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AFACI Pan-Asia Project (IMPGR):

Exploration, Regeneration and Conservation of Endangered Cereals and Grain Legumes from Central Mid and High Hills of Nepal

Project Completion Report and Outcomes

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Project Completion Report and Outcomes

Project period: 2012-2014

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AFACI established in 2009, is inter-governmental cooperation with members from 11 countries. Their mission is to promote the sustainable agricultural green growth in the Asian region and to contribute to consistent economic development in the Asian countries through the technological cooperation in agriculture and food sectors.

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Cover Page Photo: Buckwheat flower and pod of local bean

FOREWORD

Food security relies on an effective conservation and utilization of plant genetic resources for food and agriculture (PGRFA). Crop improvement is only possible when sufficient genetic variability in terms of intra and inter species diversity exists. For this exploration, regeneration, characterization, evaluation, conservation and utilization of plant genetic resources is of paramount.

Realizing the significance of conservation and sustainable use of agrobiodiversity in national development, the Government of Nepal and Nepal Agricultural Research Council established National Agriculture Genetic Resources Center (Genebank) in 2010. To complement the Government efforts, Asian Food and Agriculture Cooperation Initiative (AFACI) supported the conservation activities through the country project "Promoting Conservation and Sustainable Use of Genetic Resources of Food and Agriculture for Enhancing Food Security in Nepal" for three year period effective from June 2010 to May 2013.

This is an outcome of the AFACI supported country project and has been successful in delivering the outputs as outlined in the project proposal within given time frame. I hope this report will be helpful to AFACI for expanding new avenues with Nepal for further cooperation in the area of plant genetic resources management for mutual benefit between South Korea and Nepal.

I would like to acknowledge AFACI, RDA and highly appreciate for technical and financial supports, from which, many genebank related activities have been initiated and made substantial progress. Sincere thank goes to BK Joshi, KH Ghimire and SK Shrestha for their hard work in bringing this report in this shape.

Madhan Raj Bhatta
Chief, NAGRC

ABBREVIATION

AFACI : Asian Food and Agriculture Cooperation Initiative
ACR : Active Collection Room
APGR : Agricultural Plant Genetic Resources
BCR : Base Collection Room
DNA : Deoxyribo-Nucleic Acid
GIS : Geography Information System
GoN : Government of Nepal
IMPGR : Integrated Management System of Plant Genetic Resources
MAS : Marker Assisted Selection
NAGRC : National Agriculture Genetic Resources Center
NARC : Nepal Agricultural Research Council
NGO : Non-Governmental Organization
RDA : Rural Development Administration
SD : Standard Deviation

CONTENT

Exploration, Regeneration and Conservation of Endangered Cereals and Grain Legumes from Central Mid and High Hills of Nepal

INTRODUCTION

Nepal is rich in agricultural biodiversity (BPP 1995, HMG/MFSC 2002, Upadhaya and Joshi 2003) (Figure 1) and about 599 food plant species have been estimated. Continued availability of agricultural plant genetic resources (APGR) is necessary for food and nutrition security. However, losses of these genetic diversities have been reported widely for a number of crops. Regular exploration and collection missions should therefore be organized to capture the existing genetic diversity including rare and endangered. After conservation in the Genebank, it is important to regenerate at certain interval and to characterize for accelerating utilization of APGR. The Government of Nepal (GoN) and Nepal Agricultural Research Council (NARC) have prioritized the conservation and sustainable use of agro-biodiversity. Realizing the significance of long term conservation of agriculture plant genetic resources (APGR) in food security, NARC has established Genebank called National Agriculture Genetic Resources Centre (NAGRC) in September, 2010 with the mission of conservation and sustainable use of agricultural genetic resources for sustained agricultural growth and livelihood. The Centre has considered the following strategies for management of agricultural genetic resources (Joshi et al 2012).

1. Ex-situ conservation
    - i. Seed Conservation (Seed Bank)
    - ii. In-vitro Tissue Conservation (Tissue Bank)
    - iii. Field Genebank
    - iv. DNA Bank
    - v. Cryobank

2. On-farm Conservation (Community Seed Bank, Landrace Enhancement, Community Field Genebank)
3. In-situ Conservation (collaboration with Protected Areas, World Heritage Sites, Ramsar Sites, Religious Places)

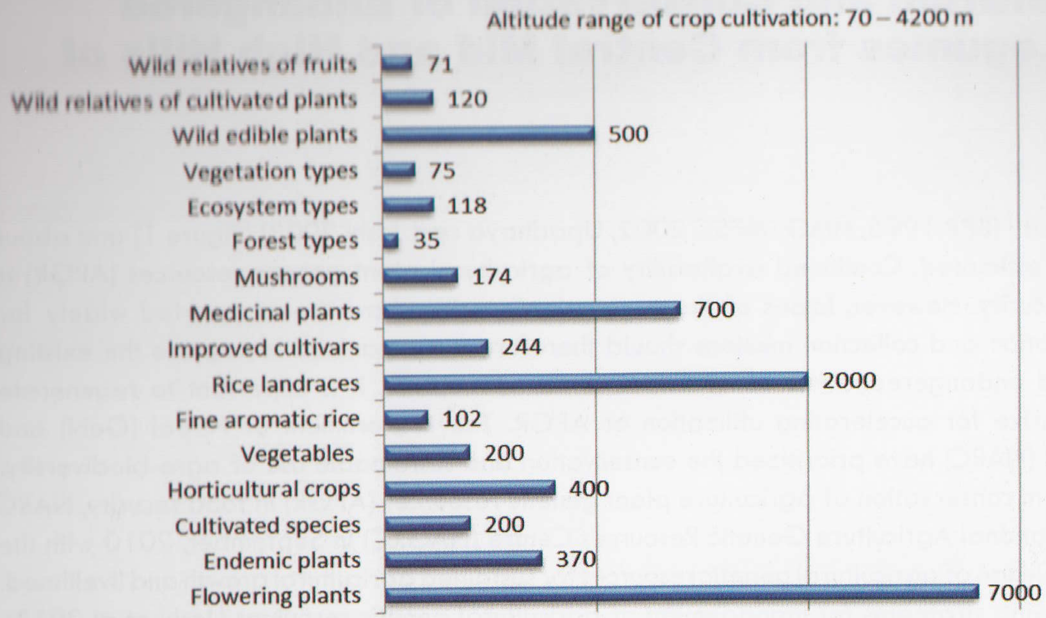


Figure 1. Plant Biodiversity in Nepal (Upadhyay and Joshi 2003, Joshi, 2004).

NATIONAL GENEBANK (NAGRC)

After the establishment of National Genebank, APGR have been systematically explored, collected, conserved, characterized and distributed. NAGRC is location in Khumaltar and it has five different unit namely Collection and distribution unit, Conservation unit, Characterization and evaluation unit, Biotechnology unit and Documentation, publication and training unit. A total of 2.4 ha is allocated for this Center and additional one ha is available for field experiment near the center. Out of 2.4 ha, Genebank building has occupied 0.092 ha, 0.26 ha is allocated for Field Genebank and 0.83 ha for regeneration, multiplication, characterization, evaluation and post quarantine activities. NAGRC is managing all kinds of APGR through five different banks eg seed bank, tissue bank, DNA bank, field genebank and community seed bank. With the financial support of GoN and RDA, Korea and other organizations, following facilities have been created in the Genebank (Joshi et al 2012).

- **Long Term Storage:** Cold store room (called Base Collection Room, BCR) with -20oC with storing capacity of about 100,000 accessions
- **Medium Term Storage:** Cold store room (called Active Collection Room, ACR) with 10oC and 35-45% RH with storing capacity of about 50,000 accessions.
- **Seed Processing and Testing Lab:** Facilities for seed cleaning, germination testing, drying and characterizing.
- **In-vitro Tissue Culture Lab:** Facility for tissue culture and Tissue Bank (50,000 samples).
- **Molecular Research Lab:** Facility for DNA works eg genotyping, genetic diversity assessment, identification (DNA fingerprinting, MAS), genes mapping and tagging.
- **Field Genebank:** Field Genebank around the Genebank building and at different agro-zones.
- **Experimental Plot:** Fields for regeneration, multiplication, characterization and evaluation.
- **Database Management:** Facilities for passport, management, characterization, evaluation, pre-breeding, genotyping and utilization data.

CLIMATIC VARIATION, AGRO-BIODIVERSITY AND PROJECT CONCEPT

Nepal has broadly 3 agro-eco-zones (Figure 2). The upper most range is called High Hill, the middle range is Mid Hill and lower range is Tarai. Tarai has a tropical climate, mid hill experiences sub-tropical to sub temperate and high hill has temperate to alpine climate. The altitude range of crop cultivation is from 70 to 4200 m. Agro-biodiversity in Nepal is also associated with diverse climatic variation and diverse culture. Due to this great variation in climate, Nepal is the 10th richest country for agricultural biodiversity in Asia. She has 7000 flowering plant species. Among them 370 species are endemic and more than 200 species are under cultivation.

