	2016	Endangered
4.	Barnyard millet	Sama	Gorkha	2016	Endangered
5.	Bean	Sokta Simi	Makwanpur	2016	Endangered
6.	Buckwheat	Bhate Phaper	Dolpa	2014	Endangered / rare
7.	Cat mint, catnip	Ngeta	Gorkha	2016	Rare, endemic to Barpak
8.	Colocasia	Khari Padalu	Lamjung	2016	Endangered
9.	Cowpea	Rato Bodi	Kavrepalanchowk	2016	Endangered
10.	Field pea	Sikkime Kerau	Dhading	2016	Endangered
11.	Finger millet	Dhuwakote	Dhading	2016	Endangered
12.	Finger millet	Nangre Kodo	Lamjung	2016	Endangered
13.	Finger millet	Seto Kodo	Lamjung	2016	Endangered
14.	Horse gram	Kailo Gahat	Makwanpur	2016	Rescued
15.	Leaf mustard	Thulo Pat	Dhading	2016	Rescued
16.	Lentil	Kalo Musuro	Gorkha	2016	Rare
17.	Maize	Talware Makai	Makwanpur	2016	Rescued
18.	Maize	Seto Sathiya Makai	Lamjung	2016	Endangered
19.	Mustard	Aafal Tori	Lamjung	2016	Rescued
20.	Naked barley	Karu	Dhading	2016	Endangered
21.	Pearl millet	Ghoge	Nuwakot	2014	Rare and unique
22.	Perilla	Kalo Silam	Kavrepalanchowk	2016	Endangered
23.	Pumpkin	Madale Pharsi	Makwanpur	2016	Endangered
24.	Rice	Bange Masino	Dhading	2016	Endangered
25.	Rice	Darmali	Gorkha	2016	Rescued
26.	Rice	Pinyali Khoya	Rasuwa	2016	Rescued
27.	Rice	Rato Anadi	Lamjung	2016	Rare
28.	Rice	Manunge Sali Dhan	Lamjung	2016	Endangered
29.	Rice bean	Kalo Siltu	Lamjung	2016	Endangered
30.	Soybean	Masino Bhatta	Lamjung	2016	Rare
31.	Soybean	Seto Sthaniya Bhatmas	Makwanpur	2016	Rescued
32.	Sponge gourd	Basmati Ghiraula	Kavrepalanchowk	2016	Rare
33.	Upland rice	Basaune Ghaiya	Gorkha	2016	Endangered
34.	Wheat	Bangare	Dolakha		Endangered

Table 2. Some crop landraces that needs to rescue

SN	Crop	Landrace	Location	Unique traits
1.	Banana	Mungre Kera	Lamjung and Tanahun	Unique
2.	Buckwheat	Seto and Kalo Kishe	Dolpa	Endangered and rare
3.	Buckwheat	Bhate Phaper	Dolpa	Unique
4.	Cauliflower	Sthaniya	Aaruchaur, Rupakot, Syangja	Unique
5.	Cucumber	Madale Kaakro	Pelakot, Aaruchaur, Rupakot, Syangja	Unique
6.	Finger millet	Dalle Kodo, Barshe Kodo	Ghanapokhara-5, Lamjung	Unique
7.	Foxtail millet	Mal kaguno	Saurpaani, Gorkha	Endangered
8.	Ginger	Syangja	Chilaune bas	Unique
9.	Lapsi	Bhagara Sthaniya	Bhagara, Parbat	Unique
10.	Lentil	Sindur	Siraha	Unique
11.	Maize	Murali	Chapakot, Syangja	Unique
12.	Mandarin	Suntala local	Dhading	200 years old
13.	Mandarin	Local Suntala	Baskharka, Parbat	Very old
14.	Mandarin	Rumjataar Ko Suntala	Rumjataar, Okhaldunga	Unique
15.	Mango	Supari Aanp	Lamjung	Very old tree
16.	Mango	Many local	Bhinsen Gau, Gorkha	Very old and threat due to Budi Gandaki Hydro Dam
17.	Mayal	Local Mayal	Marpha	Unique
18.	Naked barley	Kalo Uwa	Jhong, Mustang	Unique
19.	Pigeon pea	Dhanusha Local	Dhanusa	Unique
20.	Potato	Tarkhole Seto, Dhorpatan Local	Tara VDC, Bobaang VDC, Baglung	Unique
21.	Potato	Sthaniya	Jantarkhani, Okhaldunga	Unique
22.	Potato	Sthaniya	Gatlang, Rasuwa	Unique
23.	Radish	Choto	Jumla, Humla	Unique
24.	Rice	Pokhareli	Pokhara	Unique
25.	Rice	Junde Masino	Lamjung	Unique
26.	Rice	Anadi	Gandaki zone	Unique
27.	Rice	Ekle, Jhinuwa, Lekali, Basmati	Ghanapokhara-5, Lamjung	Unique
28.	Rice	Mallaji (Red and Black)	Lekhphant, Parbat	Unique
29.	Rice	Anadi	Bhagwana, Parsa	Unique
30.	Rice	Jarneli	Chapakot, Syangja	Unique
31.	Rice	Jhinuwa	Syangja	Unique
32.	Rice	Gudura	Aruchaur, Syangja	Unique
33.	Rice	Mansara	Aadhikhola, Syangja	Unique
34.	Rice	Ate, Belguti, Chirakhe	Ikhu, Terathum	Unique
35.	Rice	Ghaiya, Chattar, Chobo, Pakhe Jhinuwa, Debkotini, Kalo jhinuwa	Bhanu, Tanahun	Unique

SN	Crop	Landrace	Location	Unique traits
36.	Rice	Atte marsi, Dudhe marsi	Lokhim, Salyan, Tingala, Solukhumbu	Unique
37.	Rice	Anadi	Pokharathok, Palpa	Unique
38.	Sea buck thorn	Tora/Daale chuk	Muktinath	Unique
39.	Sesame	Nawalpur Khario Til-1	Chitwan	Unique
40.	Sponge gourd	Basaune Ghiraula	Syangja	Unique
41.	Taro	Hattipau, Kharibot,	Purkot, Aabu, Tanahun	Unique
42.	Sesame	Kalo and Seto Til	Kotdarbar, Ramjakot, Sundhara; Tanahun	Unique
43.	Wheat	Kadu	Kimtang, Nuwakot	Unique
44.	Wheat	Naaphal	Humla	Unique

Source: Joshi et al 2017b

Why Germplasm Rescue

Crop diversity is the most important for genetic improvement of any crop species. Many years are needed to evolve any particular trait in a landrace. Due to the different factors there is a danger of genetic erosion or extinction of either particular trait or a landrace from certain locality. Prime reason therefore is to protect existing crop diversity from being extinction and make available for uses in future and at present. After disasters, generally there is no priority works on local agricultural plant genetic resources (APGRs). Even during intervention of new technologies, local APGRs are never valued and consequently resulted in the loss of crop diversity. National Genebank therefore organize rescue mission and encourage others for implementing such kind of mission to conserve the endanger germplasm in ex-situ system and promote their use in cultivation through repatriation to communities in disaster prone areas. Such materials can be needed for immediate use (eg for breeding, immediate planting, land management, repatriation, etc). It is also carried out for gap filling in the ex-situ collections. If there is no immediate use of rescued germplasm, later farming communities may be interested on those materials and can be repatriated. Farmers getting their own materials after a certain period of time may feel happy and proud. It has significant contribution on restoring the crop diversity, strengthening local seed system and safeguarding biodiversity of traditional crops in marginal areas such as remote hills and mountains of Nepal (Gauchan et al 2016).

Determination of Conservation Status of Germplasm

Conservation (red list) status means groups of crops landraces that are assessed using different criteria, which basically reflects on the trend of genetic erosion. For example decreasing population size over the time of any landrace indicates that this landrace is at endangered state and it may extinct soon. Red list groups for APGRs are common, vulnerable, endanger, extinct and not evaluated. This is important to determine the red list status of crop landraces for setting priority attention for conservation as well as planning different types of actions for particular groups of landraces. Red list status can be determined through different techniques which are explained below.

Survey

Survey is very common and popular tool to assess the status of any crop landraces. Simple interviewing (asking) farmers about possibility of genetic erosion of any particular landrace over the time period is helpful to determine the red list status. Any one or group of survey methods eg household survey, focus group survey, key informant survey and literature survey can be used. Simple questionnaire should be developed considering different criteria related to extend of genetic erosion among crop landraces.

Distribution and Population Size Analysis

Landraces can be grouped under five classes based on the distribution pattern and population size as well as based on the area coverage and number of farmers growing this particular landraces in a village. Earlier it is commonly called Four Cell Analysis (Sthapit et al 2006, Joshi et al 2004), which considers areas and number of farmers growing this landrace to group into four classes (large area by many farmers, small area by many farmers, large areas by few farmers and small area by few farmers). To have a complete picture of any particular areas of total crop landraces, five different classes which is called red list status, is now in practice (**Figure** 1) and this helps to give due attention for collections of endanger landraces. The distribution and population size of any landrace can be analyzed either by directly measuring the variables or organizing the focus group discussion. The simplest method is FGD and National Genebank is generally organized FGD for red list assessment.

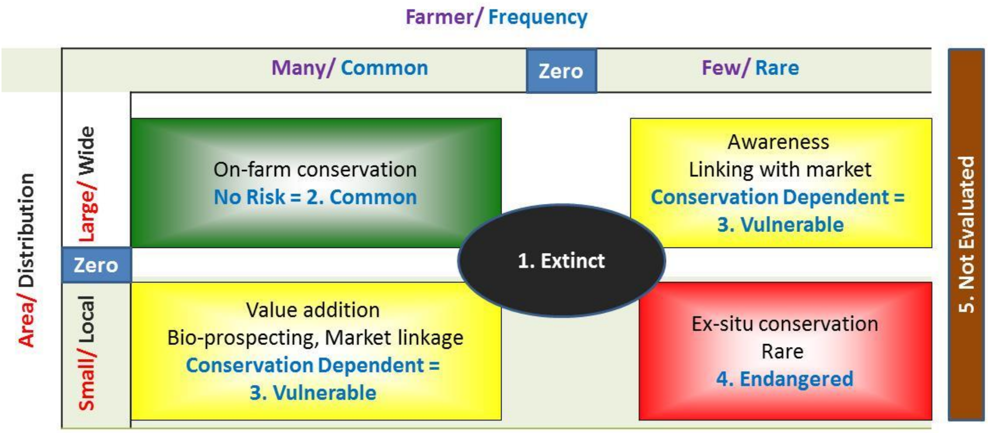

Figure 1. Categorization of crop landraces based on the distribution and population size.
Source: Joshi et al 2004 (modified)

Trait Distribution Analysis

Specific trait distribution can be analyzed like areas and number of growers of any landraces. Four classes of trait distribution analysis are given in **Figure** 2. Landrace with specific trait which is not available in other landraces is called unique landrace. Potential danger in such case is possibility of loss of particular trait, therefore considered such landrace as endangered state and need immediate attention for conservation. Landraces falling in other three classes are not at risk of extinction for a time period. For example, Gamadi rice landrace has unique trait which makes it unique. Its panicle always remains enclosed by flag leaf and this landrace is grown in a particular small area of central Tarai. Therefore, it has more chance of extinction and need immediate collection for conservation. Another example is Bhate Phaper (landrace of buckwheat) which has loose husk and available and cultivated in small area only in Dolpa. This landrace is considered as unique and falls under endangered class.

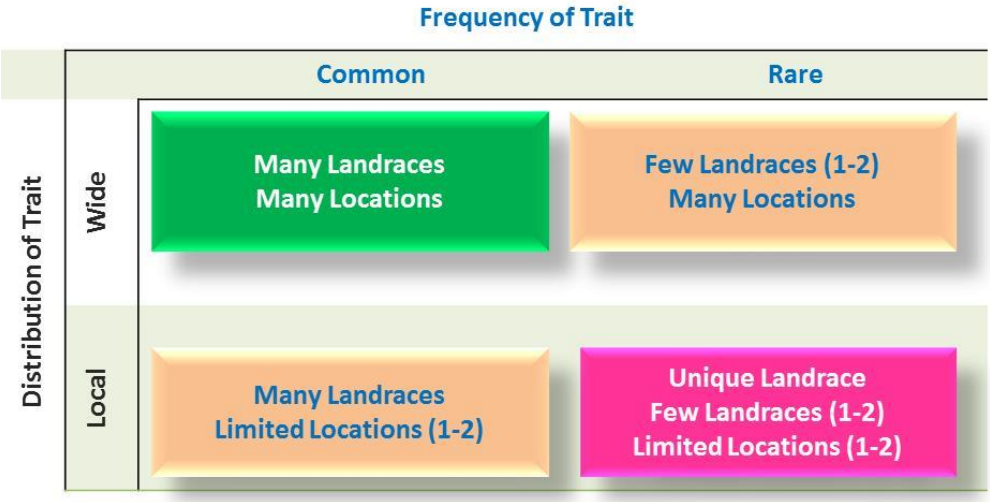

Figure 2. Categorization of crop landraces based on the distribution of traits.

Red Zoning Farming Areas

Red zone is the agricultural areas where the diversity in local crops is decreasing over the seasons due to many factors. There are major six factors that turn agricultural lands in to red zone (**Figure** 3).These factors include *ad hoc* distribution of modern varieties, heavy drought, disease and pests, natural disasters, migration of farmers after disasters, change in land use and commercialization. For example farming areas in earthquake affected districts are red zone and it demand immediate action for the protection of crop diversity. We have noticed loss of many landraces due to these factors across the country. Best strategy for not losing the diversity is to collect before happening these factors in a particular area as far as possible. For example, we can collect local landraces before distribution of modern varieties from a particular area. Concerned stakeholders also need to minimize such factors which has direct impact on reducing the crop diversity.

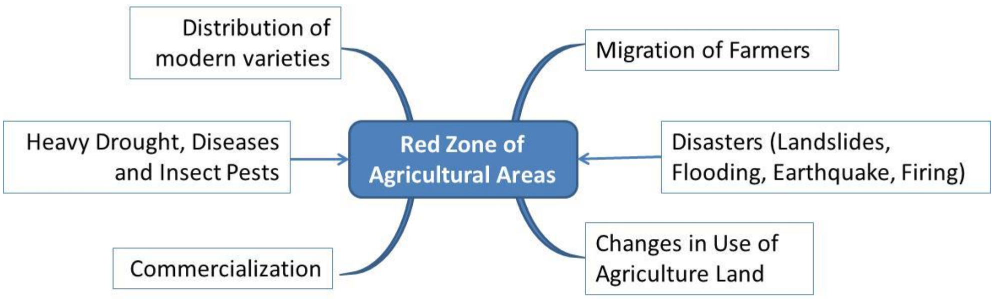

Figure 3. Factors that turn agricultural land to red zone (ie area where crop landraces become endangered).

Collection Gap Analysis

Geographical information system (eg DIVA-GIS) is very useful to generate the existing collections map of any crop species. National Genebank has commonly applied GIS for a number of crop species to generate a collection for spotting further collection sites. One example of finger millet collection is given in **Figure** 4. Collection map then is used to analyze the gap in the collections. To validate the gaps, it is more effective to relate gaps with information generated from literature review, FGD and KIS. This gaps are the potential areas for extinction of crop diversity, therefore needs to rescue them. After identifying gaps, further discussion and information collection should be organized to know the red list status of landraces available in these gap areas.

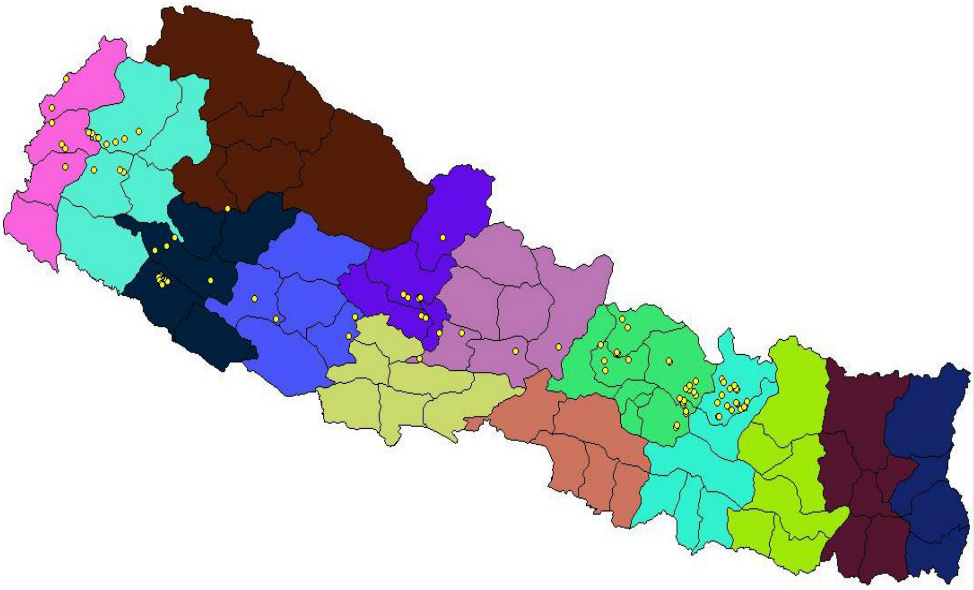

Figure 4. Collections map of finger millet using DIVA-GIS to analyze the gaps in collections.

Factors making Germplasm Rescued

Genetic erosion is the main cause to make germplasm at endangered state. A number of factors have been reported to cause genetic erosion (Engels et al 1995). It is difficult to quantify the genetic erosion of each crop landraces from the field. For the practical ease, crop landraces need to group under different conservation status. Based on the distribution pattern and population size over the areas and time period, crop landraces are grouped under five categories, called conservation status. These are common, vulnerable, endangered, extinct and not evaluated (Joshi et al 2004). Over the time the status of landraces might be changed due to different factors. For example common landrace might be endangered after few years due to availability and adoption of modern varieties. Factors that make crop landrace endangered are given below.

- Distribution of modern variety, introduction of foreign germplasm
- Natural and human made disasters eg landslides, firing, earthquake, flooding, industrial pollution
- Epidemics of diseases and insect pests; prolonged drought and heavy rainfall

- Changes in land use pattern and leaving land fallow or habitat loss caused by urban expansion, land clearance, dam and road construction and over-exploitation
- Changes in occupation, abandon agriculture, war or insurgency
- Old trees of which progeny has not been generated
- Rapid commercialization of agriculture; mono-genotyping the farming land
- Migration of farmers and land abandonment for cultivation
- Deteriorating the genetic performance on farmers' preferred traits
- Over-exploitation eg loss of species caused by over-grazing or by uncontrolled harvesting in the wild

Rescue Techniques

After locating red zone of agricultural areas and identifying landraces that are vulnerable and endangered, they can be collected (rescued) with different techniques for example visiting areas in person for directly collecting germplasm, requesting farmers or relevant stakeholders to collect germplasm along with passport data (**Figure** 5). In red zones, organizing diversity fair is very effective to know the status of local landraces as well as to rescue them from the fair. Participatory seed exchanges (PSEs) among local communities also help to identify rare landraces and rescue them. For orthodox seeds, one can collect in normal way as other common seeds. In-vitro collection is more efficient for very rare and endangered crop landraces that are non-orthodox. Announcement from the mass media might be useful to collect the endangered landraces from larger areas within a very short period of time. There should be certain incentive for farmers who bring the seeds of endangered landraces, the system called Reward Call.

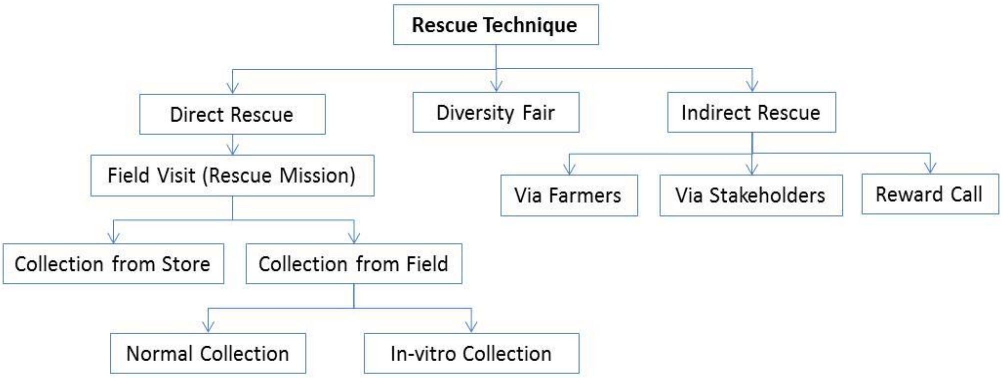

Figure 5. Different techniques to rescue germplasm from the red zones.

Conclusions and Way Forward

Germplasm rescue is essential and effective to protect the crop diversity from extinction. There are several factors that influence loss of crop diversity from given area for which rescue collection is essential. These factors include *ad hoc* distribution of modern varieties, heavy drought, disease and pests, natural disasters, migration of farmers after disasters, change in land use and commercialization. Rescue mission can be carried out after or before disasters. The rescue process involves the collection of endangered landraces from the red zone areas of farming and conservation of them either on-farm or ex-situ. Formal germplasm rescue mission was started since 2015 in Nepal. Rescue mission can be undertaken with different techniques for example visiting areas in person for directly collecting germplasm, organizing diversity fairs, participatory seed exchanges and requesting farmers or relevant stakeholders to collect germplasm along with passport data. To organize the rescue mission, it is necessary to identify the endangered landraces, through the process called red listing. Red list status (also called conservation status) is determined either through survey, distribution and population size analysis, trait distribution analysis, red zoning farming areas and gap analysis. Geographical information system (eg DIVA-GIS) is very useful to generate the existing collections map of any crop species and identify gap in collections. The rescue collection mission was organized immediately after mega earthquake of 2015 in 10 earthquake affected districts from 2015 July to 2017 June, where a total 921 accessions of 61 crops have been rescued from 35 VDCs of the 10 affected districts.

The different techniques of rescue collection such as field survey, distribution and population size analysis, trait distribution analysis, red zoning of farming areas and gap analysis using GIS CAT (Climate Analogue Tool) are very useful techniques to collect, assess and document rare and endangered crop landraces for their ex-situ and on-farm conservation. Rescue mission has helped to restore lost crop diversity, strengthen local seed system and safeguard biodiversity of agricultural crops. Rescue missions, therefore should be organized regularly in collaboration with relevant stakeholders following different rescue techniques specified above for safeguarding crop biodiversity for the future. Red listing

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Rebuilding Local Seed System of Native Crops in Earthquake Affected Areas of Nepal (Bal K. Joshi and Devendra Gauchan, eds). Proceedings of Sharingshop, 18 Dec 2017, Kathmandu; NAGRC, BI and Crop Trust; Nepal

Assessment of the Impact of 2015 Earthquake in Cereal Crop Diversity in the selected Mountainous Districts of Nepal[1]

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Abstract

A rescue collection mission was carried out in seventeen VDCs of Gorkha, Nuwakot, Kavre and Rasuwa districts. A total of 131 households were surveyed along with collection and rescue of local crop landraces. FGD, PRA and four cell analysis were done to identify major cereal crops of those areas and their varieties along with their areas, before and after earthquake. The main objective was to assess the impact of earthquake in local cereal crop diversity. The data was entered in MS Excel, , analyzed and calculated community richness, average farm richness, community evenness and average farm evenness of three major cereal crops; rice, maize and wheat, and two minor crops; finger millet and barley. Varietal diversity was observed high for maize and finger millet in all of the districts. Only a single variety of barley was recorded in all the study sites with richness being 1 and evenness being 0, and unchanged by earthquake. Wheat had similar case as barley where only Nuwakot was seen to be affected after earthquake, both measurements of evenness being slightly increased. For maize, community evenness decreased in two of the districts; Gorkha and Kavre being slightly changed. Community richness was found to decrease in Kavre and increase in Gorkha by 1. Community evenness decreased in all districts for finger millet after earthquake. Community richness also decreased for rice and finger millet in all districts except Rasuwa, where it remained unchanged after earthquake. The study recommends to concentrate on rescue collection and conservation of endangered rice landraces in Gorkha and Nuwakot while concentrate on maize and finger millet in all areas of hills, as they were found highly diverse in those places and diversity being mostly affected by earthquake.

Keywords: Cereal crop diversity, Earthquake, Evenness, Divergence, Richness

[1] This is part of MSc Thesis of first author submitted to IAAS, TU, Kirtipur.

Introduction

Nepal is very rich in agro biodiversity, 10th richest in Asia and 31st richest in the world ranking (MoFSC 2014). If seen in crop diversity, Nepal has 64 different agronomic crop species, 484 indigenous crop species, 224 crop wild relatives species, 577 cultivated plant species and 30000 crop landraces (Joshi 2017, Joshi et al 2017, Upadhyay and Joshi 2003). In cereals, rice, wheat and maize alone contribute 60% of total food energy (FAO 2011) and in Nepal, rice, maize and wheat is grown in 42.5%, 25.4%, 22.6% of total land area with 44%, 25.8%, 25.1% contribution in national food security respectively (MoAD 2013). Cereals satisfy most of the Nepalese people's livelihood where seventeen different species of cereals is observed in any of the months. Even within a species, many landraces support diversified needs of farmers and consumers (Bhatta et al 2017). A detail description on cereal crop diversity of rice, wheat, maize, barley and millets present in Nepal is given by Bhatta et al (2017). Crop diversity being affected by population structure and natural selection, is also affected by human selection and management. Crop genetic resources which passes from generation after generation is influenced by many natural and human selection pressures that defines crop diversity structure of a place, where environmental, biological, cultural and socioeconomic factors influence a farmer's decision to select or maintain a particular crop cultivar at any given time (Jarvis et al 1998, Jarvis and Hodgkin 2000). A large number of genetic erosion is evident in major food crops which are important for food and nutrition security and 50% of traditional varieties are estimated to be lost from farmers' field in Nepal (Joshi et al 2017).

Due to 7.6 magnitude earthquake which hit Barpak on April 2015, damage and losses to agriculture was estimated to be 16,405 and 11,952 million rupees including losses of stocked food grains and next generation seeds respectively (NPC 2015a, 2015b). The FAO Global Plan of Action on Plant Genetic Resources for Food and Agriculture states: In the modern world and especially in developing countries, people are threatened with and vulnerable to natural disasters, civil strife and war. Such calamities pose huge challenges to the resilience of agricultural systems. Often, adapted crop varieties are lost and cannot be recuperated locally. Food aid during war, calamities and disasters for emergency seed assistance with supply of poorly adapted seed may result in loss of local crop diversity and have a negative impact on household food production and security in subsequent years (Friis-Hansen and Rohrbach 1993, Richards and Ruivenkamp 1997, Sperling 1997, Friis-Hansen and Kiambi 1998). Due to earthquake, many of the winter crops ready to harvest ie wheat, barley, young maize were lost; carefully household stored seeds of widely grown crops like rice, millet, buckwheat, foxtail, proso-millet and summer vegetable seeds were damaged or destroyed along with minor crops which were only stored in low quantities (Sthapit and Gauchan 2016, Gauchan et al 2016).

Thus, there was a need to assess the impact of earthquake on agro-ecosystem of those affected areas, measure the change brought to existed cereal crop diversity which sustains the livelihood of rural hilly communities. The scientific community has developed a wide range of methods of measuring various dimensions of agrobiodiversity, each with different levels of certainty, accuracy and complexity (Jarvis et al 2008, Jarvis et al 2016, Brown 1999). Species and varietal diversity are key indicators for ABD in production system. Similarly, access to species and varietal diversity in seed system and % area under specific crop varieties on-farm are potential indicators for genetic resource management systems

(Sthapit et al 2017, Joshi et al 2012). Area can be used as a predictor of diversity (Joshi et al 2012, Brown and Brubaker 2002), that specific area plantation of crop is an approximation of population size and can be used as indicator of genetic diversity for temporal and spatial comparisons for any crop within a particular agricultural production system. Richness and evenness are two key notions of biological diversity where richness is the total different kinds of individual regardless of their frequencies and evenness measures how similar the frequencies of different variants are, with low evenness indicates dominance by one or few individuals (Frankel et al 1995, Magurran 2003). Other very common diversity index is Shannon Diversity Index, which has been used for comparing diversity between species, between modern varieties and landraces, and among household in Nepal (Joshi and Baniya 2006, Joshi et al 2018, Joshi et al 2007). The diversity contained within plants or animals or any ecosystem helps the human communities to cope and adapt with the challenges of changes-at now and in the future as well as for resource poor farmers in rural livelihoods, crop varieties and cultivars adapted to particular micro-niches, stresses, or uses are the main resources available to maintain or increase production and provide a secure livelihood (Sthapit et al 2006). This paper summarizes the comparison of diversity indices of richness and evenness of local crop varieties before and after earthquake and provides conceptual framework for different conservation stakeholders to develop different types of mitigation measures for uplifting existed local cereal crop diversity in the affected areas.

Methodology

Gorkha, Nuwakot, Kavre and Rasuwa were identified as target districts by reviewing the effects of earthquake on those places, reviewing different literatures on earthquake and after consultation with the scientists of National Genebank, Khumaltar and Bioversity International. Saurpani, Barpak, Laprak and Gumda VDCs; Kimtang, Cahule, Valche and Rautbesi VDCs; Mahadevsthan, Anekot, Rani Opi, Budhakhani, Phoksingtar and Kartike Deurali VDCs and Haku, Bridim and Syafru VDCs were identified as study sites which are crop diversity rich and critically affected VDCs after discussion and consultation with the DADO (District Agriculture Development Office) officials for Gorkha, Nuwakot, Kavre and Rasuwa districts respectively. Discussion on the major crops grown and affected in those VDCs was also done with DADO officials and field officers of Agriculture Service Centers.

A rescue collection mission was carried out in those areas and rice, wheat, maize, finger millet and barley were identified as major cereal crops grown in those areas by Focus Group Discussion (FGD) and other Participatory Rural Appraisal (PRA) tools and landraces distribution analysis (Joshi et al 2004), also called four cell analysis. Thereafter, detailed information was collected from sample survey of 35, 31, 29 and 31 households in Gorkha, Nuwakot. Kavre and Rasuwa districts respectively. Household questionnaires were filled up to each sample respondents to gain information on household crop varietal diversity (HH diversity index) and area change to calculate change in varietal richness and evenness before and after earthquake. Area of each crop variety was noted in Ropani (500 square meter), which is major land unit in hilly regions. All possible care was taken to determine the consistency in farmers' naming and describing rice landraces by comparing information from farmer households and different social groups. The data was then entered and managed in MS Excel. The proportion of each variety of cereal crops per household was calculated and was analyzed by MS Excel to compute community evenness of crop landraces (CR), average farm evenness of crop landraces (AFE), community richness of crop landraces (CE) and average farm richness of crop landraces (AFR), before and after earthquake (AE, BE). The evenness was estimated as a complement of D (1 − D), where D is the Simpson measure of dominance, calculated and transformed logarithmically 1/(1−LN) (Magurran 2003, Jarvis et al 2008). Average farm richness was calculated as the average number of traditional varieties per household, excluding households that grew no traditional varieties. The Simpson index itself is a measure of dominance, and it is more convenient to tabulate its complement (1-SI) as the estimate of evenness diversity, including only farms that grew at least one traditional variety. Total community richness was calculated by summing the number of distinct traditional varieties found across villages in the community.

Results and Discussion

Maize and finger millet were seen to be diverse in terms of local varieties in all of the four districts while rice was found to be diverse in two districts; Gorkha and Nuwakot. Barley found to be dominant of single variety in all of the districts while wheat being diverse in only a district, Nuwakot. In Gorkha district, we found that, there was no difference in community richness and average farm richness for wheat and barley. The values for both the measurements were equal to one in both cases ie before and after earthquake. Similarly, community evenness and average farm evenness was also equal to 0 in both cases for wheat and barley as there was dominant of single variety of both crops.

We can see the changes for two of the major crops, rice and maize and one of the neglected crop; finger millet (**Figure** 1). The community richness of rice decreased from 11 to 10, average farm evenness been decreased from 2.29 to 1.77, community evenness increased from 0.83 to 0.85 and average farm evenness decreased from 0.36 to 0.21 respectively from before earthquake to after earthquake. Whereas, community richness of finger millet been increased from 5 to 6, mean farm richness been increased from 1.7 to 1.8, community evenness decreased from 0.68 to 0.53 and average farm evenness increased from 0.28 to 0.31 before and after earthquake respectively. Finally, for maize, the community richness decreased from 6 to 5, average farm richness increased from 1.38 to 1.44, community evenness decreased from 0.62 to 0.51 and average farm richness increased from 0.16 to 0.18.

