CHALLENGES AND STRATEGIES IN PROMOTING CONSERVATION OF CROP LAND RACES - A POLICY DOCUMENT

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CONTENTS

1

LANDRACES

Crop landraces and types:

The term "landrace" represents a dynamic population of crop plants, which are locally adapted, genetically diverse having historical origin, distinct identity and are associated with conventional farming systems (Camacho Villa *et al.,*2005). In other words, crop landraces are referred as heterogeneous local adaptationof domesticated species providing genetic resources, having potential to overcome existing and novel challenges for farming under stressful environmental conditions (Dwivedi *et al.,*2016). Landraces are highly nutritious, exhibit variable phenotype and low to moderate edible yield. Landraces are pivotal genotypes for crop breeding, as they provide great source of genetic diversity andpossess higher caliber to acclimatize to explicitconditions ofenvironment. Despite low productivity, landraces areimportant repositories of genetic variability,valuable in agriculture for exploration of desired genes responsible for resistance and tolerance to abiotic and biotic factors, such as disease resistance, salinity stress, high temperature and water stress (Benlioglu and Adak, 2019)**.** Landraces being reservoirs of genetic diversity form base material for breeding of new plant varieties (Cuquma, 2010). Besides balancingbiodiversity, landraces are indispensable for possessing higher medicinal and nutritional values. Prior to the advancement in breeding techniques, every year farmers utilize their seasonally preserved seeds from grown crops forcultivation. The seeds areselected from parental crop plants having best characteristics,which evolved because of natural selections (Carvalho *et al.,* 2012). Thus, over generations, various desirable traits have been utilized by this selective breeding approach. The method of seed saving is being utilized for maintaining genetic diversity of crops cultivated in specific habitat and for development of crops resilient to diseases of local origin,thus leading the evolution of these landraces as a valuable genetic resource for upcoming generations. Landraces are classified into two categories:

- Primary landraces
- Secondary landraces

Primary landraces: Primary landraces can be defined as a crop, which has not undergone any modification through formal breeding techniques, and its exclusive features have been developed through unprecedented *in-situ*grower selection. Primary landraces arefurther categorized into two categories: autochthonous and allochthonous (Zeven, 1998).

- **Autochtonous**: Landrace crop grown in its original location and has developed uniqueproperties through the selection of farmers. Its socio-economic and genetic features arerelatedto its habitat of cultivation.
- **Allochthonous**: Landrace crop introduced in another location and is acclimatized to local environmental conditions, but has developed its special features in another habitatthrough theselection of farmer.

Secondary landraces: Secondary landraces have been defined as a crop developed through formal breeding techniques andaremaintained through seed saving and continuous *in-situ*farmer'sselection. Thus, the crop is genetically diverse than the original breeding material.

2

ORIGIN AND HISTORY OF CROP LANDRACES

The origin of crop landraces includes both spatial and temporal components for initial development. They have a comparatively long history than the transient lifespan of modern cultivars. Various authors have suggested that landraces have originated over alongtime, since time immemorial, over thousands of years, for many generations and centuries (Azeez *et al.,*2018). On the other hand, few reports areprecise regarding the time period a landrace can be grown and considered as a landrace. For example, Louette (1997) estimated a time period of over 30 years (at least one farmer generation) for maize to be called a landrace, while Astley (1998) estimated '50–70 or even 100 years' for vegetable landraces.

Hawkes (1983) proposed that landraces are related to one particular geographical location in comparison to the cultivars grown in diverse locations or remotely Thus, landraces are closely linked with particular locations and exhibit the name linked to particular 'location' (Von Runker, 1908). For example, Kent Wild White Clover from the UK country of Kent and Tuxpeno maize from the Tuxpan region in Mexico. Nevertheless, seed flow (migrations) of traditional landraces from their original place to new places has also occurred as local informal variety introductions. Examples includeTuxpeno maize and Kent Wild White Clover, grown in regions other than their origin. Tuxpeno maize is grown in several regions of Southern Mexico, whileKent Wild White Clover is cultivated in hilly areas of Scotland. Another type of landrace includes 'Creole' landrace resulting from an original breeding variety, becomes a valuable landrace after undergoing numerous recurring cycles of farmer seed selection.For example,a cultivar known as Square Head Master Wheat, identified in the National List of the UK has been continuously cultivated since 1930by a farmer from Suffolk, UK (Paul Watkin) by saving its seeds every year. Individual cultivation and continuity as well as collective cultivation and discontinuity both play noteworthy roles in the evolution of landraces. Individual farmers frequently recover and lose landraces, because of the management of a vibrant collection of landraces, replacement of seeds, and due multiple stochastic events such asfloods, drought, diseases, and pests (Wood *et al.,*1997; Zeven *et al.,*1999). Local or village level or community level continuity also plays a key role in maintaining landraces through the exchange of seeds among farmers (Zeven *et al.,* 1999; Almekinders *et al.,*1994; Louette *et al.,*1996). Such confined seed exchange also aids in the continuity of landraces. Moreover, the introduction of exotic varieties leads to the adulteration of landraces in terms of their local adaptation and uniqueness.

N. I. Vavilov was the first to study and collect the landraces in rice. These landraces are less uniform, have stable yield, and respond well to the method of selection. In the Indian gene center, a large number of historic races of maize and rice were collected in the Himalayanfoothills of the northeastregion, which include Arunachal Pradesh, Assam, and Meghalaya. Likewise, native races of minor millets, which include Setaria, Echinochloa, Panicum, and Paspalum, are available in abundance in tribal regions of Madhya Pradesh, Bihar, hilly regions of Uttarakhand and Orissa. Moreover, resistant stocks of various legume crops were produced through systemic research. For instance, resistance to yellow mosaic virus of *Phaseolus* species, such as urdbean (*Vigna mungo*) from Gujrat and mung bean (*Vigna radiata*) from Punjab (Gill *et al.,*1975). Further, five cultivars of chickpea from India and one cultivar from Afghanistan (ICRISAT 1976) were found to be resistant to wilt and 18cultivars were resistant to *Ascochyta blight.* Moreover, wheat and ricelandraces offered resistance to various biotic and abiotic stresses. In wheat, Hindi-62 has been used for heat tolerance and NP4 for grain quality. Kharchia Local/Kharchia-65 has been used for salinity tolerance in various countries (Gautam *et al.,* 2004).In rice, Peta, Mas and Intan, are the three varieties of Indonesia, whichhave been resulted due to the crossing of the Chinese variety Cina and Indian variety Latisail, while Peta is parent of IR8. In addition, landraces have been collected in sorghum, pearl millet,maize and many other crops especially in South Asia.