However, large degree of genetic erosion is evident in major food crops that are the basis of food and nutrition security and livelihood of Nepalese people. It is estimated that 50% of traditional varieties have disappeared from farmers' field and existing landraces could be in an endangered condition. Therefore, this project (entitled Exploration, Regeneration and Conservation of Endangered Cereals, Grain Legumes from Central Mid and High Hills of Nepal) is designed to speed up the conservation activities of genetic resources considering the following conditions in the country (Bhatta 2012).

- Most of old collections (collections before 2010) need to regenerate. Ex-situ conservation was started from 1986 in Nepal. But due to poor facility and limited manpower, most of the old collections had not been regularly regenerated.
- Necessary to recollect from the old collection sites due to non-viability of most of the old collections
- Existence of landraces in most of the farming communities of Central Mid and High Hills of Nepal
- Poor utilization of genetic resources due to limited information on plant genetic resources (need to characterize)
- Availability of medium term storage facility

This project is part of regional project called integrated management system of plant genetic resources (IMPGR) under the AFACI Pan-Asia Project. IMPGR were implemented in 11 countries including Nepal. The project period was from 2012 to 2014 in Nepal. The achievements over the years were presented in different meetings and published partly to different proceedings (Joshi and Bhatta 2012, Joshi et al 2013, Bhatta et al 2014). This is about the project completion report and outcomes of the Nepal component.

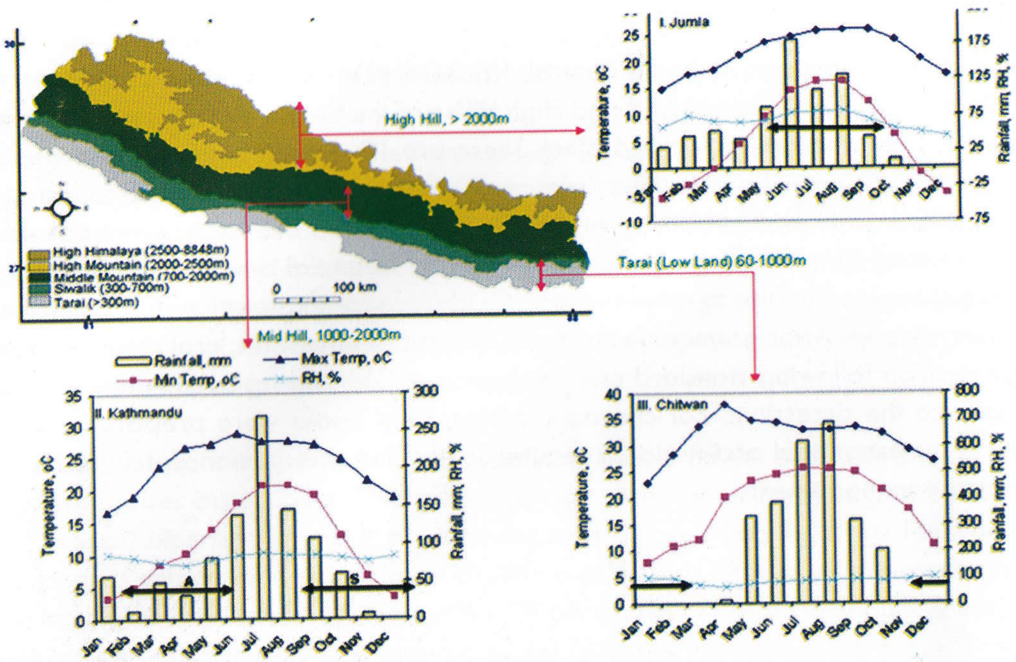


Figure 2.Three agro-ecozones in Nepal and their climate (Joshi 2008).

PROJECT OBJECTIVES

- Explore and collect endangered crop species
- Regenerate and characterize the accessions effectively
- Insure long term conservation of endangered (rare), unique and available plant genetic resources
- Strengthen national capacity of NAGRC for undertaking efficient and effective genebank management

PROJECT ACTIVITIES

- Collection of 800 accessions of cereals, grain legumes and okra along with passport data
- Regeneration and characterization of 2000 old accessions (collections before 2010)
- Conservation of these accessions in two-tier systems of seed storage (active and base collections)Training to and exchange of scientists

PROJECT AREA AND TARGET DISTRICTS

Nepal is politically divided into five development regions: Eastern, Central, Western, Mid-Western and Far-Western. Within each region, there is High Hill, Mid Hill and Tarai. Central Mid and High Hills are the target districts for collections of cereals, grain legumes and okra (Figure 3, shaded areas) in this project. There are 19 districts in the Central Nepal and this project aims to collect from about 12 districts. Before collections, gaps analysis was done based on the old collection maps (Joshi, 2004; Joshi et al, 2006; Joshi et al, 2008; Joshi, 2008), regenerated old collections maps and review and interview. GIS has also been utilized for gap analysis and for identifying potential sites to collect the crop species. This is applied not only to the target region but also to other regions. Guidelines for exploration and collections and genebank activities have also been developed. After germination test, old accessions of cereals, grain legumes and okra were planted in the field for regeneration following standard crop husbandry. Field plots used for regeneration and multiplication were used to characterize the accessions. For characterization, field books were prepared based on the descriptors developed by Bioversity International and national requirements. Characterization data are being processed for further analysis and database management.

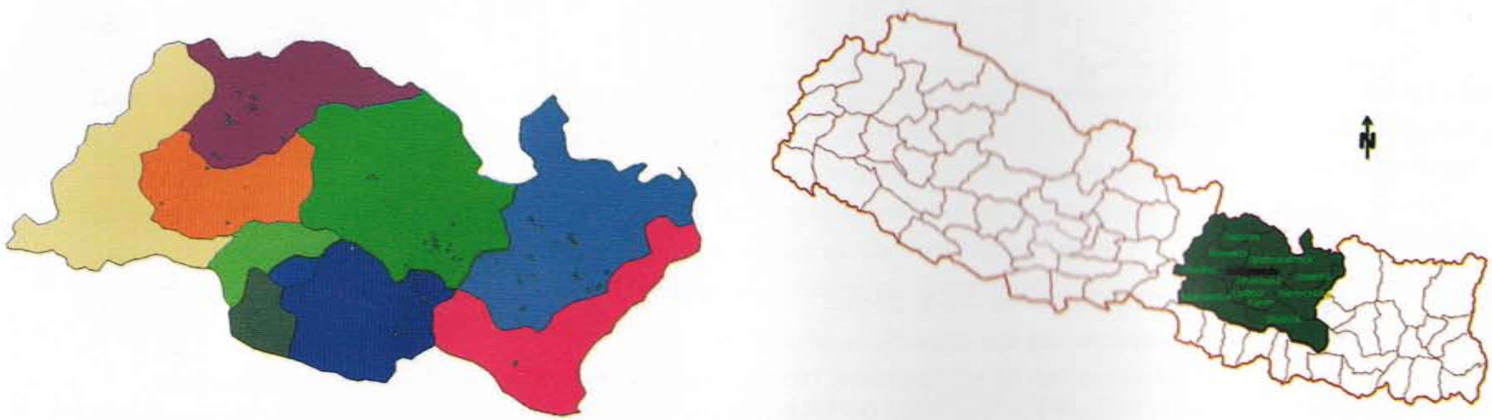


Figure 3. Target sites (shaded area) for exploration and collections of target crops

TARGET CROPS, RARE (ENDANGERED) AND UNIQUE LANDRACES

The project has its target on cereals, grain legumes and okra. The major cereals grown in mid and high hills of central development region are rice, maize, finger millet, wheat, barley, buckwheat and amaranths. Similarly, the major grain legumes grown in the project area are beans, cowpea, rice bean, soybean, black gram and horse gram. Thus, the project focused on exploration and collection, regeneration, characterization and conservation of endangered, unique and available local landraces of these crops.

The objective of this project is to collect rare and unique landraces. To identify the rare (also called endangered), category and methodology explained by Joshi et al (2004) is being used. It is not possible to collects all landraces at a time, therefore, it is necessary to prioritize them. Information on area coverage and number of farmers growing each landrace is collected through the focus group discussion. Based on these data, distribution pattern of each landrace is analyzed in term of area coverage and number of farmer growing and four groups have been formed. The landrace growing in small areas and by few farmers is grouped as rare or endangered landraces (Figure 4). We have also asked Community seed bank to evaluate the distribution pattern of landraces in terms of area coverage and number of farmers growing. Based on these categories, priority is given to rare (endangered) landraces for ex-situ conservation. Some examples of endangered landraces are Gol Kande Iskush (chayote), Pani Makai (maize), Gamadi Dhan (rice) and Kubinde Pharsi (pumpkin).

Similarly, unique landraces have been defined based on the trait distribution analysis. Each landrace is grouped into four categories based on the frequency of trait (common or rare) vs distribution of trait (local or wide) (See slide 9 of our presentation for detail). If a particular trait is found only in a few landraces of particular area, such landrace is defined as unique landrace (Figure 5). Some examples of unique landraces are Gujmuje Rayo (broad leaf mustard) having highly wrinkle and puckered leaf, Bhate Phaper (rice tartary buckwheat) possessing loose husk, Sali Dhan (rice) which is upland with bold and scented grain, Akabare Khursani (chili) possessing special high pungency.