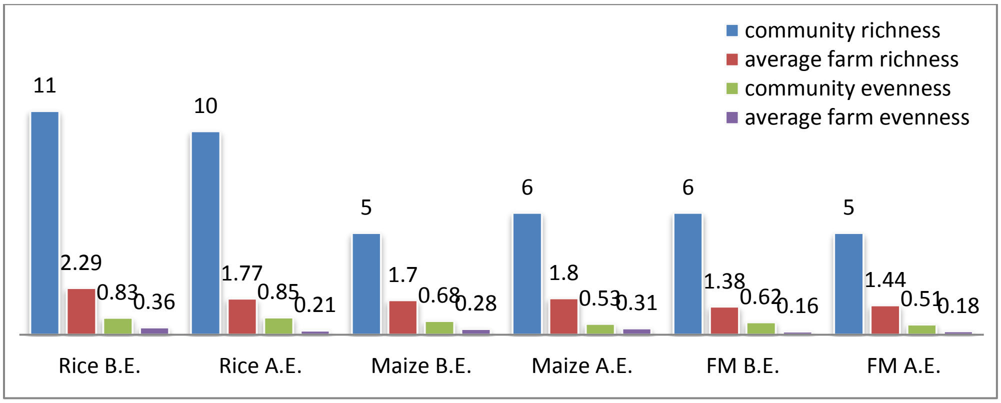

Figure 1. Changes in crop landrace diversity in Gorkha district.
BE, Before earthquake; AE, After earthquake; FM, Finger millet

Similarly, for Kavre district, we could not find and collect any of the rice landrace in any of the six visited VDCs. Therefore, we could not assess diversity change for rice. While, we could assess the varietal diversity change for one major cereal, maize and another neglected crop; finger millet in Kavre (**Figure** 2). For maize, community richness was found to be decreased from 3 to 2, average farm richness been decreased from 1.36 to 1.08, community evenness been decreased from 0.53 to 0.46 and finally, average farm evenness been increased from 0.15 to 0.41 before and after earthquake respectively. Similarly for finger millet, community richness has been decreased from 5 to 4, average farm richness been decreased from 1.4 to 1.38, community evenness been decreased from 0.7 to 0.66 and average farm evenness been increased with slight difference of 0.15 to 0.16 before and after earthquake respectively.

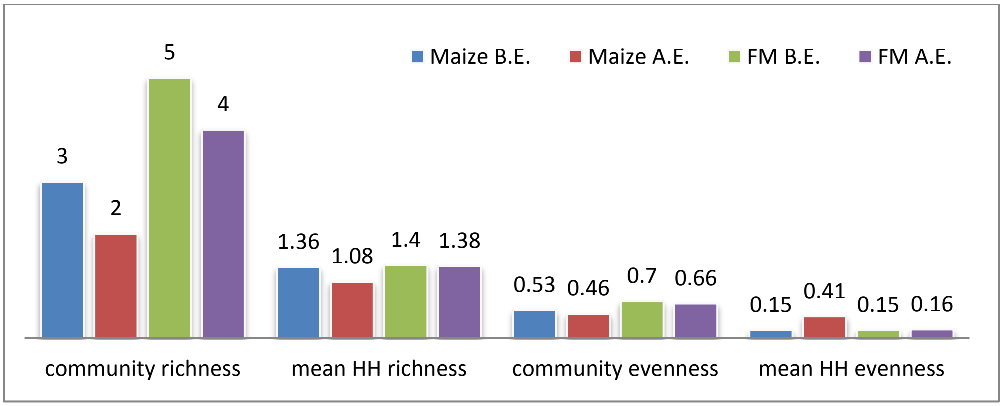

Figure 2. Changes in crop landrace diversity in Kavre.
BE, Before earthquake; AE, After earthquake; FM, Finger millet

The case of barley was seen same as Gorkha and Kavre in Nuwakot. The diversity changes was seen for three of the major crops; rice, maize and wheat and, one of the neglected crop, finger millet in Nuwakot (**Figure** 3). The change in the community evenness was seen the highest for rice for this district ie decreased from 9 to 5, average farm richness was seen to be decreased from 1.28 to 1.06, community evenness decreased from 0.71 to 0.51 and average farm evenness increased from 0.1 to 0.29 before and after earthquake respectively. For maize, there was not much change seen for all the measures before and after earthquake. For finger millet, there was a decrease in community richness from 4 to 3, decrease in community evenness from 0.8 to 0.55 before and after earthquake while average farm evenness and richness not much affected. For wheat, there was no difference in community richness, average farm richness meagerly increased, community evenness increased from 0.45 to 0.51 and average farm evenness increased from 0.35 to 0.45 before and after earthquake respectively.

Similarly, the cases of wheat and barley was seen same as Gorkha and Kavre in Rasuwa. There was not much diversity change, even for finger millet (**Figure** 4). While average farm richness has been increased from 0.153 to 1.39 while all other three of the measures unchanged or meagerly changed.

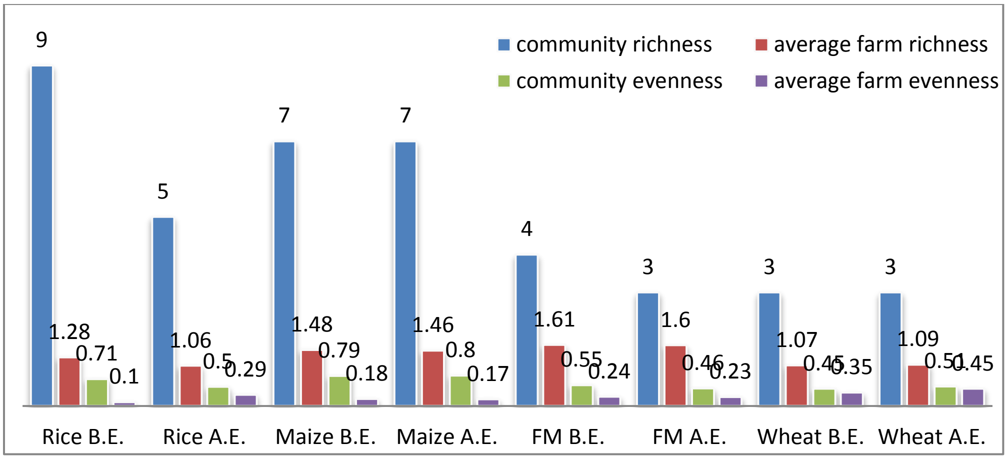

Figure 3. Changes in crop landrace diversity in Nuwakot.
BE, Before earthquake; AE, After earthquake; FM, Finger millet

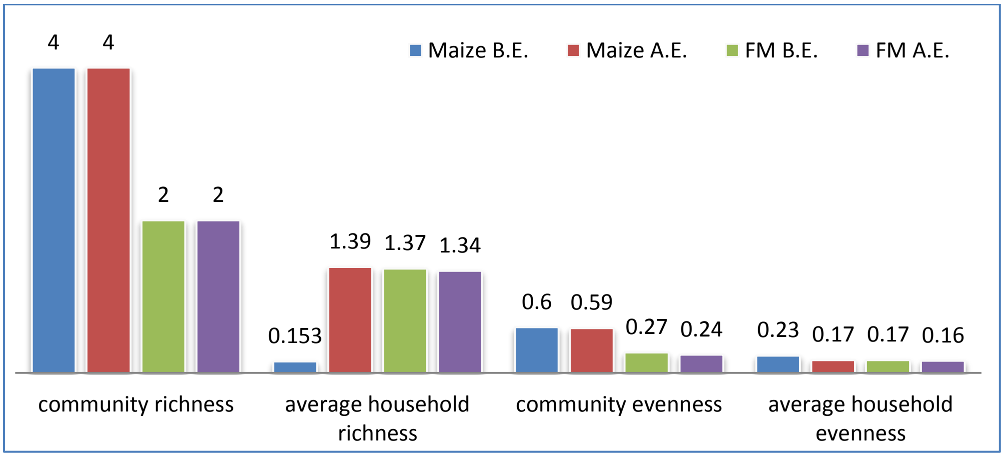

Figure 4. Change in crop landraces diversity in Rasuwa.
BE, Before earthquake; AE, After earthquake; FM, Finger millet

If seen for maize, the diversity indices in Nuwakot are seen less affected and not changed after earthquake (**Figure** 5). Community richness has been seen to be increased after earthquake in Gorkha district. The cause may be as because the farmers of those area may have introduced new local landrace of maize in their area to meet seed demand in next cultivating season. Community evenness is seen to be equal in all cases with only small decrease in Gorkha after earthquake. Average farm evenness is seen to be equal in all cases with small increase in Kavre district after earthquake.

As seen in **Figure** 6, the diversity indices is seen to decrease for all of the parameters after earthquake in Gorkha, Kavre and Nuwakot with no noticeable change in Rasuwa district.

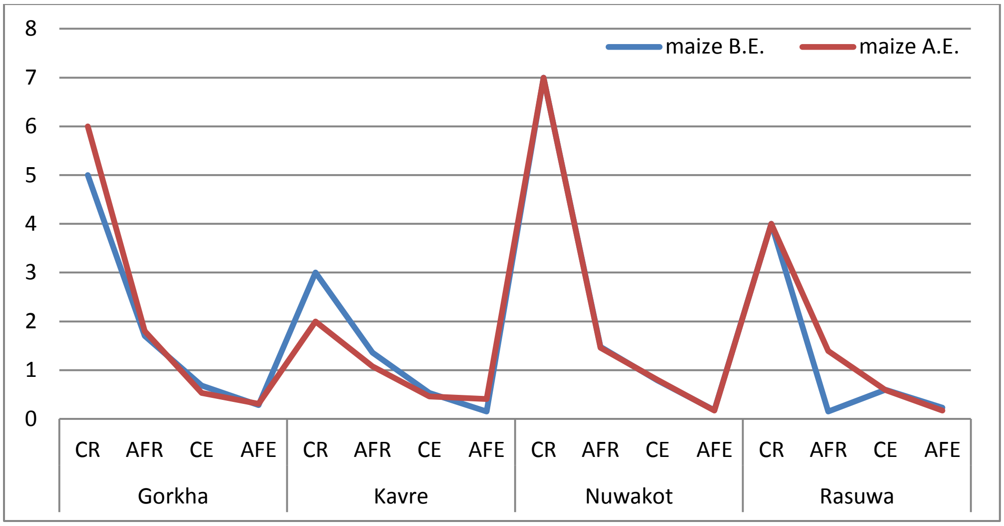

Figure 5. Maize varietal diversity changes across all study sites.

BE, Before earthquake; AE, After earthquake; CR, Community richness; CE, Community evenness; AFR, Average farm richness; AFE, Average farm evenness.

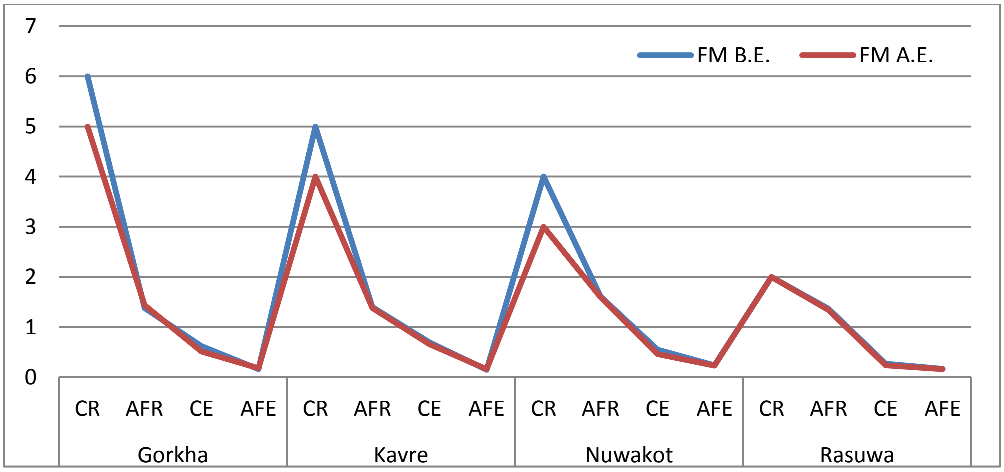

Figure 6. Finger millet varietal diversity changes across all study sites.

BE, Before earthquake; AE, After earthquake; CR, Community richness; CE, Community evenness; AFR, Average farm richness; AFE, Average farm evenness; FM, Finger millet.

Conclusion

Some level of genetic erosion is evident in rice and millet crops that have relatively higher level of genetic diversity and also are important for food and nutrition security of the people in the earthquake affected areas. Changes in community evenness, community richness, average farm evenness and average farm richness were observed in two of the major crops; rice and maize and one of the neglected crop; finger millet. Maize and millet were seen to be highly diverse in hilly regions in all study sites and varietal diversity was most affected by earthquake. In some districts varietal diversity of maize was found slightly increasing or constant after earthquake which probably due to distribution of maize varieties as a seed relief. In wheat and barley the diversity was low and there was no change after earthquake. Rice, with the highest number of local varieties in Gorkha and Nuwakot was also seen to be affected in community richness and community evenness value after earthquake. Future rescue collection and conservation need to be focused on rice and finger millet that have high native diversity and are also important for food and nutrition security of the small holders in Nepal.

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Rebuilding Local Seed System of Native Crops in Earthquake Affected Areas of Nepal (Bal K. Joshi and Devendra Gauchan, eds). Proceedings of Sharingshop, 18 Dec 2017, Kathmandu; NAGRC, BI and Crop Trust; Nepal

Participatory Seed Exchanges Restore Farmers' Access to Diverse Seeds in the Aftermath of the 2015 Earthquake in Nepal

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Abstract
Participatory seed exchange (PSE) is a low cost community-based mechanism for improving farmers' access to locally adapted seeds and planting materials and discovery of the rare varieties, which promotes farmer led on-farm conservation of the agrobiodiversity of the community. PSEs were organized in six earthquake hit VDCs of Dolakha, Ramechhap and Sindhupalchowk in December 2015 as part of LI-BIRD's post-earthquake rebuilding program. In these six events, 485 farmers brought 2058 samples of seeds to share and 503 farmers took 1249 samples of seeds from the exchange. Legumes, vegetables and cereals were most prominent in the exchange. Over 98% of the seed exchange transactions were for varieties not in the official national notified list of varieties, which demonstrates the valuable complementary role that PSE can play to the formal seed sector. PSE was also found invaluable for exploring and identification of the indigenous genotypes of the community and their easy access for passport data and sample seed collection. In total 444 samples of local seed of 46 crops were collected along with passport data and handed over to National Agriculture Genetic Resources Center (Genebank) out of which 78% of the samples were processed for conservation in the National Genebank for safety duplication. Seed collection, rescue and PSE have played important role in exploration collection, distribution, conservation and promotion of the local genotypes. Hence, we recommend carrying out PSE for collection, conservation and repatriation of farmer preferred seeds regularly during summer and winter season in a community.

Keywords: Access to seed, Agricultural biodiversity, Informal seed system, Local varieties, Participatory seed exchange

Introduction
Due to devastating earthquake of 2015, Nepal suffered great loss of human life and development structures including agriculture loss. Agriculture is the main source of livelihood for two-thirds of Nepal's population, including many subsistence farmers. Affected families have lost livestock, food and seed stocks, standing crops and agricultural inputs, while facing market disruptions and constrained movement of emergency

assistance. The official estimate by the Government of Nepal indicated that stored food grains and seeds amounting to more than NPR 8 billion (USD 80 million) were lost and about 60% of households' food and seed stocks were completely destroyed by the mega earthquake and subsequent aftershocks (FAO 2015).

Seed or genetic resource is one of the few resources available to resource-poor farmers and women to ensure sustainable livelihoods, food and nutritional security. Participatory seed exchange (PSE) in the Seed Rescue Project was introduced as a low cost community-based mechanism for improving farmers' access to locally adapted seeds and planting materials and approach to conserve agrobiodiversity in farmer's field. In this mechanism of seed exchange individual farmers bring seed for exchange with other. Seed exchange is needed when farmers want to test new varieties out of curiosity. This phenomenon is widespread and often targeted at new tastes or higher yields. Farmers seem to take any opportunity they came to exchange seeds with their friends and relatives when they observe a good variety (Carpenter 2005, Badstue et al 2007). Farmers are typically actively exchanging seed material with neighbors, relatives, and even distant strangers, thereby moving crop genetic diversity across farming units (Emperaire et al 1998, Chambers and Brush 2010, Coomes 2010). During the aftermath of the earthquake seeds of that locality were in vulnerable situation and really important for them to meet their daily nutrition. PSE was first piloted in Nepal by the Western Tarai Landscape Complex Project (WTLCP) in 2008 and 2009. As part of the agrobiodiversity component of the project farmers in home garden groups participated in these first PSEs in Bardiya, Kailali and Kanchanpur. In total, 126 farmers attended, 74 farmers brought seeds to the exchanges and 96 farmers took seeds of 1 to 10 varieties (Shrestha et al 2013). It was further tested by USC Canada in NABIC Nepal partner meetings as well as in the Custodian Farmers Workshop and was found to be an engaging and effective mechanism. PSE has been conducted annually via Community-based Biodiversity Management (CBM) Project in six districts of Nepal since 2009. This method was adopted in Seed Rescue Project in the aftermath of earthquake in Nepal to provide farmers' easy access to diverse seeds for strengthening agrobiodiversity and restoring food security. Sharing seeds along with indigenous knowledge, strengthening local seed system and conservation and promotion of agrobiodiversity in community to restore food security for farmers and their families in disaster affected areas were the major objective of the study in the target areas.

Methodology

The Seed Rescue Project was the part of the Phase 2 of LI-BIRD's Rebuilding Family Farms program funded through GRPI-2 project of Bioversity International. The bulk of the phase 2 of program was set around providing access to seeds and planting materials to over 64,000 earthquake affected households over two planting seasons. Meticulous preparation and planning have gone into identifying crops and varieties to provide as seeds to the farmers. Respective District Agriculture Development Offices (DADOs), field-based staffs and partners as well as elevation of working VDCs were consulted to plan for the list of crops and varieties to be distributed. However, due to the urgency of the post-earthquake response and communication challenges, certain assumptions inevitably had to be made. We were also restricted to supplying crops and seeds that were available in the market to ensure the safeguarding of locally adapted germplasm as well as facilitating its exchange.

The following steps were adopted to carry out the Seed Rescue activity in the aftermath of earthquake.

Site Selection and Seed Samples Collection

LI-BIRD chose the three districts, Dolakha, Ramechhap and Sindhupalchok to implement the Seed Rescue Project after consultation with Bioversity International and the National Genebank. In each district, two VDCs were selected for the field work covering different ecological zones and range of elevation of the earthquake affected districts (Table 1). The project was carried out during the period from June 2015 to 31 December 2015.

Table 1. Sites for the implementation of the LI-BIRD component of the Seed Rescue Project.

Feature	Dolakha		Ramechhap		Sindhupalchok	
VDC	Jugu	Namdu	Betali	Tilpung	Marming	Petaku
Altitude, masl	1000-3000	500-2500	500-3500	500-2500	1200-3800	1400-2300
Major ethnicities	Hill Brahman/ Chhetri	Hill Brahman/ Chhetri	Hill Brahman / Chhetri	Hill Brahman/ Chhetri	Disadvantaged Hill Janajati	Hill Brahman/ Chhetri
Cropping system	rice→wheat, barley→ maize & finger millet→wheat, buckwheat, barley→maize	Rice →wheat→ maize & finger millet→ maize	wheat + legumes (lentils, pea)→ maize →rice	wheat + legumes (lentils, pea)→maize →rice	finger millet → maize→ barley	Rice →wheat, finger millet
Households	1115	1715	997	876	855	690

Preparation of the varietal inventory played the crucial role in seed collection and filling up of passport data. Technical assistant, community motivator and OJT's of every site primarily visited the house of the farmers (participants) after contacting them. They also went to the house suggested by the farmers for the collection of local seed and passport data information. Simple introduction about project and its advantage in future was shared with farmers during passport data collection. Collection or donors number was given with specific coding created by the collector themselves and was clarified clearly in a note to minimize the confusion regarding it. Passport data form was filled as per the farmer's knowledge and suggestion regarding the information required. After completing the detail required about the seed, seed were collected in cotton cloth bags for big quantity seed sample and paper bags for small quantity seed sample so that damage due to moisture could be minimized. Furthermore bulk of the collection was made via participatory seed exchange. Accession meeting the requirement of basic sample size and quality were noted during the event and were collected respectively.

Participatory Seed Exchange

Arrangement of the meeting to share experience and advantage about Participatory Seed Exchange (PSE) helps to create the better environment of seed exchange in local level. Meeting with Ward Citizen Forum, Biodiversity Community Development Committee, progressive farmers, active agricultural committees and local political leaders was done to share the past experience of the PSE organized by the LI-BIRD at six different VDC's of the country. Despite the damage of the seed from the earthquake there were still many seed remained in the locality. All of the villages and farmland were not completely destroyed. There were remnant seed either in storage or in those areas where earthquake had not made serious damage. Steps involved during participatory seed exchange events were adapted from Shrestha et al (2013) and are briefly described below.

1. **Seed registration and display:** Each ward was provided with a stall, display materials, seed entry form, tags. Farmers from the ward registered the seed they brought with them into an inventory, applied labels and put it on display. Farmers not only brought seeds but also propagative materials for display.
2. **Seed observation:** After all the seed and planting materials were registered and put on display in the stall, the session for observation was started. Farmers along with the other participants walked from stall to stall making note of the seeds on display and what they would like to take.
3. **Discussion and knowledge sharing:** At the end of the observations session, participants from each stall described the varieties they had and shared information on cropping time, climatic requirements, intercultural practices, agronomic traits, nutritional value, medicinal value, traditional significance and other properties of the varieties and crops. They also took questions and provided clarifications.
4. **Seed demand collection and seed exchange:** After the participants had the chance to observe the seed and learn about associated traditional knowledge, each stall was provided with a form to collect the names of the farmers interested to take seeds of the varieties in the stall. Volunteers helped with the record keeping. Based on the demand collected, the available seed was portioned out to meet the demands. Usually, participatory seed exchanges in the past have been done farmer to farmer. But this time, we opted to organize the exchange by ward, while still keeping track of who brought and took the seeds.
5. **Evaluation:** Each stall was evaluated by a committee of judges including farmers, agriculture technician and LI-BIRD staff. The criteria of seed diversity, seed quality, seed quantity and quality of knowledge and information sharing were used to declare the best stall of the event.

Data collected from PSE and passport data collected during the seed collection phase were recorded in excel sheet.

Results and Discussion

PSE was successfully carried out in 6 VDC's of 3 severely earthquake hit districts of Nepal. Farmers of different community brought different kind of seeds showing wide range of crop diversity. There were 485 seed collectors and 366 seed donors during the PSE events (**Table** 2). Collectors are the farmers that brought seeds or planting materials to the PSE, recipients are the farmers that took seeds or planting materials at the PSE and donors are the farmers whose seeds or planting materials were taken by recipients. In total of 485 collectors, 20 farmers were top collectors having majority of them women farmers (17). Similarly in total of 366 donors, 18 donors were top donor among which 13 were women farmers. The active participation of the women in PSEs shows the pivotal role of women in conservation and promotion of the local seed (Gauchan et al 2016). Furthermore, the overwhelming participation of the 503 farmers for receiving seeds in PSE also signifies importance of seed and seed exchange to the farmers in the earthquake affected areas.

Indirectly PSEs covered 503 households where the indigenous genotypes are being conserved and promoted via farmers led field conservation.

Table 2. Summary of seed collectors, recipients and donors during PSE event in 3 districts

Districts /VDCs	Collectors	Recipients	Donors
Dolakha	**159**	**142**	**83**
Jugu	29	79	26
Namdu	130	63	57
Ramechhap	**232**	**235**	**164**
Betali	131	89	70
Tilpung	101	146	94
Sindhupalchowk	**94**	**126**	**119**
Marming	44	55	33
Petaku	50	71	86
Total	**485**	**503**	**366**

In total 2058 seed samples of different crop types were collected in the event, out of which 1249 were exchanged among the farmers (**Figure** 1). The exchange of the seed within farmers ensured the no-farm conservation and promotion of the agrobiodiversity. Legume crop (679 and 497) were the highest collected and exchanged seed item during the PSE event held in 3 earthquake affected districts followed by cereals crop (432 and 192). Even if some farmers mostly save their seeds and only rarely acquire them from elsewhere, they are still part of a web of exchanges (Almekinders et al 1994, Badstue et al 2006, Dyer et al 2011). During the disaster exchange is helpful to restore food security and agrobiodiversity conservation in the community. Over 99% of the seed exchange transactions were for varieties that were not in the official (SQCC's) list of 605 notified varieties, which demonstrate the valuable complementary role that PSE can play to the formal seed sector.

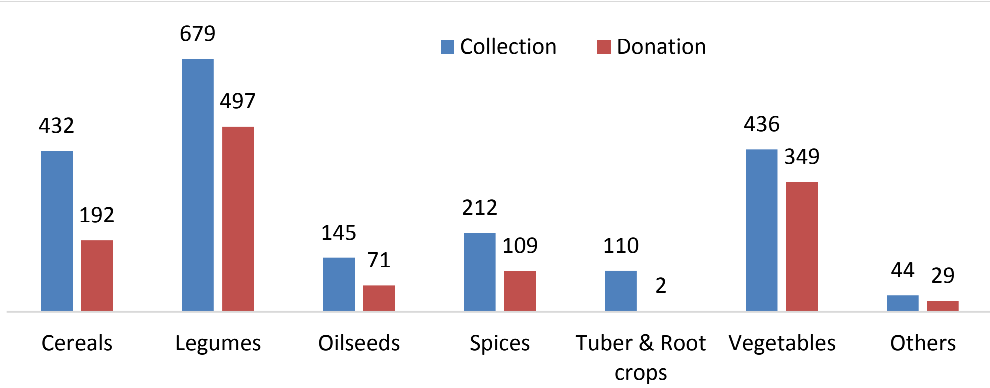

Figure 1. Summary of seed samples collected and donated during PSE event in 3 districts.

The seed rescue and data collection was undertaken in the three most severely hit districts where 444 samples of seeds were collected representing 46 crops covering major cereals, legumes, vegetables, oilseeds and spices (Gautam et al 2016, Gauchan et al 2016, and Sthapit and Gautam 2016) (**Table** 3). Of these, 78% of the samples were processed for conservation in the National Genebank for conservation (Gauchan et al 2016). PSE made collection much easier by providing abundant room for exploration and identification of the diverse seed during the event. From Jugu and Namdu VDCs of Dolakha, 105 and 62 local crop accessions, respectively, were collected out of which 40 accessions were endangered. 64 and 62 accessions of seeds were collected from Marming and Petku VDCs of Sindhupalchowk out of which 32 accessions were endangered. Similarly, from Betali and Tilpung VDCs of Ramechhap, 84 and 67 local crop seed accessions were collected out of which 10 accessions were endangered. This shows that with strategic collaboration with the national genebanks, PSE can strengthen the informal seed system while also adding to the national ex-situ germplasm collection for future varietal developments.

Highly endangered local varieties of rice collected from Jugu are Angha, Basmati, Pakhey, Sano Marmi, Tauli; of wheat are Bhagerey, Rato Potey; of maize are Kokale, Murali, Rato, etc. In Namdu, collected accessions of local rice varieties, Anpjhuttey and Motey Dhan, and a bean variety, Choti are endangered. From Petku, collected local crop varieties such as Kalo Jai, Mudey Jai, Kalo Bhatmas, Kailo Bhatmas, Bhote Farsi and Hariyo Kankro are endangered. Local soybean (Kalo Bhattamas) in every site is in endangered condition (Gautam et al 2016). These accessions collected are now conserved in National Genebank and some of the invaluable genotypes are being multiplied and promoted via Local Crop Project (LCP) implemented by NARC, LI-BIRD, Department of Agriculture and Bioversity International which is funded by Global Environment Facility (GEF) and United Nation Environment Program (UNEP). Nevertheless, all the diversity could not be collected in gene banks, during 1970–1980s a few scientists, based on work in biological conservation, proposed a complementary strategy of conservation referred to as in-situ conservation where diversity is maintained in the field (UNCED 1992, Pistorius 1997, Fowler et al 2000, FAO 2002). On-farm conservation is a farmer-led conservation approach where landraces are given due attention. It also refers to specific formal projects and programs to support the maintenance of crop diversity (Brush 2000). Therefore, PSE process carried out with the communities in the earthquake affected areas of three districts has helped promoting on-farm conservation of rare and endangered crop genetic resources. It also provided process for enhancing access and use of locally adapted and farmer preferred crop varieties in the communities.

Table 3. Summary of different crops collected under seed rescue project

District	No of Crops Collected	Total Accessions	Accessions Cultivated in Few Places	Accessions Cultivated in Many Places	Accessions Endangered
Dolakha	**57**	**167**	**119**	**8**	**40**
Jungu	35	105	67	3	35
Namdu	22	62	52	5	5
Ramechhap	**44**	**151**	**141**	**10**	**10**
Betali	22	84	80	4	5
Tilpung	22	67	61	6	5
Sindhuplanchok	**59**	**126**	**45**	**49**	**32**
Marming	29	64	21	42	1
Petaku	30	62	24	7	31
Total	**46**	**444**	**305**	**67**	**82**

PSE also played important role in identification of the native crop and carrying out seed collection and rescue within short period of time with preciseness. Also, during the rescue program and PSE process researchers came in contact with farmers who provided knowledge of locally adapted climate resilient, disease and pest tolerant, medicinally important and nutritious crops landraces which could be conserved and promoted in future in different research and development programs. We observed that collection and rescue of the local crop genetic resources after disaster was useful but it was also difficult and time consuming work. Therefore, it was difficult to assess and estimate actual loss of crop landraces due to earthquake and other factors such as subsequent effects of farmers' migration, *ad hoc* distribution of untested exotic seeds and hybrids in the affected study areas.

Conclusion and Way Forward

The project has managed to collect 444 samples of seed representing cereals, legumes, vegetables, oilseeds and spices. Role of PSE was complementary to identify and explore the most endangered and valuable local seeds of traditional crops. Exchange of indigenous knowledge of crop along with seed samples was very propitious and in future it will be obviously useful in varietal development research. Coming across the 2058 seed samples during PSE event created the easy access of farmers to rare and indigenous crop varieties of the locality. It also increased the synergy and harmony among the community. Over 90% of the collected and shared seeds in the earthquake affected local communities were not in the official national notified list of varieties in Nepal, which demonstrates the valuable complementary role that PSE can play to strengthen the local seed system. All transactions during PSEs were made almost free of cost thus making it more cost effective and appropriate for marginalized farmers. The process of rescue collection and PSEs adopted after disaster have improved linking ex-situ and on-farm conservation and enhanced access of locally adapted crop seeds and varieties not readily available in the market. This has also helped to restore lost diversity, revive and strengthen the local seed system and safeguard biodiversity of native crops. Based on the experience and lessons learned from this study, we recommend collection, conservation and repatriation of farmer preferred seeds regularly through participatory seed exchanges. We recommend organizing a summer and a winter PSE at the village level not only after disasters but also during normal years regularly as an effective and low cost mechanism for improving seed access, strengthening local seed system and continuing farmer led on-farm conservation of agricultural biodiversity.

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Rebuilding Local Seed System of Native Crops in Earthquake Affected Areas of Nepal (Bal K. Joshi and Devendra Gauchan, eds). Proceedings of Sharingshop, 18 Dec 2017, Kathmandu; NAGRC, BI and Crop Trust; Nepal

Socioeconomic Aspects and Farmer Views on the Management and Use of Diversity of Underutilized Crops in Earthquake Affected Districts of Nuwakot and Rasuwa

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Abstract

A study was conducted to assess socio-economic aspects of underutilized crops relevant to agrobiodiversity, to understand farmers' views on impact of earthquake on agrobiodiversity and to find influence of socioeconomic use of underutilized crops and conservation in earthquake affected districts of Nuwakot and Rasuwa. Result showed that except for finger millet, popularity for cultivation of underutilized crops is poor at present context. Similar cases were observed for barley and naked barley in Rasuwa, which has been popularly used for local beverage purposes. Farmers reported that losing popularity is due to lesser yield in indigenous underutilized crop landraces and thus their varieties are disappearing. Major causes of decreasing of the underutilized crops areas are (i) There is no market price and demand for underutilized crops (barley, finger millet, buckwheat, amaranth) and market price if available is also lower, (ii) There is no use of these crops in commercial value chains and marketing, (iii) Farmers are presently more attracted to major food cereals and cash crops due to public support, subsidies and investment on R &D consequently disincentives for underutilized crops, (iv) Migration of peoples to lower accessible belt and urban areas of Kathmandu and other places including increased trend in Foreign employment. Despite these negative incentives to small and vulnerable farmers in risk-prone disaster affected areas of remote mountains, farmers continue to cultivate underutilized minor crops where other crops are least possible to grow. Regular monitoring, collection, conservation and repatriation programs will be more effective to conserve and promote the underutilized and other crop landraces diversity in such areas. Further, value addition, market linkage and diversification are needed to induce demand of these crops and provide incentives to farmers.

Keywords: Conservation, Earthquake impact, Landrace, Sociocultural usage, Underutilized crops

Introduction

Nepal is mountainous country and lies between the Hindu-Kush region having greatest and highest peaks of the world. Due to this, Nepal is rich in mountain crop diversity that is prevalent in the country (Joshi et al 2017, Upadhyay and Joshi 2003). Different ethnic people living in different regions of Nepal are using traditional underutilized mountain crops such as barley, naked barley, buckwheat, amaranth and finger millet in different ways in their life time (birth to deaths). Indigenous and local communities living particularly in the mountainous regions, use these minor or underutilized crops in different forms, from food security to ritual, cultural and economic purposes, where other crops are least possible to grow and adapted in harsh risk-prone mountains areas. Underutilized crops have been growing in hill and mountain areas of Nepal with higher diversity since ancient time.