3

NEED TO CONSERVE LANDRACES

Crop landraces are under threat and are suffering continuously from genetic erosion due to various factors, such as habitat loss, changing farming practices and climate change. Genetic erosion can be assessed through loss of allelic diversity, genetic diversity and reduction in species richness. Moreover, cultural erosion also leads to the loss of landraces due to its unabated use in various cultural activities. In addition, use of modern technologies in agriculture has also led to the drastic change from traditional agricultural practices to modern day agricultural practices, which had a large impact on diversity and crop yield. These factors have resulted in loss of landraces up to the level of extinction. In addition, local cultural erosion led to the loss of biodiversity via., replacing local varieties by improved cultivars, genetically uniform hybrids, practicing mono-cropping and crops having desired traits (Ceccarelli and Grando, 2000; Sarker and Erskine , 2006; Rodriguez *et al.,*2008; Abay and Bjornstad, 2009; Frison *et al.,*2011). Currently, only few improved cultivars of crops, such as potato, wheat, rice and maize accounting to only 60% of diets are able to feed most of the population (Esquinas-Alcazar, 2010). According to World Conservation Monitoring Centre (1992), about 75% of potato production is obtained from 4 cultivars, 50% of wheat is derived from 9 cultivars, 50% of soybean is derived from 6 cultivars and 74% rice cultivars (staple crop) of Indonesia are mainly derived from a single stock. Further, in southern Italy and Albania, landrace diversity has been reduced by 72.8% and 72.4% respectively (Hammer *et al.,* 1996). After utilization of modern practices, wheat landraces have been lost upto 95% in Greece (Lopez, 1994). Farmers in various areas of the world are rapidly losing crop landraces because of their restricted use (Walter, 2018). In addition, loss of important genetic resources over time is associated with the less multiplication, conservation and field cultivation by farmers.

Humans over millions of years have unintentionally influenced crop evolution by planting and saving seeds from crop plants possessing favorable traits. Later processhas permitted advancement of crop landraces acclimatized to diverse conditions of environment, such as extreme temperatures, altitude, diseaseresistances, drought conditions and saline soils. In the schemes of world production, landrace loss had a remarkable effect on restricting the amount of conservation and on-farm genetic maintenance of this valuable and diverse genetic material. Despite critical utilization and perpetuation of landraces near the primary and secondary centers of crop diversity, which has happened because of the evolution of alleles over millions of years at these regions, the amount of genetic diversity is disappearing at alarming pace.Thus, there is definite reduction of genetic base taking place in all staple food crops having destructive impact on food production and future generations.

Landrace population loss is critical to all crop species gene pools, as genes that have evolved over millions of years are being lost forever from various crop plant genomes. In order to overcome crop landrace losses, it is imperative to conserve them at global level. The primary aim of landrace conservation is the maintenance of broad base genetic diversity within each of the species (i.e., intra-specific genetic diversity) to ensure the availability of landraces for present and future generations. Gene pool conservation is of utmost importance for showing resilience to present and future influences of climate change as well as for supporting food security. Apart from landraces, other local varieties must also be conserved as a source of genetic diversity. Various efforts have been initiated by international and national agencies to conserve landrace diversities. The characterization of important traits and conservation of germplasm provides valuable information to breeders,increasing utilization of genetic resources among the scientific communities. Identification of tolerant abiotic stress alleles in landraces of rice, wheat and maize clearly indicates the significance of exploring and conserving landrace germplasm. The conserved germplasm will serve as a source to identify agronomically valuable alleles for increasing productivity and adjustment to stress-prone environments (Terzopoulos,2009).

4

STRATEGIES ADAPTED FOR LANDRACE CONSERVATION

Natural and anthropogenic interventions have affected landraces diversity in all directions. In order to avoid such unprecedented gene erosion, the most pivotal concern is to conserve genetic diversity, which is a phenomenon of retaining gene pool diversity with the opinion of its effective utilization (Cuquma, 2010).The main objective of conserving crop landraces is to obtain broad base genetic diversity within each species having potential value, which ensures availability of these resources for their utilization by current and future generations (Khanna and Singh, 1991).In 1992, a worldwide initiative was established in Rio-de-Janiero during the Earth Summit towards conservation of biological resources with the aim of safeguarding the genetic pool as resources for the constant search of new products having large applicability. Currently, preservation of genetic resources is of paramount importance. Crop germplasm has been historically conserved in centers of diversity, in gardens and on farms. Moreover, from past three centuries, germplasm has been conserved through *ex-situ*conservation as well in researcher's own collections, in academic institutions, public institutions, botanic gardens, on public agricultural experiment stations; in special-purpose germplasm repositories, such as Vavilov Institute in Russia is the most important example. In addition, Private seed breeding farms have also maintained collections, information of which is very less available to public. All these conservation strategies are discussed below:

***In-situ* conservation:**

The *in-situ* conservation is defined as the method of conserving; maintaining and recovery of important crop species particularly crop landraces in their natural habitats or at the places where they have developed their unique characteristics. *In-situ* conservation is generally accomplished in protected areas, such as nature reserves and other places with limited access. Preserving crop landraces in this manner within natural ecosystems is both practical and facilitates the process of constant acclimatization. This results in the evolution of valuable traits like disease resistance that may help farmers to reduce the requirement of pesticides in order to improve their yields. The *in-situ* crops require backups, which are preserved in *ex-situ* facilities in order to maintain its genetic purity and ensure easy facilitation of material to plant breeders and researchers.

On-farm conservation:

The main aim of on-farm conservation is to conserve variability in farmers' fields as an inculcated part of farm activities. This will aid in the maintenance of associated traditional knowledge, farming practice, and adaptive ability of the crop varieties. On-farm and *in-situ* conservation are used in conjunction with ex-situ conservation methods, so that crops that have been vanished from nature reserves or farmer's fields can be reintroduced from national gene banks.

***Ex-situ* conservation:**

Ex-situ conservation is defined as the maintenance and conservingsamples of living organism's outside their natural habitat in the form of seeds, cells or tissue cultures, pollen, whole plants or vegetative propagules. Vavilov was the first to create modern seed bank in St Petersburg and recognize the value of genetic diversity.