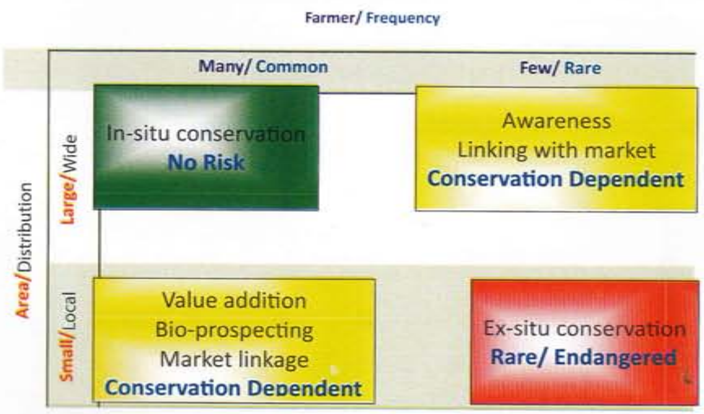


Figure 4. Approach of identifying rare landraces based on distribution pattern.

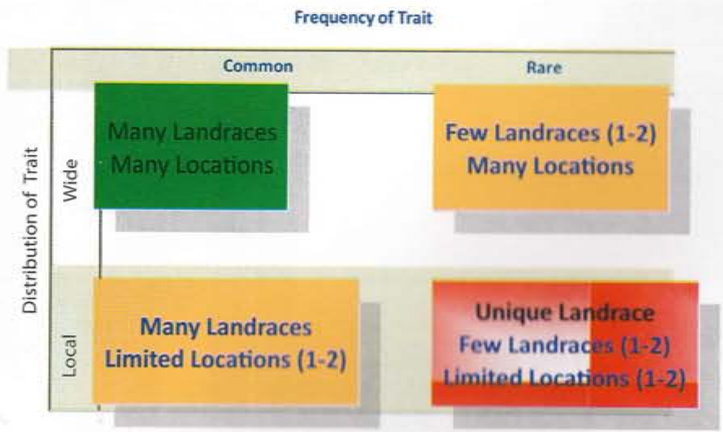


Figure 5. Process for identifying unique landrace based on the trait distribution analysis.

PROJECT OUTCOMES

1. Project achievement summary

There are major four activities targeted in the project. Year-wise achievement of each activity has been summarized in Table 1 and Figure 6.

Table 1. Status of project achievements from the beginning and target of the project

Activity	1st year	2nd year	3rd year	Total	Target
Collection	416	254	374	1044	800
Regeneration	825	1301	434	2560	2000
Characterization	577	1060	1521	3158	2000
Training/exposure	3	3	2	8	2

As targeted in the project, 416, 254 and 374 accessions of targeted crops (cereals, grain legumes and okra) were explored and collected during first, second and third year, respectively. A total of 2560 accessions (825 in first year, 1301 in second year and 434 in third year) were regenerated during the project. Similarly during project period of 3 years, a total of 3158 accessions (577, 1060 and 1521 accessions respectively, in 1st, 2nd and 3rd year) were characterized morphologically. Of the total target, the project achieved 130% of exploration and collection, 128% of regeneration, 158% of characterization and 400% of training and exposure to scientists in 3 years.

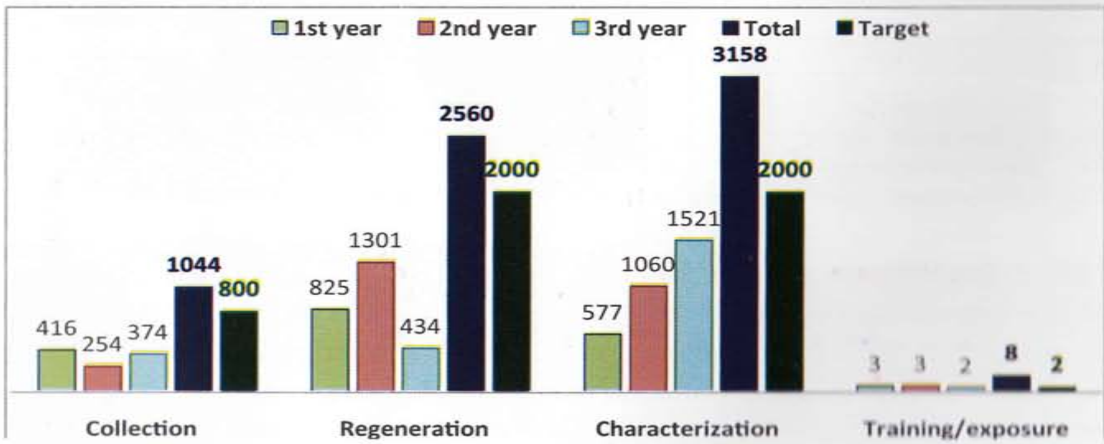


Figure 6. Relative achievements in project period as targeted in the project.

2. Exploration and Collections

Based on the Genebank guidelines (Figure 7), cereals and grain legumes were explored and collected from seven districts, ie Nuwakot, Rasuwa, Dolakha, Ramechhap, Kavre, Lalitpur and Sindhupalchok (Figure 8) in 3 years. Total collection of target crops during project period has been shown in Figure 9.

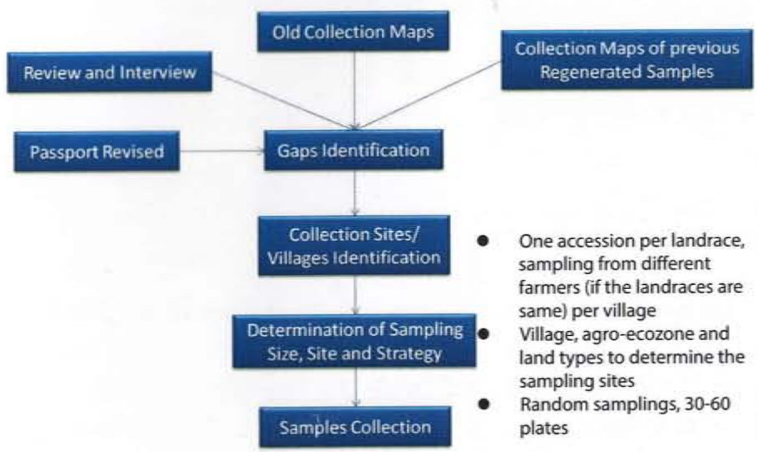


Figure 7. Steps followed during exploration and collections of cereals, grain legumes and okra.

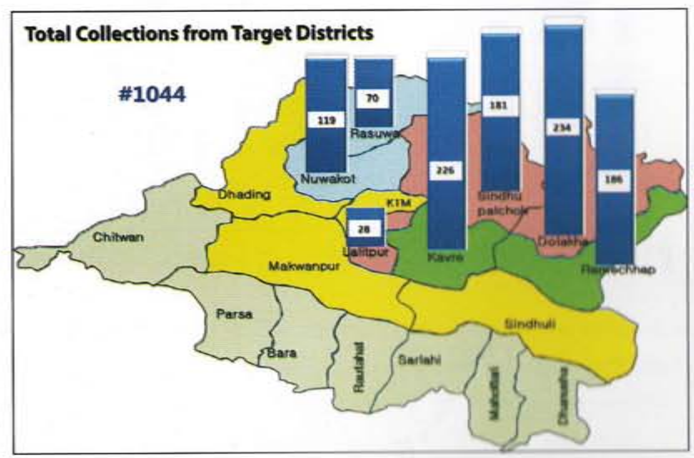


Figure 8. District-wise total collection of landraces during project period.

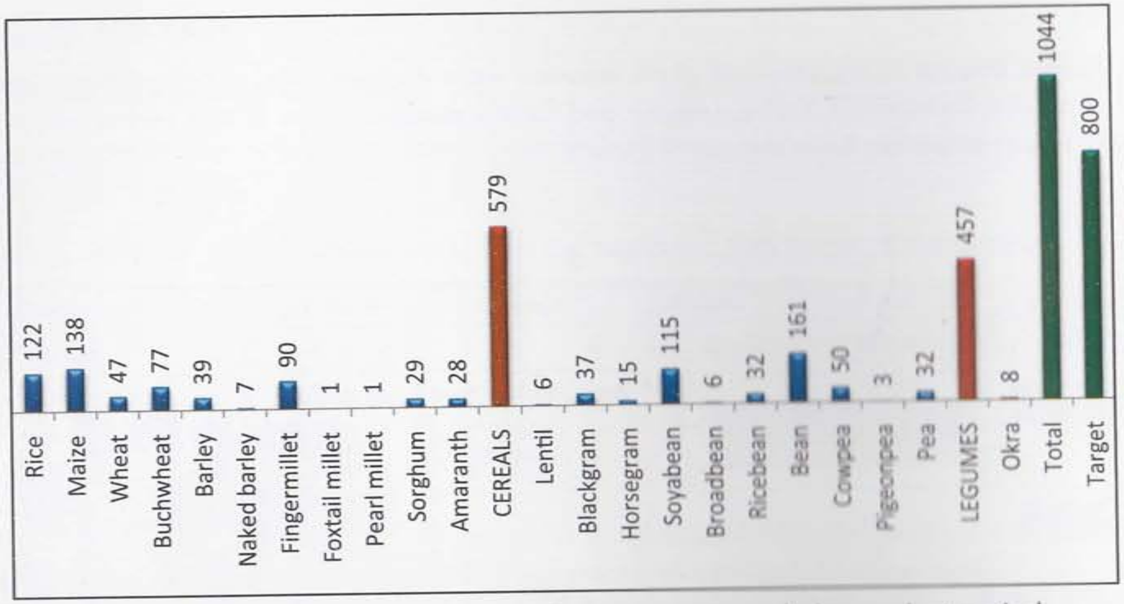


Figure 9. Crop-wise collection of landraces from target area during project period.