Padulosi et al (2013) defined neglected and underutilized species (NUS) are those to which little attention is paid or which are entirely ignored by agricultural researchers, plant breeders and policymakers. They further stated major challenges to the sustainable use of NUS due to neglect by agronomic researchers and policy makers resulting in genetic erosion, loss of local knowledge and adverse effect of climate change (**Annex** I). In Nepal, criteria for defining NUS have been developed and in general, NUS is the species of which any varieties have not been either released or registered (Joshi and Shrestha 2017).

Several researchers have found influence of socioeconomic and cultural factors on conservation of plant genetic resources across Nepal and abroad. Riu-Bosoms et al (2014) identified three main categorical factors important in landrace conservation. These are (i) intrinsic characteristics (eg propagule viability, productivity), (ii) socio-economic characteristics (eg commercial interest, uniqueness vs. substitutability), (iii) cultural significance (eg tradition, local organoleptic perceptions). Velásquez-Milla et al (2011), in an study of tubers in Peru found that maintenance and promotion of indigenous Andean culture is crucial for ensuring conservation of both traditional agroecological systems and agrobiodiversity, and policies supporting Andean culture (through educational, cultural and economic programs) that are having directly link with conservation of traditional varieties. Literature shows that culturally valued landraces and landraces with farmers' preferred traits have not been at risk of extinction (Joshi et al 2005).

Swiderska et al (2011) found traditional varieties of maize having drought and wind resistant in SW China, maize resistant to unpredictable weather and new pests in coastal Kenya, and potato varieties in Bolivia that are more resistant to new pests and lack of rainfall, and the study suggested need to support landrace conservation, local seed production, seed fairs, community seed banks, and community based conservation and adaptation. Wang et al (2016) stated ethnic traditional cultures and custom practices are crucial factors on rice landrace variety diversity and genetic diversity. Gauchan et al (2005) found that household-specific socioeconomic, agroecological and market factors are important in determining on-farm rice diversity. Rana et al (2007) explained rice varieties having socio-cultural and economic (food security, market, religious and cultural uses), adaptive (abiotic and biotic) traits, are of determining factors for continued existence on-farm, and socio-cultural and religious use values are likely to be cultivated by more HHs in compared to other landraces (ie, landraces used in making special dishes for offering to deities or making traditional dishes specific to certain ethnic groups). Rana et al (2003) stated that culturally valued and unique rice varieties are maintained by farmers (for example Anga for medicinal value and Sathi for rituals). Landraces having multiple uses have better chances of survival on-farm (eg Hattipaupidalu (taro) in Begnas).

Despite these above mentioned literature, socioeconomic and conservation aspects of neglected and underutilized crops are yet to be explored and studied more in Nepal particularly after 2015 Nepal mega earthquake. Even though, study on socio-economic aspects of the crops (market price, cultural values and social utilization) are considered determining factors in on-farm conservation and promotion of genetic diversity, we have limited understanding and evidence of impact of April 2015 earthquake in Nepal. Therefore, attempts have been made here to study socioeconomic aspects of the underutilized crops and their influence on conservation and use in severely earthquake affected VDCs of Nuwakot and Rasuwa districts through rescue collection mission and socioeconomic surveys of households and communities.

The objective of the study were (i) To assess socio-economic aspects of underutilized crops relevant to agrobiodiversity and earthquake in Nuwakot and Rasuwa districts, (ii) Farmers' views on impact of earthquake on agrobiodiversity and (iii) Linking influence of socioeconomic use of underutilized crops with on-farm conservation and strengthening local seed system in earthquake affected areas.

Methodology

Site Selection

Sites were selected purposively on the basis of ecology (where indigenous landraces of minor/ underutilized crops are grown and utilized) and earthquake areas (which were prone to loss of diversity), with the consultation of District Agriculture Development Office (DADO).

Area Covered and Sample Size

A total of four village development Committees (VDCs) in Nuwakot (Kimtang, Bhalche, Kaule and Shikharbesis) and three VDCs in Rasuwa (Haku, Briddhim and Syafru) districts were covered for the study. Focus group discussions (FGDs) and key informant interviews were conducted in each VDC. Information were supplemented with transect walk, direct observation and informal interaction with farmers and local communities.

Key Informant Interview

Experienced and knowledgeable farmers were identified and personal as well as interview in group was conducted. For this purpose, semi-structured questionnaire was administered covering 2-3 knowledge farmers in each VDC.

Focus Group Discussion

All the interested farmers were gathered at a particular place to obtain more information of a particular area. Then focused group discussion (FGD) was made with them about the cultivations of local seeds, status and impacts of earthquake on their products. For this purpose, structured questionnaire was used to find loss assessment and threatened genetic resources. One FGD was made from each VDC covering a total of 7 FGDs from 7 VDCs from two districts.

Transect Walk and Direct Observation

Information on socioeconomic and religio-cultural values was obtained from individual farmers in the routes and places we visited through direct observation and transect walks carried out in the landscapes, villages, agricultural fields and cultural sites.

Findings and Discussion

Impact of Earthquake in Agriculture and Agrobiodiversity

According to FAO (2015), District Agriculture Development Office (DADO) in collaboration with government organizations (GOs) and non-government organizations (NGOs) distributed seeds of improved varieties of maize, finger millet, legumes and vegetable crops as relief materials to cultivate in respective seasons due to damage of their home and crops in the affected areas of the districts. Brief descriptions of losses (as given in Annex II) are: i. **Stored crop loss:** Although there is no VDC/district data available on stored crop loss in earthquake districts, overall data showed, the loss of crops were significant. Ii. **Livestock deaths:** The overall or complete estimate of animal loss is not available. However, compilation of animal deaths in the Rasuwa was significantly higher and lowered in Nuwakot. Iii. **Agricultural infrastructure:** Comparative agriculture infrastructure damage due to earthquake is given in below. The damage in Nuwakot and Rasuwa district was significant compared to other districts.

Field survey and assessment from rescue mission revealed the significant losses of native crops varieties from both earthquake damage and also subsequent effect of *ad hoc* distribution of seeds of improved crop varieties as relief materials. Local communities, farmers and local developmental agencies reported higher losses of seed stocks from earthquake as compared to extent of losses reported from FAO study (2015). In Hanku VDC of Rasuwa, farmers and local communities reported complete losses of seed stocks and few endangered varieties of crops from earthquake damage and subsequent landslides and outmigration of local people to Dhunche (district headquarter of Raswua) and other lower parts of Rasuwa for over six months. Many farmers were willing to grow lost local crop landraces due to its adaptability, taste quality, nutritional benefits. For example, farmers in Briddim in Rasuwa were seeking for lost (7-8 years ago) variety of rice, because of its drought tolerant trait, good taste and its adaptability.

Socioeconomics of Underutilized Crops

Socioeconomics dimension of cultivation and use of underutilized crops was varying from place to place and VDC to VDC in the study sites, and hence assessed accordingly. They are briefly highlighted in following sub-headings.

I. Market price and Utilization of Underutilized crops

(A) Market price of Underutilized Crops at Nuwakot: In Nuwakot, the study showed that market price of common buckwheat in these areas are ranged from 40 (hilly area) to 140 (low land) per kg. Similarly, market price of finger millet ranged from 25 (hilly area) to 48 (low land)/kg. Price of the crops increased in the low land area. Farmers remarked that they do not grow buckwheat and amaranths because, there is no market value for these crops. According to farmers, the area of the crops is in decreasing trend. In low land in the foot hills and river basin very, less areas of minor crops are grown (eg amaranths). Farmers do not grow tartary buckwheat, and but they brought some time to the market from higher elevations than the places we visited (**Table** 1). In Rasuwa district, the studied sites were very remote and there was no market for most of the underutilized crops. Thus prices are relatively lesser than in Nuwakot district (**Table** 2).

Table 1. Cost price of underutilized crops in different VDCs of Nuwakot district

SN	Crop	Selling price, Rs/kg		
		Shikharbesi (mainly lowland)	Kimtang (hilly area)	Kharanitar (low land)
3	Sweet buckwheat	140	40	140
4	Bitter buckwheat	100	-	100
5	Amaranths	87.5	-	-
6	Finger millet	37.5	25	48

Kharanitar VDC is closer to Samudratar (buspark) on the way to Shikharbesi VDC.

Table 2. Cost price of underutilized crops in different VDCs of Nuwakot district

SN	Crop	Selling price, Rs/kg		
		Thulo Syafru (hilly)	Thulo Haku (Mountainous/slope)	Bridim (Mountainous/slope)
1	Finger millet	50	75	
2	Naked barley	50	-	No buying/selling, due to no market
3	Buckwheat	100	125	
4	Barley	50	-	No buying/selling, due to no market
5	Latte (Mhendo)	Less growing due to no market value and less use	125	No buying/selling, due to no market
6	"Ekle Ghughu" or "Ghughu"*	Not grown	Not grown	No buying/selling, due to no market

** Ekle Ghughu" or "Ghughu": According to farmers, it looked like amaranths or Bethe crops, but having single panicle (drooping type).*

From these price data showed that price of underutilized traditional crops are lower in higher mountain and relatively better in the lowland. In remote mountains, no market price exists for some of these crops due to remoteness, lack of market centers and very traditional subsistence farming of these crops.

(B) Utilization of Underutilized Crops at Nuwakot and Rasuwa: In Nuwakot, the utilization of underutilized crops ranged from usage in different forms of food (buckwheat, amaranth, finger millet, barley/naked barley), beverage (Finger millet, naked barley), religio-cultural (amaranth, barley and naked barley) and fodder (barley) (**Table** 3).

In Rasuwa, Thulo Syafru, underutilized crops has been used as food (Finger millet, naked barley, buckwheat, barley, amaranths), beverage (finger millet, barley), religio-cultural (finger millet, naked barley, amaranths), fodder (barley) and medicinal perception (barley) (**Table** 4). Similarly in Thulo Haku, the crops are used as food (amaranths, buckwheat, finger millet, naked barley and barley), beverage (finger millet), local culture (amaranths, barley, naked barley), fodder (barley, naked barley) and medicinal purpose (barley, naked barley) (**Table** 4). In Briddim, Rasuwa, barley has not been grown at present, farmers reported that it was grown 15-16 years ago. Other minor crops has been used for food (Naked, amaranths, Ghughu), beverage (Naked barley Ghughu), religio-cultural (Naked barley, amaranths), medicinal perception (Ghughu, naked barley) (**Table** 4).These information indicates that underutilized crops are used in multiple purpose for food, feed and beverages including cultural uses.

Table 3. Utilization of underutilized crops at different VDCs (Kimtang, Bhalche, Kahule, Shikharbesi) of Nuwakot district

SN	Crop	Growing area	Utilization			
			Food	Beverage	Religio-cultural	Fodder
1	Buckwheat	Hilly area	Roti Dhindo	-	-	-
2	Amaranth	Hilly area	Tarkari Bhutera (Roasted grain) Achar	-	Worship to god	-
3	Finger millet	Low to high hill areas of Nuwakot	Dhindo Roti	Raksi	-	-
4	Barley	Lower to higher elevation	-	-	Worship to god (Bramhan/Chhetri)	Livestock feeding
5	Naked barley	Higher elevation	Sattu	Raksi	Worship to god	-

Table 4. Utilization (summary) of underutilized crops in different VDCs of Rasuwa district

SN	VDC	Utilization				
		Food	Beverage	Religiocultural	Fodder	Medicinal perception
1	Thulo Syafru	Finger millet, naked barley, buckwheat, barley, amaranths	Finger millet, barley	Finger millet, naked barley, amaranths	Barley	Barley
2	Thulo Haku	Amaranths, buckwheat, Finger millet, Naked barley, Barley	Finger millet	Amaranths, Barley, naked barley	Barley, naked barley	Barley, Naked Barley
3	Bridim	Naked barley, amaranths, Ghughu	Naked barley, Ghughu	Naked barley, Amaranths	-	Ghughu, Naked barley

II. Farmers' Views on Impact of Earthquake on Diversity of Underutilized Crops

Farmers of study districts reported some impact of earthquake on landrace loss of underutilized crops, but higher level of impact on losses of seed stock stored in the house which caused acute problem of recovery (because of buried in houses) due to infrastructure damage by earthquake in villages, loss of water sources in some place, and low rainfall (land became dry) in earthquake area in year 2072 BS. However, there are simultaneous losses of crop landraces year by year due to other crops encroachment (such crops are vegetables, legumes, etc). Farmers reported that the conservation of local landraces of underutilized crops is difficult due to encroachment of improved varieties for economic benefit, and thus trend of cultivation area of local landraces and underutilized crops are in decreasing. Thus, separate programs are needed like value addition and involvement of conservation organizations to conserve local landraces.

III. Linking Influence of Socioeconomic Use of Underutilized Crops

There seemed strong link between crops use and its area stability, as finger millet is widely grown in these areas, due to because of its use in distilled liquor (Raksi), which has greater importance during different rituals and social functions. It has a greater social value as a drink in social functions and its nutritious local food value used as roti and Dhido to meet local food security. However, its selling price is relatively low. Similarly, naked barley, grain amaranths and barley being demanded crops for religion purpose, hence they could play important role in the conservation and sustainable use of these crops in the study area.

From above information it shows that these underutilized crops have food use value, economic value as grains (in case of finger millet), including beverage (eg karu and finger millet), and their values in socioculture (amaranths, barley and naked barley, fodder (Jau), and perceived medicinal value (Naked barley and Ghughu) indicated that these crops are more likely to be grown and conserved. Due to wider usage of these crops in the locality, it is unlikely to be extinct even though there is a declining area of these crops. Similar results were also reported and underlined by earlier researchers (eg Swiderska et al 2011, Wang et al 2016, Gauchan et al 2005, Riu-Bosoms et al 2014, Rana et al 2007, Rana et al 2003). This study has some limitations.

Conclusion

Except finger millet, the popularity for cultivation of most of the underutilized crops is low at present context. The utilization of finger millet is significant as local liquor (Raksi) and use in food (Dhindo, Roti) by different ethnic groups in Nuwakot. The crop has been using for alcohol (Raksi) and consumed in many different social and cultural activities including traditional feast and social gatherings since ancient time. Similarly for naked barley (Uwa/Jau) in Rasuwa, it is popular as local beverage (Rakshi). Farmers reported that losing popularity is due to lesser yield in indigenous crop landraces and thus landraces are losing. Major causes of declining trend of the cultivation of underutilized crops are (i) lack of market price and demand for underutilized crops (barley, finger millet, buckwheat, amaranth) and lower market price (ii) Limited commercial use value of these crops due to lack of value addition and marketing, (iii) Attraction of farmers towards higher income earning cash crops (vegetables, legumes), (iv) Migration of peoples to lower belt and Kathmandu, and increased trend in Foreign employment, (v) cultivation of minor crops in marginal low productive and risk-prone rainfed lands resulting in low return .

Therefore, there is a need of promotion of social, cultural, nutritional and ecosystem value of underutilized crops through awareness creation, technology development and targeted interventions. These crops can be suitable in marginal risk-prone rainfed areas to ensure food security and reduce poverty of marginalized and disadvantaged ethnic groups in remote hills and mountains. Special priority is to be given in research and development of these crops including introduction of community seed bank and promoting them through market linkages and value addition. Regular monitoring, collection and repatriation program will be more effective to conserve the underutilized and other crop landraces diversities in such areas. Value addition and diversification are needed to induce demand of these crops.

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Annex I. Challenges to NUS by category

1	Social	• Decisions of farmers to replace traditional, local crops with new varieties and improved crops • Changes in diet that accompany urbanization • Loss of the indigenous knowledge of traditional and local crops • Inadequate awareness of the nutritional value of local varieties • Perceived low status of some local and traditional foods • Migration of farm labor to urban areas • Overexploitation of wild resources
2	Economic	• Changes in land use • Low commercial value of NUS • Lack of competitiveness of NUS with other crops • Lack of market infrastructure • Lack of market niches for NUS • Lack of incentives for farmers to continue to maintain NUS in their fields and gardens
3	Environmental	• Genetic erosion of NUS genepools through the effects of droughts, fires, • pests, diseases, overexploitation, overgrazing, land clearing and deforestation • Effects of climate change • Environmental pollution • Ecosystem degradation
4	Agronomic	• Insufficient propagation materials and seeds • Lack of seed supply systems • Insufficiently trained human resources • Overuse of pesticides, fertilizers and other agrochemicals
5	Political	• Failure of national and local governments to make conservation and use of NUS a priority • Lack of funds for ex-situ conservation • Lack of adequate facilities and electricity supplies to maintain ex-situ collections • Failure of governments to support scientific research on NUS • Lack of characterization, breeding and evaluation information • Absence of legal frameworks, policies, projects, national programs and strategies • Lack of integration between conservation and use programs

Source: Padulosi et al 2013.

Annex II. Agriculture related earthquake profile

A. Households reporting a stored crop loss of more than 50%

Crop	Percentage of households reporting over 50% crop loss	
	In the 6 districts	In the 11 districts
Rice	77%	59%
Maize	73%	43%
Wheat	72%	63%
Barley	56%	49%
Potato	66%	53%
Millet	74%	66%

Source: FAO 2015.

B. Animal death from DLSO reports

District	Animal deaths (in % of total population)		
	Large	Small	Poultry
Nuwakot	0.9	2.7	1.5
Sindhupalchock	3.8	8.4	19.4
Rasuwa	2.0	6.5	21.4
Dhading	1.0	2.1	9.3
Dolakha	0.1	0.3	2.1
Gorkha	0.6	1.4	1.9
Total	**1.3**	**3.3**	**6.9**

Source: FAO 2015.

C. Proportion (%) of households reporting damaged productive assets, by district

District	Livestock shed	Storage facility	Sickle	Spade	Doko basket	Other agricultural tools
Dhading	65.4%	41.6%	18.8%	19.9%	14.4%	27.2%
Dolakha	41.6%	50.3%	40.5%	42.6%	39.5%	42.9%
Gorkha	27.2%	28.3%	15.1%	14.6%	16.7%	10.3%
Kabhrepalanchok	69.5%	19.2%	40.0%	40.8%	36.3%	15.8%
Makawanpur	3.4%	1.1%	0.5%	0.5%	0.3%	0.0%
Nuwakot	42.4%	39.2%	26.8%	24.2%	25.8%	13.4%
Okhaldhunga	21.1%	19.6%	8.4%	7.8%	7.6%	6.0%
Rasuwa	44.7%	47.4%	58.9%	51.3%	54.7%	18.9%
Sindhuli	15.5%	9.2%	2.4%	2.4%	2.1%	4.2%
Sindhupalchok	72.1%	52.9%	56.1%	55.0%	56.8%	49.5%
Ramechhap	45.3%	11.6%	19.7%	20.0%	15.0%	9.7%

Source: FAO 2015.

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Rebuilding Local Seed System of Native Crops in Earthquake Affected Areas of Nepal (Bal K. Joshi and Devendra Gauchan, eds). Proceedings of Sharingshop, 18 Dec 2017, Kathmandu; NAGRC, BI and Crop Trust; Nepal

Analogue Sites of Earthquake Affected Areas in Nepal for Deployment of Climate Smart Rice Landraces[2]

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Abstract
A rescue collection mission was carried out to identify and collect endangered crop landraces, to identify matching sites of earthquake affected areas and rice landraces for exchange and to explore the potential of repatriating the rice germplasm conserved in national and foreign genebanks. Twenty-nine village development committees (VDCs) of seven districts were visited and seeds and information were collected through household survey, FGD, semi-structured questionnaire and four cell analysis. DIVA-GIS software was used to construct a collection map and Climate Analogue Tool (CAT) was used to identify the analogue sites of earthquake affected areas. Based on the analogue sites, Nepalese rice landraces were identified from National Genebank, Nepal; National Institute of Agro-biological Sciences (NIAS), Japan and Genesys database for repatriation in earthquake affected areas. On an average about 50 accessions of rice were identified. The potential sites of repatriation were mapped for the deployment of identified and rescued landraces to ensure safe on-farm conservation, minimize the risk of extinction and strengthen food security.

Keywords: Analogue sites, Climate analogue tool, Crop diversity, Earthquake, Endangered rice landraces

Introduction
Nepal experiences a wide range of climatic and micro-climatic variations ranging altitude from 60 to 8848 meters, and rank the 10th richest country in Asia for biodiversity with 6973 different flowering plant species (Joshi 2017, Joshi et al 2017a, MoFSC 2002, Upadhyay and Joshi 2003). Nepal is rich in agricultural biodiversity (BPP 1995, Upadhyay and Joshi 2003, Joshi et al 2016) and about 484 cultivated native species have been reported. Still, human beings are dependent only in few different crops being rice, maize and wheat comprising 60% of calories requirement from plant sources (FAO 2011b). Only if seen for rice, Nepal

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has more than 2000 rice landraces with 102 different fine grain and aromatic rice landraces (Upadhyaya and Joshi 2003, Joshi 2004).

A rapid rate of genetic erosion is evident in major food crops which are important for food and nutrition security (MoAC 2010), where 50% of traditional varieties are estimated to be lost in the last four decades from farmers field (Joshi et al 2017a). Due to 7.6 magnitude earthquake which originated from Barpak (Gorkha) on April 2015, damage and losses to agriculture was estimated to be 16,405 and 11,952 million rupees including losses of stocked food grains and next generation seeds (NPC 2015). The FAO Global Plan of Action on Plant Genetic Resources for Food and Agriculture states: In the modern world and especially in developing countries, people are threatened with and vulnerable to natural disasters, civil strife and war. Such calamities pose huge challenges to the resilience of agricultural systems. Often, adapted crop varieties are lost and cannot be recuperated locally. Food aid during war, calamities and disasters for emergency seed assistance with supply of poorly adapted seed may result in loss of local crop diversity and have a negative impact on household food production and security in subsequent years (Friis-Hansen and Rohrbach 1993, Richards and Ruivenkamp 1997, Sperling 1997, Friis-Hansen and Kiambi 1998).

The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) allows the nations for interdependence of each other for PGRs and provides multilateral system of access and benefit sharing by possible exchange of plant genetic resources of 64 listed foods and forages species. Once obtained those PGRs from international genebanks, these could be used by breeders, scientists, researchers or anyone interested to use (Vernooy et al 2015). Farmers are dependent on each other for use, conservation and improvement of desired germplasm to secure their livelihood (FAO 2011b). A large number of genotypes of many crops are available in the world but the problem is to identify that which one suits the best to a particular place. For such, use of CAT (Climate Analogue tool) can be one approach to deploy climate smart landraces to their specific location (Chaudhary et al 2016, Joshi et al 2017b, 2017c). CAT, open access tool, can be used to identify potential analogue sites for present as well as future for a specific reference site. Climate change has a propound effect in agriculture plant genetic resources (APGRs) disturbing the livelihood of farmers in rural marginal environment which navigates for the need of other climate suitable germplasm for better adaptation (Esquinas-Alcazar 2005, FAO 2011a, Fujisaka et al 2011). Geographic information system and Climate Analogue Tool help in analysis of climate changes and their impact on seed systems; identification of plant genetic resources that have potential to adapt to identified climate changes and mechanisms for the acquisition of plant genetic resources that have potential to adapt to identified climate changes (Vernooy et al 2015). The analogue site of a place exists either within country or outside the country between which germplasm could be exchanged (Chaudhari et al 2016). DIVA-GIS and CAT have been used to manage agrobiodiversity in Nepal by NAGRC (Joshi et al 2008, Joshi et al 2017b).

An assessment was done in the earthquake affected districts to find out the conservation status (endangered from past, endangered by earthquake, rare or common with no risk of extinction) of crop landraces. The objectives were to identify and rescue the earthquake endangered landraces, collect and conserve those landraces in National Genebank for future. It also aimed to find out the analogue sites or the matching sites of the earthquake affected areas, identify the rice germplasm for exchange among the analogue sites and to explore the potential of repatriating the germplasm identified and conserved in National and foreign Genebanks.

Methodology

A rescue collection mission was carried out in 7 of the 14 crisis hit districts by earthquake of April 2015. The germplasm rescue team explored the most affected VDCs of those districts (Dhading, Makwanpur, Gorkha, Lamjung, Nuwakot, Kavre and Rasuwa) and information about earthquake effect on crop landraces status were obtained by Focus Group Discussion, household questionnaire and key informant interview. The conservation status of landraces was assessed by four cell analysis and interview with farmers. The geo-references were noted for each of the collection places. A total of 29 VDCs were visited in seven districts. The earthquake affected areas from where rescue of rice landraces was carried out were studied as the reference sites. The places from where germplasm were collected or rescued were mapped using geo-location coordinates to construct collection map by DIVA-GIS 7.5.0 software. Online Climate Analogue Tool (http://www.ccafs-analogueues.org/tool/) was used to assess current and future climatic conditions and identify sites analogous to the reference sites based on 19 bioclimatic indices. It was used to prepare the map of analogue places or the matching sites of the earthquake affected areas (the rescued sites) in backward scenario to identify the current statistically climatic analogue places of future earthquake affected areas with monthly mean precipitation as climatic and bioclimatic variables with equal weights of 0.5. DIVA-GIS software (http://www.diva-gis.org) was used to analyze and study those maps and tracing was done to track down the rice germplasm conserved by the foreign genebanks (NIAS, http://www.gene.affrc.go.jp/index_en.php and Genesys, https://www.genesys-pgr.org/) and National Genebank, Khumaltar. Those tracked germplasm were the rice landraces which could be deployed in the earthquake affected sites (rescue sites) at near future as well as potentially to be exchanged among the matching sites of future analog places of those sites. Then, current-future (forward) scenario was used with same bio-climatic variables to find out the matching sites or analogue places of previously used reference sites. Those maps provided potential areas to repatriate the identified germplasm and rescued landraces.

Results and Discussion

Twenty nine VDCs of 7 districts (Dhading, Makwanpur, Gorkha, Lamjung, Nuwakot, Kavre and Rasuwa) were visited (**Table** 1). A total of 513 landraces of 57 crop species were collected. The main focus was given to cereals and pseudo-cereals (rice, maize, wheat, barley, naked barley, finger millet, foxtail millet, buckwheat and amaranth) and legumes (soybean, black gram, rice bean, cowpea, beans, pea, chickpea and horse gram). Out of 62 rice landraces collected, 33 were found to be endangered due to earthquake and were rescued from 9 VDCs of 6 crisis hit districts (except Kavre).

Table 1. Endangered rice landraces due to earthquake in affected areas

SN	Earthquake affected area	Name of rescued rice landraces endangered by earthquake
1.	Darkha, Dhading	Biramphool, Rajbhog, Manbhog
2.	Jharlang, Dhading	Nadang Masino Dhan, Marshi

SN	Earthquake affected area	Name of rescued rice landraces endangered by earthquake
3.	Gumdi, Dhading	Kalokathe, Manbulikalo, Gurjidhan-1, Gurjidhan-2, Jhutte-1, Jhutte 2, Jhinuwa Kalo Masino
4.	Phaparbari, Makwanpur	Purano Basmati
5.	Ilampokhari, Lamjung	Basmati Dhan, Purano Anadi Dhan, Masino Basmati
6.	Bichaur, Lamjung	Kohili Dhan, Aanga, Thakali Lahare
7.	Kimtang, Nuwakot	Rato Dhan
8.	Haku, Rasuwa	Pinyali Khoya, Khaya Those
9.	Saurpani, Gorkha	Darmali, Kalo Kathe, Begani, Anande, Seto Gauriya, Seto Begani, Dali Ghaiya, Manbhog, Gokul Mansuli, Grujo Dhan, Yempali Dhan

Maximum number of rice landraces found endangered by earthquake and rescued from Saurpani VDC of Gorkha. Dhading proved to be the district with 3 VDCs as earthquake affected areas from where rice landraces were rescued. Kavre proved to be a district with no rice landrace being endangered by earthquake. The rice collection and rescued rice collection map (endangered by earthquake) are presented in **Figure** 1 and 2.

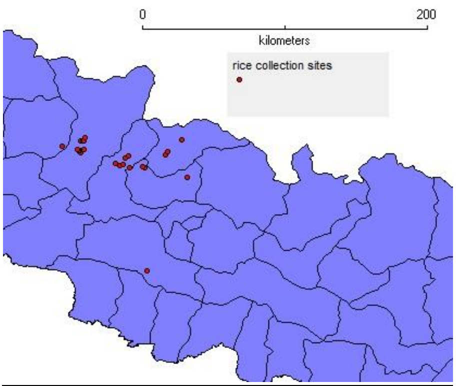

Figure 1. Rice landraces collection map prepared by DIVA-GIS.

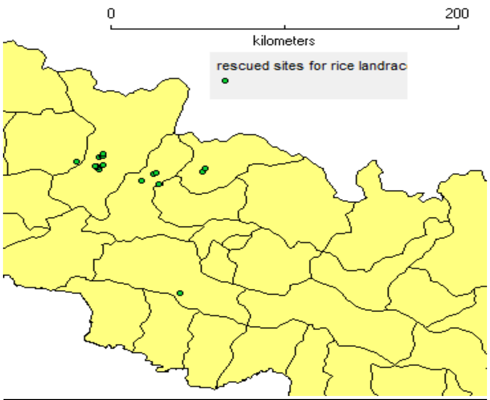

Figure 2. Collection map of rescued rice landraces endangered by earthquake.

The analogue places of all the rescued sites at current met mostly with the foot hills, mid hills or high hills of the western, central and eastern regions. Therefore, it can be well said that the rice germplasm which were found in those places which resemble the climate of most of the rescued sites at present.

The germplasm were traced for climates which were analogue with each other at more than 70% probability level. The highest number of rice germplasm for exchange was seen for Phaparbari VDC of Makwanpur with 225 from the international Genebanks, whereas none from our National Genebank. Our national Genebank showed the highest number of germplasm exchange for Darkha VDC of Dhading ie 5. Genesys database showed the larger amount of germplasm exchange for most of the rescued sites except Jharlang VDC of Dhading, Bichaur of Lamjung and Saurpani VDC of Gorkha. NIAS Genebank gave the largest number of germplasm exchange for Darkha VDC of Dhading ie 17. On an average, 49 rice germplasm were identified for each of the study sites (**Table** 2). Similar study was done by Joshi et al (2017b) using CAT and found that analogue sites were found within and outside of Nepal and identified more than 100 rice germplasm from national and international Genebanks which could be possibly exchanged among the sites of Begnas, Kaski and Kachorwa, Bara. The tracing of rice germplasm from international Genebanks and National Genebank is presented in **Figure** 3.

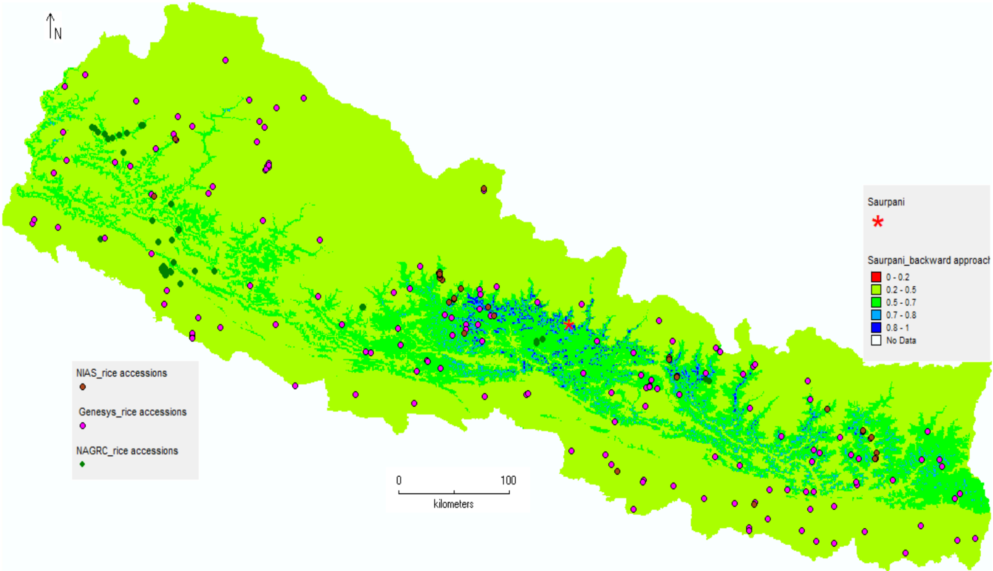

Figure 3. Tracing of rice germplasm from International Genebanks (Genesys and NIAS) and National Genebank for Saurpani VDC, Gorkha by using CAT and GIS tools.

Table 2. Number of germplasm identified for possible exchange and deployment in rescued VDCs from National and International Genebanks

SN	Rice landraces rescued VDCs (Reference sites)	National Genebank	International Genebank	
			Genesys	NIAS
1.	Phaparbari, Makwanpur	0	212	13
2.	Darkha, Dhading	5	28	17
3.	Jharlang, Dhading	0	7	5
4.	Gumdi, Dhading	0	28	6
5.	Ilampokhari, Lamjung	3	29	9
6.	Bichaur, Lamjung	0	8	0
7.	Saurpani, Gorkha	0	6	5
8.	Kimtang, Nuwakot	0	19	10
9.	Haku, Rasuwa	0	24	8

As seen in **Figure** 4, the analogue places of future Saurpani at current met mostly with the mid hill and high hill of central region. Therefore, it can be well said that the rice germplasm which were found in those places at current can resemble climate of Saurpani in near future. Those 11 climate smart rice landraces identified can safely be deployed in Saurpani in near future. The highest number of climate smart rice landraces were identified for Phaparbari VDC of Makwanpur ie 225 (212 from Genesys and 13 from NIAS) which is shown in **Table** 3. The same process was used by the researchers in Zimbabwe, to identify accessions of pearl millet, sorghum and finger millet with desired traits, conserved in national and various international genebanks (Vernooy et al 2015).