Gene banks:

The principle aim of gene bank is to collect, conserve and make genetic resources available to scientific and public communities. Maintaining genetic identity of crop accessions is dominant objective of gene banks. Over 50 years ago, gene banks were established to conserve crop diversity in local landraces that were threatened by destruction of natural habitats and replaced by advanced varieties (Jorge *et al.,*2010). There are various types of gene banks, which include seed banks, field banks, *in-vitro* banks, cryo-banks, vegetative banks, and DNA banks. Previously, gene banks were largely maintained and developed individually by plant breeders at Universities. As a result, the collections assembled through years of effort were being lost, thus increasing the insecurity of germplasm conservation (Postman *et al.,*2006).Various procedures are hard to find in the public domain, because they exist only in the form of institutional manuals or guidelines. Former approaches paid attention on identifying unbending standards that curators were expected to follow in all gene banks (FAO/IPGRI, 1994). For the management of germplasm, a modern approach is required to assemble individual crop best practices. In order to exchange information, best practices, approaches, experiences, traditional indexed publications, such as dictionaries and encyclopedias are replaced by the use of searchable web-based tools (December, 1996).

Gene banks are collectionsof wide range plant genetic resources, aiming in accessibility,and long-term conservation of plant germplasm to researchers, plant breeders and other users. Sustainable preservation of these plant genetic resources depends on efficient and effective execution of gene banks through the utilization of procedures and standards that guarantees the constant availability and survival of plant genetic resources. Proactive measures are being taken by centers in order to prevent inadvertent introgression of foreign genes, including transgenes, not already present into samples conserved in their gene banks. Gene bank protocols and proper germplasm management procedures must be followed properly in order to ensure integrity and quality of accessions. Conventional and transgenics are liable to undergo certain biological processes of gene flow, natural selection, mutation, introgression and recombination. Germplasm management requires best practices as it varies from crop to crop, affected by pollination system, nature of the plant (perennial/annual) or by its breeding system. These best practices involve procedures that intend to restrict the transfer of genes from other unreliable sources. Mode of transfer by other sources includes pollination and admixture of seeds. It has been realized that complete segregation of unintended presence of exotic genes including transgenes in gene bank accessions is not permitted by the available technical means. Moreover, available testing techniques do not offer an absolute guarantee, without testing every single plant or seed that any given accession is transgenic free. The chief gene bank operations required to be evaluated are collection, characterization, acquisition, regeneration, conservation, evaluation, delivery, documentation, testing health and viability. Gene banks are vulnerable to unplanned introduction of transgenes at the stage of collection and acquisition as the germplasm may be exposed to gene flow outside the control of the gene bank.

Careful documentation of data is required for the proper identification of seed samples conserved in gene banks. It is initiated by recording collection data or donor information and passport data. This information is also required to be recorded for the classical collections in genebanks for which passport data was either incomplete or was not recorded earlier. For precise identification of seed samples, seed reference collections and herbarium voucher specimens play a pivotal role. To further ensure the identity of germplasm accessions, modern techniques such as molecular markers and accession labels with printed barcodes provides accessibility for germplasm management by reducing the error possibility. The various types of gene banks include community seed banks, national and regional gene banks and International gene banks are described below:

i. Community seed banks:

Community seed banks are the repositories of seeds donated by farmers. These seed banks germinates, multiplies and conserves the seeds, such that farmers have easy facilitation to seed varieties,which are well acclimatized to local conditions and possess diverse traits. In addition, farmers are provided with access to training, assistance and education from scientists and plant breeders. The crop diversity preserved in community seed banks is propagated in national gene banks in order to reduce the threat of genetic material being lost.

ii. **National and regional gene banks:**

National and regional gene banks are defined as the gene banks, which aim to facilitate and conserve crop diversity originating from a region or from a country. The material originates either from collection centres or from plant material used by breeders or farmers, which they have later donated to the gene bank. These gene banks provide general assistance, guidelinesand provide back-up services for *in-situ* conservation and community seed banks. National and regional gene banks conserve material for cultural and historic value, provide material to scientists, crop breeders and others access to their material for breeding, educational purposes and research. Additionally,National and regional gene banks may utilize the Svalbard Global Seed Vault for long-term security storage.

iii. International gene banks:

International gene banks emphasize ongroups of crops or specific crops having global coverage. These gene banks focus on research, crop-breeding activities, conservation, and consist of the entire ‘gene pool’ (all the genetic diversity related with a crop, including its relatives). The international gene banks facilitates preservation of material stored in nationaland regional gene banks and also helps them in repatriation of their material. Most of the international gene banks also maintain their seeds in the Svalbard Global Seed Vault.Parts of crop plants other than seeds (Vegetative material)that do not reproduce easily from seeds are utilized as propagating material and are conserved through *ex-situ* conservation. Examples include potatoes, sweet potatoes, cassava and bananas. There are various techniques involved:

• In-field collections allows farmers to observe clearly the features of the growing plant.

• *In-vitro* methods prevents the material from being lost, and facilitates researchers and farmers with disease free healthy material.

Botanical gardens:

Gardens, which preserve collections of live plants chiefly for conservation, study, education and scientific research. In other words, they have a dual mission of education and conservation. Moreover, it also play role in recreation and tourist attraction. According to Chakravarthy and Mukhopadhyay (1990), botanical gardens are living depository of plants, where the collections are frequently marked or labeled for identification purposes, which are maintained and arranged on several scientific grounds. Each year, about 100 million people visit different botanical gardens worldwide. Seed banks, living collections, scientists, trained specialists are the assets of botanical gardens, which guarantee the species conservation. In botanical gardens, plants are usually labeled and the passport data available provides information regarding scientific names, local names, family, partsused and other special features. At times, the labels may provide us more information about time and location of plant being collected, range of distribution, habitat, etc. There are about 2,500 botanic gardens in the world and with increase in latitude, species richness of living collections also increases.