A total of 1044 accessions of 22 crop species (11 cereals, 10 legumes and okra) were collected from seven districts during the project period. The highest number of collections was from Dolakha (234) followed by Kavre (226), Ramechhap (186), Sindhupalchok (181) and from Nuwakot (119) (Figure 8 and Table 2). The highest number of collections ie161 of beans followed by 138 of maize, 122 of rice and 115 of soybean (Figure 10).Total collections of each crop species from each district are given in Table 2.

Table 2. Total collections of different target crops from seven districts of Central Mid and High Hills of Nepal

SN	Crop	Number of accessions collected							
		Dolakha	Kavre	Lalitpur	Nuwakot	Ramechhap	Rasuwa	Sindhupalchok	Total
1	Bean	30	40	9	17	25	18	22	161
2	Maize	27	22	7	20	23	9	30	138
3	Rice	32	23	0	10	12	12	33	122
4	Soybean	30	22	5	8	26	7	17	115
5	Finger Millet	24	15	1	11	11	4	24	90
6	Buck Wheat	18	20	0	3	25	2	9	77
7	Cow Pea	13	9	0	7	2	3	16	50
8	Wheat	15	13	0	4	10	4	1	47
9	Barley	10	10	0	11	3	2	3	39
10	Black Gram	8	6	0	8	2	1	12	37
11	Pea	10	12	0	0	6	1	3	32
12	Rice Bean	6	11	3	4	2	0	6	32
13	Sorghum	3	7	0	1	17	1	0	29
14	Amaranths	3	5	3	2	14	1	0	28
15	Horse Gram	2	4	0	3	3	0	3	15
16	Okra	1	1	0	6	0	0	0	8
17	Naked Barley	0	0	0	0	5	2	0	7
18	Broad Bean	1	2	0	2	0	0	1	6
19	Lentil	1	1	0	1	0	3	0	6
Total		**234**	**226**	**28**	**119**	**186**	**70**	**181**	**1044**

During collections, other non-target crop species have also been collected but not mentioned in this report. Most of the farming areas in Nepal have not been connected with road. Collectors have to walk sometimes whole day and somewhere more than a week too. Therefore, whatever the crops are available, are collected during field visit.

3. Regeneration and characterization

Steps for regeneration of old accessions are depicted in Figure 10. During 3 years, a total of 2560 old accessions of 13 different crops were regenerated. Among these, 1870 accessions were of cereals (rice, wheat, barley, naked barley, maize, finger millet and buckwheat), 630 accessions were of grain legumes (soybean, beans, lentil, chickpea and pea) and 60 accessions of okra (Figure 11). Seeds of regenerated accessions were processed, dried and conserved in medium-term and long-term storage.

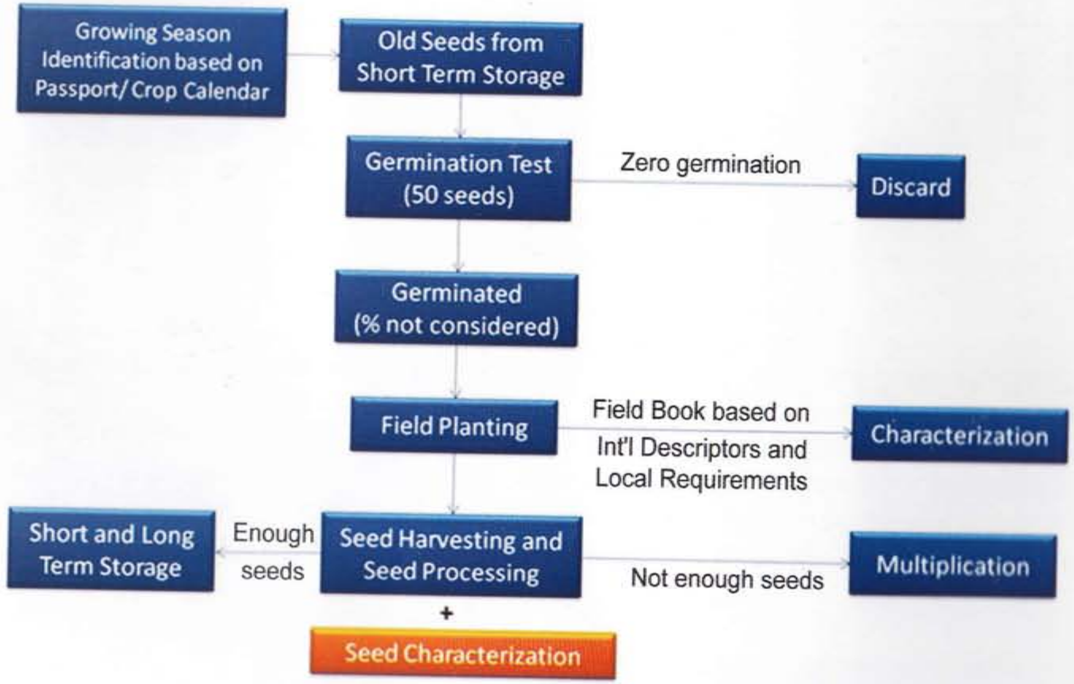


Figure 10. Steps followed during regenerating old collections.

Similarly, a total of 3158 accessions of 10 different crops were characterized morphologically during the project period (Figure 11). Out of which, 700 accessions were of rice, 800 of which, 560 of barley, 40 of naked barley, 200 of maize, 300 of finger millet, 230 of soybean, 125 of beans, 140 of pea and 63 accessions were of okra..Summary of characterization data of these crops has been presented in Table 3 to 22.

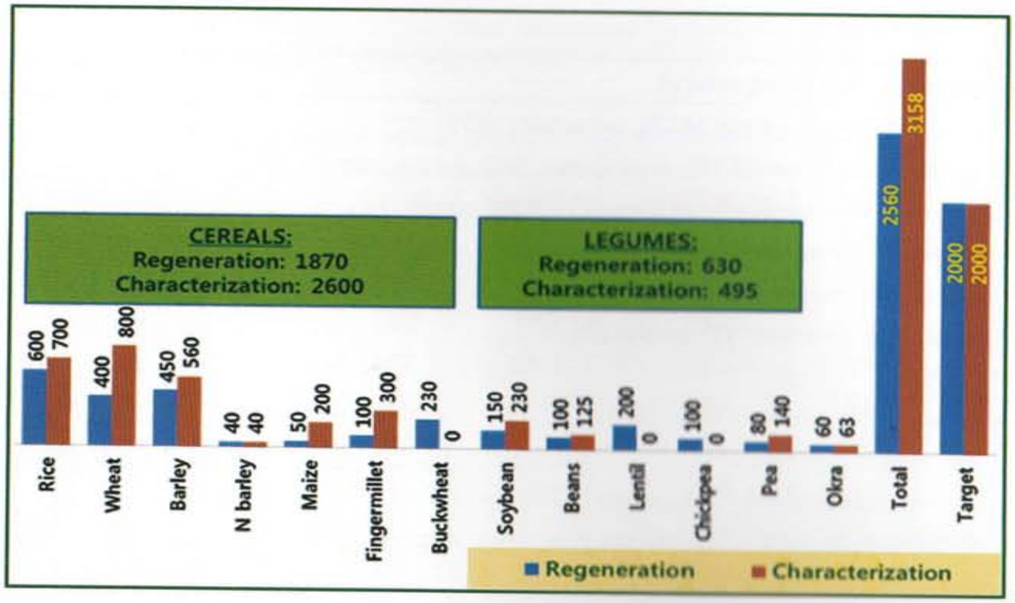


Figure 11. Status of regeneration and characterization accessions of different crops.