Table 3. Identified climate smart landraces for Phaparbari VDC

Genesys	573138, 594714, 615398, 615388, 591810, 569336, 570140, 570046, 570019, 569464, 569961, 569971, 569973, 570017, 570022, 570060, 570095, 570096, 570098, 570108, 570113, 591788, 591806, 594495, 600149, 615200, 615202, 615383, 615384, 615622, 615665, 875176, 879353, 540926, 540927, 540928, 645478, 569333, 569956, 569335, 569466, 569953, 569960, 569967, 569974, 569975, 569377, 569378, 569387, 569470, 569955, 569965, 570004, 570011, 570023, 570051, 570071, 570089, 570110, 570111, 570125, 570146, 570147, 570141, 570006, 570037, 570052, 570091, 570109, 570121, 570124, 570141, 570013, 570028, 570030, 570036, 570036, 570041, 570044, 570068, 570083, 570126, 570137, 570139, 570084, 570088, 570092, 570134, 570136, 570933, 570931, 570355, 570014, 570024, 570029, 570035, 570042, 570045, 570055, 570059, 570061, 570064, 570069, 570077, 570085, 570099, 570102, 570114, 570116, 570122, 570131, 570132, 570246, 571893, 571897, 571901, 571919, 571800, 571879, 571889, 571866, 571870, 571922, 571886, 571814, 573169, 590247, 590250, 590355, 590246, 590248, 590249, 594483, 594493, 594498, 594486, 594489, 594494, 594492, 594490, 594491, 591800, 591802, 591805, 591796, 591795, 591803, 591804, 591809, 591811, 600157, 600888, 600151, 600153, 600155, 606537, 606314, 600144, 600148, 600154, 600156, 600889, 615220, 615385, 615586, 615606, 615209, 615212, 615392, 615609, 615214, 615371, 615373, 615378, 615396, 615402, 615590, 615610, 589794, 594490, 594491, 611301, 615372, 875170, 643985, 617452, 622685, 611302, 611303, 615203, 615380, 615391, 615576, 615587, 615604, 615607, 615653, 875165, 875167, 875169, 875179, 875185, 875187, 875192, 877664, 877911, 877913, 879351, 879380, 632601, 875168, 875175, 875177, 875183, 875194, 875197, 877663, 877912, 879356, 632482, 632483
NIAS	JP 48974, JP 71226, JP 73820, JP 73815, JP 73816, JP 76234, JP 76235, JP 78754, JP 99550, JP 37813, JP 70481, JP 67959, JP 71368

Only few landraces could be identified from National genebank for most of the sites. The maximum numbers of landraces identified were from Genesys global portal, followed by NIAS genebank of Japan. The landraces identified for other sites is shown in Table 4.

Table 4. Climate smart rice landraces identified from rest of the sites

SN	Rice landraces rescued VDCs (Reference sites)	National Genebank	International Genebank	
			Genesys	NIAS
1	Darkha, Dhading	NGRC04998, NGRC04999, NGRC05000, NGRC05001, NGRC05002	570081, 591794, 600150, 606313, 615390, 875194, 569463, 570129, 570130, 570144, 570153, 590254, 591807, 615386, 615608, 875182, 875188, 606022, 605650, 569337, 570128, 570138, 590412, 606410, 606592, 615204, 875181, 877662, 606049	JP 73559, JP 87497, JP 87498, JP 87499, JP 87500, JP 87501, JP 87502, JP 87503, JP 87508, JP 87509, JP 87505, JP 87506, JP 53958, JP 73561, JP 73562, JP 87510
2.	Jharlang, Dhading	0	632483, 632484, 632829, 643986, 571869, 636473, 606051	JP 73569, JP 73567, JP 87511, JP 87512, JP 67955
3.	Gumdi, Dhading	0	606442, 606613, 632483, 632484, 632829, 643986, 569972, 570040, 570054, 570057, 570075, 570103, 570149, 591801, 600145, 675184, 877529, 878505, 341430, 605653, 571801, 571795, 571807, 590353, 600159, 600163, 636473, 606051	JP 71229, JP 73569, JP 73567, JP 87511, JP 87512, JP 67955
4.	Ilampokhari, Lamjung	NGRC05000, NGRC05001,	294432, 451937, 453244, 467644, 571791, 601522, 618113, 621037,	JP 73559, JP 87497, JP 87498, JP 87499,

SN	Rice landraces rescued VDCs (Reference sites)	National Genebank	International Genebank	
			Genesys	NIAS
		NGRC05002	571907, 606447, 23309, 71316, 103311, 103329, 103330, 167110, 294444, 373552, 373573, 437395, 501001, 627220, 601564, 601887, 606405, 606583, 636479, 606049, 636473	JP 87500, JP 87501, JP 87502, JP 87503, JP 67955
5.	Bichaur, Lamjung	0		0
6.	Saurpani, Gorkha	0	571869, 737473, 601564, 601887, 606405, 606583	JP 73560, JP 73567, JP 87511, JP 87512, JP 67955
7.	Barpak, Gorkha	50	69	21
8.	Kimtang, Nuwakot	0	606442, 606613, 571792, 571793, 571803, 571932, 571933, 570930, 571884, 571944, 606047, 571869, 571799, 571794, 571797, 571806, 571871, 571874, 571894	JP 73573, JP 87488, JP 73533, JP 53952, JP 53953, JP 71229, JP 73560, JP 73567, JP 87511, JP 87512
9.	Haku, Rasuwa	0	571877, 618107, 618111, 570930, 571884, 571909, 571792, 571793, 571803, 571932, 571933, 571799, 606442, 606613, 606047, 571869, 571867, 643981, 571794, 571797, 571806, 571871, 571874, 571894	JP 87488, JP 53952, JP 53953, JP 73533, JP 73560, JP 73567, JP 87511, JP 87512

The researchers of Université de Ouagadagou, from Burkina Faso are applying the similar knowledge of trends of climate change and for the identification and acquisition of superior and best adapting finger millet accessions from all around analogue to present and future climate of Burkina Faso. Similarly, the two plant breeders and staff of the National Biodiversity Centre of Bhutan used CAT and GIS to analyze the climate change trends and identification and acquisition of best promising accessions of four major crops; rice, maize, potato and chili taking 2030 as reference year. Both the cases are explained by Vernooy et al (2015).

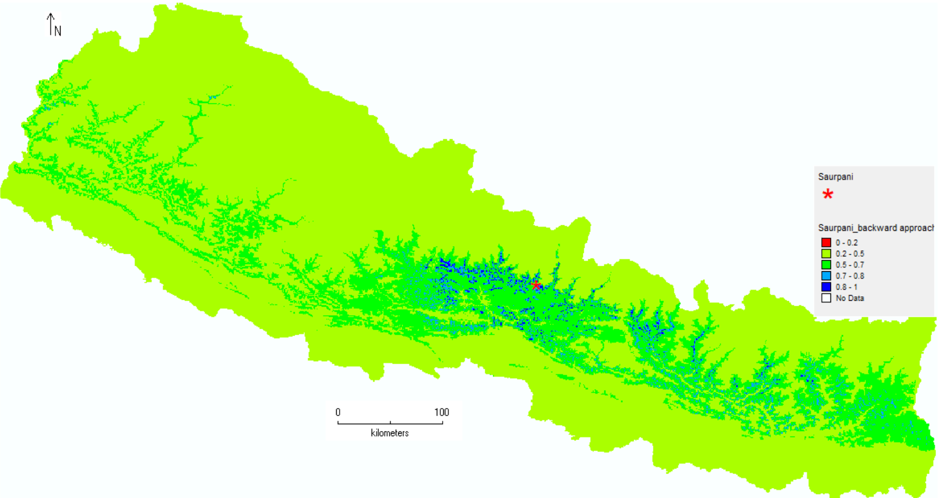

Figure 4. Analogue places of future Saurpani VDC, Gorkha at current (1960-1990) prepared by Climate Analogue tool and DIVA-GIS.

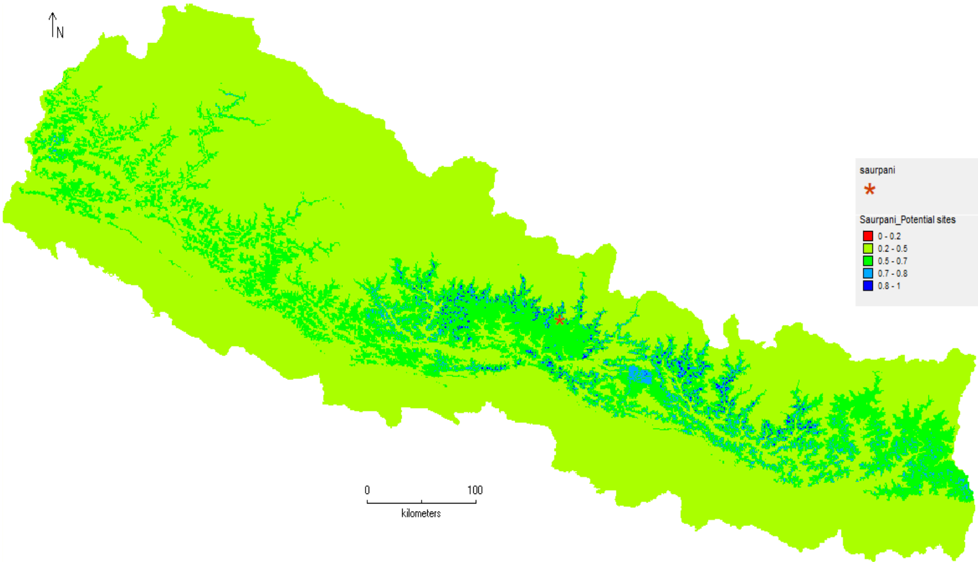

Figure 5. Potential areas for repatriation (current-future scenario) ie 2020-2049 for Barpak, Gorkha prepared by Climate Analogue tool and DIVA-GIS.

The potential analogue sites were also found out where these identified landraces could be repatriated. The rescued landraces ie endangered or rare can be sent back to its place of origin or places statistically analogue and similar to the place of origin with the use of GIS and CAT and termed as repatriation as defined by Joshi et al (2017b).

Studying climate change pattern between current and future are shown in **Figure** 4 and **Figure** 5, we see the analogue sites shifting northwards than the previous regions. This seems the potential repatriation sites of the identified landraces changes in near future and tracking of those potential sites gives better adaptability to climate change for their sustainable production in affected sites.

The potential analogue sites for repatriation in near future is shown in two cases ie districts with greater than 50% of its area for greater than 50% and 70% level of probability of matching as shown in **Table** 5.

Table 5. Potential sites for repatriation of identified climate smart rice landraces in future

SN	Rice landraces rescued VDCs (Reference sites)	Potential repatriation sites	
		>50% level of probability	>70% level of probability
1.	Haku and Kimtang	Gulmi, Pyuthan and Rolpa	- Upper Makwanpur, Sindhuli and Dhading - Central Kavre, Okhaldunga, Dolakha, Sindhupalchok, Gorkha, Lamjung, Kaski, - South half of Lalitpur, southern Myagdi - Peripheral Ramechhap and Nuwakot - Eastern Khotang, eastern and central Baglung, western Bhojpur

SN	Rice landraces rescued VDCs (Reference sites)	Potential repatriation sites	
		>50% level of probability	>70% level of probability
2.	Ilampokhari and Saurpani	Gulmi, Palpa, Pyuthan, Rolpa, Ilam, Panchthar, Terhathum	- Whole of Kathmandu and Bhaktapur and half of Sindhupalchok - Southern Ramechhap, Solukhumbu, Myagdi and south half of Okhaldunga - Central Dolakha, Lamjung, Gorkha, Dhading, Kaski - Eastern Baglung and Parbat, upper Syangja - Upper and central Khotang and Bhojpur
3.	Jharlang and Barpak	Same as Haku and Kimtang	- Same as Haku and Kimtang - Upper Ilam, eastern Panchthar and west central Terhathum
4.	Gumdi and Darkha	Same as Saurpani	- Same as Saurpani except Kathmandu and Bhaktapur
5.	Bichaur, Lamjung	Same as Barpak	- Same as Barpak
6.	Phaparbari	Ilam, Jhapa, Morang, Sunsari, Mahottari, Sarlahi, Rautahat, Bara, Parsa, Chitwan,	- Central Gulmi, Makwanpur and Nuwakot - Southern Gorkha, Dhading and Tanahun - Northern Kavre, Nawalparasi and Morang - Central and upper Sindhuli and Udaypur - Eastern Khotang, Parbat and western Bhojpur

Similar study was done by Chaudhary et al (2016) and Joshi et al (2017c) who have listed the analog sites and suitable crop landraces from National and International Genebanks studied for Kachorwa VDC of Bara district.

The most future analogue sites are shifting upward in this study. These are the potential sites where we can repatriate the identified germplasm from national and international genebanks. The future analogue sites of most of the sites were similar with slight differences on their movement upwards. The potential sites were mostly from Western and Central regions with lesser areas of hills and mid-hills of Eastern development region. The potential sites were merely seen in the areas of Mid-western and Far-western development regions.

Conclusion

Disasters, disease epidemics and natural hazards are factors for losing APGRs. As the rice landraces were endangered by earthquake 2015, they were prone to risks of extinction in many affected areas. A total of 33 earthquake endangered rice landraces were identified and rescued from 9 earthquake affected VDCs of six districts (Gorkha, Dhading, Lamjung, Nuwakot, Makawanpur and Rasuwa). The germplasm were traced for climates which were analogue with each other at more than 0.7 probability level. On an average, about 50 accessions of rice were identified from analogue sites of each affected area from national and foreign genebanks. Based on the analogue sites, Nepalese rice landraces were identified from National Genebank, NIAS and Genesys database for repatriation in earthquake affected areas. The analogue sites of affected areas were much more similar with the eastern and central hilly regions in terms of monthly mean temperature and monthly mean precipitation. The analogue places of earthquake affected areas are seemingly shifting northward from current to future. The potential sites of the identified accessions were mapped for repatriation. APGR based coping mechanism is the best method to adapt towards climate change and food security. Climate is the prior cause in disturbance of crop performance. The repatriation of rescued rice landraces to analogue places where rice diversity is low, not only saves the endangered landraces from risks of extinction but also help in increasing crop diversity, strengthening local seed system and providing food and nutrition security in rural farming community.

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Rebuilding Local Seed System of Native Crops in Earthquake Affected Areas of Nepal (Bal K. Joshi and Devendra Gauchan, eds). Proceedings of Sharingshop, 18 Dec 2017, Kathmandu; NAGRC, BI and Crop Trust; Nepal

Germplasm Exploration from Earthquake Affected Areas: Collections, Opportunities and Challenges

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Abstract

Massive earthquake of 25 April 2015 caused a huge loss of human property, lives and agriculture systems including agro-biodiversity in Nepal. Germplasm rescue mission was organized in seven earthquake affected districts of Nepal in order to safeguard local crop diversity in genebank and repatriate back to local communities again and to assess the farmers' reflection. A total of 513 accessions of 57 crops were collected where 391 farmers were interacted. Among the collections 312 were common (no risk of extinction), 105 were endangered, 26 were rare based on distribution and 73 were at risk of loss due to earthquake. The main causes of making local germplasm at risk of loss are haphazard distribution of large amount of improved seeds as a relief material, burial of stored seeds, destruction of agricultural lands, dearth of knowledge holder custodians, migration of farmers and change of livelihood strategies. Collection of earthquake endangered landrace was a major opportunity for conservation and sustainable use, whereas continuous aftershocks and tedious walk during collection were the challenges. These rescued landraces were characterized, multiplied and conserved in National Genebank. Work has been also initiated to reintroduce farmer demanded collected rare and endangered germplasm back to communities in earthquake affected areas.

Keywords: Agrobiodiversity, Earthquake, Endangered, Rare, Rescue, Challenges

Introduction

Nepal has been listed as one of the highly earthquake prone areas in the world, the latest event being witnessed on 25 April 2015. The earthquake of 7.6 Richter scale followed by different aftershocks of high magnitude hit the country. Devastating earthquake of 25 April 2015 followed by aftershocks of 12 May 2015 demonstrated the extent of vulnerability in Nepal (NPC 2015). Damage and losses to agriculture was estimated to be 16,405 and 11,952 million rupees including losses of stocked food grains and next generation seeds in the affected areas as estimated by National Planning Commission (NPC), Government of Nepal. The government of Nepal estimates loss of NPR 8 billion (US$ 8 million) only amounting for stored food grains and seeds where 60% of the households were completely destroyed by the mega earthquake and subsequent aftershocks (FAO 2015). The FAO Global Plan of Action on Plant Genetic Resources for Food and Agriculture states "In the modern world and especially in developing countries, people are threatened with and vulnerable to natural disasters, civil strike and war. Such calamities pose huge challenges to the resilience of agricultural systems. Often, adapted crop varieties are lost and cannot be recuperated locally (FAO 2011). Along with the destruction of human lives and properties, crop germplasm were also in endangered/rare state and needed urgent rescue.

To respond to the immediate disaster caused by the earthquake, significant efforts were made by the national government, international donors and non-government organizations to rescue human beings and provide immediate relief materials to the disaster affected households. However, no immediate initiatives were made in affected areas to rescue seeds and endangered native crop varieties as a means to quickly revive and strengthen the local seed system and conserve diversity for the future (Gauchan et al 2016). Thus, there was a need to find out the status of local crop diversity in earthquake affected areas, identify the vulnerable and endangered landraces and act to conserve them for sustainable use in the future. NAGRC has started germplasm rescue mission since 2015 (Joshi 2017) and Bhate Phaper was rescued from Dolpa (Joshi and Ghimire 2016).

Plant genetic resources (PGR) include primitive forms of cultivated plant species and landraces, weedy types and related wild species (IPGRI 1993). Local landraces and wild relatives provide wide range of broad genetic base other than the new superior varieties with low constricted genetic base, which is useful for breeders and scientists for future application and plant breeding (Guarino et al 1995). It provides basic materials for selection, and improvement through breeding techniques which is useful in ensuring food security (Upadhaya et al 2008). The world population is expected to increase by 2.6 billion over the next 45 years, from 6.5 billion today to 9.1 billion in 2050. The world needs astonishing increase in food production to feed its population (Hammer and Teklu 2008). In order to increase food production, biodiversity conservation is essential which maintains the ecological balance among different living forms and for self-sustaining growth in crop production processes (Gautam et al 2004). NAGRC has now good facility for long term conservation of APGRs (Joshi et al 2016).

Such important resources are now under threat due to different factors. One of the factors is earthquake which occurred in 25 April 2015 in Nepal and devastated biodiversity. Government of Nepal has listed fourteen most severely affected districts by mega earthquake of 2015. Among them, seven affected districts were explored for the collection of germplasm. The objectives of the study were to assess the loss of crop species and cultivars (varieties and landraces), explore and collect germplasm related to food, vegetable, spices and oil from earthquake affected districts for ex-situ conservation and characterization. Additionally experiences and farmers reflections on agrobiodiversity were collected which are discussed in this paper.

Methodology

Orientation meeting was held in NAGRC, Khumaltar. Table work was done about earthquake affected districts and VDCs in National Genebank through literature review, newspapers, earthquake affected district profiles and consultation with District Agriculture Development Officials (DADO) before field visit. Thereafter, a visit plan was made to earthquake affected areas, where maximum crop diversity was found. The study was carried out from January 2016 to December 2016. After identification of those VDCs, major areas were visited where diversified crop landraces were available. 29 VDCs of seven severely affected districts ie Darkha, Jharlang, Satya devi, Gumdi VDCs of Dhading; Phaparbari, Chattiwan, Khairang, Namtar of Makwanpur; Ilampokhari, Kolki, Bichaur and Dudhpokhari of Lamjung; Saurpani, Barpak, Laprak and Gumda of Gorkha; Kimtang, Valche, Cahule and Rautbesi of Nuwakot; Mahadevsthan, Rabi opi, Anekot, Budhakhani, Phoksingtar and Kartike deurali of Kavre and Haku, Briddim and Syafru VDCs of Rasuwa were explored (**Table** 1).

In the field, the farmers were gathered for Focus Group Discussion and four cell analysis was carried out (Sthapit et al 2006b) to gain information on status of crop diversity and extent of their erosion at the local level.. Some ideal and experienced farmers, key informants and elderly-knowledgeable farmers were consulted through semi-structured questionnaire survey and general conversation to identify the rare, unique, endangered and earthquake endangered landraces (Joshi et al 2004, Sthapit et al 2006b). The endangered, unique and rare landraces were rescued and collected in paper envelop with their local name, crop name and place of collection. The geo-references were noted for the collected landraces; details of description for each of them were filled in passport data form and brought to National Genebank, Khumaltar. The impacts of earthquake on agrobiodiversity were also discussed with farmers.

The seeds of different crops were provided in the form of diversity kit (Sthapit et al 2006a) to farmers who contributed their seeds. Kits composed of any four varieties of okra, cucumber, bean, chili, broad leaf mustard, radish, cauliflower and garden cress. This process helped to increase crop diversity in the distributed areas and also as incentives to the farmers for immediate grow.

The collected samples were reviewed, checked by CAC (collection acceptance committee) team and displayed along with preliminary seed quality assessment for their validation of purity, inert matter, disease-pest attack, moisture content, quantity for conservation, etc. If the collected seeds samples did not meet the Genebank standards, they go for multiplication. Data compilation and analysis was carried to synthesis findings of the rescue collection.

Results and Discussion

Germplasm Rescue Sites

The visited VDCs lies in the river basin to hilly region which range from an altitude of 289 masl (Chattiwan, Makwanpur) to 2725 masl (Laprak, Gorkha). Most of the VDCs were located in remote parts of the mid hill region ranging from 800-1500 masl altitude with two cropping seasons per year (**Figure** 1).

Collected and Rescued Germplasm

The priority was given for the collection of cereals and pseudo cereals (rice, wheat, maize, barley, naked barley, finger millet, foxtail millet, amaranth and buckwheat) and legumes (beans, cowpea, chick pea, rice bean, soybean, fava bean, horse gram and black gram). A total of 513 seed samples of 57 different crop species were collected from 391 households from seven earthquake affected districts during rescue collection mission (**Table** 1). Among the 57 crop species, 73 landraces of 18 crop species were found to be endangered by earthquake from six districts excluding Kavre. Among all the visited districts, no any landraces seemed to be endangered by earthquake in Kavre district. The highest collection was done for rice landraces (62 with 34 rescued), followed by maize (42 with 4 rescued), finger millet (39 with 3 rescued), soybean (38 with 6 rescued) and beans (34 with 1 rescued). The highest number of rescue was done from Saurpani VDC, Gorkha district with 14 rescued landraces (11 of rice and 3 of cowpea) (**Table** 2).

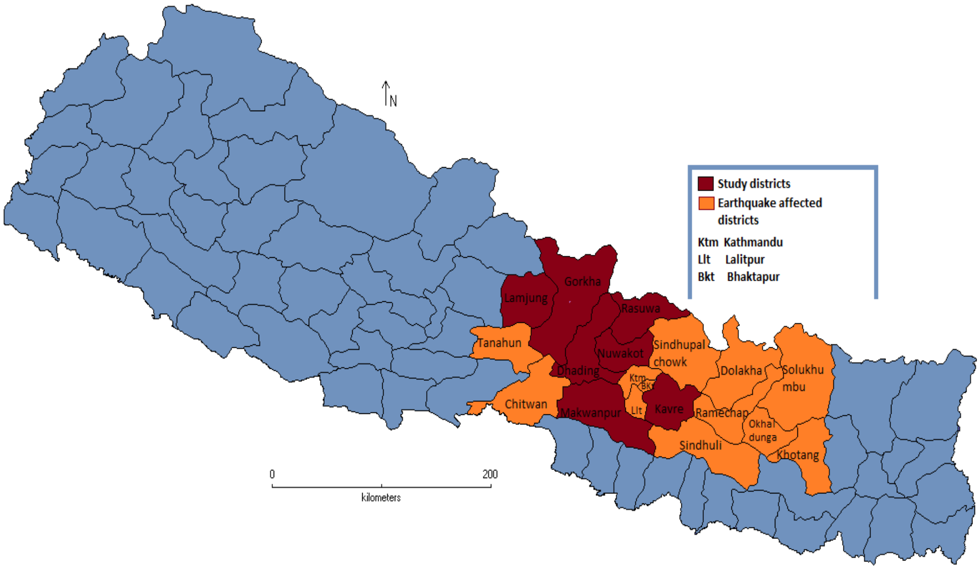

Figure 1. Map of Nepal showing collection districts.

Among the total samples collected, 61% were in normal condition (no risk of extinction), 20% were in endangered condition (due to other reasons rather than earthquake), and 14% seeds were endangered by earthquake (rescued) while 5% of them were rare.

Table 1. VDC wise collection of landraces

SN	District	VDCs	Collection	Total collection
1	Dhading	Satyadevi	8	
		Darkha	13	74
		Jharlang	18	
		Gumdi	34	
2	Makwanpur	Phaparbari	12	
		Chittawan	11	50
		Khairang	9	
		Namtar	18	
3	Lamjung	Kolki	20	
		Illampokhari	35	73
		Bichaur	9	
		Dudhpokhari	9	

SN	District	VDCs	Collection	Total collection
4	Gorkha	Saurpani	40	
		Barpark	28	123
		Laprak	24	
		Gumda	31	
5	Kavre	Madhavesthan	18	
		Anekot	10	
		Ravi opi	6	83
		Budhakhani	18	
		Foksintar	12	
		Kartikae deurali	19	
6	Rasuwa	Haku	20	
		Bridim	14	50
		Syafru	17	
7	Nuwakot	Kimtang	24	
		Valche	4	59
		Cauhule	20	
		Rautbesi	11	

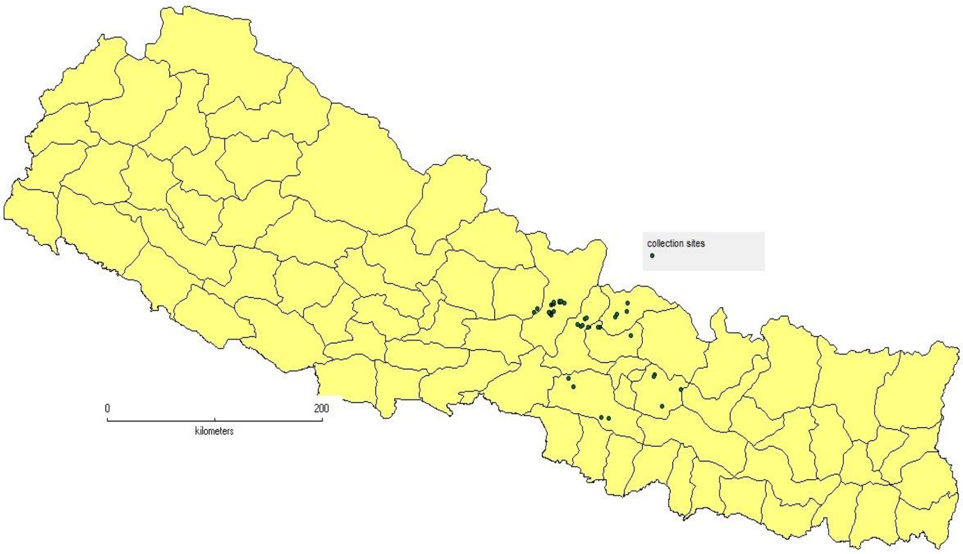

Figure 2. Collection map prepared by DIVA-GIS software.

Table 2. Germplasm rescue collections and their status in 7 earthquake affected districts

District	Common landrace	Endangered landrace	Rescued landrace	Rare landrace	Total collection
Dhading	45	15	14	-	74
Makwanpur	25	15	10	-	50
Gorkha	93	9	15	6	123
Lamjung	25	15	20	13	73
Nuwakot	42	13	3	1	59
Kavre	50	29	-	4	83
Rasuwa	32	9	11	2	51
Total	**312**	**105**	**73**	**26**	**513**

A total of 18 different crop species were rescued from six districts visited, while 34 different crop species were endangered from seven affected districts whereas 16 different crop species were rare. Among the 57 different species of crops collected maximum number of collection was done of rice landraces 62 in total (where 34 of them were rescued, 11 were endangered and 4 of them were rare). The number of rescued landraces of each crop is given in **Table** 3.

Table 3. Rescued, endangered and rare crop species of earthquake affected districts

Rescued crop species	Endangered crop species	Rare crop species
Rice (34), Field pea (1), Broad leaf mustard (1), Maize (4), Lady's finger (1), Buckwheat (3), Cowpea (7), Soybean (6), Horse gram (1), Bean (1), Finger millet (3), Snake gourd (1), Mustard (2), Foxtail millet (3), Barley (2), Radish (1), Naked barley (1), Rice bean (1)	Rice (11), Finger millet (12) Cucumber (1), Maize (8), Rice bean (8), Turmeric (1), Buckwheat (9), Peas (1), Hemp (1), Pumpkin (2), Black gram (5), Cowpea (5), Tomato (1), Mustard (3), Chilly (1), Bean (1), Bitter gourd, Niger (1), Rapeseed (1), Taro (1), Soybean (5), Barley (8), Barnyard millet (1), Naked barley (3), Seed amaranth (2), Horse gram (3), Wheat (3), Grain sorghum (1), Groundnut (1), Sponge gourd (1), Peas (1), Perilla (1), Sesame (1), Potato (1)	Horse gram (1), Rice (4), Soybean (2), Cowpea (2), Rice bean (1), Radish (1), Foxtail millet (1), Barley (1), pumpkin (2), BLM (1), Grain amaranth (1), Lentil (1), Sponge gourd (1), Finger millet (2), Chinni (1), Ghuku (1)

These diversity collections will have great role to secure food and nutrition security in the country in the future. Crop genetic resources are the invaluable assets and unique global heritage which meet the need of increasing population through crop production and productivity so that their conservation and utilization should be immediate concern (Varaprasad and Sivaraj 2016). The PGR contributes enormously toward achieving the Millennium Development Goals of food security, poverty alleviation, environment protection and sustainable development (Upadhaya et al 2008). Genetic diversity gives species the ability to adopt in changing environments, including new pests, diseases and new climatic conditions (Hammer and Teklu 2008). Among the natural resources available in the world plant genetic resources are the most important components of it and during the last 2-3 decades major focuses are made in their conservation by both in-situ and ex-situ methods (Frankhel and Bennet 1970, Frankel Hawkes 1975, Holden and Williams 1984, Plucknest et al 1987, Watanabe et al 1998, Ramantha Roe et al 1999). Seed conservation is a popular and most efficient tool for germplasm conservation at global level which helps in the preservation of genetic variability.

Factors making Landraces Endangered

There were many reasons encountered during exploration and germplasm rescue mission which were also the causes of making crop landraces endangered. Migration of farmers to new and safer settlements leaving their villages for more than a year is the main cause for making landraces endangered by earthquake which was seen for 31% of the rescued landraces. The second main reason was replacement of landraces by hybrid/improves seeds distributed by NGOs/INGOs as relief materials which were seen for 23% of the rescued landraces. Similarly, other reasons found were landrace replacement by farmers themselves (8%), replacement by other high value crops (10%), seed burial along with houses after earthquake (10%), attraction towards other occupation (4%), production decreased after earthquake (4%), labor intensive crops replaced by low-labor intensive crops (3%), cultivable land converted to housing area (3%), landslide occurred in cultivating area (2%) and standing crop fed by released animals after earthquake (2%). The maximum number of crop landraces rescued was of rice ie 34 endangered basically due to migration of farmers and replacement of landraces by seeds distributed by NGOs and INGOs.

After Collections

Quality Assessment: The immediate preliminary seed quality assessment was done in National Genebank by the collection team where inert materials, seeds uniformity, disease-insect attack, sufficient amount for conservation were analyzed along with the photographs of the collected seeds. Those seeds which met the standard quantity are preceded for conservation along with their passport data and images, whereas the seeds of which quantity was not enough were multiplied and regenerated. Seeds were also characterized in Seed Processing Lab and processed further for long term conservation.

Characterization and Multiplication Germplasm: The descriptors were developed with the references of the descriptors developed by Bioversity International, UPOV, NIAS, IRRI for the rice descriptors. AVRDC was also referred to develop vegetable crops descriptors. Characterization of 5 summer crops (amaranth, finger millet, foxtail millet, maize and rice) had already done in the multiplication and regeneration block of genebank. Other winter crops (wheat, naked barley, barley) were also characterized (see other paper by the same author for characterization data).