For exploration of world biodiversity, botanical gardens play a key role in *ex-situ*conservation. Moreover, it also plays a pivotal role in conserving species that support well-being and needs of humans (Waylen, 2006). The classical role of botanic gardens encompasses collection, identification, classification and growing of plant species originating from whole world. The common practice is to present the different plant species under the finest and visually most attractive conditions (Balic, 1986). Previous tropical botanical gardens had a primary role in the introduction, cultivation and distribution of both local and foreign crops of potential value and also provided advice and guidance to the local farmers about the cultivation and maintenance of crops and how to keep them disease free (Heywood, 1983). The botanic gardens are regarded as the last resort for the maintenance and conservation of endangered and rare species. Botanic gardens provide an efficient network for plant conservation for aesthetic value and utility besides having their role in safeguarding ecological balance, preventing deterioration of environment and maintaining natural atmosphere. They are also considered as chief centersfor maintenance of plant resources from their loss as well as:

1) Serves as a "safe abode" for endemic and rare plants as well as functions as a storehouse of plants of selected exotic species of a particular country.

2) Accommodates germplasm collection of selected plants and their wild progenitors of ornamental, medicinal and economical value.

3) Promotes research and educational programmesin ornamental horticulture and experimental botany.

4) Creates awareness about curious, interesting beautiful plants and value of trees with delightful display and landscaping.

5) Introduction of economically vulnerable species.

6) Data bank for documentation and information on holdings in botanic gardens of the region or country.

Cryopreservation:

Cryopreservation is a method that assures long-term, safe conservation of genetic resources of plant species with refractory seeds or products such as cell lines, genetically transformed material, somatic embryos and vegetatively propagated species.The technique was initiated at the end of the 20thcentury and is used today for routine cryo-storage as long as some important factors were taken into consideration (Reed, 2001). It is an indispensable complementary*ex-situ* tool to *in-situ* conservation, as genetic back-up in case of genetic diversity loss, and it is the policy of preference, when *in-situ* strategies are unsuccessful in evading unnecessary losses of breed extinction or genetic variation (Gustavo *et al.,*2007). The technique comprised of shoot apices vitrification isolated from *in-vitro* stock somatic embryos and shoot culture. In recent years, the procedures of tissue culture are generally required to proliferate supercooled material via somatic embryogenesis or axillary shoots, and were improved for use with tree species (Nehra *et al.,* 2005). Additionally, molecular breeding procedures and production of transgenic tree species needs efficient cryopreservation protocols (Haggman *et al.,*2001).Three major genetic risks in *ex-situ*collections are mutation accumulation, adaptation to cultivation and genetic drift.

5

POLICY TOOLS TO PROMOTE CONSERVATION OF CROP LAND RACES

The major concern for the loss of traditionally grown cultivars and locally adopted varieties is replacement by high yielding modern varieties. These modern varieties have drastically affected agro-biodiversity resources as they are led by market-oriented cropping systems, requirelarge irrigation inputs and respond quickly to chemical fertilizers. Moreover, other concerns include land degradation, fragmentation, climate change impacts, post-harvest losses, and spread of invasive alien species, inappropriate crop rotation, water scarcity and excessive tillage. To combat the loss of crop landraces, the government has devised various policies and recommendations:

A. Global and national governance for conservation of crop landraces

Center of Biodiversity (CBD) provides a global structure for sustainable use and conservation of biodiversity. Food and Agriculture Organization commission (FAO) on genetic resources for food and Agriculture is a permanent inter-governmental forum for governments to negotiate and discuss matters particularly in relevance to agricultural biodiversity. It takes suitable actions through codes of conduct, guidelines and global action plans and visualizes the status of genetic resources for food and agriculture. For sustainable agriculture and food security, the aim of the International Treaty on Plant Genetic Resources for Food and Agriculture in harmony with CBD is conservation, sustainable use of plant genetic resources and the synchronized sharing of benefits arising out of their use. In Japan, a protocol namely 'The Nagoya Protocol's" is an obligatory legal network adopted to promote effective and transparent execution of the Benefit Sharing and admittance concept at the national, local and regional level. Some of the national frameworks in India dealing with agriculture and food sector include, National Agricultural Policy, 2000,National Seed Policy, 2002, National Policy for Farmers, 2007, Protection of Plant Varieties and Farmers' Rights Act (PPV&FRA), 2001 and Biological Diversity Act, 2002, National Policy on Agro forestry, 2014, National Policy on Biofuels 2009, Insecticides Act, 1968, Live-stock Importation Act, 2001,andFood Safety and Standards Act, 2006. The objective of policy study is to augment agro-biodiversity by conserving the landraces, cultivars, domesticated breeds/stocks, wild varieties and folk varieties. Before undertaking the global and national governance, several missions, programmes and schemes implemented by the Ministry of Agriculture and Farmers Welfare (MoA&FW) were reviewed; resulted in valuable recommendations towards enhancing India's agro-biodiversity wealth for human welfare. These key recommendations are discussed below:

i. Conservation of Agro Biodiversity

a) Agro-biodiversity Hotspots and On-farm Practices

- Agro-Biodiversity Index (ABI) and Agro-biodiversity hotspots can be prepared and protected respectively to measure and manage the agro-biodiversity across four dimensions: conservation, production, diets and seed systems. This will help the governments, decision makers, companies, investors, consumers and farmerstoensure that food systems are sustainable and diverse.
- These gene sanctuaries/ agro-biodiversity hotspots can be used for on-farm/*in-situ* conservation of crops and the agro-biodiversity associated business can be improved in these hotspot areas, which will help in generation of employment opportunities for youth.
- Areas rich with agro-biodiversity are required to be documented through People's Biodiversity Registers (PBRs) and encouragement of proper branding of produce, such as organic certification, Geographical Indications (GI) are important for improved monetary benefits. Moreover, documentation, conservation and recognition of on-farm conservation (crops) sites and cultivation practices are needed to be mapped state wise.
- In order to reduce the resource loss to agro-biodiversity, farmers actively involved in the practices of on-farm conservation should be facilitated with crop Incentives. Development of an on-farm conservation model is required in the agro-biodiversity hotspots. Further, registration of all varieties available with private/public sector and agricultural farmers with the national repositories is also important.
- Development of a national level database onessential crop plants is important. These resources along with their related conventional knowledge are required to be mapped agro-climatic zone wise, which is necessary for conservation of these resources.
- Conventional farmer's varieties/landraces should be conserved through *in-situ*/on-farm

and *ex-situ* methods to ensure constant availability of their quality seed materials.

b) Conservation of Traditional Seed Varieties

- Creation of seed banks in each agro-climatic zone is important, such that these quality seeds can be used by the farmers of new generation. In addition, encouragement of Community seed banks (CSBs) at village level is also needed.
- Establishment of CSBs on priority basis is important to ascertain the *In-situ*conservation of farmers' varieties. Various schemes such as National Food Security Mission (NFSM), ParamapragatKrishiVikasYojana (KVY)/ bio-village and MIDH schemes, National Mission on Oilseeds and oil palm (NMOOP) have provisions to provide subsidy to farmers during distribution of seeds to them so that these useful resources can be preserved and utilized by new generation farmers.
- Encouragement of Community Seed Banks in the Centre's of conventional seed diversity areas holding Plant Genetic Resources (PGRs) of fodder, food, income, health and nutrition, value is important. For maintenance of biodiversity, other crop varieties providing importance to biodiversity needs to be considered, while releasing high yield seeds/varieties.
- Hermetic storages i.e., storage of seeds in airtight containers made of metal, wood, terracotta, etc. are widely promoted and recommended to be the most effective form of seed storage.