3.1. Rice characterization

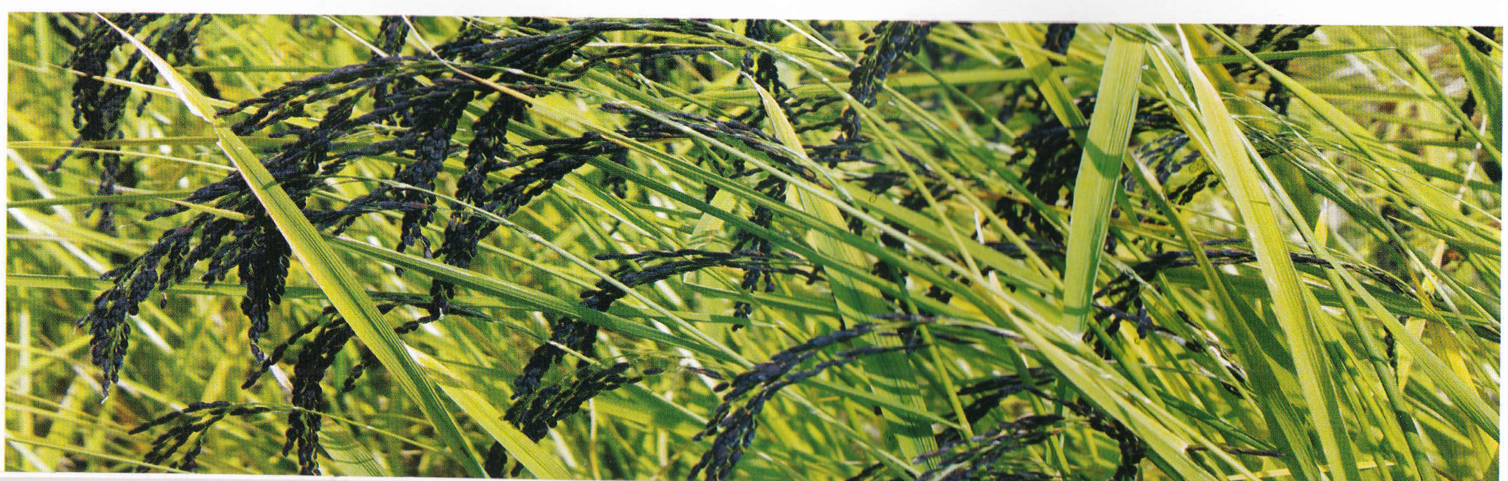
Summary of different quantitative and qualitative traits of 700 rice accessions were presented in Table 3 and 4.

Table 3. Descriptive statistics of rice accessions in different quantitative traits

Quantitative trait	Count	Minimum	Maximum	Average	SD
Flowering days	700	66	155	109	23
Maturity days	700	107	194	145.0	24.2
Plant height, cm	700	63	210	126.5	22.4
Panicle length, cm	700	12.8	68.2	23.3	3.2
Ligule length, cm	700	0.6	5.8	1.8	0.5
Leaf length, cm	700	19.80	67.40	41.77	7.93
Leaf width, cm	700	0.48	2.64	1.02	0.23

Table 4. Descriptor states of rice accessions with frequency in different qualitative traits

Qualitative trait	Count	Descriptor states (Frequency)
Leaf blade pubescence	700	Glabrous (34), intermediate (427), pubescent (239)
Leaf blade colour	422	Pale green (201), green (198), dark green (20), purple margin (3)
Basal leaf sheath colour	700	Green (582), green with purple lines (91), light purple (18), purple (9)
Leaf angle	700	Erect (444), intermediate (187), horizontal (69)
Flag leaf angle	700	Erect (286), intermediate (293), horizontal (121)
Ligule colour	700	White (689), purple lines (8), purple (3)
Ligule shape	700	Cleft (700)
Collar colour	700	Pale green (698), green (1), purple (1)
Auricle colour	700	Pale green (699), purple (1)
Culm angle	700	Erect (214), intermediate (321), open (122), spreading (43)
Internode colour	700	Green (221), light gold (405), purple lines (69), purple (5)
Panicle type	700	Compact (30), intermediate (582), open (88)
Secondary branching	700	Absent (408), light (263), heavy (29)
Panicle exertion	700	Well exerted (120), just exerted (157), partly exerted (217), enclosed (206)
Panicle axis	700	Droopy (689), straight (11)
Shattering	700	Very low (7), low (125), moderate (257), moderately high (242), high (69)
Awning	700	Absent (631), present (69)
Apiculus colour	424	White (3), brown (131), straw (208), purple apex (58), purple (13), red apex (5), red (6)
Spikelet sterility	424	Highly fertile (345), partly sterile (62), highly sterile (13), completely sterile (4)



3.2. Wheat characterization

Summary of different quantitative and qualitative traits of 800 wheat accessions were presented in Table 5 and 6.

Table 5. Descriptive statistics of wheat accessions in different quantitative traits

Quantitative trait	Count	Minimum	Maximum	Average	SD
Heading days	800	77	148	124.2	10.7
Flowering days	800	84	153	132.1	9.1
Maturity days	800	163	199	179.7	5.1
Plant height, cm	800	56.3	157.7	94.6	10.53
Number of seed/spike	800	9.7	24.3	16.5	2.40
Number of seed/spikelet	800	2.0	6.3	3.5	0.62

Table 6. Descriptor states of wheat accessions with frequency in different qualitative traits

Qualitative trait	Count	Descriptor states (Frequency)
Growth class	800	Spring (800)
Tillering capacity	800	High (176), medium (395), low (229)
Spike density	800	Very dense (36), dense (296), intermediate (381), lax (87)
Glume colour	800	White (641), red to brown (119), purple to black (40)
Glume hairiness	800	Absent (560), low (197), high (43)

3.3. Maize characterization

Summary of different quantitative and qualitative traits of 200 maize accessions were presented in Table 7 and 8.

Table 7. Descriptive statistics of maize accessions in different quantitative traits

Quantitative trait	Count	Minimum	Maximum	Average	SD
Tasseling days	200	45	97	74.8	10.55
Silking days	200	46	100	78.0	10.48
Maturity days	200	88	140	123.1	12.41
Ear height, cm	199	30.0	433.2	128.5	41.54
Plant height, cm	199	89.6	321.2	234.6	44.02
No. of leaves above ear	200	4.6	7.8	6.2	0.56
Ear length, cm	197	10.4	23.5	16.5	2.47
Ear diameter cm	197	9.2	16.8	12.9	1.46
Number of kernel/row	198	4.0	18.4	11.1	2.26
Kernel length. mm	199	7.538	12.124	10.0	0.87
Kernel width, mm	199	6.504	12.168	9.9	1.06

Table 8. Descriptor states of maize accessions with frequency in different qualitative traits

Qualitative trait	Count	Descriptor states (Frequency)
Shape of uppermost ear	200	Conical (68), conical-cylindrical (60), cylindrical (69), round (3)
Kernel type	200	Pop (9), flint (121), semi-flint (29), semi-dent (34), dent (7)
Kernel color	200	White (73), white cap (10), yellow (74), orange (33), purple (8), mottled (1), mix (1)

3.4. Finger millet characterization

Summary of different quantitative and qualitative traits of 300 finger millet accessions were presented in Table 9 and 10.

Table 9. Descriptive statistics of finger millet accessions in different quantitative traits

Quantitative trait	Count	Minimum	Maximum	Average	SD
Heading days	161	55	109	81.7	11.18
Maturity days	300	91	168	143.0	14.50
Plant height, cm	300	32.2	131.6	90.0	16.73
Productive tiller/hill	253	1.4	20	2.8	1.26
Leaf blade length, cm	300	13.3	52.4	34.1	5.21
Leaf blade width, cm	300	0.46	3.12	1.1	0.17
Leaf sheath length, mm	139	6.7	11.7	9.6	1.08
Blade length of flag leaf, cm	300	7.9	500	27.5	27.83
Blade width of flag leaf, cm	300	0.34	1.28	0.9	0.13
Ear exertion, cm	252	4.2	19.5	12.9	2.52
Finger length, cm	139	3.8	12.1	7.1	1.65
Number of leaf/plant	139	8	18.8	14.2	2.00

Table 10. Descriptor states of finger millet accessions with frequency based on different qualitative traits

Qualitative trait	Count	Descriptor states (Frequency)
Growth habit	300	Erect (254), decumbent (46)
Plant pigmentation	300	Pigmented (107), not pigmented (193)
Ear shape	300	Compact (48), semi-compact (115), open (109), droopy (28)
Ear size	300	Large (103), intermediate (185), small (12)
Spikelet shattering	300	Absent (141), present (159)
Grain colour	300	Copper brown (65), light brown (137), purple brown (86), white (12)
Grain shape	139	Round (139)

3.5. Barley characterization

Summary of different quantitative and qualitative traits of 560 barley accessions were presented in Table 11 and 12.

Table 11. Descriptive statistics of barley accessions in different quantitative traits

Quantitative trait	Count	Minimum	Maximum	Average	SD
Heading days	560	89	131	102.1	6.46
Flowering days	560	91	465.0	106.1	16.54
Maturity days	560	122	166	141.4	7.23
Plant height, cm	560	79.5	348.0	105.2	15.53

Table 12. Descriptor states of barley accessions with frequency based on different qualitative traits

Qualitative trait	Count	Descriptor states (Frequency)
Growth habit	560	Erect (391), intermediate (134), prostate (35)
Stem pigmentation	560	Green (459), purple (100), purple - basal only (1)
Auricle pigmentation	560	Green (554), pale purple (6)
Spike density	560	Dense (39), intermediate (251), lax (270)
Lemma awnhood	560	Awnless (79), awnletted (4), awned (467), elevated hoods (10)
Lemma awn barbs	560	Smooth (1), intermediate (60), rough (499)
Glume colour	560	White (160), yellow (48), brown (292), black (60)
Awn colour	560	Amber (323), brown (183), black (16), reddish (8), yellow (30)

3.6. Naked barley characterization

Summary of different quantitative and qualitative traits of 40 naked barley accessions were presented in Table 13 and 14.