Table 4. Field characterization of rescued landraces from earthquake affected districts

SN	Crop	District visited							Total
		Dhading	Makawanpur	Lamjung	Gorkha	Nuwakot	Kavre	Rasuwa	
1	Amaranth	1	-		5	2	1	5	14
2	Finger millet	3	6	9	5	4	12	3	42
3	Foxtail millet	-	-	3	-	-	-	-	3
4	Maize	6	3	2	8	-	-	-	19
5	Rice	16	3	10	15	6		2	51
6	Wheat	2	-	-	5	2	-	-	9
7	Barley	1	-	2	4	4	-	-	11
8	Naked barley	1	-	-	1	-	-	-	2
9	Chili		1	-	2	1		1	5
10	Cucumber	2	-	-	1	-	1		4
11	Okra	-	1	-	-	-	1	-	2
	Total	**32**	**14**	**26**	**46**	**19**	**15**	**11**	**162**

Future Plan for Collected Samples: The collected samples will be further characterized and multiplied in genebank field. Those collected seeds which meet the criteria for conservation will be forwarded for germination testing, cleaning, drying and adjustment to proper moisture content. The endangered and rare landraces will be deployed to their places of origin in the earthquake affected areas.

Opportunities

- Collection of 105 endangered and 73 earthquake endangered landraces from 7 severely earthquake affected districts is an advantage to conserve them ex-situ in National Genebank. If those landraces were not rescued from the earthquake affected areas, they would have been lost from those places in future.
- Germplasm rescue mission gave a chance to know about the actual conditions of farmers, the activities and ways they are following to cover their grief and miseries.
- Most of the places were new with new people to interact and different places were composed of diversified culture and castes. Visit to Gorkha and Nuwakot gave an offer to interact with all types of people including Brahmin, Chettri, Dalit, Sunar, Newar and Tamangs too. Visit to Rasuwa even provided opportunity to interact with Tibetan Tamang community and Nepali Tamang Community.
- In many places, new crops were introduced by distribution of Diversity kits. Such as for Gorkha district, four season beans, chili, okra and cucumber were distributed through diversity kit, where okra was found to be a new crop in all of the four visited VDCs. For Rasuwa district, four season beans, broad leaf mustard, garden cress and radish seeds were distributed in diversity kits, where except four season beans, all others were found new in all of the three VDCs visited.

Challenges

- It was very difficult to interact and conduct group discussion and interviewing with farmers in such difficult livelihood situation after earthquake in rural villages. In Haku VDC, Rasuwa, there was not even a home stay or small cottages to live to stay night and that situation made team member to sleep underneath tents in very cold season. Many farmers were demoralized due to houses destruction and death of family members or relatives. The situation made very difficult to conduct programs, gain information about crop status and ask them to give seeds for conservation. In many places, farmers thought of getting huge relief aids as other aid programs and working to make our program successful in such mental situation of farmers was a real challenge.
- During rescue collection mission there was continuous flow of aftershocks while visiting to Dhading and Makwanpur. It was very difficult to reach destination place through routes of landslide and soil erosion which made the mission a bit difficult. Even roads were very difficult to travel to reach earthquake affected areas like Budhakhani and Kartike Deurali VDC of Kavre, Jharlang of Dhading, Kimtang of Nuwakot, etc. But even though how risky the situations were, the study was carried out regularly and successfully.
- A continuous and tedious walk during exploration of the earthquake affected areas with minimal amount of rest to reach destination place and conduct program was difficult. A journey over sloppy areas, difficult terrains and up and down over hills was real challenging in many of the places like Haku of Rasuwa, Betini of Makwanpur, Barpak of Gorkha, Jharlang of Dhading, etc. Four days of continuous walk from Saurpani to Barpak, then to Laprak to Gumda and fourth day back to Barpak was really challenging and needs a larger amount of commitment to do so.
- Seed samples available from many farm households during rescue collections were very small and of poor quality, which were not adequate to meet quantity and quality standards for safe storage in National Genebank. Many farmers were also not willing

to share larger quantity of seeds and also field team found difficult to carry larger sample sizes, when traveling on foot.

Conclusion

Majority of the landraces became endangered after earthquake because of migration of farmers to a new and safer settlement and by replacement of landraces by hybrid/improve seeds. There were many reasons due to which crop landraces were being endangered and this study helped in assessing those landraces, rescuing them from the earthquake affected sites and bring them to National Genebank for ex-situ conservation. The rescued landraces were characterized, multiplied and conserved in National Genebank. Work has been also initiated to reintroduce farmer demanded collected rare and endangered germplasm back to communities in earthquake affected areas.

Natural calamities and disasters are very common cause for the losses of PGRs. If no actions are taken for their conservation and protection, it would be very difficult to save them and use them in future. Exploration, collection and rescuing of earthquake endangered and unique/rare landraces of diversified crops were the opportunities of this mission since the process will be helpful in strengthening conservation of rare and endangered native crop genetic resources and their use in future crop improvement and rebuilding local seed system and ensuring food security. However, the major challenges were convincing farmers to collect threatened seeds from their household stores when they are at grief and distress from the earthquake effect. Similarly, tedious and continuous walk in remote hills and steep mountains for exploration was difficult and challenging for research team and field staff. Beside these it was difficult to assess collected landrace to know their endangered state by the earthquake effect. We learned that there are several factors that have contributed to their endangered status triggered subsequent other natural calamities such as landslide, flooding including short and longer term migration of farmers to outside the residential areas from earthquake damage. Seed samples available from many households are not adequate to meet quantity and quality standards for safe storage in National Gene bank, since farmers were not willing to share larger quantity of seeds and also field team found difficult to carry larger sample sizes, when traveling on foot. Future rescue collection missions need to consider these constraints, challenges and opportunities and prepare accordingly.

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Rebuilding Local Seed System of Native Crops in Earthquake Affected Areas of Nepal (Bal K. Joshi and Devendra Gauchan, eds). Proceedings of Sharingshop, 18 Dec 2017, Kathmandu; NAGRC, BI and Crop Trust; Nepal

Existing Collections and Important Germplasm in Genebank from Earthquake Affected Districts

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Abstract

Passport data from National Agriculture Genetic Resources Centre (NAGRC) was analyzed with the objective of summarizing existing collections from the 2015 earthquake affected districts. After the establishment of NAGRC, a total of 8,500 accessions were collected from 62 districts of the country during 2010-2015. Among them, 1,852accessions of 40 crops had been collected and kept in medium and long term conservations of NAGRC before 2015 earthquake from 13 districts that are severely and moderately affected by the 2015 mega earthquake. Maximum collections (406 accessions) with the species richness of 22 was found in the collections from Dolakha whereas the minimum (11 accessions) was from Makawanpur. Among those collections, the maximum intra-specific diversity was of rice (385 accessions) followed by finger millet (218 accessions) and maize (202 accessions). Inter-specific diversity was found the highest (23 species) in the collection of Rasuwa. There are many important landraces conserved in NAGRC which are still growing by many farmers of many districts due to their unique traits. These are Anadi, Amjhutte, Thapachini and Mansara of rice, Kalo Maas, Nangkatuwa Kodo, Paundur Kodo, Kalo Bhatta, Murali Makai, etc. There are also some important landraces endemic to certain districts such as Kalo Musuro, Borang Dhan, Gatlange Smi from Rasuwa; Pani Makai, Gujmuje Rayo, Dunde Rayo from Lalitpur; Pahenlo Simi from Dolakha; Bariyo Kaguno from Lamjung, etc. Farmers from other similar areas can easily get access to the seeds of these germplasm from genebank and deploy new diversity to their areas.

Keywords: Accession, Diversity, Exploration, Germplasm, Landrace, Richness

Introduction

Agricultural plant genetic resources (APGRs) are the basics for crop improvement and food security. This is only possible when sufficient genetic variability in terms of intra and inter species diversity exists. Genebanks are for the ex-situ collections of agricultural biodiversity. Exploration and collection of agricultural plant genetic resources (APGRs) are the key activity in genebank. Although the NAGRC was established in 2010 at Khumaltar under NARC, the exploration and collection of APGRs was formally started from 1984 after the establishment of PGR Unit in Agricultural Botany Division, Khumaltar (Genebank 2016, Joshi 2017a). Before 2010, there was a collection of 10,781 accessions in this Division. However, majority of those collections were lost their viability due to lack of proper storage facility. Exploration and collection was re-started after the establishment of

NAGRC. In total, NAGRC holds 11,200 accessions of more than 130 crop species from 75 districts. Among them, a total of 8,410 accessions of more than 100 species were collected from 67 districts of the country after 2010 (**Figure** 1).

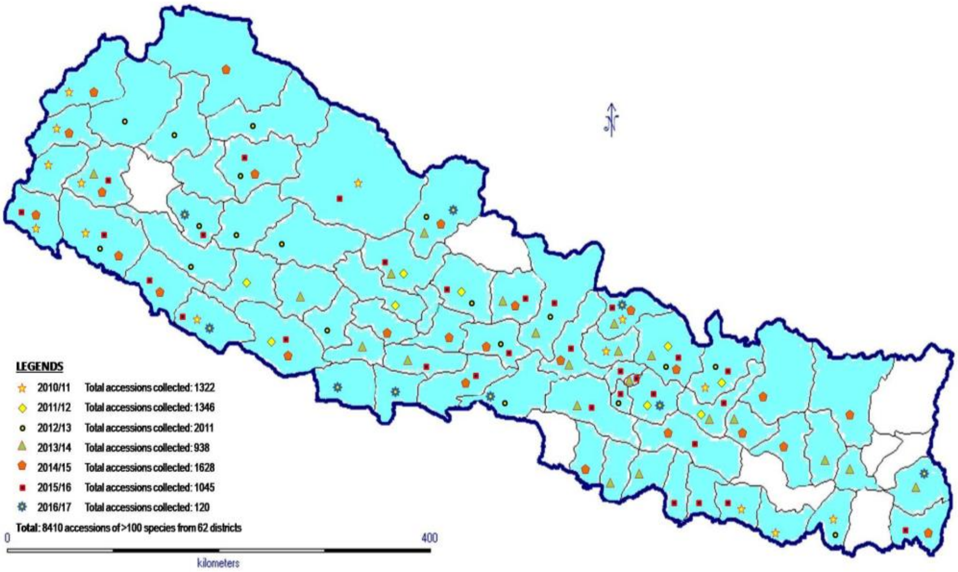

Figure 1. Map of Nepal showing PGR exploration districts with year of exploration and collected number of accessions (Un-explored 8 districts: Taplejung, Panchthar, Tehrathum, Morang, Udaypur, Parsa, Manang, Achham).

Nepal is rich in agro-biodiversity (Joshi et al 2017a). Diverse agro-climatic environments with complex and varied farming systems, a broad mixture of ethnicity and races, varied socioeconomic settings, big altitude differences and complex topography are the factors to create an array of micro-niches with huge agricultural diversity in the country (Genebank 2016, Upadhyay and Joshi 2003). Due to this variation across the country, diverse forms of genetic resources are being evolved and maintained. Crop genetic resources contain the essential building blocks that are critical to food security. Several exploration missions were conducted to mid hills of central and western region before 2015. This region experienced the devastating mega earthquake in 2015. After the earthquake, NAGRC in collaboration with Bioversity International with the funding support of Crop Trust launched the germplasm rescue mission to collect rare and endangered landraces and conserve in genebank as well as to repatriate landraces from the old collections to the areas where those landraces were lost.

Earthquake affected districts from where we have collection in NAGRC are Gorkha, Lamjung, Dhading, Nuwakot, Rasuwa, Kavre, Sindhupalchok, Dolakha, Ramechhap, Kathmandu, Lalitpur, Bhaktapur and Makwanpur. This paper summarized the status of existing collections in genebank from those affected districts and highlighted some of the important landraces that can be promoted or repatriated to those affected areas through diversity kits or IRD kits.

Methodology

Passport data from National Agriculture Genetic Resources Centre (NAGRC) was analyzed with the objective of summarizing existing collections from the 2015 earthquake affected districts. Among the 14 severely and 17 moderately earthquake hit districts, we considered 12 (except Sindhuli and Okhaldunga) and one district (Lamjung) respectively for analyzing the germplam collections. Passport data of 1852 accessions of 40 crops from 13 earthquake affected districts were processed and some of the missing geo-reference information was tracked from Google map. Collection map was generated with DIVA-GIS software using latitude and longitude information of the collecting sites. Important landraces were listed from the passport data. Distinguishing traits and functional traits were reported based on the passport information and some of the literatures related to characterization. Landraces found in many districts (among these studied districts) were listed as common whereas those found in particular areas or districts were listed as endemic landraces.

Results and Discussion

Collection Sites Map

In passport data, collections from 13 districts (highlighted with sky blue color) that are severely and moderately affected by the mega earthquake 2015 were geographically referenced with latitude (27.0 to 28.3^{o}N) and longitude (83.79 to 88.05^{o}E). Collection sites were plotted with yellow dots in the map of Nepal (**Figure** 2).

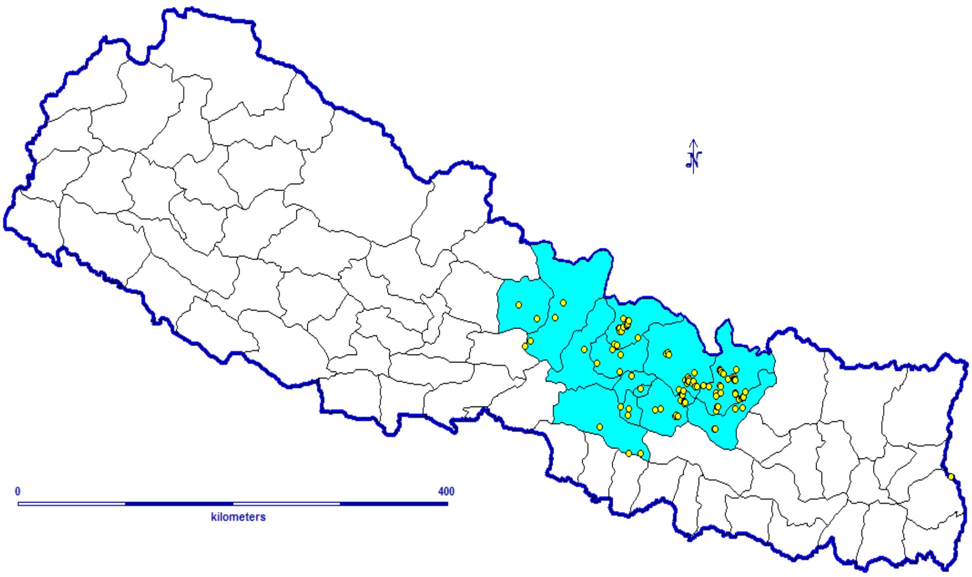

Figure 2. Map of Nepal showing collection sites of germplasm in NAGRC from earthquake affected districts done before 2015 mega earthquake.

Existing Collections in Genebank

There are 1,852 accessions of 40 crop species (**Table** 1) collected from 13 districts that are affected by the mega earthquake of 2015. Among those collections, the maximum intra-specific diversity was of rice (385 accessions) followed by finger millet (218 accessions) and maize (202 accessions) whereas the inter-specific diversity was found the highest (23 species) in collections from Rasuwa followed by 22 species each from Dolakha and Sindhupalchok (**Figure** 3). Maximum collections were from Dolakha (406 accessions) followed by Sindhupalchok (306 accessions), Kavre (273 accessions) and Ramechhap (271 accessions) whereas the minimum from Makawanpur (11 accessions of 2 crops), Bhaktapur (12accessions of 2 crops) and Kathmandu (15accessions of 2 crops).A total of 46% collections were of cereals (848 accessions) followed by pulses (28% or 515 accessions), millets (14% or 252 accessions), pseudo-cereals (8% or 152 accessions), vegetables (2% or 45 accessions) and forages (4 accessions).

Table 1. Crop-wise number of accessions in NAGRC from earthquake affected districts collected before 2015 mega earthquake

SN	Crop	नेपाली नाम	Scientific name	Number of accessions
1	Amaranth	लट्टे/मार्से	Amaranthus caudatus L. Amaranthus cruentus L. Amaranthus hypochondriacus L.	30
2	Azuki bean	गुराँस	Vigna angularis (Willd.) Ohwi & Ohashi	2
3	Barley	जौ	Hordeum vulgare L.	130
4	Bean	सिमि	Phaseolus vulgaris L. Dolichos lablab L.	174
5	Berseem	बर्सिम	Trifolium alexandrium L.	1
6	Blackgram	मास	Vigna mungo L. Hepper	37
7	Black mustard	कालो तोरी	Brassica junceaCass.	2
8	Broad bean	बकुल्ला	Vicia faba L.	9
9	Buckwheat	फापर	Fagopyrum esculentum L. Fagopyrum tataricum L.	122
10	Cauliflower	काउली	Brassica oleraceaL. var. botrytis	1
11	Cowpea	बोडी	Vigna unguiculata L.	50
12	Finger millet	कोदो	Eleusine coracana Garetn.	218
13	Foxtail millet	कागुनो	Setaria italica L.	4
14	Garden cress	चम्सुर	Lepidium sativum L.	8
15	Horsegram	गहत	Dolichos biflorus L.	16
16	Lentil	मुसुरो	Lens culinaris Medic.	7
17	Lettuce	जिरीको साग	Lactuca sativa L.	1
18	Maize	मकै	Zea mays L.	202
19	Leaf mustard	रायो	Brassica juncea L. var. rugosa	5
20	Naked barley	उवा	Hordeum vulgare L. var. nudum Hook f.	27
21	Niger	झुसे तिल/फिलिंगे	Guizotia abyssinica (L. f.) Cass.	1
22	Oat	जै घाँस	Avena sativa L.	2
23	Okra	भिंडी/रामतोरिया	Abelmoschus esculentus L.	14
24	Pea	केराउ	Pisum sativum L.	32
25	Pearl millet	घोगे	Pennisetum glaucum (L.)R.Br.	1
26	Pigeon pea	रहर	Cajanus cajan Millsp.	3
27	Pumpkin	फर्सी	Cucurbita pepo L.	5

SN	Crop	नेपाली नाम	Scientific name	Number of accessions
28	Radish	मुला	Raphanus sativus L.	4
29	Rapeseed	तोरी	Brassica campestris var. toria Dutch.	30
30	Rice	धान	Oryza sativa L.	385
31	Ricebean	मस्यांग/सिल्टुम	Vigna umbellata (Thunb.)	58
32	Rye	राइ घाँस	Lolium multiflorum L.	1
33	Sorghum	जुनेलो	Sorghum bicolor (L.) Conrad Moench	29
34	Soybean	भटमास	Glycine max (L.) Merr.	136
35	Turnip	सलगम	Brassica oleracea var. rapa L.	1
36	Wheat	गहुँ	Triticum aestivum L.	104
	Total			**1,852**

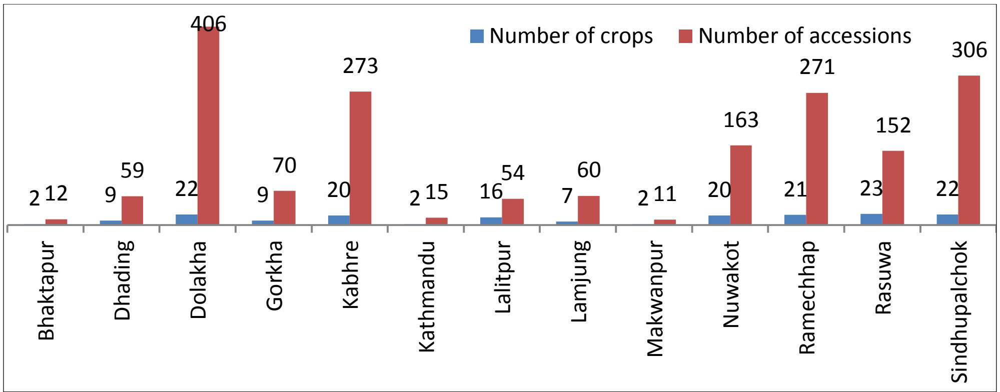

Figure 3. District-wise number of collections in NAGRC from earthquake affected districts done before 2015 mega earthquake (1,852 accessions of 40 crop species from 13 districts).

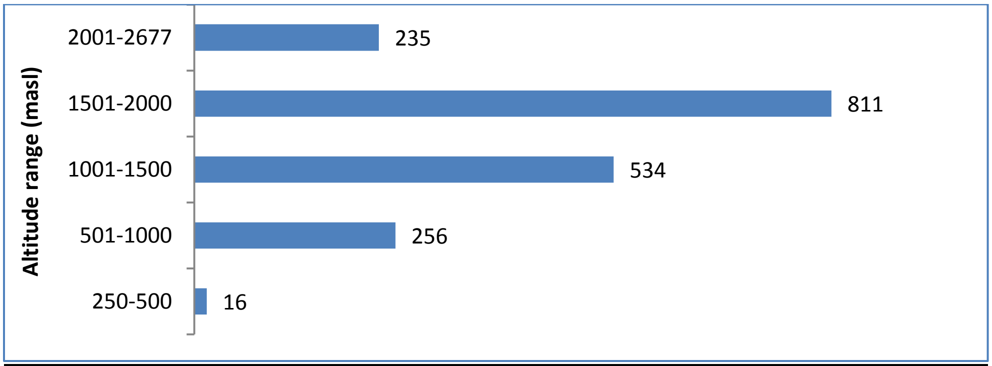

Figure 4. Number of accessions in NAGRC collected from different altitude ranges of earthquake affected districts before 2015 mega earthquake.

Germplasm have been collected from 250-2677 meter above sea level (masl) (**Figure** 4). Maximum collections with 811 accessions were from the altitude range of 1500-2000 masl. Crops like wheat, barley, naked barley, buckwheat, rapeseed, radish, etc were collected from high hills (>2500 masl) of Sindhupalchok and Dolakha districts. In contrast, crops like rice, okra and finger millet were collected from the lowest altitude (<500 masl) of Makwanpur, Gorkha and Dhading districts.

Important Germplasm in the Collections

Some of the landraces in the collections have higher economic value and grown by many farmers. These are known as important landraces. Those landraces found in many districts are known as common landraces (Table 2) whereas those found in certain area are known as endemic landraces (Table 3).

Table 2. Important landraces in the existing collections that are common in many earthquake affected districts with their important traits

SN	Crop	Landrace	Distinguishing trait	Functional trait
1	Rice	Anadi	Tall plants, red coarse grains	Sticky, consumed as sweet dish in festivals, medicinal value
2	Rice	Ampjhutte	Short round grains, tall plants	High yielding, good taste
3	Rice	Thapachini	Long white grains, tall plants	High yielding, good taste
4	Rice	Mansara	Short white grains, tall plants	High yielding, good taste
5	Finger millet	Paundur Kodo	Short height, small ear heads	Early maturing, medicinal value, grown in spring season
6	Finger millet	Dalle Kodo	Compact ear heads	High yielding
7	Finger millet	Nangkatuwa Kodo	Short height, small ear heads	Easy to harvest with nails, high yielding
8	Finger millet	Seto Kodo	White colored ears heads and grains	High yielding
9	Black gram	Kalo Maas	Blackish grains	Fast cooking, good taste
10	Soybean	Kalo Bhatmas	Black grains	Medicinal value
11	Buckwheat	Tite Fapar	Few green and white flowers	High yielding, medicinal value
12	Maize	Sathiya Makai	Yellow flint grains	Early maturing, good popping
13	Maize	Murali Makai	Flint pointed grains, thin long cobs	Very good popping quality, early maturity
14	Pea	Sano Kerau	Small brown grains, small plants	Good taste, dry grains eaten raw after soaking as pickles
15	Horsegram	Kalo Gahat	Blackish grains	Fast cooking, good taste, medicinal value
16	Pumpkin	Kuvinde Farsi	Medium sized fruits with white stripes in dark green skin	Year round production of young shoot, highly prolific
17	Chili pepper	Akbare Khursani	Small round fruits	Very hot, medicinal value

Anadi is a culturally important landrace of rice found in all 13 districts affected by 2015 earthquake. It is glutinous rice popular for a special sweet dish in festivals and possesses medicinal value (Bhatta et al 2017, Joshi 2017b). Other common landraces of different crops still growing by many farmers are Anadi, Amjhutte, Thapachini and Mansara of rice, Kalo Maas of black gram, Nangkatuwa Kodo and Paundur Kodo of finger millet, Kalo Bhatta of soybean, Murali Makai of maize, etc.

Table 3. Important landraces in the existing collections those are endemic to certain areas with their important traits

SN	Crop	Landrace	District	Distinguishing trait	Functional trait
1	Rice	Borang Dhan	Goljung, Rasuwa	Coarse grain, red color grain	Cold tolerant
2	Rice	Chobo	Gorkha, Dhading	White long grains	Drought tolerant, high yielding
3	Rice	Begani Ghaiya	Palungtar, Gorkha	Fine, red grains	Aromatic, drought tolerant
4	Rice	Jhinuwa	Gorkha, Dhading	Grains with black tip	Aromatic, good quality
5	Rice	Masino	Gorkha, Dhading	Black grains	Aromatic, good quality
6	Lentil	Kalo Musuro	Goljung, Rasuwa	Black grains	Good quality daal High iron content
7	Bean	Seto Simi	Gatlang, Rasuwa	White smaller grains	Best quality daal
8	Bean	ChhirbireSimi	Gatlang, Rasuwa	Mottled larger grains	Best quality daal
9	Bean	Pahenlo Simi	Jugu, Dolakha	Yellowish pods and grains	Fresh pods are good for vegetable and grains for daal (dual purpose)
10	Leaf mustard	Gujmuje Rayo	Dalchoki, Lalitpur	Large and wrinkled leaves	High leaf yield, good taste
11	Leaf mustard	Dunde Rayo	Dalchoki, Lalitpur	Leaves with long canalled petiole	High leaf yield, good taste
12	Leaf mustard	Kande Rayo	Dalchoki, Lalitpur	Serrated leaves	Good taste, drought tolerant
13	Maize	Pani Makai	Dalchoki, Lalitpur	White grains, tall plant	Water logging tolerant
14	Maize	Bhirkaule Makai	Dhaibung, Rasuwa	Small pointed flint grains	Good popping quality
15	Foxtail millet	Bariyo Kaguno	Ghanpokhara, Lamjung	White grains, large panicles	High yield, good taste, drought tolerant
16	Pearl millet	Ghoge	Ratmata, Nuwakot	Plants looks like maize, hairy heads	Used for alcohol and animal feed, drought tolerant
17	Radish	Choto	Gatlang, Rasuwa	Short fleshy root like turnip	Tasty, adapted to cold temperature
18	Chayote	Golkande Eskush	Dhapakhel, Lalitpur	Small round fruits with dense spines	High yield, good taste
19	Yam	Pindalu Tarul	Palungtar, Gorkha	Small hairy tubers, shallow rooted like taro (pindalu)	Easy harvesting, very good taste, low yield

Source of some information: Joshi et al 2017, Humagain 2017.

In contrast, there are some unique and important landraces of different crops growing in some particular areas. For example, Kalo Musuro is a landrace of lentil from Rasuwa having black seed coat, fast cooking and good taste. It is also considered that this landrace has medicinal value as well. The landraces endemic to certain areas such as Kalo Musuro (Joshi et al 2017b), Borang Dhan (Humagain 2017), Seto and Chhirbire Simi from Rasuwa; Pani Makai, Gujmuje Rayo and Dunde Rayo from Lalitpur (Joshi et al 2017b); Pahenlo Simi from Dolakha; Bariyo Kaguno from Lamjung; Jhinuwa Dhan from Gorkha; need to be conserved ex-situ in the genebank as well as need to be promoted to wider areas for cultivation through IRD or diversity kits. Value added products of such landraces should be supplied to domestic and international markets with their geographic indicators (Joshi et al 2017b).

Conclusion

In total, NAGRC holds 11,200 accessions of more than 130 crop species from 75 districts. Among them, a total of 8,500 accessions were collected from 62 districts of the country after the establishment of genebank in 2010. Out of these, 1,852 accessions of 40 crop species were from 13 districts that are severely and moderately affected by the mega earthquake of 2015. Among those collections, the maximum intra-specific diversity was of rice (385 accessions) followed by finger millet (218 accessions) and maize (202 accessions) whereas the inter-specific diversity was found the highest (23 species) in collections from Rasuwa. Maximum collections were from Dolakha whereas the minimum from Makawanpur due to larger sample sizes covered in Dolakha and lower in Makawanpur.

Common landraces with unique traits such as Anadi, Amjhutte, Thapachini and Mansara of rice, Kalo Maas of black gram, Nangkatuwa and Paundur Kodo of finger millet, Kalo Bhatta of soybean, Murali Makai of popcorn, etc need to be promoted to wider areas and commercialized catching their unique functional traits. Similarly, the important landraces endemic to certain areas such as Kalo Musuro, Borang Dhan, Seto and Chhirbire Simi from Rasuwa; Pani Makai, Gujmuje Rayo andDunde Rayo from Lalitpur; Pahenlo Simi from Dolakha; Bariyo Kaguno from Lamjung; Jhinuwa Dhan from Gorkha; need to be conserved ex-situ in the genebank as well as promoted to wider areas for cultivation. Further more their value added products should be supplied to domestic and international markets branding with their geographic indicators (GI) for their conservation and sustainable use. Farmers from other similar areas of the country can easily get access to the seeds of these germplasm from genebank by developing and strengthening linkage of National Genebank with local developmental agencies, community based organizations (CBOs) and farmers in earthquake affected areas.

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Rebuilding Local Seed System of Native Crops in Earthquake Affected Areas of Nepal (Bal K. Joshi and Devendra Gauchan, eds). Proceedings of Sharingshop, 18 Dec 2017, Kathmandu; NAGRC, BI and Crop Trust; Nepal

Red Listing of Crop Landraces in Earthquake Affected Areas

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Abstract

Red list is the list of crop species, and cultivars (varieties or landraces), prepared from the conservation aspects and considered trend of genetic erosion of each landrace. Five categories of red list of agricultural plant genetic resources (APGRs) are extinct, common, vulnerable, endangered, and not evaluated. This paper aims to document the methods for red listing of crop landraces from 10 earthquake affected areas of Nepal, where rescue mission was undertaken. Through focus group discussion (FGD), landraces from the 10 earthquake affected districts were listed and grouped under these five categories. In some cases, key informant survey and household survey were considered to prepare red list. A total of 284 rare and endangered landraces were collected from 10 districts in addition to 637 common and vulnerable landraces of 61 crops. A total of 104 landraces of different crops were lost and 73 landraces become endangered due to earthquake alone in 7 affected districts. Some of these endangered and other landraces were further multiplied in Khumaltar, characterized and stored in National Genebank. Five landraces of rice, foxtail millet, naked barley and lentil were repatriated to earthquake affected areas that helps to conserve through use. Rescuing the germplasm from earthquake affected areas is very good initiative to protect the loss of crop diversity and red listing is the simple system to identify the landraces for conservation priority setting and rescuing the endangered and rare germplasm.

Keywords: Endangered, Landrace, Extinct, Rare, Red listing

Red Listing of Agrobiodiversity

Red list is the list of crop species, and cultivars (varieties or landraces), prepared from the conservation aspects and considered trend of genetic erosion. Generally population size of most of the listed cultivars is decreasing due to many factors and if such trend remains, these cultivars will disappear in future. It also includes rare and unique cultivars which are based upon the geographic range, habitat specificity, trait specificity and local population size (Rabinowitz 1981). Categorizing agricultural crop species, variety or landraces whether these are under red list is necessary to develop strategy for initiating in-situ, on-farm and ex-situ conservation appropriately. Important consideration for making the red list of crop landraces is amount and distribution of genetic diversity, process used to maintain diversity, people who maintain diversity and factors that influence farmer's decision making maintaining diverse variety (Sthapit and Jarvis 2003).

Red list categorization study is more common in wild fauna and flora. The World Conservation Union (IUCN) and Convention on International Trade in Endangered Species of wild flora and fauna (CITES) have developed their own criteria for wild fauna and flora for red listing. IUCN classifies species in 9 categories (extinct, extinct in the wild, critically endangered, vulnerable, conservation dependent, low risk, data deficient and not evaluated) (IUCN 2012). CITES which aims to establish worldwide control over trade in the endangered wild life has listed species within three categories, Appendix I, Appendix II and Appendix III (https://cites.org/eng/app/index.php). This classification is however difficult to use for cultivated crop varieties and landraces.

Red list categories for agricultural plant genetic resources (APGRs) have been already in practice (Joshi et al 2004, Rana et al 2000, Sthapit et al 2005). Such system of categorizing crop genotypes is very useful for prioritizing conservation and utilization efforts. Red listing is also considered as new approach for monitoring cultivated species (Padulosi and Dullo 2012). Based on these criteria, we slightly modified the red list categories and criteria for grouping crop landraces from earth quake affected districts. Red list was prepared in 7 districts and seeds were collected along with the information related to impact of earthquake on crop diversity.

We reported here the achievements of two mini projects. One project was 'Rebuilding local seed system: Collection, conservation and repatriation of native crop seeds in earthquake affected areas in Nepal', funded by GCDT and implemented by National Genebank in collaboration with Bioversity International. This project was started from Aug 2015 and ended at Dec 2017. Second project implemented by LI-BIRD which was funded by the Netherlands through the GRPI-2 project of the Bioversity International 'Strengthening National Capacities to implement the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)'. The project period was from June 2015 to Dec 2015

Methodology

One day orientation meeting was organized for exploration and collection of local landraces from earth quake affected districts. Total 10 staff were involved and 29 VDCs of 7 districts (Gorkha, Lamjung, Dhading, Nuwakot, Makawanpur, Kavre, Rasuwa) were visited. We discussed sampling techniques, passport data collection, organization of FGD for knowing the conservation status and collecting other information. National Genebank and Bioversity International team undertook exploration covering 2-4 VDCs in each district with a total of 29 VDCs of 7 districts and LI-BIRD team visited 2 VDCs in each district covering 6 VDCs of three districts (Dolakha, Ramechhap and Sindhupalchowk. Ten staff involved in the missions from National Genebank and Bioversity International were D Gauchan, BK Joshi, KH Ghimire, S Khatiwada, S Sapkota, DMS Dongol, S Sharma, Niru KC, Rita Thapaliya and Kritesh Poudyal. There were 12 staff from LI-BIRD, namely S Sthapit, S Neupane, B Bhandari, S Gautam, N Pudasaine, M Gurung, M Gurung, B Linkha, N Acharya, P Sapkota, H Singh, S

Jirel. District level interaction meeting was organized in Rasuwa and trainings to farmers were organized two times in Lamjung.