C) Conservation of Crop Wild Relatives (CWR)

- Documentation, conservation and characterization of crop wild relative (CWR) varieties including cereals, vegetables, orchids and pulses of medicinal/economical value is needed. Moreover, mapping of high significant crop wild relatives from primary gene pool on priority basis is also required.
- Exploration of crop wild relatives inside the protected areas and permission to researchers for collection of wild germplasm is needed for conservation, taxonomic studies and research purposes.
- Cryopreservation of CWR and endangered plants should be prioritized; Deoxyribonucleic Acid (DNA) and pollen are required to be cryopreserved as

alternative conservation strategies.

- For *in-situ*CWR conservation, establishment of global, national and regional networks and creation of CWR trait discovery, inventories and checklists should be carried out.
- The farmers of the forest tribes are required to be rewarded for their hard work in conserving the crop wild relative in the forest areas.

ii. Policy and Institutional Strengthening

- Under the Section 37 of the biodiversity Act, agro-biodiversity hotspots should be designated as Biodiversity Heritage Sites (BHSs) by the concerned State. About 22 agro-biodiversity hotspots has been already identified by the PPV&FR Authority (Plant Variety protection and Farmers Right) which can be considered by the State Governments for designating as Biodiversity Heritage Sites (BHSs).
- Development of a descriptive note for conventional breeding should be prioritized.
- Preparation of guidelines for utilization of Local Biodiversity Funds, State Biodiversity Funds and National Biodiversity Funds need to be ensued as modalities and royalties to be developed for allocating the benefits to the benefit claimers.
- In order to make the whole process transparent and easy while processing Access and Benefit Sharing (ABS) application forms, a single network is required to be developed by integrating PPV&FRA, State Biodiversity Boards, National Biodiversity Authority, Biodiversity Management Committee, Patent Office etc.
- Development of strategies related to national level invasive exotic species is important for identifying pathways, managing, monitoring strategies mapping, controlling and eradicating invasive alien species associated with agriculture. Moreover, development of databases related to these invasive alien species is also needed.Species, which are problematic, are required to be prioritized based on the studies of risk assessment and awareness regarding these invasive species should be created among the related stakeholdersby development of early warning systems.

ii. **Finance Mobilization and Incentive Mechanism**

- Exploration of both monetary and non-monetary funding mechanisms aremandatory to conserve the agro-biodiversity. The monetary mechanism includes, biodiversity fund (National/State/Local), green tax for organic products, gene fund, and visitor's fee can be charged while tourist visiting Biodiversity Heritage Sites (BHSs), seed banks, agro-biodiversity hotspots, conventional farming practices.
- Incentives can be provided from the Biodiversity Funds as specified in the BD Act, 2002and from Gene fund of the PPV&FRA, 2001 (State and Local) for conserving on-farm sites (conserved by the private owners).
- Farmers should be given economic incentives for shifting from the chemical intensive farming to the ecological agriculture farming practices, which includes farming using land races, Integrated Pest Management practices and organic farming etc.
- Funding mechanisms, which are non-monetary, includes transfer of technology establishing development, and research, Corporate Social Responsibility, venture capital fund and joint venture.
- The "Polluter pay principle" can be utilized for the salvage of the agricultural lands Influenced by industrial pollution.

B. Policies of J&K government for conservation of crop land races:

Jammu & Kashmir is gifted with wealthy natural heritage including beautiful landscapes, treasure houses of important genetic and ecosystem diversity and endemic biodiversity hotspots. In reality, the state is internationally recognized for its natural scenic beauty, which is most important for ecotourism. In retaliation to changing environmental conditions, our wetlands and different biodiversity zones, especially those in altered climatic regimes are the nature's laboratories for advancement of wild species. Therefore, the state can utilize this valuable resource base for the profit of the people with the condition that the suitable Intellectual Property Rights (IPRS) with regard to their ethno-biological knowledge are conferred on local communities and genetic resources are conserved. Biodiversity loss including threat to landraces is occurring at alarming pace in our state. The key factors responsible for this threat includes climate change, land degradation, introduction of alien and invasive species, unsustainable patterns of production, consumption and unsustainable harvesting of natural resources. In order to frame policy of the state, a vast exercise has been carried out and the following measures were taken to provide inputs regarding the loss of landraces:

- ✓ Reinforce the protection to areas of native genetic resources, while facilitating resources and providing alternative livelihoods to the affected local communities.
- ✓ Genetic material of vulnerable species of landraces is conserved across the state. In addition, *in-situ* and *ex-situ* conservation of genetic resources is initiated in selected gene banks.
- ✓ Strict enforcement of Patents Act, 1970 in the state, such that applicant provides a declaration in relation to seeking obligatory consent of the competent authority to utilize the biological material from the state.
- ✓ Establish mechanisms to ascertain that the advantages arising from facilitation to genetic resources, including conventional knowledge, technology and intellectual property rights shared equally with communities residing in areas, where the genetic material is originated.
- ✓ Protect and respect knowledge of local communities and make them to participate in landrace conservation.
- ✓ Self-government institutions must be involved in implementation.
- ✓ Encourage and regulate bioprospecting and sustainable use of biological resources in compliance with law. Attention is paid carefully to the possible influence of development projects on biodiversity resources.
- ✓ Implement and develop a strategy to control and alleviate invasive and alien species.