Table 13. Descriptive statistics of naked barley accessions in different quantitative traits

Quantitative trait	Count	Minimum	Maximum	Average	Standard deviation
Heading days	40	82	116	97.3	7.53
Flowering days	40	91	124	104.8	8.15
Maturity days	40	140	165	149.8	8.35
Plant height, cm	40	75	142	111.0	15.82

Table 14. Descriptor states of naked barley with frequency accessions based on different qualitative traits

Qualitative trait	Count	Descriptor states (Frequency)
Growth class	40	Facultative (10), winter (30)
Stem pigmentation	40	Green (20), purple - basal only (20)
Auricle pigmentation	40	Green (23), pale purple (17)
Spike density	40	Dense (3), intermediate (32), lax (5)
Lemma awn hood	40	Awned (31), awnleted (3), elevated hoods (4), sessile hoods (2)
Lemma awn barbs	40	Rough (40)
Glume colour	40	White (35), brown (1), black (4)
Awn colour	40	Amber/white (32), brown (1), reddish (4), black (3)

3.7. Soybean characterization

Summary of different quantitative and qualitative traits of 230 soybean accessions were presented in Table 15 and 16.

Table 15. Descriptive statistics of soybean accessions in different quantitative traits

Quantitative trait	Count	Minimum	Maximum	Average	SD
Flowering days	230	55	92	71.9	7.78
Maturity days	230	116	139	129.4	4.86
Terminal leaflet length, cm	230	5.06	16.78	11.69	2.18
Terminal leaflet width, cm	230	2.24	10.18	6.35	1.60

Table 16. Descriptor states of soybean accessions with frequency based on different qualitative traits

Qualitative trait	Count	Descriptor states (Frequency)
Seedling vigour	230	Vigorous (40), medium (72), poor (118)
Corolla colour	230	White (82), purple throat (137), purple (11)
Leaflet shape	230	Broad (64), intermediate (123), narrow (43)
Stem determination	230	Determinate (186), semi-determinate (31), indeterminate (13)
Shattering score	206	No shattering (171), slight shattering (33), high shattering (2)
Mature pod colour	206	Brown (200), tan (6)
Pod pubescence	206	Normal (206)
Pubescence colour	206	Light brown (94), brown (112)
Lodging	205	None (98), slight (26), moderate (27), severe (25), very severe (29)

3.9. Pea characterization

Summary of different quantitative and qualitative traits of 140 pea accessions were presented in Table 19 and 20.

Table 19. Descriptive statistics of pea accessions in different quantitative traits

Quantitative trait	Count	Minimum	Maximum	Average	SD
Flowering days	140	76	129	97.0	11.52
Maturity says	140	115	164	150.5	7.16
Plant height, cm	140	13.2	184.6	95.7	31.08
Pod length, cm	119	3.20	7.94	5.34	1.08
Pod width, mm	119	0.91	9.11	5.74	1.39
Number of seeds/pod	119	0	7.8	5.6	0.94
100 seed weight, g	115	3.2	28.5	10.6	6.07

Table 20. Descriptor states of pea accessions with frequency based on different qualitative traits.

Qualitative trait	Count	Descriptor states (Frequency)
Growth habit	140	Pole type (137), bush type (3)
Foliage colour	140	Yellow green (51), green (83), blue green (6)
Tendril colour	140	Pale green (33), green (52), purplish green (55)
Sub- tendril	140	Present (2), absent (138)
Leaf size	140	Very small (7), small (31), medium (60), large (38), very large (4)
Flower colour	140	White (63), purple (77)
Immature pod colour	90	White green (11), pale green (33), green (41), dark green (3), green with purple margins (2)
Twining tendency	140	Pronounced (45), intermediate (58), slight (37)
Growth pattern	140	Determinate (3), indeterminate (137)
Pod texture	90	Smooth (83), coarse (2), wrinkled (5)
Seed size	119	Small (42), medium (43), large (34)
Seed colour	119	White (37), green (44), brown (38)
Seed wrinkling	119	Absent (74), present (45)

3.10. Okra characterization

Summary of different quantitative and qualitative traits of 63 okra accessions were presented in Table 21 and 22

Table 21. Descriptive statistics of okra accessions in different quantitative traits.

Quantitative trait	Count	Minimum	Maximum	Average	SD
Maturity days	63	107	159	116.7	10.26
Fruit length at maturity	63	10.5	24.2	18.5	2.85
No. of internodes/plant	63	8.4	21.4	12.7	2.37
No. of fruits/plant	63	3.4	15.8	7.77	2.39

Table 22. Descriptor states of okra accessions with frequency based on different qualitative traits

Qualitative trait	Count	Descriptor states (Frequency)
Growth habit	63	Erect (17), medium (46)
Branching	63	Moderately branched (57), orthotropic stem only (6)
Stem pubescence	63	Slight (63)
Stem colour	63	Green (20), green with red patches (42), red (1)
Leaf colour	63	Green (43), green with red veins (20)
Shape of epicalyx segments	63	Linear (63)
Petal colour	63	Cream (63)
Red colouration of petal base	63	Both side (63)
Position of fruit on main stem	63	Erect (63)
Fruit colour	63	Green (18), green with red patches (45)
Number of epicalyx segments	63	From 8 to 10 (50), more than 10 (13)
No.of ridges per fruits	63	From 5 to 7 (43), from 8 to 10 (20)
Fruits pubescence	63	Prickly (9), slightly rough (54)

4. Conservation in medium and long term storage

Regenerated seeds of more than 1500 accessions are conserved in medium and long term storages after viability testing (>85% germination) and drying (5-7% seed moisture content). Plastic bottle are being used for medium-term storage and aluminum foil for long-term storage. Long-term facility (-200C) in NAGRC is under construction now, therefore, aluminum foil with required amount of seeds are placed in medium-term storage and will be shifted to long-term after the facility comes in operation. Test samples as well as reference samples (seed herbaria) are being maintained for each accession. The collections of 2014 and newly regenerated accessions are under the process of storage (cleaning, viability testing and drying). If the genebank standard met, the accessions will be directly stored in medium-term storage. In case of low quantity of seeds, these accessions will be multiplied in next season.

5. Documentation

Two-day workshop was organized to standardize the passport descriptors and to make clear on data formatting and entering data in MS excel. A system of data checking is also established so that further analysis could be more effective and accurate. Problems faced during collections in the fields were also shared and measures are suggested and documented. An exploration and collection reference guidelines are drafted which will be useful during field trips. Following posters were published.

1. Joshi BK. 2013. Germplasm management system in NAGRC (Genebank). Khumaltar, Kathmandu. Poster
2. Joshi BK, MR Bhatta and KH Ghimire. 2013. Unique Crop Landraces. Genebank-NARC, Khumaltar. Pictorial poster.
3. Joshi BK, MR Bhatta and KH Ghimire. 2013. Cultivated and Wild Amaranths (Amaranthus sp., 2n=32, 34). Genebank-NARC, Khumaltar. Pictorial poster.
4. Joshi BK, MR Bhatta and KH Ghimire. 2012. An introduction to National Agriculture Genetic Resources Center (Genebank). NAGRC-NARC, Khumaltar.
5. Joshi BK and MR Bhatta. 2012. Agro-biodiversity in Maps. NAGRC-NARC, Khumaltar.
6. Joshi BK and MR Bhatta. 2012. Stepwise activities in Genebank. NAGRC-NARC, Khumaltar.

6. Human Resources Interaction (Training and Workshop)

- One scientist attended the PI meeting held in Bangkok from 7-11 November 2012.
- Three scientists attended the training workshop entitled 1st AFACI International Training Workshop on Germplasm Management System (GMS) in Asia, held from 20-29 May 2013 in National Agrobiodiversity Center, RDA, Suwon, Republic of Korea.

- Two scientists attended the international training workshop on In-vitro Conservation of Plant Genetic Resources Germplasm Management System, held from 11-23 May 2014 in National Agrobiodiversity Center, RDA, Suwon, Republic of Korea.
- Hosted the Annual Project Meeting on Integrated Management System of Plant Genetic Resources (IMPGR), held from 23-27 September 2013 in Kathmandu, Nepal.
- Workshops were also organized in Genebank, Khumaltar involving farming communities and agricultural scientists to develop an exploration guideline and make them aware about the conservation and utilization of APGR.

6.1.Training on Field Genebank Establishment and Management

Agricultural research could not move forward without germplasm. Nepal has functionalized the Genebank for making access to Agricultural Plant Genetic Resources (APGR) to all researchers and farmers. National Genebank has considered three strategies ie ex-situ, in-situ and on-farm for conserving all APGR in the country. Base on the conservation perspectives, all APGR are being grouped under three categories namely orthodox seed crops, recalcitrant seed crops and vegetatively propagated crops. Recalcitrant seed crops and vegetatively propagated crops are being conserved in field as Field Genebank and through in-vitro tissue conservation as tissue bank.