During collections in 7 districts, 200 diversity kits (containing 3 to 5 varieties) were provided to 200 farmers to support them for food and nutrition security as gift. These projects also supported two community seed banks (one in Lamjung and other in Dolakha) on technical aspect and some materials, with the objective of making farmers easy access to planting materials. In Jungu, Dolakha, the rescue project led from LI-BIRD also supported seed money of USD 8000 to lay foundation for community seed banks. Focus was given on how the earth quake makes landraces endangered and how to collect such landraces. Red list (conservation status) of crop diversity in each village site was prepared employing methods for modified red listing of crop genetic resources (Joshi et al, 2004) and 4-cell analysis (Sthapit et al 2005). Farmers were asked to list the total known crop landraces along with their important traits. From the list, first extinct landraces from the area were sorted out and causes of extinction were discussed. We also encouraged farmers to discuss on the impact of earthquake on crop diversity and possibly abandoning the landrace to grow. From the remaining list of crop landraces, they were then divided into four groups (**Figure** 1), 1. Common: Landraces growing in large areas by many farmers, 2. Vulnerable: Landraces growing in small areas by many farmers and landraces growing in large areas by few farmers, 3. Endangered: Landraces growing in small areas by few farmers and 4. Not evaluated: Landraces of which information not assessed or not known.

Farmers were requested to compare the landraces during grouping them on the basis of current scenario as well as potentially future scenario. Major causes of falling landrace in a particular class were also documented. Farmers were also asked what types of cultivars they liked to grow. Many factors are considered when assessing the conservation status of a landrace eg distribution pattern, the overall increase or decrease in the population over time, breeding success rates, economic values or known threats.

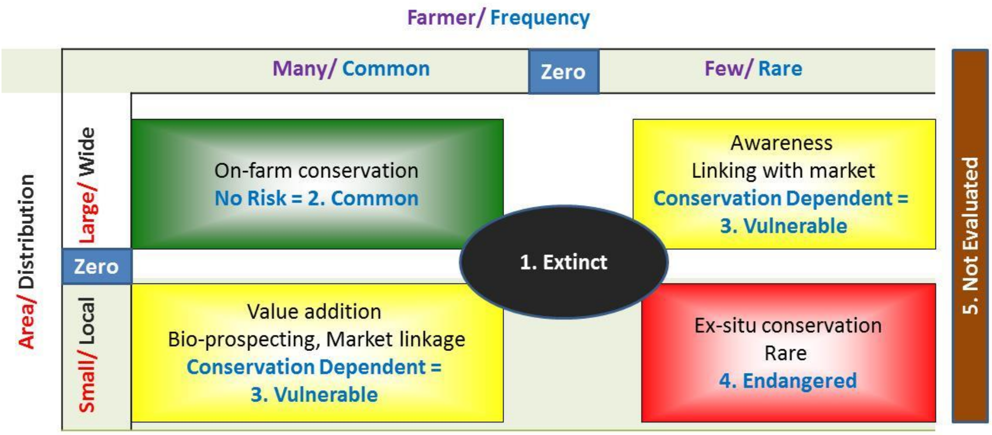

Figure 1. Five groups of crop landraces based on their conservation status.
Source: Joshi et al 2004 (modified)

The definition and main criteria of red list (conservation status) classes are given below.

Common landraces: Landraces that are grown in large areas by many farmers or landraces distributed widely and common in many spots. Because of very useful and economically important landraces under this group, they are not at any risk of extinction or genetic erosion and therefore, do not come under conservation priority.

Vulnerable landraces: Such landraces are those which are grown in large areas by few farmers or in small areas by many farmers. A vulnerable landrace is likely to become endangered unless the circumstances threatening its survival and reproduction improve. It is also called conservation dependent.

Endangered landraces: Such landraces are those grown in small areas by few households. An endangered landrace is likely to become extinct. Rare landraces as well as unique landraces are also included in this group in addition to landraces of which genetic erosion is rapid.

Rare landraces: A rare landrace is those which is very uncommon, scarce, infrequently encountered or grown in a very specific location by a very specific farmer. However, its population size remains same over the years and has limited risk of extinction compared to endangered landraces. Because of small size (small population), generally rare landraces are considered endangered. Rare landraces move into the endangered if the negative factors affecting them continue to operate. Unique landrace may also be rare based on the availability of particular trait.

A landrace may be endangered or vulnerable, but not considered rare if it has a large, dispersed population, but its numbers are declining rapidly or predicted to do so. Rare landraces are generally considered threatened because a small population size is more likely to not recover from stochastic events.

Extinct landraces: Farmers knew the name of landraces and it was grown in the past but now its seeds are not available at this locality. Farmers may have knowledge on traits of extinct landraces. Such landraces are lost from certain areas however, it may be available by the same name from other areas.

Not evaluated landraces: Only the name is known but its status eg distribution pattern, population size, number of growers, unique traits, etc are not assessed.

Details approaches applied to list and collect endangered landraces are given in **Table** 1. Farmers were asked to list the landraces that would be potential lost in the near future. Factors making landraces endangered were also documented.

Table 1. Approaches adopted to list the endangered and rare landraces of different crops in earthquake affected districts

SN	District	VDC	Approaches and analysis tools	Participants involved, n
1	Dhading	Gumdi	KIS, PRA, RRA	5
		Satyadevi	KIS, PRA, RRA	5
		Jharlang	KIS, FGD, PRA, RRA	25

SN	District	VDC	Approaches and analysis tools	Participants involved, n
		Darkha	KIS, FGD, PRA, RRA	9
2	Gorkha	Barpak	KIS, FGD, HH survey	12
		Saurpani	KIS, FGD, HH survey, Four cell analysis	12
		Laprak	KIS, FGD, HH survey	10
		Gumda	FGD, HH survey	14
3	Kavrepalanchowk	Mahadevsthan	KIS, FGD, PRA	10
		Rabi Opi	KIS, PRA, RRA	5
		Kartike Deulrali	KIS, FGD, Four cell analysis, HH survey	8
		Anaikot	FGD, PRA, RRA	15
		Phoksintar	KIS, FGD	7
		Budhakhani	KIS, FGD, Four cell analysis, HH survey	25
4	Lamjung	Kolki	FGD, PRA, RRA	9
		Ilampokhari	FGD, PRA, RRA	12
		Bichaur	FGD, PRA, RRA	20
		Dudhpokhari	FGD, PRA, RRA	20
5	Makwanpur	Chhatiwan	KIS, FGD, Four cell analysis, PRA, RRA	20
		Phaparbari	KIS, PRA, RRA	4
		Khairang	KIS, PRA, RRA	7
		Namtar	KIS, FGD	15
6	Nuwakot	Kimtang	KIS, FGD, Four cell analysis, HH survey	35
		Bhalche	KIS, FGD, Four cell analysis, HH survey	15
		Kahule	KIS, Four cell analysis, HH survey	7
		Rautbesi	KIS, FGD, Four cell analysis, HH survey	12
7	Rasuwa	Haku	KIS, FGD, Four cell analysis, HH survey	25
		Bridim	KIS, FGD, Four cell analysis, HH survey	20
		Syafru	KIS, FGD, Four cell analysis, HH survey	12
8	Dolakha	Jungu	KIS, FGD, HH Survey, PSE	29
		Namdu	KIS, FGD, HH Survey, PSE	130
9	Sindhupalchowk	Marming	KIS, FGD, HH Survey, PSE	44
		Petaku	KIS, FGD, HH Survey, PSE	50
10	Ramechhap	Tilpung	KIS, FGD, HH Survey, PSE	101
		Betali	KIS, FGD, HH Survey, PSE	131

FGD, Focus group discussion; KIS, Key informant survey; HH, Household; PRA, Participatory rural appraisal; RRA, Rapid rural appraisal; PSE, Participatory Seed Exchange

Results and Discussion

The estimated number of crop species in 10 earthquake affected districts are 150. About 5-10% of total crop landraces were lost due to earthquake. If this rescue mission was not implemented, about 20% of crop landraces would have been lost. Now these rare and endangered landraces are conserved in National Genebank.

Earthquake Making Landrace Endangered

Earthquake has greatly affected crop diversity and many of landraces become endangered. Followings are the major causes to make landraces endangered.

- Distribution of planting materials collected from outside the target areas by different organizations
- Damage of standing crops by landslides

- Damage of grain and seed store by collapse of house buildings
- Remaining of few amount of plant materials which could not cover the planting areas therefore, farmers went to other alternatives
- Many crops could not be harvested and stored seeds and grains were used as food
- Farmers forced to migrate abandoning agriculture and planting materials

Collections of Endangered and Rare Crop Landraces

Team could able to collect 921 accessions of 61 crops from 35 VDCs of 10 severely affected districts by 2015 earthquake along with passport data (**Table** 2). The highest number of collections was from Dolakha followed by Ramechhap and Gorkha districts. The least number of collections ie 50 was from Makawanpur district.

The numbers of extinct, rare and endangered landraces are given in **Table** 3. We found extinct of 104 landraces, 26 landraces rare, 73 landraces endangered due to earthquake and 185 landraces endangered due to other factors. The maximum numbers of landraces were lost from Nuwakot. In Lamjung, the total number of rare and endangered landraces due to earthquake was found the highest in number followed by Dolakha. This is because rescue collection was focused in eastern part of Lamjung bordering Gorkha where serverity of earthquake was very high. Dolakha was also epicenter for second earthquake of 12 May 2017. Only 10 rare and endangered landraces were found in Ramechhap. Name list of rare and endangered landraces are given in **Annex** I and lost landraces in **Annex** II.

Table 2. Total collections of agrobiodiversity from 10 earthquake affected districts

SN	Crops	Dhading	Gorkha	Kavre	Lamjung	Makawanpur	Nuwakot	Rasuwa	Dolakha	Ramechappe	Sindhupalchok	Total
A. Cereals												
1.	Barley	1	4	4	2		4	3	2	2	5	**27**
2.	Barnyard millet		1									**1**
3.	Finger millet	3	5	12	7	5	4	3	16	13	9	**77**
4.	Foxtail millet		2		3							**5**
5.	Ghunku							1				**1**
6.	Grain sorghum			1								**1**
7.	Maize	7	8	5	5	6	7	5	8	8	8	**67**
8.	Naked barley	1	1					5				**7**
9.	Rice	18	21		12	2	6	3	36	37	12	**147**
10.	Wheat	2	5	1			2	3	14	5	9	**41**
B. Pseudo cereals												**0**
11.	Buckwheat	1	4	5	2	2	3	2	11	8	3	**41**
12.	Grain amaranth	1	5	1			3	5		1	4	**20**
C. Legumes												**0**
13.	Beans	3	6	3	2	8	6	6	12	9	14	**69**
14.	Black gram	2	3	2	4	3	1		4	6	3	**28**
15.	Cowpea	4	6	6	6	3	3	1	8	1	1	**39**
16.	Faba bean			2								**2**
17.	Field pea	2	2	4			1	1	3	2	4	**19**

SN	Crops	Dhading	Gorkha	Kavre	Lamjung	Makawanpur	Nuwakot	Rasuwa	Dolakha	Ramechappe	Sindhupalchok	Total
18.	Garden pea		3							1		**4**
19.	Horse gram	2	2	2	2	2			3		2	**15**
20.	Lentil		1					2			1	**4**
21.	Rice bean	2	7	4	6	2	1	2				**24**
22.	Soybean	6	8	5	8	4	3	7	8	12	6	**67**
D. Oilseeds												**0**
23.	Broad leaf mustard	1	3	1	2		2					**9**
24.	Mustard	3	2	4	3	3	2		6	4	8	**35**
25.	Rapeseed	3				2						**5**
26.	Groundnut			1								**1**
27.	Sunflower								1			**1**
28.	Sarson		2	1					1		1	**5**
E. Cucurbits												**0**
29.	Cucumber	2	1	2			1		1	6	2	**15**
30.	Pumpkin	3	1	2	5	1	2	1	2	8	4	**29**
31.	Sponge gourd	1		3					2	1	2	**9**
32.	Bitter gourd		1			1				3	1	**6**
33.	Bottle gourd					1			1			**2**
34.	Water melon					1						**1**
35.	Snake gourd		1		1							**2**
36.	Balsam apple		1									**1**
37.	Ridge gourd		1									**1**
38.	Ash gourd									2		**2**
F. Spices												**0**
39.	Chili pepper	1	3			1	1	1	1	1	3	**12**
40.	Garlic								1			**1**
41.	Ginger	1										**1**
42.	Hemp	1	1									**2**
43.	Turmeric	1										**1**
44.	Niger		2	1		1						**4**
45.	Perilla		5	3			1					**9**
46.	Sesame		2	1					2	5	3	**13**
47.	Fenugreek		1									**1**
48.	Cardamom						1					**1**
49.	Coriander			2			1		1	1	3	**8**
50.	Chinni			1								**1**
51.	Dill (Soyaa)			1					1			**2**
G. Vegetables												**0**
52.	Potato	2					2					**4**
53.	Lady's finger			2		1	1					**4**
54.	Brinjal								2		2	**4**
55.	Turnip									1	1	**2**
56.	Tomato					1			2	1		**4**
57.	Taro				1				2			**3**
58.	Radish				2		1		3		2	**8**

SN	Crops	Dhading	Gorkha	Kavre	Lamjung	Makawanpur	Nuwakot	Rasuwa	Dolakha	Ramechappe	Sindhupalchok	Total
59.	Cress			1					1	1	1	**4**
H. Others												**0**
60.	Catmint (Sinek)		1									**1**
61.	Opium		1									**1**
	Total	**74**	**123**	**83**	**73**	**50**	**59**	**51**	**155**	**139**	**114**	**921**

Ghunku: small seed looks like Amaranth; Chinni: sour, very small and flat seeded.

Table 3. Extinct, rare and endangered crop landraces in earthquake affected districts

SN	District	Extinct	Rare	Endangered	
				Due to earthquake	Due to other factors
1.	Dhading	14	-	14	15
2.	Dolakha	NR	NR	40	
3.	Gorkha	24	6	15	9
4.	Kavre	17	4	-	29
5.	Lamjung	2	13	20	15
6.	Makawanpur	14	-	10	15
7.	Nuwakot	27	1	3	13
8.	Ramechhap	NR	NR	10	
9.	Rasuwa	6	2	11	7
10.	Sindhupalchok	NR	NR	32	

The extinct landraces are according to travel reports only, however, detail assessment could show more extinct landraces. NR, Not recorded

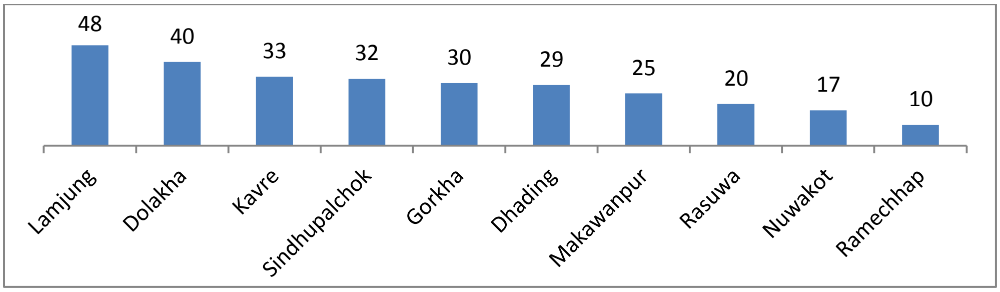

Figure 1. Number of total collected rare and endangered crop landraces from 10 earthquake affected districts.

The red list of crop plants along with detail methodology on listing has been documented for Romania (Antofie 2011). Germany has prepared red list of all groups of species of native crops, as well as their varieties, including regional varieties, which were of significance and have adapted to local conditions in Germany (https://pgrdeu.genres.de/rlist). Some 19% of the crop wild relatives species are endangered as stated on the National Red List of Germany. Hammer and Khoshbakht (2005) applied IUCN criteria and Red List Categories to agricultural and horticultural plants (excluding ornamentals). About 200 threatened cultivated plants are presented in five different categories ie extinct, endangered, vulnerable, rare and indeterminate. Rescuing the germplasm also greatly help to restore the lost diversity in disaster prone areas later in the future (Gauchan et al 2016).

Approaches for Rescue Mission

During collections mission from earthquake affected areas, team visited many households, fields, collapsed buildings, interacted farmers and officials. Preliminary information on crop diversity and impact of earthquake were collected from district agriculture development office. Followings are the techniques followed during collections of APGRs.

- Harvesting of seeds from remnant plants directly from the field
- Searching planting materials in collapse building and collections of seeds
- Harvesting seeds from the standing crops grown within collapse buildings (some seeds of some crops were germinated within collapse buildings)
- Digging out the buildings for getting seeds with the help of farmers
- Providing diversity kits to deploy diversity and requesting farmers to provide few seeds of local crops
- Asking farmers where can be found these lost landraces nearby and visiting such sites for collections

Conclusion

Red listing is the system to identify the landraces for conservation priority setting and rescuing the endangered and rare germplasm. Red list of crop diversity in each village site was prepared employing methods for modified red listing of crop genetic resources and 4-cell analysis in earthquake affected areas of Nepal. During germplasm rescue mission, farmers were asked and consulted in groups to list the total known crop landraces along with their important traits during PRA such as focus group discussion, key informant surveys and household survey, Participatory focus group discussion and consultation with farmers identified five categories of red list of agricultural plant genetic resources (APGRs) which includes extinct, common, vulnerable, endangered, and not evaluated from 10 earthquake affected areas. A total of 284 rare and endangered landraces were collected from 10 districts in addition to 637 common and vulnerable landraces of 61 crops. A total of 104 landraces of different crops were lost and 73 landraces become endangered due to earthquake alone in 7 affected districts. Rescuing the germplasm from earthquake affected areas is very good initiative to protect the loss of crop diversity.

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Annex I. Collected endangered and rare crop landraces from earth quake affected districts

SN	Crop	Landrace	Status	District	VDC
Dhading					
1	Rice	Bange Masino	Endangered	Dhading	Satyadevi
2	Finger millet	Dhuwakote	Endangered	Dhading	Satyadevi
3	Rice	Himali Marsi	Endangered	Dhading	Darkha
4	Rice	Rajbhog	Rescued	Dhading	Darkha
5	Rice	Manbhog	Rescued	Dhading	Darkha
6	Rice	Birmphool	Rescued	Dhading	Darkha
7	Cucumber	Seto Kankro	Endangered	Dhading	Jharlang
8	Rice	Seto Ghaiya	Endangered	Dhading	Jharlang
9	Naked barley	Karu	Endangered	Dhading	Jharlang
10	Rice	Nadang Masino Dhan	Rescued	Dhading	Jharlang
11	Field pea	Sthaniya Kerau	Rescued	Dhading	Jharlang
12	Rice	Marsi	Rescued	Dhading	Jharlang
13	Rice	Jeera Masino	Endangered	Dhading	Gumdi
14	Rice	Salyani	Endangered	Dhading	Gumdi
15	Maize	Dhede Makai	Endangered	Dhading	Gumdi
16	Maize	Rato Makai	Endangered	Dhading	Gumdi
17	Maize	Sthaniya Makai	Rescued	Dhading	Gumdi
18	Maize	Thulo Makai	Rescued	Dhading	Gumdi
19	Rice bean	Thulo	Endangered	Dhading	Gumdi
20	Turmeric		Endangered	Dhading	Gumdi
21	Buckwheat	Tite Phapar	Endangered	Dhading	Gumdi
22	Field pea	Sikkime Kerau	Endangered	Dhading	Gumdi
23	Hemp	Bhang	Endangered	Dhading	Gumdi
24	Rice	Kalo Kathe	Rescued	Dhading	Gumdi
25	Rice	Manbuli Kalo	Rescued	Dhading	Gumdi
26	Rice	Gurje Dhan-1	Rescued	Dhading	Gumdi
27	Rice	Gurje Dhan-2	Rescued	Dhading	Gumdi
28	Rice	Jhuttte Dhan-1	Rescued	Dhading	Gumdi
29	Rice	Jhutte Dhan-2	Rescued	Dhading	Gumdi
30	Rice	Jhinuwa Kalo Masino	Rescued	Dhading	Gumdi
31	Leaf mustard	Thulo Pat	Rescued	Dhading	Gumdi
Makwanpur					
1	Bitter gourd	Tite Karela	Endangered	Makwanpur	Phaparbari
2	Maize	Kalo Makai	Endangered	Makwanpur	Phaparbari
3	Maize	Talware Makai	Rescued	Makwanpur	Phaparbari
4	Okra	Local Bhindi	Rescued	Makwanpur	Phaparbari
5	Rice	Purano Basmati	Rescued	Makwanpur	Phaparbari
6	Buckwheat	Mithe Phapar	Rescued	Makwanpur	Chhatiwan
7	Cowpea	Gajale Bodi	Rescued	Makwanpur	Chhatiwan
8	Soybean	Seto Sthaniya Bhatmas	Rescued	Makwanpur	Chhatiwan
9	Horse gram	Kailo Gahat	Rescued	Makwanpur	Chhatiwan
10	Finger millet	Kalo Kodo	Endangered	Makwanpur	Khairang
11	Finger millet	Seto Kodo	Endangered	Makwanpur	Khairang
12	Pumpkin	Madale Pharsi	Endangered	Makwanpur	Khairang
13	Black gram	Kalo Mas	Endangered	Makwanpur	Khairang

SN	Crop	Landrace	Status	District	VDC
14	Cowpea	Kartike Bodi	Endangered	Makwanpur	Khairang
15	Tomato	Sthaniya Golbheda	Endangered	Makwanpur	Khairang
16	Mustard	Kalo Tori	Endangered	Makwanpur	Khairang
17	Chili	Sthaniya Khursani	Endangered	Makwanpur	Khairang
18	Bean	Sokta Simi	Endangered	Makwanpur	Khairang
19	Bean	Chhirke Simi	Rescued	Makwanpur	Namtar
20	Cowpea	Khairo	Rescued	Makwanpur	Namtar
21	Finger millet	Mudule Kodo	Rescued	Makwanpur	Namtar
22	Maize	Rato Makai	Endangered	Makwanpur	Namtar
23	Rapeseed	Pahenlo	Endangered	Makwanpur	Namtar
24	Rice bean	Pade	Endangered	Makwanpur	Namtar
25	Niger	Jhuse Til	Endangered	Makwanpur	Namtar
Kavrepalanchowk					
1	Black gram	Kalo Mas	Endangered	Kavrepalanchowk	Mahadevsthan
2	Finger millet	Chyatle Kodo	Endangered	Kavrepalanchowk	Mahadevsthan
3	Groundnut	Lokal Badam	Endangered	Kavrepalanchowk	Mahadevsthan
4	Maize	Murali Makai	Endangered	Kavrepalanchowk	Mahadevsthan
5	Pea	Masino Kerau	Endangered	Kavrepalanchowk	Mahadevsthan
6	Perilla	Kalo Silam	Endangered	Kavrepalanchowk	Mahadevsthan
7	Sesame	Khairo Til	Endangered	Kavrepalanchowk	Mahadevsthan
8	Sponge gourd	Basmati Ghiraula	Rare	Kavrepalanchowk	Mahadevsthan
9	Sponge gourd	Lokal Kalo Ghiraula	Endangered	Kavrepalanchowk	Mahadevsthan
10	Finger millet	Seto Kodo	Endangered	Kavrepalanchowk	Anekot
11	Grain sorghum	Junnelo	Endangered	Kavrepalanchowk	Anekot
12	Horse gram	Kalo Gahat	Endangered	Kavrepalanchowk	Anekot
13	Maize	Sathiya Makai	Endangered	Kavrepalanchowk	Anekot
14	Finger millet	Lamre	Endangered	Kavrepalanchowk	Budhakhani
15	Maize	Sthaniya Pahenlo	Endangered	Kavrepalanchowk	Budhakhani
16	Wheat	Sthaniya Gahun	Endangered	Kavrepalanchowk	Budhakhani
17	Mustard	Sthinya Tori	Endangered	Kavrepalanchowk	Rabi opi
18	Horse gram	Rato Gahat	Endangered	Kavrepalanchowk	Phoksintar
19	Rice bean	Local Masyang	Endangered	Kavrepalanchowk	Phoksintar
20	Finger millet	Seto Kodo (Mudke)	Endangered	Kavrepalanchowk	Phoksintar
21	Buckwheat	Mithe Fapar	Endangered	Kavrepalanchowk	Phoksintar
22	Soybean	Kalo Bhatmas	Endangered	Kavrepalanchowk	Phoksintar
23	Black gram	Kalo Mass	Endangered	Kavrepalanchowk	Phoksintar
24	Finger millet	Pahenlo Kodo	Rare	Kavrepalanchowk	Phoksintar
25	Mustard	Bari Tori	Endangered	Kavrepalanchowk	Kartike Deurali
26	Rice bean	Local Masyang	Endangered	Kavrepalanchowk	Kartike Deurali
27	Buckwheat	Mithe Fapar	Endangered	Kavrepalanchowk	Kartike Deurali
28	Amaranth	Seto Latte	Endangered	Kavrepalanchowk	Kartike Deurali
29	Cowpea	Rato Bodi	Endangered	Kavrepalanchowk	Kartike Deurali
30	Cowpea	Makai Simi	Endangered	Kavrepalanchowk	Kartike Deurali
31	Finger millet	Paundure Kodo	Rare	Kavrepalanchowk	Kartike Deurali
32	Chhini	Local	Rare	Kavrepalanchowk	Kartike Deurali

SN	Crop	Landrace	Status	District	VDC
Gorkha					
1	Cowpea	Kattike	Rescued	Gorkha	Saurpani
2	Cowpea	Makai	Rescued	Gorkha	Saurpani
3	Cowpea	Kolo	Rescued	Gorkha	Saurpani
4	Rice	Darmali	Rescued	Gorkha	Saurpani
5	Rice	Kalokathe	Rescued	Gorkha	Saurpani
6	Rice	Begani	Rescued	Gorkha	Saurpani
7	Rice	Anande	Rescued	Gorkha	Saurpani
8	Rice	Seto Gauriya	Rescued	Gorkha	Saurpani
9	Rice	Seto Begani	Rescued	Gorkha	Saurpani
10	Rice	Dali Ghaiya	Rescued	Gorkha	Saurpani
11	Rice	Manbhog	Rescued	Gorkha	Saurpani
12	Rice	Gokul Mansuli	Rescued	Gorkha	Saurpani
13	Rice	Gurjo Dhan	Rescued	Gorkha	Saurpani
14	Rice	Yempali Dhan	Rescued	Gorkha	Saurpani
15	Barnyard millet	Sama	Endangered	Gorkha	Saurpani
16	Buckwheat	Mithe Phapar	Endangered	Gorkha	Barpak
17	Upland rice	Seto Ghaiya	Endangered	Gorkha	Barpak
18	Upland rice	Basaune Ghaiya	Endangered	Gorkha	Barpak
19	Upland rice	Tamare	Endangered	Gorkha	Barpak
20	Naked barley	Borchen	Endangered	Gorkha	Barpak
21	Lentil	Kalo Musuro	Rare	Gorkha	Barpak
22	Foxtail millet	Kaguno	Rescued	Gorkha	Barpak
23	Buckwheat	Fapar	Endangered	Gorkha	Laprak
24	Millet	Lekali Kodo	Endangered	Gorkha	Laprak
25	Seed amaranth	Rato Latte	Rare	Gorkha	Laprak
26	Buckwheat	Mithe Fapar	Endangered	Gorkha	Gumda
27	Upland rice	Tamre Ghaiya	Endangered	Gorkha	Gumda
28	Horse gram	Kaida	Endangered	Gorkha	Gumda
29	Pumpkin	Guliyo Farsi	Rare	Gorkha	Gumda
Rasuwa					
1	Barley	Sthaniya	Rescued	Rasuwa	Haku
2	Naked barley	Choto Jhuse	Rescued	Rasuwa	Haku
3	Barley	Sthaniya	Rescued	Rasuwa	Haku
4	Naked barley	Lamo Jhuse	Rescued	Rasuwa	Haku
5	Rice	Pinyali Khoya	Rescued	Rasuwa	Haku
6	Rice	Khaya Thosa	Rescued	Rasuwa	Haku
7	Rice bean	Sthaniya	Rescued	Rasuwa	Haku
8	Cowpea	Sthaniya	Rescued	Rasuwa	Haku
9	Soybean	Seto	Rescued	Rasuwa	Haku
10	Buckwheat	Mithe Fapar	Rescued	Rasuwa	Haku
11	Soybean	Kanchi	Rescued	Rasuwa	Haku
12	Rice bean	Sthaniya	Endangered	Rasuwa	Bridim
13	Ghunku		Rare	Rasuwa	Bridim
14	Rice	Pakhe Dhan	Rare	Rasuwa	Bridim
15	Maize	Seto	Endangered	Rasuwa	Syafru
16	Maize	Rato	Endangered	Rasuwa	Syafru

SN	Crop	Landrace	Status	District	VDC
17	Naked barley	Lekali	Endangered	Rasuwa	Syafru
18	Finger millet		Endangered	Rasuwa	Syafru
19	Buckwheat	Mithe Fapar	Endangered	Rasuwa	Syafru
20	Barley	Sthaniya	Endangered	Rasuwa	Syafru
Nuwakot					
1	Wheat	Khairosthaniya	Endangered	Nuwakot	Kimtang
2	Barley	Jhuse	Endangered	Nuwakot	Kimtang
3	Barley	Mudulejau	Endangered	Nuwakot	Kimtang
4	Barley	Mudejau	Endangered	Nuwakot	Kimtang
5	Finger millet	Seto Kodo	Endangered	Nuwakot	Kimtang
6	Buckwheat	Tin Sure Fapar	Endangered	Nuwakot	Kimtang
7	Potato	Kimtangealu	Endangered	Nuwakot	Kimtang
8	Rice	Chautarimarshi	Highly endangered	Nuwakot	Kimtang
9	Rice	Ratodhan	Rescued	Nuwakot	Kimtang
10	Soybean	Masinalahare (Kalobhatmas)	Rescued	Nuwakot	Kimtang
11	Mustard	Kalo	Rescued	Nuwakot	Bhalche
12	Rice	Wala Sing Dhan	Endangered	Nuwakot	Bhalche
13	Black gram	Kalo Mass	Endangered	Nuwakot	Rautbesi
14	Soybean	Seto Bhatmas	Endangered	Nuwakot	Rautbesi
15	Rice	Krishnabeli Dhan	Endangered	Nuwakot	Rautbesi
16	Rice	Kalo Kathe	Endangered	Nuwakot	Rautbesi
17	Rice	Samudrafini	Rare	Nuwakot	Rautbesi
Lamjung					
1	Finger millet	Nangre Kodo	Endangered	Lamjung	Kolki
2	Rice bean	Kalo Siltu	Endangered	Lamjung	Kolki
3	Colocasia	Khari Padalu	Endangered	Lamjung	Kolki
4	Rice bean	Sato Siltu	Endangered	Lamjung	Kolki
5	Horse gram	Local Gahat	Rare	Lamjung	Kolki
6	Rice	Rato Anadi	Rare	Lamjung	Kolki
7	Soybean	Masino Bhatta	Rare	Lamjung	Kolki
8	Cowpea	Local Bodi	Rare	Lamjung	Kolki
9	Rice bean	Masino Masyang	Rare	Lamjung	Kolki
10	Buckwheat	Lokal Phapar	Rescued	Lamjung	Kolki
11	Foxtail millet	Kaguno	Rescued	Lamjung	Kolki
12	Finger millet	Dalle Kartikae Kodo	Rescued	Lamjung	Kolki
13	Cowpea	Kurmi Bodi	Endangered	Lamjung	Illampokhari
14	Cowpea	Karta Bodi	Rare	Lamjung	Illampokhari
15	Cowpea	Kartkae Bodi	Rescued	Lamjung	Illampokhari
16	Finger milet	Mangisare Kodo	Endangered	Lamjung	Illampokhari
17	Finger millet	Mangisare Kodo	Rescued	Lamjung	Illampokhari
18	Foxtail millet		Rare	Lamjung	Illampokhari
19	Foxtail millet	Kaguno	Rescued	Lamjung	Illampokhari
20	Maize	Seto Sathiya Makai	Endangered	Lamjung	Illampokhari
21	Maize	Local Pahelo Makai	Rescued	Lamjung	Illampokhari
22	Mustard	Aafal Tori	rescued	Lamjung	Illampokhari
23	Radish	Sthinya Mula	Rare	Lamjung	Illampokhari
24	Rice	Manunge Sali Dhan	Endangered	Lamjung	Illampokhari