6

CONSERVATION OF UNDERUTILIZED CROPS: BUCKWHEAT AND COMMON BEAN GERMPLASM

The term underutilized crops or neglected/under exploited/minor crops is more often used due to various reasons, including genetic, cultural, agronomic and economic issues. Since, these crops are not in competition with other species in identical agricultural environment, thus consumers and farmers are not using these crops to large extent. As a result, these species have been abandoned and genetic erosion of their gene pools has become inadequate. Underutilized crops are mainly cultivated in the marginal areas by small landholders despite their abundance in diverse ecosystems. These crops are typically characterized by having significance in production and consumption systems, mainly comprising of landraces or local types, need comparatively low inputs, adapting to specific agro-ecological niches, being cultivated with local knowledge and receiving insufficient attention by national agricultural and biodiversity conservation efforts.Increased dependence on major food crops has led to the narrowing of the food basket on which humankind has been relied for generations. The narrowing of biodiversity in agriculture has reduced both the inter and intra-specific diversity of crops, thus increasing the threat among users especially the poorer sections for whom crop diversity is not a choice, but in turn is important for their survival. During past 10-15 years, various underutilized crops have been incorporated in global action plans after having effectively increased the interest of decision-makers. Among the different underutilized crops viz. buckwheat, faba bean, adzuki bean, horse gram, amaranth, chenopods, rice bean grown in diverse parts of world, buckwheat and beans have gained consideration as important crops. These crops possesses enormous caliber due to their nutraceutical attributes, medicinal properties, nutritional quality, high grain yield, and multipurpose usages. Keeping their importance in view, these crops need to be conserved through diverse strategies.

Conservation of Buckwheat Germplasm:

With the advancement in agricultural technologies, cropping patterns as well as food habits have changed to large extent. This has resulted in rapid genetic erosion and neglecting of conventional varieties and crops,such as buckwheat. In order to conserve the genetic resources of underutilized crops, *ex-situ* conservation has played an important role especially for buckwheat, and has proved to be an alternative to prevent further genetic erosion. In India, National Beareau of plant genetic resource (NBPGR) is the nodal office for *ex-situ* conservation of plant genetic resources and buckwheat germplasm is maintained at the following facilities:

1. For long-term storage purposes, about 994 germplasm collections are preserved as base collections at New Delhi in the National Gene Bank at 4–5% relative humidity and –20°C temperature.
2. For medium storage, about 1,055 germplasm accessions are conserved at Shimla as working collections at 35% relative humidity and 7–8°C temperature.

The working collections are employed for germplasm exchange and are maintained through intermittent regeneration. Moreover, other institutes such as ICAR Research Complex for NEH Region, Vivekananda ParvatiyaKrishiAnusandhan Shala, Almora, G.B. Pant Agricultural University, Hill Campus, Ranichauri, NBPGR Regional Station, Shillong, Agricultural University, Palampur, at Sangla and Kukumseri, are also involved in maintenance of about 350 working collections. In the Western Himalayan region of India, on-farm conservation for several landraces and crops including those of buckwheat has also been started at few preferred conventional farming systems. To maintain on-farm native genetic diversity, conventional farming systems are of great importance as they also play a crucial role in local communities for livelihood and food security. However, it is pertinent to mention that it is difficult to achieve on-farm conservation particularly for underutilized crop, buckwheat, during the current boom of commercial farming in India. On the other hand, organizing brainstorming sessions and awareness camps and at groundlevel involving extension agencies and farmers highlighting its medicinal and food value have created more interest among farming communities for conserving and growing buckwheat genetic resources.

Documentation of buckwheat germplasm is important for its conservation. NBPGR has documented the data generated from characterization, explorations and evaluation. Currently, characterization data of 775 germplasm accessions and 900 germplasm accessions are maintained as a database in MS Access and about 1000 accessions in MS Excel. NBPGR has also published a catalog of about 408 germplasm accessions (Joshi and Paroda, 1991). Apart from this, the information has also been published in different forms such as bulletins, popular articles and research papers etc.

Conservation of Common bean germplasm:

Common bean (*Phaseolus vulgaris* L.) belonging to the sub-family Papoilionacae and family *Leguminosae*is one of the most important crop grown in all continents worldwide except in Antartica. It is also known as "Rajmash" in Hindi, kidney bean, haricot beanand snap bean. The primary centre of origin for common beans is Peruvian Andes in South America and meso-America from where it was introduced into Europe during 16th and 17th centuries.In India, the crop was introduced from Europe during 17th century (Prakash and Ram, 2014). Based on the centre of origin of common beans, the crop has been classified into two gene pools- Andes gene pool and Meso-American gene pool. The crop has gained its importance because of its high fiber, complex carbohydrate and protein content. It is consumed as dry grains, green grains as vegetables and as immature tender pods. Common beans are also called as "poor man's meat" as it contributes to the under-nourished people of the developing countries in the form of essential proteins. Moreover, dry beans are rich in calcium, vitamin B and Iron, which are vital components, required for maintaining general health, bone structure, effective nervous system and blood making respectively (Karasu and Oz, 2010).

Common bean is currently dispersed in Asia, Africa and Europe, where it identifies similarities to Mesoamerican and Andean gene pools or forms hybrids between both gene pools. The concept of landrace is beneficial for identification or differentiating among cultivated varieties through unproblematic characteristics that are adapted locally to conventional farming systems (Camacho *et al.,* 2006). In this context, landraces of the common bean are utilized as the unit of diversity of the farm-managed population, which farmers sow and select during every crop cycle. For the production food grain, the landraces of common beans contribute to about 70–90% of the seed planted by farmers in Latin America and in Asia, the seeds preserved by farmers accounts to about 80–90% of all of the seeds utilized (Arenas *et al.,*2015; GRAIN, 2016). Thus, it is indispensable to realize the role of such landraces in genetic and phenotypic diversity including their contribution to traditional diets and on farm conservation.

Large amounts of genetic erosion of plant species including common beans has occurred at rapid pace due to damage of habitats and ecosystems by multiple factors. Various strategies have been adopted globally to preserve thelandraces/genetic resources of common beans, which includes *ex-situ*, *in-situ* and in seed banks. *Ex-situ* conservation involves conservation of seeds in cold stores for longer periods at low temperatures ranging from -20 to +4 °C. Although, certain disadvantages are also related to *ex-situ* conservation as it influences the genetic integrity of conserved genotypes. Continuous rejuvenation is necessary for the materials preserved as seeds in order to prevent the reduction in genetic variability. On the contrary, *in-situ* conservation is carried on-farms, which allows the cultivars to change and evolve continuously by following the normal production systems. Thus, combining both the strategies efficiently (*in-situ* and *ex-situ*) is the best-integrated approach for conservation of common beans. Protocols aredesigned worldwide to minimize the probability of altering the genetic structure of preserved seed samples by mutations, accidental contamination, selection or random drift.