Field Genebank should be established across the country in different locations. Genebank has initiated to establish Field Genebank in different NARC stations. These stations will conserve all recalcitrant seed crops and vegetatively propagated crops on-station available in their command areas. A field with representative diversity of agriculture in the station will be a single window that anyone can see the regional APGR in a single field and be a source of germplasm for all researchers and farmers. Being a new concept, it is necessary to provide the training to the personnel who will lead the Field Genebank in research station.

National Agriculture Genetic Resources Center (Genebank) therefore organized training on Field Genebank Establishment and Management from 27-29 Dec 2014 in National Genebank, Khumaltar. with the goal of conserving agricultural plant genetic resources near to the farming communities, making access to APGR and getting scientific information. This training was part of the project financially supported by AFACI, Korea. The main objectives of the training were:

- Enhance the capacity of agricultural researchers on establishing and managing Field Genebank
- Understand the management and accessioning system of APGR
- Prepare the list of crops available in the command areas and database for field genebank
- Initiate the field genebank in different NARC stations
- Systematize the germplasms maintenance and agricultural research

This training was oriented more towards practical for identifying non-orthodox and vegetatively propagated crops, establishing field genebank and enhancing the utilization. Participants would able at least to identify the crops available in their working areas suitable for and to establish the field genebank. Approaches followed in the training were interactive lecture, discussion, individual and group exercise, field and lab visit. Different reading materials were also provided. Detail guidelines for establishing field genebank were provided and discussed. Certificate along with official letter to all participating offices were given to each trainee. All trainees have mentioned to establish the Field Genebank in their respective office. Director, Crop and Horticulture has also send directives to all NARC stations for establishing the Field Genebank after the training. Executive Director and Directors (Crop and Horticulture, Planning and Coordination) from the NARC were also emphasized to materialize the concept during opening session.

Training was coordinated by Dr Bal K. Joshi and facilitated by Madan R. Bhatta, Deepa Singh and Krishna H. Ghimire. There were total 16 participants from different research stations of NARC (ARS, Malepatan; RARS, Tarahara; ARS, Kapurkot; ARS, Pakhribas; HCRP, Kabre; HRD, Khumaltar; SRP, Jeetpur; RARS, Parwanipur; RARS, Nepalgunj; RARS, Doti; Genebank, Khumaltar; FPRD, Khumaltar), NGO (Parivartan Nepal, Hetauda), Community Seed Bank, Dalchowki and Natural History Museum, Soyambu. Trainees were very glad and appreciated over the knowledge and skill provided during the training. One of the messages during the training was let's think agricultural biodiversity in agricultural problems.

7. Budget Expenses

Table 23. Expenditure details (in USD) of the project in 3 years

Description	1st year	2nd year	3rd year	Total expense	Total budget
100. Exploration and Collection	5,000	3150	6,500	14,650	15,000
200. Regeneration and Assessment, Characterization	10,000	7536	12,214	29,750	30,000
300. Human Resources Interaction	6,000	7619	12200	25,819	30,000
Total Cost	**21,000**	**18305**	**30914**	**70,219**	**75,000**

Note: Remaining budget will be used in training program and exploration and collections.

8. Project Contribution for APGR Management System in Nepal

- Crops diversity has been increased in the Genebank. A total of 1044 accessions of 22 crops (11 cereals, 10 legumes and okra) were collected, conserved and are accessible to all in the country.
- A total of 2560 old accessions of 13 different crops were regenerated and conserved in medium and long-term storage with required amount of seeds.
- A total of 3158 accessions of 10 different crops were characterized morphologically and documented.
- Utilization of APGR for research and production has been enhanced through the distribution of more than 250 accessions along with information and characterization data to researchers, students and farmers.
- Technical capacities of 8 scientists have been enhanced through training and visits in RDA, Korea; Thailand and Sri Lanka.
- Genebank activities have been standardized through developing formats, guidelines, protocols, etc.
- Awareness about importance of crop diversity and its conservation has been created among farmers. They are interested to cooperate and collaborate for conservation works of local crops diversity.
- Farmers themselves have initiated conservation and management of APGR in collaboration with Genebank.
- Pre-breeding work has been initiated in some crops which could help to speed up the crop improvement work.

MAIN ISSUES/ CHALLENGES IN THE FIELD

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

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

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

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

Difficulty on duplicates identification and possibility of collecting many duplicates: Names of same landrace may be different among and even within a village among different cast. In such condition, there remain to collect many duplicates. In some cases, donors and recipients may place emphasis on increasing the number of accessions, which leads to collect many samples within limited areas and from few farmers.

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

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

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

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

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

Limited manpower: Due to the limited manpower, collections and regeneration activities have not been become more effective and efficient.

PUBLIC AND PRIVATE RESEARCH ORGANIZATION INVOLVED IN THE PROJECT

Public organization	Private organization
National Agriculture Genetic Resources Center	Dalchowki Community Seed Bank
National Maize Research Program	Sindhu Community Seed Bank
National Grain Legumes Research Program	
District Agriculture Development Offices of Dolakha, Ramechhap, Sindhupalchok, Kavre, Rasuwa, Nuwakot, Lalitpur	

PURPOSE AND MAIN ACTIVITIES OF ORGANIZATION

1. National Agriculture Genetic Resources Center

Purpose: To conserve agriculture genetic resources.

Main activities:

- Exploration and gaps identification.
- Coordination with different organizations for exploration, collections and regeneration.
- Collections of seeds samples and associated passport data.
- Seed processing.
- Regeneration and characterization of old collections.
- Conservation of newly collected samples and regenerated samples in short term conservation.

2. National Maize Research Program

Purpose: Maize breeding and coordinated trials for different crop species.

Main activities: Seeding and transplanting of 300 accessions of rice of old collections for regeneration.

3. National Grain Legumes Research Program

Purpose: Grain legumes breeding and coordinated trials for different crop species.

Main activities: Seeding of 200 accessions of different grains legumes of old accessions for regeneration.

4. District Agriculture Development Offices of Dolakha, Ramechhap, Rasuwa, Nuwakot, Sindhupalchok, Kavre and Lalitpur.

Purpose: Overall agricultural development in the respective district.

Main activities: To help for mapping diversity in the districts and identifying diversity rich farmers.

5. Community Seed Banks, Dalchowki and Sindhupalchok

Purpose: Conserve local genetic resources and improve access to these landraces for farmers.

Main activities: Collections of samples and passport data, awareness creation and seed production.

TECHNICAL GAPS BETWEEN PUBLIC AND PRIVATE RESEARCH ORGANIZATION

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

WAY FORWARD

- This project is only targeted on orthodox crops. There are many economically very important crops other than orthodox. Conservation work therefore, should also be targeted to recalcitrant and vegetatively propagated crop species.
- Germplasm, Genebank operational manual and information sharing among AFACI member countries were not visualized and it is not in practice. It is necessary to share for food security and to manage and utilize the germplasm effectively.
- Financial support is also necessary for infrastructure and equipments for making Genebank functional effectively. It is not considered in the project.
- Duplicates identification remain big challenge. Names of same landrace may be different among and even within a village among different cast. In such condition, there are more chances to collect many duplicates. In some cases, donors and recipients may place emphasis on increasing the number of accessions, which leads to collect many samples within limited areas and from few farmers. Certain technical guidelines are necessary to develop for duplicates identification and samples splitting and compositing.
- Due to limited knowledge on taxonomy and local languages, collectors are frequently facing problems on recognizing the samples in the field as well as farmer's given samples. Sometime, farmers provide seeds sample with wrong name. Field guidebook to identify samples (pictorial crop dictionary) would be very useful during exploration and collection.
- Each AFACI country has different types of agricultural genetic resources and they are stored with different strategies. Publication of status of Genebank of AFACI countries would be practically useful to understand and share the information.
- Organization of travelling seminar on APGR management system will be more effective for conservation and utilization of APGR. In this seminar, all Principal investigators will visit each country's Genebank and will have presentation and Genebank visit.
- Training on in-vitro conservation is necessary for effectively managing the vegetatively propagated crops and recalcitrant crop species.
- Nepal Genebank is expecting both financial and technical supports for establishing Field Genebank and for advancing molecular research.

REFERENCES

Bhatta MR, KH Ghimire, BK Joshi, D Singh, M Bhattarai and SK Shrestha. 2014. Exploration, regeneration and conservation of endangered cereals, grain legumes from Central Mid and High Hills of Nepal. In: AFACI Expert Workshop and Planning Meeting for IMPGR, AFACI Pan-Asia Project, 25-29 Aug 2014, Sri Lanka. Pp.183-210.

Bhatta MR. 2012. Status of plant genetic resources (PGR) management system in Nepal. AFACI Pan-Asia Project Meeting on Integrated Management System of Plant Genetic Resources, 19-22 March 2012. NAAS, RDA, Korea. Pp. 112-124.

BPP.1995. Biodiversity profile of the high mountain/high himal physiographic zones. Biodiversity profile project, Publication no. 14, Department of National parks and Wildlife Conservation Kathmandu.

HMGN/MFSC. 2002. Nepal biodiversity strategy. His Majesty's Government, Nepal.