SN	Crop	Landrace	Status	District	VDC
25	Rice	Pakhe Sali Dhan	Endangered	Lamjung	Illampokhari
26	Rice	Pudki Dhan	Rare	Lamjung	Illampokhari
27	Rice	Basmati Dhan	Rescued	Lamjung	Illampokhari
28	Rice	Purano Anadi Dhan	Rescued	Lamjung	Illampokhari
29	Snake gourd	Chichindo	Rescued	Lamjung	Illampokhari
30	Soybean	Hariyo Masino Bhatta	Endangered	Lamjung	Illampokhari
31	soybean	Seto Dande Bhatta	Endangered	Lamjung	Illampokhari
32	Soybean	Kalo Bhatta	Rescued	Lamjung	Illampokhari
33	Soybean	Bhatta	rescued	Lamjung	Illampokhari
34	Barley	Sthinya Jau	Rare	Lamjung	Bichaur
35	Barley	Bhote Jau	Endangered	Lamjung	Bichaur
36	Finger millet	Seto Kodo	Endangered	Lamjung	Bichaur
37	Maize	Gaire Dhande Maki	Normal	Lamjung	Bichaur
38	Rice	Purano Lahure	Endangered	Lamjung	Bichaur
39	Rice	Masino Basmati	Rescued	Lamjung	Bichaur
40	Rice	Koheli Dhan	Rescued	Lamjung	Bichaur
41	Rice	Aanga	Rescued	Lamjung	Bichaur
42	Rice	Rato Anadi	Endangered	Lamjung	Bichaur
43	BLM	Nangle Rayo	Rare	Lamjung	Dudhpokhari
44	Maize	Thopla Kuchae	Rescued	Lamjung	Dudhpokhari
45	Maize	Dhindae Makai	Rescued	Lamjung	Dudhpokhari
46	Pumpkin	Farsi Madale Lamcho	Rare	Lamjung	Dudhpokhari
47	Radish	Dhande Mula	Rescued	Lamjung	Dudhpokhari
48	Rice	Thakai Lahare	Rescued	Lamjung	Dudhpokhari
49	Soybean	Chainae Bhatta	Rare	Lamjung	Dudhpokhari
50	Soybean	Masanae Bhatmas	Endangered	Lamjung	Dudhpokhari
Dolakha					
1	Soybean	Kailo Bhatmas	Endangered	Dolakha	
2	Soybean	Kalo Bhatmas-Thulo	Endangered	Dolakha	
3	Sunflower	Suryamukhi	Endangered	Dolakha	
4	Wheat	Bangare	Endangered	Dolakha	
5	Wheat	Garibi	Endangered	Dolakha	
6	Wheat	Kalo	Endangered	Dolakha	
7	Wheat	Rato Pota	Endangered	Dolakha	
8	Wheat	Thulo Estaniya	Endangered	Dolakha	
9	Yam	Rato Ghar Tarul	Endangered	Dolakha	
10	Niger	Jhuse Til	Endangered	Dolakha	
11	Perilla	Kalo Silam	Endangered	Dolakha	
12	Perilla	Seto Silam	Endangered	Dolakha	
13	Perilla	Seto Silame (Jui)	Endangered	Dolakha	
Sindhupalchowk					
1	Soybean	Kalo Bhatmas	Endangered	Sindhupalchowk	
2	Soybean	Kailo Bhatmas	Endangered	Sindhupalchowk	
3	Sponge gourd	Gharaula	Endangered	Sindhupalchowk	
4	Sunflower	Suryamukhi	Endangered	Sindhupalchowk	
5	Turnip	Salgam	Endangered	Sindhupalchowk	

SN	Crop	Landrace	Status	District	VDC
6	Perilla	Kalo Silam	Endangered	Sindhupalchowk	
7	Perilla	Seto Silam	Endangered	Sindhupalchowk	
Ramechhap					
1	Soybean	Kause	Endangered		
2	Tomato	Rato Lokal	Endangered	Ramechhap	

Annex II. Name list of extinct landraces of different crops in earthquake affected districts

SN	District	Crop	Extinct landrace
1	Dhading	Buckwheat	Sthaniya Phaper
		Buckwheat	Sthaniya Phaper
		Finger millet	Local
		Maize	Local Makai
		Naked barley	Local Uwa
		Rice	Mansara Dhan
		Rice	Local Dhan
		Rice	Local Dhan
		Rice	Gauria Masino Dhan
		Rice	Sali Dhan
		Rice	Kalo Marsi
		Rice	Taulihawa Dhan
		Sorghum	Junelo
		Wheat	Gahu
		Total	**14**
2	Makwanpur	Maize	Kaptere Makai
		Maize	Kharchuke Makai
		Oil seed crop	Sarso Local
		Rice	Ghiu Kumari Dhan
		Rice	Champasari Dhan
		Rice	Aampjhutte Dhan
		Rice	Marsi Dhan
		Rice	Thade Masino
		Rice	Rajbhog
		Rice	Krishnabhog
		Rice	Kalo Dhan
		Rice	Maidane Dhan
		Wheat	Rato Gahun
		Wheat	Seto Gahun
		Total	**14**
3	Kavrepalanchowk	Bitter buckwheat	Tite Phapar
		Maize	Jamune Makai
		Potato	Local Alu
		Rice	Gola Marsi
		Rice	Rambeli Dhan
		Rice	Kathe Ghaiya
		Rice	Kuwale Kathe
		Rice	Chhoto Dhan
		Rice	Aampjhutte Dhan
		Rice	Sikhar Kathe

SN	District	Crop	Extinct landrace
		Rice	Ghaiya Dhan
		Rice	Pokhareli
		Rice	Kalo Kathe
		Rice	Anga Dhan
		Rice	Mansara
		Sorghum	Sorghum
		Wheat	Local Gahun
		Total	**17**
4	Gorkha	Barnyard millet	Sama
		Buckwheat	Mithe Phapar
		Finger millet	Labre Kodo
		Foxtail millet	Kaguno
		Foxtail millet	Kaguno
		Foxtail millet	Mal Kaguno
		Foxtail millet	Seto
		Horse gram	Local Gahat
		Maize	Thaplokuche
		Maize	Murali Sano
		Naked barley	Karu
		Rice	Marse
		Rice	Gudure
		Rice	Gauriya
		Rice	Tauli
		Rice	Anga
		Rice	Kalo Jhinuwa
		Rice	Seto Jhinuwa
		Rice	Marse
		Rice	Mana Muri
		Rice	Tamre Ghaiya
		Sorghum	Junelo
		Spring rice	Simkhada
		Upland rice	Tamre
		Total	**24**
5	Lamjung	Rice	Madise Dhan
		Rice	Sobhara Dhan
		Total	**2**
6	Nuwakot	Bitter buckwheat	Kambre
		Black gram	Rato Mas
		Black gram	Kalo Mas
		Buckwheat	Phapar
		Cowpea	Bodi
		Finger millet	Panhelo Kodo
		Foxtail millet	Tangre
		Foxtail millet	Kaguno
		Horse gram	Gahat (Local Kalo)
		Lentil	Masuro
		Linseed	Alas
		Maize	Pahenlo Makai
		Maize	Seto Makai

SN	District	Crop	Extinct landrace
		Maize	Harkapure Makai
		Maize	Thumse Makai
		Naked barley	Karu
		Potato	Purano Alu
		Potato	Kimtange Alu
		Rapeseed	Kalo Tori
		Rice	Rato Dhan
		Rice	Anga Marsi
		Rice	Tauli Dhan
		Rice	Marsi
		Rice	Kalo Dhan (Lumro)
		Rice	Samudraphini Dhan
		Rice bean	Masyang
		Soybean	Bhatmas
		Total	**27**
7	Rasuwa	Barley	Jau
		Foxtail millet	Kaguno
		Naked barley	Seto Karu
		Rice	Bena Marsi Dhan
		Rice	Kana Dhan
		Rice	Batlang or Pakhe Dhan
		Total	**6**
8	Dolakha	Not recorded	
9	Ramechhap	Not recorded	
10	Sindhupalchowk	Not recorded	

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Rebuilding Local Seed System of Native Crops in Earthquake Affected Areas of Nepal (Bal K. Joshi and Devendra Gauchan, eds). Proceedings of Sharingshop, 18 Dec 2017, Kathmandu; NAGRC, BI and Crop Trust; Nepal

Repatriation of Crop Landraces in Earthquake Affected Districts

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Abstract

Repatriation of rare and threatened landraces of local crops (rice, lentil, naked barley and foxtail millet) was conducted for the on-farm conservation at the different sites of Lamjung, Kavreplanchowk and Dolakha districts based on farmers' demand. The landraces were collected from Rasuwa, Dhading, Nuwakot, Manang and Mustang districts. Landrace seeds were allocated and geo-reference of sources and repatriated districts were stratified before repatriation. At the time of harvest scoping assessment was done. Among the repatriated landraces in Kartike Deurali, Kavre and Ghanpokhara, Lamjung, results showed that Aampjhutte Dhan was good in terms of disease, insect pest, and expected yield, although it has some problem of lodging, tall and little late. Samudraphini Dhan was not good in Kavre, Lamjung and Dolakha sites, having problem of severe sterility and lodging, disease and insect problems. Major recommendations are need assessment before repatriation in small scale through local network, written consent, team monitoring and evaluation by conservationists, agricultural scientists and development specialist for promotion of landrace on-farm. One of the potential tools may be the climate analog tool to identify the sites based on the originally collected sites of landraces for repatriation.

Keywords: Conservation strategy, Farmers' preference, Landraces, On-farm, Repatriation

Introduction

Nepal is rich in floral and faunal diversity including agrobiological diversity (Joshi et al 2017a, Upadhyay and Joshi 2003, MoFSC 2014). Nepal was hit by a strong earthquake in April 24, 2015. A total of 14 districts were severely affected by the earthquake. There was concern of loss of valuable agricultural crop genetic resources in the country, particularly in the affected districts, due to earthquake. A number of rescue missions were undertaken in different sectors to rescue human beings, livestock and valuable household assets. However, no immediate initiatives were made in affected areas to rescue seeds and endangered native crop varieties as a means to quickly revive and strengthen the local seed system and conserve crop diversity for the future (Gauchan et al 2016). Therefore desperate needs of rescue operations were realized in the crop genetic resources sector. Consequently National Genebank, NARC in collaboration with Bioversity International with the local support of respective district agricultural development offices (DADOs) undertook rescue mission for crop genetic resources in 2015 July to 2016 December. Subsequently, repatriation of farmer demanded collected crop genetic resources was realized and carried out in selected communities in affected districts.

CIP (International Potato Center) defines repatriation as "the return and distribution of components of the knowledge systems such as samples of plant varieties and associated knowledge. Specifically repatriation is the return of traditional cultivars to the farming communities whose ancestors developed and conserved these landraces for millennium (https://cipotato.org/genebankcip/process/potato/repatration-2/). The objective of the repatriation is the restoration of these components of the system". The two parties: CIP and the potato park, represented by the Association for Nature and Sustainable Development (ANDES) are aware that the conservation, sustainable use and development of maximum agrobiodiversity is of vital importance in order to improve the nutrition, health and other needs of the growing global population, and play a central role in the maintenance of sustainable systems within the biosphere. In Nepal NAGRC has considered repatriation as one of the on-farm conservation techniques (Joshi 2017, Joshi et al 2017b). It is defined as returning of landraces in the site from where it was collected or growing in areas that are similar to its original place. To facilitate the repatriation, climate analogue tool has been considered effective (Joshi et al 2017c).

This paper summarizes the findings of crops rescued and accomplishment of repatriation mission in the affected districts, implemented with the objectives of (i) identification of sites and landraces that can be repatriated, (ii) repatriation of local landraces of rice (rare) named "*Samudraphini*" (collected from Dupcheswor, Shikharbesi VDC, Nuwakot) and "*Aampjhutte Masino*" (collected from Gumdi, Dhading) to different farmers of Dolakha, Kavre and Lamjung districts and (iii) repatriation of rare (endangered) landraces, foxtail millet named "*Mal Kaguno*"(collected from Rainas Nagarpalika, Lamjung), lentil "*Kalo Masuro*" (collected from Goljung, Rasuwa district) and naked barley (collected from Mustang and Manang districts) to the different farmers of Lamjung. However, the performance of winter crops (lentil and naked barley), not included here, as the crops were at the initial stage of the growth in the field, for which data are yet to be collected.

Strategies for Agricultural Plant Genetic Resources Conservation

There are mainly two strategies important for the conservation of agricultural plant genetic resources underlined by researchers, which includes on-farm conservation and off-farm conservation (ex-situ or genebank). Both these options are necessary and insufficient having its advantage and limitations (Dulloo et al 2016). However, Belon et al (2015, 2017), emphasized on-farm conservation, due to because ex-situ having limitations with the continued changing selective forces, which favors new genetic variation, subsequently interlinked to social and ecological factors and human management and preferences (Labeyrie et al 2014, Samberg et al 2013, Westengen et al 2014).

Wang et al (2016) explained that rice landraces under on-farm conservation programs had more alleles and higher genetic diversity and added that on-farm conservation can effectively promote the allelic variation and increase the genetic diversity of rice landraces.

Similarly, Dulloo et al (2016) explained strategy of on-farm conservation, stating the purpose on-farm conservation should be focused on continuous benefits of communities from crops and animals (Jarvis et al 2008). Dulloo et al (2016) underlined the advantages of on-farm conservation are that the diversity continues to evolve in response to natural and human selection, despite challenges of diversity is susceptible to threats such as disease, conflict and changing climate, land use and farmer choices (Vernooy et al 2014).

Rana et al (2003) explained landrace repatriation will be effective in the marginal growing environments where landrace could compete with the modern varieties. Similarly, de Haan and Thiele (2004) explained repatriation program will be successful through community seed banks (CSBs), provided direct involvement of local community and authorities supervised by village authorities. Similarly, Dulloo et al (2016) also emphasized the importance of CSBs in the conservation. For example, in a subsistence agriculture community in the Limpopo area of South Africa, establishment of a community seed bank halted the loss of traditional crops and varieties central to farming systems and survival (Vernooy et al 2014).

Similarly, Swiderska et al (2011) also highlighted the important of local landrace. In an study, they found traditional varieties of maize having drought and wind resistant in SW China, maize resistant to unpredictable weather and new pests in coastal Kenya, and potato varieties in Bolivia that are more resistant to new pests and lack of rainfall, and the study suggested need to support landrace conservation, local seed production, seed fairs, community seed banks, and community based conservation and adaptation.

Repatriation helps to restore lost diversity and promote on-farm conservation, which refers to the management of landrace diversity within the traditional agricultural systems, where they have developed their unique characteristics. It is the dynamic process, with the active involvement of conservationists and farmers aiming at the long-term preservation of maintaining genetic richness and evenness of the included diversity (Joshi et al 2017).

Methodology

(i) Landraces identification for repatriation

Rare and endangered landraces were identified from the analysis of the field assessment and rescue collections (after earthquake) in the earthquake affected districts and areas. Focus was given native and local crop landraces that are important for food and nutrition security of small and vulnerable farmers in severely earthquake affected districts.

(ii) Identification of sites and farmers for repatriation

Selections of sites and farmers were identified mainly based on the interest and farmers own demand of landraces, during rescue collection of crop landraces after earthquake. At that time, farmers were demanding the crop landraces that existed some years ago and lost at present. A criterion was developed for the repatriation process (**Annex** I). Sites for repatriation can be identified using climate analog tool to locate the climate analog sites, or literature review or field visit or key information survey. In our case, we discussed among key informant including farmers.

(iii) Collection of materials

Custodian farmers were identified and consulted for landraces seed collection and were collected before planting at the sites to be repatriated.

(iv) Consent building with farmers + communication with Agric. Service Centers

A oral consent was made with the farmers before repatriation of the materials, in case of the risk of damage of the crops farmers have to be ready to bear that risks, if any consequences, so that crop landraces will be supplied in their own demand only. Accordingly, information and oral communication was made with the respective service centers of Agriculture Development Offices (ADO).

Concepts

A simple step or a concept of repatriation, promotion and conservation of landrace diversity is presented for the enhancement of landrace conservation on-farm (**Figure** 1). This includes a set of multiple activities (from identification and collection of rare landraces to the repatriation to farmers field and monitoring by team members and their promotion for on-farm conservation) having role of conservationists, agricultural scientists (breeders, agronomists, pathologists), and socio-economists.

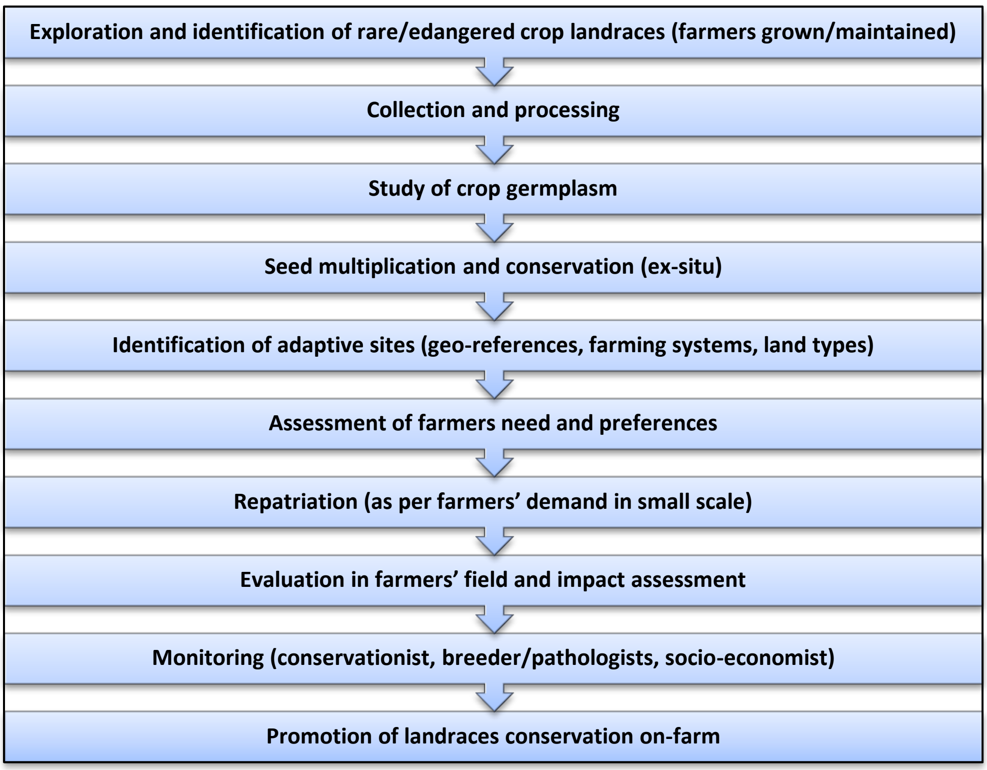

Figure 1. Steps for repatriation and on-farm conservation of crop landraces.

Findings and Discussion

Farmers' Choices of Landraces

Although, in many sites, during our rescue collection mission (after earthquake), farmers shown their keen interest in growing landraces of rice, legumes, foxtail millets, etc. sites were selected where farmers have lost already the landraces due to unavailability of seeds. For instance, farmers of Briddim VDC, Rasuwa, were demanding high altitude rice varieties for planting, where their own indigenous rice varieties have been already lost, but the rice landrace could not allocated and find the seeds. Hence, few districts and sites were selected for repatriation.

Repartriated Landraces and Sites

A total of 36.8 kg of rice landraces (Aampjhutte 19 kg, Samudraphini 17.8 kg) were repatriated to the Lamjung, Kavre and Dolakha districts covering 25 numbers of farmers. Samudraphini Dhan and Aampjhutte Dhan were collected from Dupcheswor, Shikharbesi VDC, Nuwakot and Gumdi, Dhading. Similarly, a popular lentil variety named "Kalo Masuro" collected from Goljung, Rasuwa, foxtail millet (named "Mal Kaguno") and barley were also repatriated to Ghanapokhara, Lamjung to 65 of farmers. A details description of collection and repatriated sites with geo references are provided in **Table** 1a and **Table** 1b.

Table 1a. Summary of repatriated crops and its landraces

SN	Crop	Local name	Source	Repatriated district/place	No of farmers	Total, kg
1.	Rice	Aampjhutte Masino	Gumdi, Dhading	Lamjung (Ghanapokhara)	4	4
2.	Rice	Samudraphini	Gumdi, Dhading	Lamjung (Ghanapokhara)	6	6
3.	Rice	Samudraphini	Gumdi, Dhading	Kavreplanchowk (Kartike Deurali, Sanga)	3	3.8
4.	Rice	Aampjhutte	Gumdi, Dhading	Kavreplanchowk (Kartike Deurali, Sanga)	6	15
5.	Rice	Samudraphini	Dupcheswor, Shikharbesi, Nuwakot	Dolakha (Jugu)	6	8
6.	Lentil	Kalo Masuro	GoljungRasuwa	Lamjung, Ghanapokhara (Marsyandi Gaupalika)	10	5
7.	Lentil	Kalo Masuro	Goljung Rasuwa	Dudhpokhari Gaupalika, Lamjung	15	7.5
8.	Naked barley	NGRC 04003	Dhumba Mustang	Dudhpokhari Gaupalika, Lamjung	10	5
9.	Naked barley	Local Uwa (NGRC 04902)	Pisang Manang	Dudhpokhari Gaupalika, Lamjung	10	5
10.	Foxtail millet	Mal Kaguno	Rainas Nagarpalika, Lamjung	Rainas Nagarpalika, Lamjung	20	20
		Grand total			90	79.3

Table 1b. Geo references

SN	Crop	Seed source place	Elevation (m)	Latitude	Longitude	Repatriated place	Elevation (m)	Latitude	Longitude
1	Aamjhutte Dhan	Gumdi, Dhading	1183 (± 5)	N 28° 02.653′	E 084° 56.283′	Ghanapokhara, Lamjung	1892.2	28.31405	84.31835
						Bokse, Kartike Deurali-9, Kavreplanchowk	900	27°33.204′	85°49.303′
2	Samudraphini Dhan	Dupcheswor, Shikharbesi, Nuwakot	1155	27.950624	85.394945	Jugu, Dolakha	2563.3	28.34367	84.28591
						Ghanpokhara, Lamjung	1892.2	28.31405	84.31835
						Kartike Deurali, Kavre	900 m	27°33.204′	85°49.303′
3	Kalo Masuro	Goljung, Rasuwa	2050	28.1693	85.3228	Jugu, Dolakha, Ghanpokhara, Lamjung	2563.3	28.34367	84.28591
4	Kalo Masuro	Goljung, Rasuwa	2050	28.1693	85.3228	Dudhpokrari Gaupalika, Lamjung	1790 m	28.1798	84.5193
5	Naked Barley (NGRC 04003)	Dhumba Mustang	2563.3	28.34367	84.28591	Dudhpokhari Gaupalika, Lamjung	1790 m	28.1798	84.5193
6	Naked Barley (Local Uwa: NGRC 04902)	Pisang, Manang	4554.4	28.5853	84.145	Dudhpokhari Gaupalika, Lamjung	1790 m	28.1798	84.5193
7	Mal Kaguno	Rainas Nagarpalika, Lamjung	1700	28.1276	84.4803	Rainas Nagarpalika, Lamjung	1700 m	28.1276	84.4803

Farmers' Response and Feedbacks of Repatriation

Farmers' response of repatriated rice landraces at Kattike Deurali (Bokse), Chaurideurali Gau Palika-6, Kavreplanchowk, Lamjung (Ghanpokhara) and Dolakha (Jugu) districts (**Annex** II) are as follows.

I. Aampjhutte Dhan: Almost all farmers like this variety and desirable and undesirable traits reported by farmers (although farmers remarked that this is not a true type Aampjhutte Dhan, found before in that area) are as follows.

> **Desirable traits:** Farmers reported that this rice landraces has good and attractive seed setting and long panicle, More straw yield, high rice milling recovery (Dhan Nakudne, Saglo Geda), timely matured (in Ghanpokhara), no disease and insect problems.

Undesirable traits: Major problem of this variety was lodging, and little late. The plant height is taller than a man. Farmers remarked that it could be due to height, it was lodged, especially in case of the moist and fertile place, and it could be better in barren and sun shine Khet.

Constraints: Lodging and taller in height were reported constraints in this landrace. All farmers responded that the variety of rice will be saved for seeds (range was 5-10 kg) to cultivate in coming season. They also reported that this variety is demanded by neighbors and other farmer.

Yield compare to other varieties: Most farmers said they need to harvest and thresh for final yield evaluation, however, remarked that yield of this variety would be in the same ratio with the improved varieties. Improved varieties cultivated in this area are (i) Malika, (ii) Naya Parwanipur, (iii) Makwanpur-1, etc.

II. Samudraphini Dhan: Farmers did not like this landrace, because of poor seed setting; other desirable and undesirable traits reported by farmers are as follows.

Desirable traits: Desirable trait was not reported in this variety.

Undesirable traits: Major undesirable traits reported are poor seed set in most of the cases, lodging problem, tall in height (higher than man), and disease and insect incidence, insects named "Gawaro" and "Patero" (Ganthe bug) reported in Ghanpokhara. In case of Jugu, Dolakha), no seed set due to severe sterility (100%), and blast disease was reported. In this site, farmers demanding for compensation (also one farmer in Kartike Deurali) and risk of discourage to grow other varieties (LIBIRD distribution), due to failure of Samudraphini Dhan.

Constraints: Major constraints of this variety was loss of grain production due to poor or no seed setting, problem of disease and insects, loss of production and wages of labor, tall height, lodging. One farmer (in Kartike Deurali) replied that in initial dough stage, base of panicle died and a kind of insect looked like larvae (non hairy) was seen (in Nepali: Pasaunebela Ankhlamarne, Ankhla ma sanokira, Jhusilkira jasto rau nabheyeko), and severe lodging occurred.

Only one farmer responded that the variety of rice will be saved for seeds (3 kg) to try in coming season. The variety was not demanded by other farmers.

Yield compare to other varieties: As per its performance in field, farmers remarked that yield will be relatively very less compared to other varieties of rice.

List of Local Rare and Valuable Crop Landraces willing to grow

In the areas, most of the farmers asked for rare and valuable rice crop landraces only for cultivation in coming and future seasons. Name of these landraces are (i) Aampjhutte Dhan, (ii) Rambeli Dhan, (iii) Kulo Dhan, (iv) Kathe Dhan, (v) Golamarsi Dhan, (vi) Basmati (local), (vii) Khanti Dhan, (viii) Jhinuwa Masino, (ix) Rato Marsi Dhan (in Sanga, Kavre), and (x) Kane/Kalane/Khanti. In Lamjung, farmers were willing to introduce new landraces.

Conclusion and Way Forward

Repatriation is an effective mean to maintain diversity and conserve valuable genetic resources. Farmers' responses were very good. Experience of farmers showed that Aampjhutte Dhan is better in terms of disease, insect pest, and expectation of yield, although it has some problem of lodging, tall and little late. Following are some recommendations for the repatriation activities.

- Need assessment is necessary before introducing repatriation of landraces based on real demand of farmers
- Repatriation needs to be introduced in a small scale and few interested farmers only (eg lead farmers, innovative and cooperative farmers)
- During primary stage of repatriation process, involvement of breeder and pathologist could be an advantage to promote landraces as they can provide technical support in cultivation, conservation and use
- It will desirable to have written consent of farmers to repatriate the landrace, to minimize grievances of farmers in case of crop failure
- It will be better to introduce landrace by linking with local authorities (rural municipalities and agricultural offices) for their follow-up and ownerships
- Follow up and reassessment of the repatriated landraces at corresponding sites is essential for scaling-up in other areas and strengthening local seed system
- Team monitoring by relevant specialists (conservationist, breeder/pathologist, socio-economist) is needed for the evaluation of repatriated landraces, their promotion (through local exchanges and sharing) and conservation on-farm

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Annex I. Conservation status and criteria for landrace repatriation

SN	Crop	Conservation status	Place of origin	Repatriation criteria	Repatriation place	Seeds availability
1	Foxtail millet (Mal Kaguno)	Lost by earthquake	Saurpani, Gorkha	(i) It is very unique and rare variety (ii) Since lost due to earthquake, after repatriation of this to the lost areas, it could be conserved amongst the farmers field	Gorkha district, altitude of about 1500 masl, or similar to Saurpani VDC	National genebank and International genebanks
2	Aampjhutte Dhan	Lost	Kartike Deurali, Kavre	(i) Farmers now desire to cultivate Aanpjhutte Dhan, as it was lost previously by replacement by other varieties (ii) Good in taste and equalises in production with Makwanpure-1, an improved varieties that they are cultivating nowadays	Karitke Deurali in Kavre and similar to areas of altitude ranging about 1000 masl in river basins	Can be directly bought from farmers of Dhading where we were able to collect Aanpjhutte Dhan from similar altitude range
3	Samudraphini Dhan	Rare	Sikharbesi, Nuwakot district	(i) Being rare and highly appreciated rice landrace of Nuwakot, but is endangered due to replacement by Khumal-8 and only cultivated by single household (ii) It can fall on farmers preference in repatriation area due to its high economic return due to taste and long grain size	Altitude ranging from 1000 to 1500 masl, climate similar to Sikharbesi, and on river basins	Can be directly bought by farmer cultivating this landrace in Sikharbesi, Nuwakot

Annex II. Feedbacks from the monitoring of rice landraces repatriated

SN	Question	Rice Landrace		Remarks
		Aampjhutte	Samudraphini	
1	How much seeds you are expected to produce for these varieties?	5 kg, 8-10 kg, 10-11 kg, after yield evaluation	No, 3 kg (1)	-
2	Did you like the rice varieties that are being planted? (i) Yes (ii) No	Yes	No, Undecided	-
	a. If yes, why did you like it (them)? Please specify reasons?	Due to grain seed setting, Good fodder yield, Dhan Nakudne (Saglo Geda), Phalai Thikchha, No disease and insect.	-	-
	b. If not, please specify reasons?	Mal badhi bhayeko thauma dhalne (pasaisake pachhi bala nuhiyera dhaleko)	Due to no seed set (100% sterility in Jugu and one farmer at Kartike Deurali), Tall in height (higher than man), lodging, Not seed set in many cases, Pasaune bittikai dhalne, dana nalageko	-
3	Did you face any constraints in the cultivation of the given landraces? (i) Yes (ii) No	No problem	Yes	-
	a. If yes, specify the constraints?	No, Tall height, Lodging (aglo bhayera)	Loss of grain production and wages of labor, Tall height, Lodging, Not seed set, Pasaune bela Ankhla marne, Ankhla ma sano kira (Jhusil kira jasto rau nabheyeko). 100% sterility at Jugu and one farmer of Kartike Deurali.	-
4	What do you think the benefits of the landraces you received? a. Food value b. Culture value c. Economic value	- Khanako lagi Faida - Could be used for food value, for final use, have to harvest, process and consumed first - Khana ma prayog hune - Masino bhaye kole geda badhi hunchha	-	-
5	What are the desirable and undesirable traits of the landraces?	Desirable traits: No disease, Good straw yield, Ramro phalne, Dhan Nakudne (Saglo Geda), timely mature, Makwanpur bhanda phalaima kam nadhekhiyeko, No disease and insect	Desirable traits: Not reported Undesirable traits: No grain formation (totally), severe disease (eg blast) and insect problem ("Gawaro" and "Patero" or Gandhe bug"), Tall, lodging, not good in moist place, Could be good in	-

SN	Question	Rice Landrace		Remarks
		Aampjhutte	Samudraphini	
		Undesirable traits: Lodging (little), Tall in height, Late variety, Not good in moist and fertile place, Could be better in "Banjho" and "Parilo" place, Pasai sake pachhi bal anuhiyera dhaleko	"Banjho Khet", Pasaune bittikai dhalne	
6	Do you like to cultivate the landraces in next year and future? (i) Yes (ii) No	Yes Yes (Like to try in "Parilo" place)	No, Thorai lagaune	-
7	Are you planning to save the seeds for the next year planting? (i) Yes (ii) No	Yes	No, Yes (1)	-
8	Is there any demand of the seeds from neighbors and relatives for these varieties? (i) Yes (ii) No	Yes	No	
9	Compare the yield of the given variety with the other varieties of rice you usually planted? (i) Good (ii) Fair (iii) Poor	Will be equal amount/weight compare to other varieties For yield evaluation: Harvest and threshing is needed first, after that we can know	Less yield	-
10	What local rare and valuable crop landraces you think are willing to cultivate in coming season and future?	-	-	-
	List of crops are given below:			
	(i) Aampjhutte Dhan			Planting month: Jestha
	(ii) Rambeli Dhan			Can be found in Sindhupalchowk
	(iii) Kulo Dhan			
	(iv) Kathe Dhan			Lost before 5-6 years
	(v) Golamarsi Dhan			
	(vi) Basmati			

SN	Question	Rice Landrace		Remarks
		Aampjhutte	Samudraphini	
	(local)			
	(vii) Khanti Dhan			- Very good taste. It was here until 8-10 years. - It is found in higher altitudes - Grain type: Slender and bold - Could be found in upper belt of Kavre district and Dolakha district
	(viii) Jhinuwa Masino			
	(ix) Kane/Kalane, Khanti			Pokhareli masino jastai, ali moto
	(x) Rato Marsi Dhan			
11	Any comments of farmers			This is not a true Aampjhutte Dhan. Grain of Aampjhutte is bold and height is also little lesser. Among the most yielded improved varieties are (i) Malika (ii) Naya Parwanipur (iii) Makwanpur-1
				In Jugu, farmers demanding for compensation (also one farmer in Kartike Deurali) and risk of discourage to grow other crop/varieties (LIBIRD distribution), due to failure of Samudraphini

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Rebuilding Local Seed System of Native Crops in Earthquake Affected Areas of Nepal (Bal K. Joshi and Devendra Gauchan, eds). Proceedings of Sharingshop, 18 Dec 2017, Kathmandu; NAGRC, BI and Crop Trust; Nepal

Rebuilding Local Seed System of Native Crops in Earthquake Affected Areas: Synthesis, Lessons Learned and Way Forward

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Synthesis of the Outputs

Rescue collection, conservation and repatriation of native and endangered seeds are important after disasters in order to restore lost diversity, revive local seed system and safeguard local crop biodiversity for future generation. A total of 13 papers were prepared by researchers from NAGRC, LI-BIRD and Bioversity International from the work that was carried out from July 2015 - Dec 2017 in Nepal for rebuilding local seed system of native crops. This paper summarizes the outputs of rescue collection, conservation, multiplication and repatriation of native crop seeds from 10 earthquake affected districts. The study employed several methods and approaches covering combination of participatory tools, methods and techniques in rescue collection, assessments, multiplication, conservation and repatriation of seeds to affected communities and locations.