Large germplasm collections *Phaseolus* are developed to document, acquire, maintain,distribute and evaluategermplasm in order to assist scientists in improving the yield and quality of this crop. These collectionspreserved worldwide include genotypes of both wild and domesticated species of *Phaseolus.* One of the biggest seed bank in worldisCIAT (International Center for Tropical Agriculture) located in Palmira, Colombia(Johnson *et al.,*2003). This collection comprises of about 37,390 accessions, with 4,41,225 samples disseminated for research and breeding purposes to 105 countries. About 71.6% of the distributed samples have been used actively in breeding programs conducted by CIAT, 15.5% have been requested by the National Agricultural Research System, USA (NARS), 10.4% by various universities and the remaining 2.5% has been distributed to private companies and other applicants (CIAT, 2018). It is anticipated that over 70% of the value of enhanced common bean production is because of the utilization of imported varieties obtained from breeding programs of bean collection (Johnson *et al.,*2003).*In-situ* conservation of the common bean germplasm has significance as a policy for improving resistance of crop in diverse countries under changing climatic condition (Coomes *et al.,*2015; FAO 2014; Katungi*et al.,*2011; Vernooy *et al.,*2015, 2017). Additionally, community seed banks also help in conservation of genetic diversity on farms and ensure continuity. Under on-farm conservation, abiotic and biotic factors with the systematic processes underlying phenotypes, creating genetic divergence at the subpopulation level with significant implications for conservation (Thomas *et al.,* 2015; Tiranti and Negri 2007).

7

OUR INITIATIVES AT SKUAST-Kashmir FOR CONSERVATION OF BUCKWHEAT AND COMMON BEAN

To conserve the landraces of Buckwheat and Common bean, following initiatives were taken by us under the project titled *"**Collection, characterization, evaluation of important genetic resources of J&K and Ladakh**"* sponsored by NMHS (GBPNIHESD) Kosi-Katarmal, Almora – 263643 which are envisaged as follows **(Plate 1 to Plate 5):**

Awareness programmes to farming communities:

Awareness programmes were conducted regarding the medicinal values and other related benefits of common beans and buckwheat. This led the farmers to appreciate as well as realize the initiatives taken by us, which not only preserved the diverse agricultural wealth for future generations,but also aids in maintaining this wealth in the field for a durable production system.

On farm Conservation of common bean and buckwheat:

The seeds of traditional buckwheat crop and common beans were cultivated and maintained on the fields of farmers as well as University farms for future breeding and research purposes. This helped the farmers as well as researchers to maintain the genetic diversity of these crops for future generations.

Outcomes of the initiative:

This program has brought extraordinary outcomes, which are elaborated below:

- The farmers are cultivating the landraces of buckwheat and common beans (that are nutritionally superior) in the fields, whichare kept fallow for several years, thus exhibiting positive impact on food security.
- The program may also contribute in providing opportunities to women folk by generating their income through conservation of buckwheat.
- This program has contributed in motivation and boosting of farming community for

further innovation.

- This program has provided more food choices to the consumers and also seeks to carve a niche as a health food due to the medicinal and nutraceutical properties of buckwheat.
- The program will contribute to the preservation and maintenance of diversity of conventional food culture. Farmers have realized the advantages of conserving and utilizing traditional buckwheat and common beans, thus motivated to maintain and conserve the landraces of these two crops.
- The farmers who are the owners of agro-biodiversity realize the importance of diversity and the vital role they play in preservation of this diversity for future generations.
- School children and youth were also awared about the importance of these crops and need for conservation of the germplasm.

CBZ1 CBZ2 CBZ3 CBZ4 CBZ5 CBZ6
CBZ7 CBZ8 CBZ9 CBZ10 CBZ11 CBZ12
CBZ13 CBZ14 CBZ15 CBZ16 CBZ17 CBZ18
CBZ19 CBZ20 CBZ21 CBZ22 CBZ23 CBZ24
CBZ25 CBZ26 CBZ27 CBZ28 CBZ29 CBZ30
CBZ31 CBZ32 CBZ33 CBZ34 CBZ35 CBZ36
CBZ37 CBZ38 CBZ39 CBZ40 CBZ41 CBZ42
CBZ43 CBZ44 CBZ45 CBZ46 CBZ47 CBZ48
CBZ49 CBZ50 CBZ51 CBZ52 CBZ53 CBZ54
CBZ55 CBZ56 CBZ57 CBZ58 CBZ59 CBZ60

Plate 1: Common bean germplasm collected from North West Himalayas of Jammu and Kashmir and Ladhak

Plate 2: Buckwheat germplasm collected from North West Himalayas of Jammu and Kashmir and Ladhak