Joshi BK and MR Bhatta. 2012. Exploration, regeneration and conservation of endangered cereals, grain legumes from Central Mid and High Hills of Nepal. AFACI Pan-Asia Project Meeting, 7-11 Nov 2012, Thailand. Pp.217-247.

Joshi BK, A Mudwari and MR Bhatta. 2006. Wheat genetic resources in Nepal. Nepal Agric. Res. J. 7:1-10.

Joshi BK, HB KC, MP Uadhyay, SR Gupta, BR Lu, PN Mathur. 2008. Ex-situ and in-situ management of wild and weedy rice in Nepal using a geographical information system. Plant Genetic Resources Newsletter 155: 69-74.

Joshi BK, KH Ghimire and NK Yadav. 2013. Agricultural Plant Genetic Resources Management and Agriculture in Nepal. In: AFACI 1stInternational Training Workshop on Germplasm Management System (GMS) in Asia, 20-29 May 2013, Suwon, Korea. Pp.139-177.

Joshi BK, MP Upadhyay D Gauchan, BR Sthapit and KD Joshi. 2004. Red listing of agricultural crop species, varieties and landraces. Nepal Agric. Res. J. 5:73-80.

Joshi BK, MR Bhatta and KH Ghimire. 2012. An introduction to National Agriculture Genetic Resource Centre (Genebank). NAGRC-NARC, Khumalta, Kathmandu. Poster.

Joshi BK, MR Bhatta, KH Ghimire, D Singh, M Bhattarai and SK Shrestha. 2013. Exploration, regeneration and conservation of endangered cereals, grain legumes from Central Mid and High Hills of Nepal. In: Annual Project Meeting on IMPGR, AFACI Pan-Asia Project, 23-27 Sept 2013, Kathmandu. Pp.145-159.

Joshi BK. 2004. Rice gene pool for mid and high hills and its conservation in Nepal. In: Agricultural Research for Enhancing Livelihood of Nepalese People (BK Joshi, SL Joshi and KP Paudyal, eds). Proceedings of 2nd SAS-N Convention, 30 July - 1 Aug 2003, Kathmandu. Pp.252-264.

Joshi BK. 2008. Buckwheat genetic resources: Status and prospects in Nepal. Agric. Development Journal 5: 13-30.

Joshi BK. 2013. A brief overview of community seed bank initiatives in Nepal. In: Community Seed Banks in Nepal: Past, Present, Future (P Shrestha, R Vernooy and P Chaudhary, eds). Proceedings of a National Workshop, LI-BIRD/USC Canada Asia/ Oxfam/The Development Fund/IFAD/Bioversity International, 14-15 June 2012, Pokhara, Nepal. Pp.41-46.

Upadhaya MP and BK Joshi. 2003. Plant Genetic Resources in SAARC Countries: Their Conservation and Management: Nepal Chapter. SAARC Agriculture Information Centre. Pp.297-422.

Annex I. Local name of landraces collected during 2012-2014 from Central Mid and High Hills of Nepal

SN	Crop	Landrace
1	Amaranthus	Jogi latte, Kalo latte, Khairo latte, Latte, Local bethe, Local latte, Rato latte, Rato seto latte, Seto khairo latte, Seto latte
2	Azuki bean	Rato maas
3	Barley	Jau, Jhuse jau, Junge jau, Karu, Local jau, Seto jau, Tude jau
4	Bean	Aasare simi kalo, Aasare simi rato, Aasare simi seto, Asaare simi, Bakulla simi, Bhadaure simi, Bhatte simi, Tamra, Charifule simi, Charmase simi, Chaumase simi, Chhirbire simi, Dalle simi, Ghiu simi, Golo simi, Hiude simi, Jare simi, Jhyange simi, Juneli simi, Kalo makai simi, Kalo simi, Kaplani simi, Karange simi, Kattike rato simi, Kause simi, Khairo simi, Khairo kalo simi, Kirbire simi, Lahare rato simi, Lekali pahelo simi, Lekali simi, Lekali kalo simi, Lekali seto simi, Dolo ghiu simi, Makai simi, Miskat simi, Pahenlo simi, Najhyange simi, Pate simi, Rajma, Rajma rato, Rato ghiu simi, Rato simi, Seto makai simi, Seto simi, Simi, Tate simi, Thangre simi, Thulo ghiu simi, Thulo simi, Trisuli ghiu simi
5	Black gram	Kalo maas, Khet maas, Local maas, Maas
6	Broad bean	Bakulla simi, Local bakulla
7	Buck wheat	Mithe phapar, Phapar, Tite phapar, Tite/kalo phapar
8	Cowpea	Barkhe bodi, Bodi, Bose bodi, Charchare bodi, Dalle bodi, Gajale bodi, Kattike bodi, Ghiu bodi, Local bodi, Makai bodi, Tane bodi
9	Finger millet	Arun kodo, Bhadaure kodo, Baulaha kodo, Charikote kodo, Chulthe kodo, Chyalse kodo, Chyalthe kodo, Dalle kodo, Dalle seto, Dhama, Dolkhe, Dude, Jhuppe, Kalo bunge, Kalo kodo, Kattike kodo, Kattike dallo, Kirne kodo, Kodo, Local kodo, Lurke kodo, Mangsire kodo, Mudke, Okhaldhunge, Nangkatuwa, Pahenlo kodo, Pangali, Paundur kodo, Rato kodo, Sangle kodo, Sano kodo, Seto kodo, Seto kodo, Sindhukote, Sirubare, Sunkoshi, Thulo kodo, Tinmahine kodo
10	Foxtail millet	Kaguno
11	Horse gram	Gahat, Kalo gahat
12	Lentil	Kalo musuro, Local musuro, Musuro
13	Maize	Americane makai, Bangare makai, Bhirkaule makai, Chapre makai, Chaukote makai, Chepti makai, Dhinde makai, Dimbure makai, Godhere makai, Golku chhepare makai, Golphe makai, Jureli makai, Kali makai, Kalimure makai, Kanchhi makai, Kande makai, Karkile makai, Lahele makai, Lotinge makai, Local makai, Maili sathiya makai, Murali makai, Nepali makai, Pahenlo makai, Pahenlo thulo chepte, Pani makai, Rato dherse, Rato makai, Sano pahenli makai, Sano seti makai, Sathiya, Seti makai, , Sisakhole makai, Solaghare makai, Thulo chepte seto, Thulo pahenli, Thulo seti, Thumse makai
14	Naked barley	Uwa
15	Okra	Bhindi, Local bhindi, Ramtoriya

SN	Crop	Landrace
16	Pea	Dalkhane kerau, Kerau, Local kerau, Sano kerau, Seto kerau, Thulo kerau
17	Pearl millet	Ghoge
18	Pigeon pea	Rahar, Rahari
19	Rice	Aanga dhan. Aapjhutte, Atte, Achhame, Anadi, Baichin, Baikunthe, Bange, Basmati, Bhageri, Bhangere marsi, Biji, Biju dhan, Charinangre marsi, Rato anadi, Chhote marsi, China bold, China bora, Dhapa dhan, Dudh pokhreli, Dudhe marsi, Ghaiya dhan, Gudule marsi, Hariyo dhan, Helmule marsi, Helmule dhan, Hile marsi, Himali, Himali marsi, Japhe, Jhapri ghaiya, Jhinuwa marsi, Joral masino, Jorti masino, Kalame dhan, Kalo dhan, Takmare, Kalo ghaiya, Kalo tunde, Kalta dhan, Kalta marsi, Khatte dhan, Lekali dhan, Local dhan, Makwanpure, Mansara, Marsi dhan, Masino dhan, Nangreli dhan, Oirange, Pahenlo marsi, Pahenli, Pahenlo anadi, Pakhe dhan, Pani lagne dhan, Pokchini, Pokhreli, Pokhreli masino, Rambilas, Ramsali, Rato dhan, Sano taichin, Seto dhan, Seto ghaiya, Suki ghaiya, Taichin dhan, Tari chhoto, Tarlange, Thadekate, Thailang dhan, Thapachini
20	Ricebean	Guras, Kairo masyang, Kalo masyang, Local mashyang, Masyang, Rato guras, Seto guras, Seto masyang
21	Sorghum	Junelo, Local junelo, Seto junelo
22	Soybean	Agaute bhattamas, Bahadure bhattamas, Bhatta, Bhattamas, Kailo bhattamas, kalo bhattamas, Kanchhi bhatta, Kause bhatta, Khairo bhatta, Local bhatta, Mardo, Muse bhatta, Rato khairo bhatta, Sahili bhatta, Sano bhatta, Sano kaili bhatta, Sathiya, Seto bhatta, Taichung bhatta, Thulo kailo bhatta, Thulo kalo bhatta, Thulo khairo bhatta,
23	Wheat	Bange Pakhe dhan, Charsure gahun, Dudule gahun, Gahun, Jhapali gahun, Jhatne gahun, Kalo gahun, Local gahun, Mudula gahun, Pota gahun, Rato gahun, Sano gahun, Seto gahun

Annex 2. Three years climate data of NAGRC, Khumaltar (27°40'N, 85°20'E, 1368 masl)