During the rescue mission, the priority crop cultivars collected were those that are native, high economic value and threatened by earthquake and other natural disasters (eg subsequent landslides after earthquake). The project targeted its collection routes and locations in new areas, where earlier collection missions had not been undertaken. The rescue collections were carried out employing existing networks of NARC, District Agriculture Development Offices, LI-BIRD and other local NGOs, CBOs and lead farmers in the earthquake affected districts. The collected genetic resources along with passport data are processed, assessed and maintained in national genebank and local community seed system or banks to safeguard native crop diversity for further use. The collected seeds are also multiplied, characterized and maintained as a source for immediate use and in research. The key outputs of the work are synthesised below.

1. **Collections and Conservation:** A total of 921 accessions of 61 crops were collected from 35 VDCs of 10 severally earthquake affected districts. The germplasm rescue project implemented by NAGRC with the funding support of GCDT collected 513 crop landraces of 57 crops while Seed Rescue Project implemented by LI-BIRD with the funding of GRPI-2 project of Bioversity International collected 410 accessions of 46 crops. These collected samples are processed (cleaning, germination testing, drying)

and those that meet genebank standards are in the process for safe storage in Genebank.

2. **Identification of rare and endangered landraces**: The process of rescue collection of crop landraces are assessed for their status as endangered, extinct, rare and abundance in 10 earthquake affected districts. The assessment revealed that a total of 104 crop landraces are lost, 26 are rare and unique and 258 seed types of different crops are at endangered state due to earthquake and various other factors, which needs immediate conservation measures (**Figure** 1). Furthermore, assessment showed a declining community and farm level richness and evenness of crop biodiversity of rice and finger millet in most of the surveyed households. The major perceived causes of genetic erosion occurring in the surveyed areas and germplasm at risk are the *ad hoc* distribution of large amounts of improved, untested seeds as relief material from external agencies, the sudden migration of farmers after the disaster and attraction of rural farm households towards other alternative income generating options after disaster.

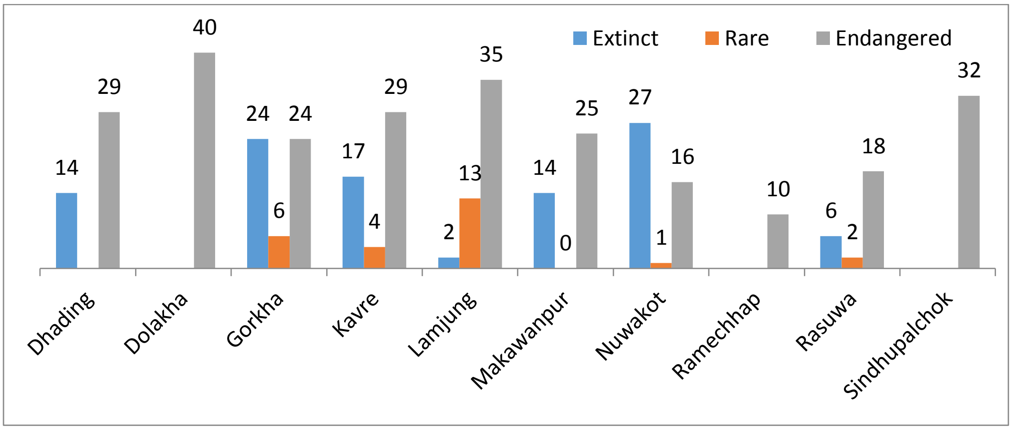

Figure 1. Assessment of crop diversity from earthquake affected areas.

3. **Characterization, evaluation and documentation**: Collected samples are processed, characterized and regenerated for their evaluation, multiplication and documentation of unique and rare traits. About 173 samples (accessions) of 11 crops are characterized in the genebank fields for their agronomic traits. Name list of 104 lost landraces were documented from 7 affected districts. 5-10% of total local crop diversity (based on the landraces) were lost due to earthquake and if rescue missions were not launched immediately after disaster, about 20% of the endangered crop landraces would have been lost in these 7 districts. Passport data and seed image bank of these collections are maintained in the National Genebank for future use. Collection acceptance committee (CAC) has been established in the genebank to check the quality of new collections. The collected samples which did not meet adequate Genebank standards (eg adequate quantity) are being used for seed increase and further processing.

4 **Diversity deployment in affected areas**: A total of 200 Diversity Kits (containing 3 to 5 varieties) of promising locally adapted materials from Genebank and those from other research stations and local sources have been developed and distributed to 200 farmers in the affected areas from whom seeds have been rescued and collected. The objectives were to provide immediate access to locally available seed, re-introduce /repatriate some promising local crop seeds to sample farm households, and back up community seed bank collections for reviving local seed systems in earthquake affected areas

5. **Repatriation of landraces**: The potential sites of repatriation were mapped for the deployment of identified, farmer demanded and rescued landraces to ensure safe on-farm conservation, minimize the risk of extinction and strengthen food security. Five landraces of four crops (rice, lentil, naked barley, beans) collected and rescued from earthquake affected areas were repatriated to communities and locations in affected areas through diversity kits distribution and organizing participatory seed exchange (PSE) with local communities.

6 **Linking Genebank with CSB and communities:** The process of rescue collection, conservation and repatriation after disaster has helped linking national genebank with community seed banks and farming communities in risk prone mountains areas. Involvement of Genebank researchers with local staff at the District Agriculture Development Offices (DADOs) and key informant farmers in earthquake affected districts provided opportunity to share and exchange knowledge on rescue collection and conservation and promoting linkages.

7. **Piloting of tools and methods**: The study has played important role in developing and testing/ validating available methods for rescue collection, conservation, evaluation and repatriation. The study has helped in mapping of the existing genebank collection to identify gaps in collections in earthquake affected districts to initiate the rescue collection in those locations where previous collections are missing and endangered crop seeds need to be rescued. The study has developed methods for identification of climate analogue sites, climate smart germplasm and validation of climate analogue tools (CAT) for the suitability of rescue collected germplasm for repatriation in similar affected areas. It has helped in red listing of crop genetic resources similar to forest and broader plant and animal biodiversity and helped in identifying gaps in collections in genebank and methods for repatriation. The process has helped in piloting 4-cell analysis for red listing of crop genetic resources and participatory seed exchange (PSE) for rescue collection and revival of local seed system.

8. **Awareness creation and information sharing:** Sensitization of local stakeholders and communities was key component of the process of rescue collection. This was carried out both for seeking local support in rescue collection and creating awareness for conservation of rare and endangered traditional crop seeds and safeguarding genetic diversity for food security. It created awareness to 425 farmers and 35 extension and development workers particularly on utilization and conservation of local crop diversity in 10 affected districts. Two major district level interaction workshops were carried out in 2015 and 2016 in Dolakha (Charikot) and Rasuwa (Dhunche) respectively

for creating awareness on rescue collection and conservation of native crop landraces after disaster.

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9. **Capacity building:** Two community seed banks (one in eastern Lamjung managed by COPPADES, a local NGO and second in Jugu, Dolakha managed by Local Crop Project of GEF UNEP) were strengthened through technical and financial supports. Rescue Project of the GRPI-2 of the Bioversity International implemented by LI-BIRD provided US$ 8,000 to lay foundation for community seed bank in Jungu, Dolakha. Project also provided orientation training to 75 farmers and members of Community Seed Banks in Rainash and Gaunda Rural Municipality in eastern Lamjung on June 2016 and September 2017 in seed production, collection and conservation. In addition it provided orientation and training to 22 field staff of project implementing institutions (NARC, LI-BIRD) and the local field staff of COPPADES. One graduate intern (female) was employed and trained during the project period for implementing project activities. One master student was trained and supported for thesis research which was based on the information collected on agrobiodiversity from earthquake affected districts. The project also provided equipment supports such as Digital balance for laboratory seed measurements and GPS and 15 i-buttons for NARC Genebank, Agricultural Research Station (ARS), Jumla; Hill Crops Research Program (HCRP), Kavre, Dolakha and GEF UNEP Project sites (Dolakha, Lamjung, Jumla and Humla) to generate climate data from seed regeneration plots as well as to support for on-farm evaluation of farmer preferred rescue collected seeds.

10. **Linkages and synergies with on-going initiatives**: The current work has also been linked with on-going programmes and projects of the National Genebank for collection, conservation and use of native crop landraces in crop breeding and research programme. The work has been also linked with the GEF UNEP project activities in project sites of Dolakha and Lamjung for on-farm testing and conservation of some locally adapted seeds including seed collection and conservation work of community seed bank in eastern Lamjung supported by NGO COPPADES.

Communications and Wider Sharing of Progress of the Project Outputs

Communication and Wider Sharing in National and International Workshop

Progress of the early collection missions and their findings were prepared, analyzed and presented in International Mountain Conference in Changing World (MoChoW) held in Kathmandu from 2-3 Oct 2016 (3 presentations) and International Agrobiodiversity Congress held in 6-9 Nov 2016 in New Delhi, India (one presentation). In addition, findings of the works were presented in district level interaction meeting in Rasuwa (4 papers) among stakeholders, farming communities and news media on 7 Dec 2016 and output of seed rescue collections led by LI-BIRD was shared in district level seed handover meeting in Charikot, Dolakha on 15 Feb 2016. A paper developed from on-going project activities have been already published in Indian Journal of Plant Genetic Resources (IPGRs) from India in 2016 (Gauchan et al 2016) included in this proceedings. In addition, the outputs of project work are being documented in 13 different papers and included in this proceedings (Joshi and Gauchan 2017) for wider sharing with national level stakeholders.

List of Publication of Outputs in News Media

1. Safeguarding native seeds and rebuilding local seed systems in the aftermath of Nepal earthquake, http://www.bioversityinternational.org/news/detail/safeguarding-native-seeds-and-rebuilding-local-seed-systems-in-the-aftermath-of-the-nepal-earthquakes/
2. Matching seeds to needs in the aftermath of the Nepal earthquake- Bioversity International Website, http://www.bioversityinternational.org/news/detail/matching-seeds-to-needs-in-the-aftermath-of-the-nepal-earthquakes/
3. Deploying crowdsourcing and seed diversity in disaster recovery efforts in Nepal, http://www.bioversityinternational.org/news/detail/deploying-crowdsourcing-and-seed-diversity-in-disaster-recovery-efforts-in-nepal/
4. Crowdsourcing Nepal's Seeds: SciDev.Net, September 2015, http://www.scidev.net/south-asia/food-security/news/crowdsourcing-seed-data-in-nepal.html
5. Why getting Nepal the rights seeds after the earthquakes matters: National Geographic, September 2015, http://theplate.nationalgeographic.com/2015/09/16/why-getting-nepal-the-right-seeds-after-the-earthquakes-matters/
6. Safeguarding Seeds in the Aftermath of the Earthquake in Nepal, http://www.libird.org/app/news/view.aspx?record_id=35
7. Farmers get to work to establish vital community seed banks in Nepal, http://www.bioversityinternational.org/news/detail/farmers-get-to-work-to-establish-vital-community-seedbanks-in-nepal/
8. Program for conservation of endangered seeds through rescue collection and conservation in earthquake affected areas of Nepal, FM Radio-Ujyaalo Network, http://.ujyaaloonline.org/download. Eghara Chhapanna no.8, 2016-12-08 Dec 8, 2016 | 34:32 | 47.45 MB, Rasuwa, Nepal.

Lessons learned

- The most important is developing synergy and linkage with existing projects as well as developing local partnership, collaboration and networking with district agricultural extension offices, research stations, NGOs, CBOs, and local government offices for implementing the project activities efficiently and timely. Since Bioversity International, the National Genebank, NARC and LI-BIRD had on-going GEF project offices, and staff, they could leverage on-going good partnership with the local NGOs such as COPPADES, community groups and NARC research programs in the target locations. In addition, it was possible to carry out project activities in remote areas and create awareness because of linkage and goodwill of National Genebank and LI-BIRD with Districts Agricultural Development Offices in earthquake affected districts.

- Another lesson is that rescue collection of seeds during and after disasters was difficult due to continuous aftershocks of earthquake until nearly one year. To organize the rescue collection of endangered landraces by visiting household in remote mountainous locations after a disaster turned out to be a challenging task due to remoteness, the heavy damages caused, the state of shock of people affected, and the hesitance to share with other the few possessions left in the hands of affected farmers. This required strong rapport building and local support of the farming communities and local stakeholders.

- Rescue collection after or during disasters provided only limited sample of seeds which didn't meet genebank standards in terms of quantity and quality for safe storage. Smallholder farmers have had very limited quantity of seeds stored in their household stores as most of them were damaged. Hence, it required regeneration and seed increase of collected seeds for processing and safe storage. Moreover, seasonality was important for crop seed multiplications since many native local crop landraces require specific seasons and climatic environments to regenerate and multiply. Hence, the process of safe conservation, multiplication and repatriation for rebuilding local seed system requires longer period of time (minimum three years).

- The important lessons learned from implementing this project is that the work has helped in creating awareness, build skills on rescue collection and conservation tools and techniques thereby strengthening national capacity in rescue collection, conservation and repatriation during disasters. It has currently helped capacity of researchers in national genebank, partner research organizations in NARC and NGOs (LI-BIRD, COPPADES). The work has assisted in supporting MS thesis of a Nepali graduate student and build skills of two young graduate interns on rescue collection and repatriation methods using advanced tool such as GIS and Climate Analogue Tool (CAT). The work is also unique and appreciated by the academic professionals and the stakeholders.

- In addition, participatory information and seed collection by mobilizing local field staff of the DADO, NGOs and using local knowledgeable farmers in the rescue mission is important to achieve collection missions effectively and efficiently. Use of local DADO and NGO staff and knowledgeable farmers helped easy identification of rescue collection locations and households, organized local community meetings and assisted reliable information collection. Collaboration with local stakeholders and DADOs also provided visibility and applicability of work to rescue endangered seeds and develop plan for repatriation to target group of farmers.

- Participatory research and information collection and use with active engagement of local community based organizations (CBOs) such as farmers' cooperatives, farmers' groups and community based seed producer groups were effective in accomplishing participatory seed exchange in the communities and rescue collection and exchange rare and native seeds available locally for rebuilding local seed system of native crops. The process also helped in identifying farmers' preferred crop varieties and make plan for repatriation. The participatory approach also helped to identify and visit right locations and communities and accomplish timely seed sample and information collections as well as assisting in repatriation of collected seeds.

Way Forward

The process of rescue collection, conservation and repatriation has helped to assess status of diversity of traditional crops, identify endangered, extinct and rare crop landraces, document and characterize their unique agronomic traits and develop and validate methodology for conservation of native crops by linking on-farm and ex-situ approaches. The work has enhanced farmers' awareness and access of APGRs from other similar areas of the country. It has also helped to restore lost diversity, revive and strengthen the local seed system and safeguard biodiversity of native crops to adapt to more extreme and changing climatic conditions. The work has helped building national capacity and resilience to cope with future disasters and laying a foundation for community seed banks. This study has collected, characterized and identified some landraces with unique functional traits and values which needs to be conserved, used and promoted for the benefit of communities and societies as a whole. These unique and valuable genetic resources with their value added products should be promoted to domestic and international markets by branding with their geographic indicators (GI) for their conservation and sustainable use.

Future priority in relief and rebuilding agriculture should consider to rescue collection, conservation and repatriation in disaster prone areas, where potential genetic erosion is high and farmers' food security can be recovered sooner and sustainable way. Focus should be on access and availability of locally adapted varieties and quality seeds of the local crops, that perform well in farmers' existing management systems and changing climate conditions, since locally adapted seeds are the heart of agriculture and food security of vulnerable people in fragile affected areas. Promotion of traditional crops and their adapted seeds enhance not only sustainability of local agricultural system but also promote conservation and use of biodiversity of traditional crops. Regular monitoring, collection and repatriation program will be more effective to conserve the underutilized and other crop landraces diversity in marginal areas. Furthermore, works to be initiated for further strengthening linkage of National Genebank with local developmental agencies, community based organizations and farmers in earthquake affected areas for timely and regular access of well adapted climate resilient germplasm. Focus of future approaches should adopt participatory action research and development with active engagement of local community based organizations, district line agencies and relevant national stakeholders. Finally, there is a need to rebuild human resource, institutional capacity and governance in agrobiodiversity conservation and building local seed system linked to disaster risk reduction through massive training and capacity building of youth in agriculture and agrobiodiversity conservation.

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Appendix I. List of crop species available in target districts

List of crop (agronomic and horticultural) species grown by the farmers in 10 districts, that were explored for rescue mission

SN	Name of the crop	नेपाली नाम	Scientific name
1.		घुन्कु	
2.		छिन्नी	
3.	Air potato	भ्याकुर	Dioscorea bulbifera L.
4.	Amaranth	लट्टे (नुहिने)	Amaranthus caudatus L.
5.	Amaranth	लट्टे (ठाडो, झुस नहुने)	Amaranthus cruentus L.
6.	Amaranth	लट्टे (ठाडो, झुस हुने)	Amaranthus hypochondriacus L.
7.	Amaranth	काँडे लुँडे	Amaranthus spinosus L.
8.	Apple	स्याउ	Malus domestica Borkh.
9.	Ash gourd, Wax gourd	कुभिन्डो	Benincasa hispida (Thunb.) Cogn.
10.	Asparagus	कुरिलो	Asparagus officinalis L.
11.	Avocado	एभोकाडो, घिउ फल	Persea americana Mill.
12.	Azuki bean	गुराँस	Vigna angularis (Willd.) Ohwi & H.Ohashi
13.	Baccatum	समोसा खुर्सानी	Capsicum baccatum L. = Capsicum microcarpum Cav.
14.	Balsam apple	बरेला	Momordica balsamina L.
15.	Banana	केरा	Musa x paradisiaca L.
16.	Barley	जौ	Hordeum vulgare L.
17.	Barn yard millet	सामा	Echinochloa frumentacea Link
18.	Bean	घिउ सिमी, मकै सिमी, दाल खाने सिमी	Phaseolus vulgaris L.
19.	Bird's eye chili	जिरे खुर्सानी	Capsicum frutescens L. var. longum Bailely
20.	Bitter brinjal	तिते भन्टा, विंही	Solanum aethiopicum L.
21.	Bitter gourd	करेला	Momordica charantia L.
22.	Black gram	मास	Vigna mungo L. Hepper
23.	Black mustard	कालो तोरी	Brassica nigra (L.) K.Koch
24.	Black pepper	मरिच	Piper nigrum L.
25.	Bottle gourd	लौका	Lagenaria siceraria (Molina) Standl.
26.	Brinjal, Egg plant	भन्टा	Solanum melongena L.
27.	Broad bean	बकुल्ला	Vicia faba L.
28.	Broccoli	ब्रोकाउली	Brassica cretica Lam. = Brassica oleracea var. italica Plenck
29.	Brown mustard	सर्स्युँ	Brassica juncea (L.) Czern.
30.	Buckwheat, Common-	मिठे फापर	Fagopyrum esculentum Moench
31.	Buckwheat, Tartary-	तिते फापर	Fagopyrum tataricum (L.) Gaertn.
32.	Cabbage	बन्दा	
33.	Capsicum, Sweet pepper, bell pepper	भेडे खुर्सानी	Capsicum annuum L. var. grossum (Wild.) Sendt.

SN	Name of the crop	नेपाली नाम	Scientific name
34.	Carrot	गाँजर	Daucus carota L.
35.	Caster	अडिर	Ricinus communis L.
36.	Catnip, Catmint	ङेता, सिनेक	Nepeta cataria L.
37.	Cauliflower	काउली, फुल्गोबी	Brassica oleracea var. botrytis L.
38.	Chayote	स्कुस	Sechium edule (Jacq.) Sw.
39.	Chenopodium	बेथे	Chenopodium album L.
40.	Chickpea	चना	Cicer arietinum L.
41.	Chili pepper	खुर्सानी	Capsicum annuum L.= Capsicum frutescens L.
42.	Celery	सेंलेरी	Apium graveolens L.
43.	Coriander	धनिया	Coriandrum sativum L.
44.	Cotton	कपास	Gossypium arboreum L.
45.	Cowpea	बोडी	Vigna unguiculata (L.) Walp.
46.	Cress	चम्सुर	Lepidium sativum L.
47.	Cucumber	काँक्रो	Cucumis sativus L.
48.	Cumin	जीरा	Cuminum cyminum L.
49.	Custard apple	सरिफा, सिताफल	Annona squamosa L.
50.	Dill	सोया, सुँप	Anethum graveolens L.
51.	Dragon fruit, Pitaya	सिउंडी फल	Hylocereus undatus (Haw.) Britton & Rose
52.	Faba bean	बकुल्ला सिमि	Vicia faba L.
53.	Fennel	सौंप	Foeniculum vulgare Mill.
54.	Fenugreek	मेथी	Trigonella foenum-graecum L.
55.	Field pea, Small pea	सानो केराउ	Pisum sativum subsp. arvense (L.) Asch. & Graebn.
56.	Finger millet	कोदो	Eleusine coracana (L.) Gaertn.
57.	Foxtail millet	कागुनो	Setaria italica L.
58.	Gac, Cochinchin gourd	चट्टेल	Momordica cochinchinensis (Lour.) Spreng.
59.	Garlic	लसुन	Allium sativum L.
60.	Ginger	अदुवा	Zingiber officinale Roscoe
61.	Grapes	अंगुर	Vitis vinifera L.
62.	Grass pea	खेसरी	Lathyrus sativus L.
63.	Ground apple, Yacon	भुँइ स्याउ	Smallanthus sonchifolius (Poepp.) H. Rob.
64.	Groundnut, Peanut	बदाम	Arachis hypogaea L.
65.	Guava	अम्बा, बेलाउँती	Psidium guajava L.
66.	Hemp	भांगो	Cannabis sativa L.
67.	Horse gram	गहत	Macrotyloma uniflorum (Lam.) Verdc.
68.	Hycianth bean	हिउँदे सिमी, टाटे सिमी	Dolichos lablab L.
69.	Indian gooseberry	अमला	Phyllanthus emblica L.
70.	Jackfruit	कटहर	Artocarpus heterophyllus Lam.
71.	Java plum, Jambolan	जामुन	Syzygium cumini (L.) Skeels
72.	Jimbu	जिम्बु	Allium hypsistum Stearn
73.	Jute	पाट	Corchorus olitorius L.
74.	Kidney bean	राज्मा	Phaseolus vulgaris L.

SN	Name of the crop	नेपाली नाम	Scientific name
75.	Kiwi	किवी, ठेकी फल	Actinidia deliciosa (A.Chev.) C.F.Liang & A.R.Ferguson
76.	Knol khol	ग्यठगोबी	Brassica oleracea var gongylodes L
77.	Kumquat	मुन्तला	Citrus japonica Thunb.
78.	Large cardamom	अलैंची	Amomum subulatum Roxb.
79.	Leaf mustard	रायो	Brassica juncea (L.) Czern. = Brassica juncea L. var. rugosa
80.	Leek	छयापी	Allium ampeloprasum L.
81.	Lemon	ठुलो कागती	Citrus limon (L.) Osbeck
82.	Lentil	मुसुरो	Lens culinaris Medik.
83.	Lettuce	जिरीको साग	Lactuca sativa L.
84.	Lima bean	गहते सिमी, बोडा	Phaseolus lunatus L.
85.	Lime	कागती	Citrus aurantiifolia (Christm.) Swingle
86.	Linseed, Flax	आलस	Linum usitatissimum L.
87.	Little millet	कुट्की सामा	Panicum miliare Lam.
88.	Lovage	ज्वानो	Levisticum officinale W.D.J.Koch
89.	Lychee	लिची	Litchi chinensis Sonn.
90.	Maize	मकै	Zea mays L.
91.	Mandarin orange	सुन्तला	Citrus reticulata Blanco
92.	Mango	आँप	Mangifera indica L.
93.	Mint	पुदिना	Mentha spicata L.
94.	Mung bean	मुंग	Vigna radiata (L.) R.Wilczek
95.	Naked barley	उवा	Hordeum vulgare var. nudum (L.) Hook.f.
96.	Nepalese hog plum	लप्सी	Choerospondias axillaris (Roxb.) B.L.Burtt & A.W.Hill
97.	Niger	झसे तिल/फिलिंगे	Guizotia abyssinica (L.f.) Cass.
98.	Okra	भिंडी/रामतोरिया	Abelmoschus esculentus (L.) Moench
99.	Olive	जैतुन	Actinidia deliciosa (A.Chev.) C.F.Liang & A.R.Ferguson
100.	Onion	प्याज	Allium cepa L.
101.	Papaya	मेवा	Carica papaya L.
102.	Pea, Garden pea	केराउ	Pisum sativum L. = Pisum sativum subsp. arvense (L.) Asch. & Graebn
103.	Peach	आरु	Prunus persica (L.) Batsch
104.	Pear	नासपाती	Pyrus communis L.
105.	Pearl millet	बाजरा, घोगे	Pennisetum glaucum (L.) R.Br.
106.	Pepino melon	पेपिनो	Solanum muricatum Aiton
107.	Perilla	सिलाम	Perilla frutescens (L.) Britton
108.	Persimon	हलुवावेद	Diospyros kaki L.f.
109.	Pigeon pea	रहर	Cajanus cajan Millsp.
110.	Pineapple	भुइँ कटहर	Ananas comosus (L.) Merr.
111.	Plum	आरुवखडा	Prunus domestica L.
112.	Pointed gourd	परवल	Trichosanthes dioica Roxb.
113.	Pomegranate	अनार, दाडिम	Punica granatum L.

SN	Name of the crop	नेपाली नाम	Scientific name
114.	Pomelo	भोगटे	Citrus maxima (Burm.) Merr.
115.	Potato	आलु	Solanum tuberosum L.
116.	Pricky coriander, Culantro	काँडे धनिया	Eryngium foetidum L.
117.	Pumpkin	फर्सी	Cucurbita pepo L.
118.	Radish	मुला	Raphanus raphanistrum subsp. sativus (L.) Domin = Raphanus sativus L.
119.	Rapeseed	तोरी	Brassica campestris var. toria Dutch.
120.	Rice	धान	Oryza sativa L.
121.	Rice bean	मस्यांग/सिल्टुम	Vigna umbellata (Thunb.) Ohwi & H.Ohashi
122.	Ridge gourd	तिरै, पाटे घिरौंला	Luffa acutangula (L.) Roxb.
123.	Roselle	अमिली भिंडी	Hibiscus sabdariffa L.
124.	Rough lemon	ज्यामिर	Citrus jambhiri Lush
125.	Sesame	तिल	Sesamum indicum L.
126.	Shallot	छ्यापी	Allium ascalonicum L.
127.	Snake gourd	चिचिन्डो	Trichosanthes cucumerina L.
128.	Sorghum	जुनेलो	Sorghum bicolor (L.) Moench
129.	Soybean	भटमास	Glycine max (L.) Merr.
130.	Sponge gourd	घिरौंला	Luffa cylindrica (L.) M.Roem.
131.	Straw berry	भुइँ काफल	Fragaria × ananassa (Duchesne ex Weston) Duchesne ex Rozier
132.	Sugarcane	उखु	Saccharum officinarum L.
133.	Sunflower	सूर्यमुखी	Helianthus annuus L.
134.	Sweet orange	मौसम, जुनार	Citrus sinensis (L.) Osbeck
135.	Sweet potato	सखरखण्ड	Ipomoea batatas (L.) Lam.
136.	Swiss chard	चाइनिज साग	Beta vulgaris L.
137.	Sword bean	तरबारे सिमी	Canavalia gladiata (Jacq.) DC.
138.	Szechuan button	मरेटी	Acmella oleracea (L.) R.K.Jansen
139.	Taro	पिंडालु	Colocasia esculenta (L.) Schott
140.	Timur, Sichuan pepper	टिमुर	Zanthoxylum armatum DC.
141.	Tomato	गोलभेंडा, टमाटर	Solanum lycopersicum L.
142.	Tree tomato, Tamarillo	रुख टमाटर	Solanum betaceum Cav.
143.	Turmeric	हलेदो, बेसार	Curcuma longa L.
144.	Turnip	सलगम	Brassica rapa L.
145.	Velvet bean	काउसे सिमी	Mucuna pruriens (L.) DC.
146.	Walnut	ओखर	Juglans regia L.
147.	Wheat	गहुँ	Triticum aestivum L.
148.	Wood apple	बेल	Aegle marmelos (L.) Correa
149.	Yam	तरुल	Dioscorea alata L.
150.	Zuchini	स्क्वास, जुकिनी	Cucurbita maxima Duchesne

First two crops are unidentified

Germplasm Rescue in the Picture


Makawanpur


Makawanpur

Lamjung


Lamjung

Lamjung

Lamjung

Rasuwa

Khumaltar

Gorkha

Gorkha

Dhading

Dhading

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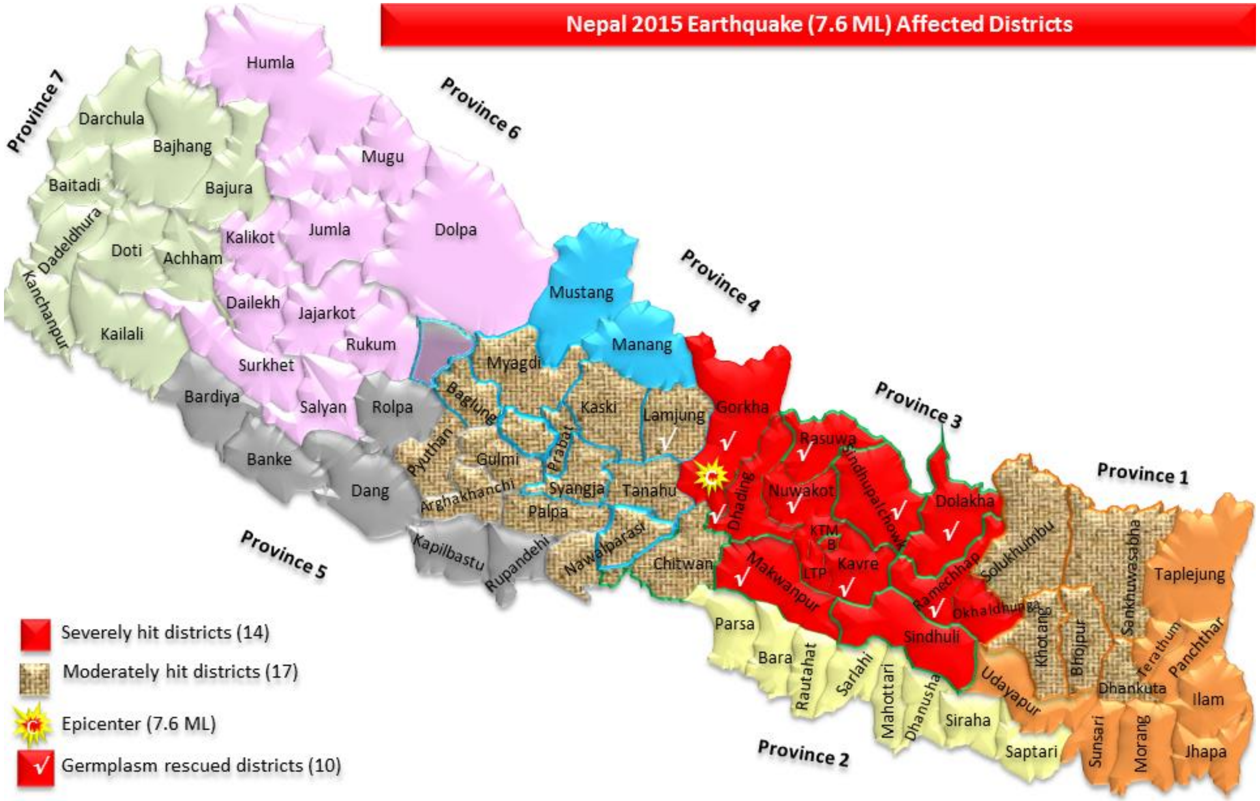
Nepal 2015 Earthquake (7.6 ML) Affected Districts



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