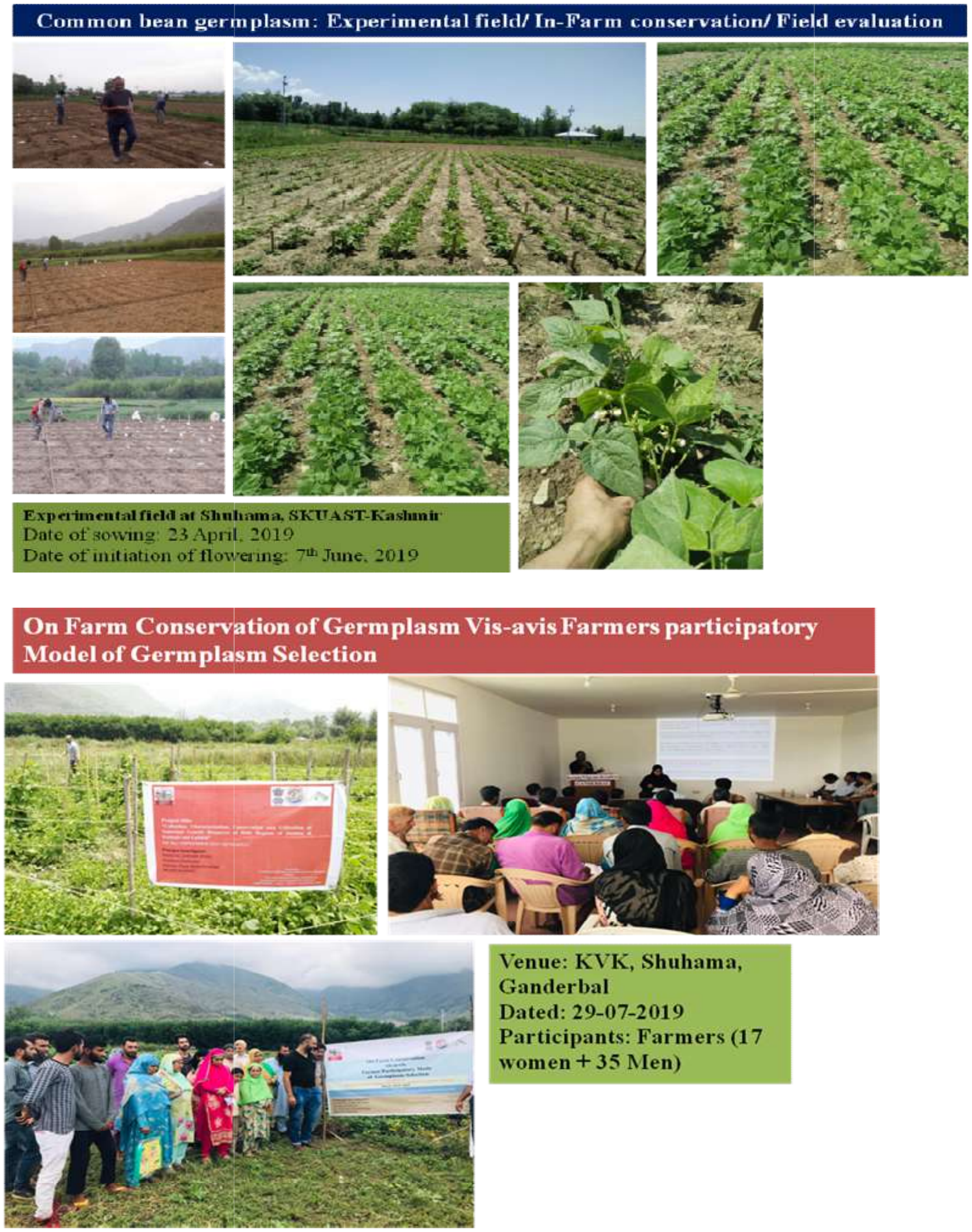

Plate 3: Common bean germplasm (landraces): On Farm conservation

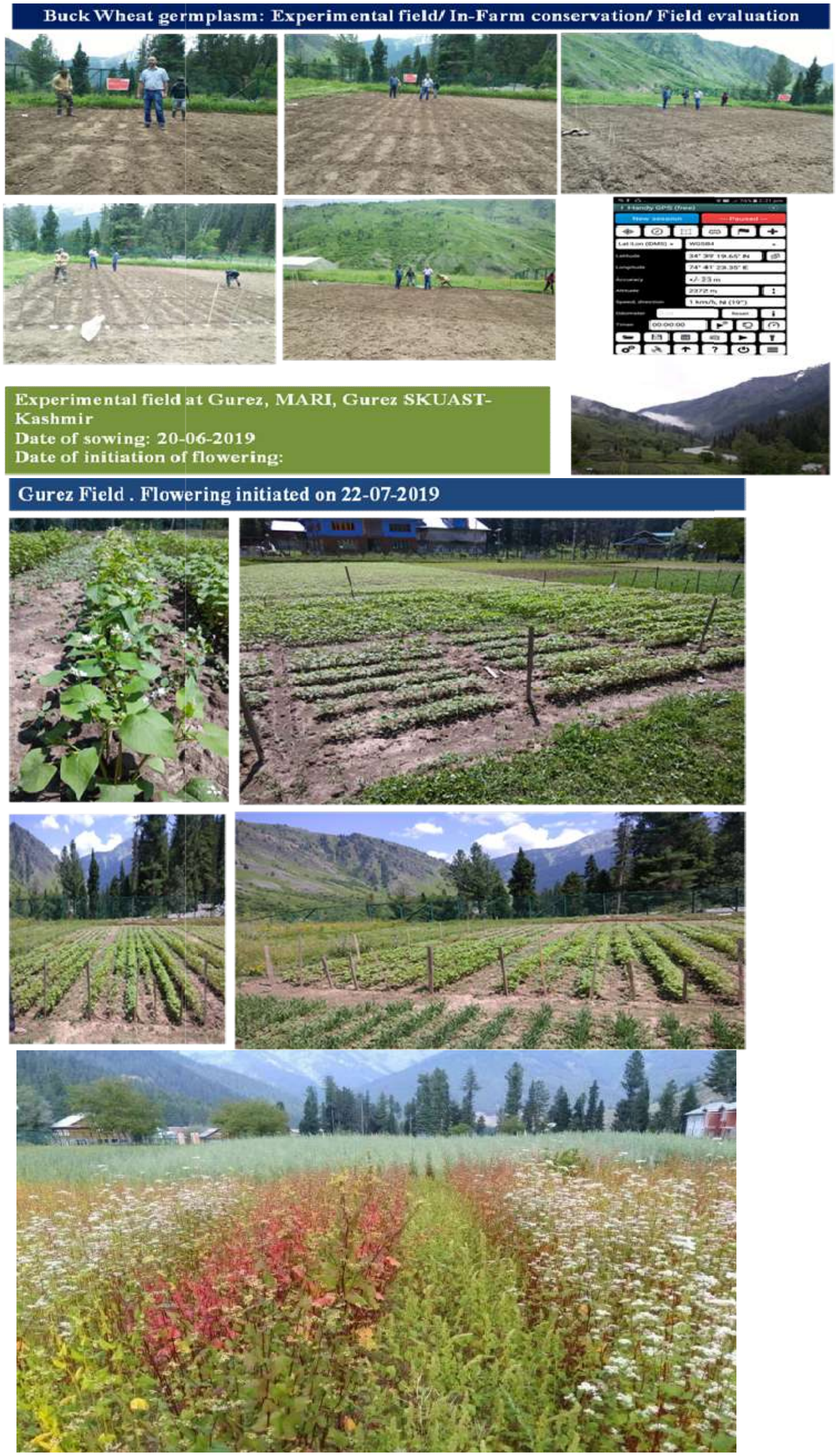

Plate 4: Buckwheat germplasm (landraces): On Farm conservation

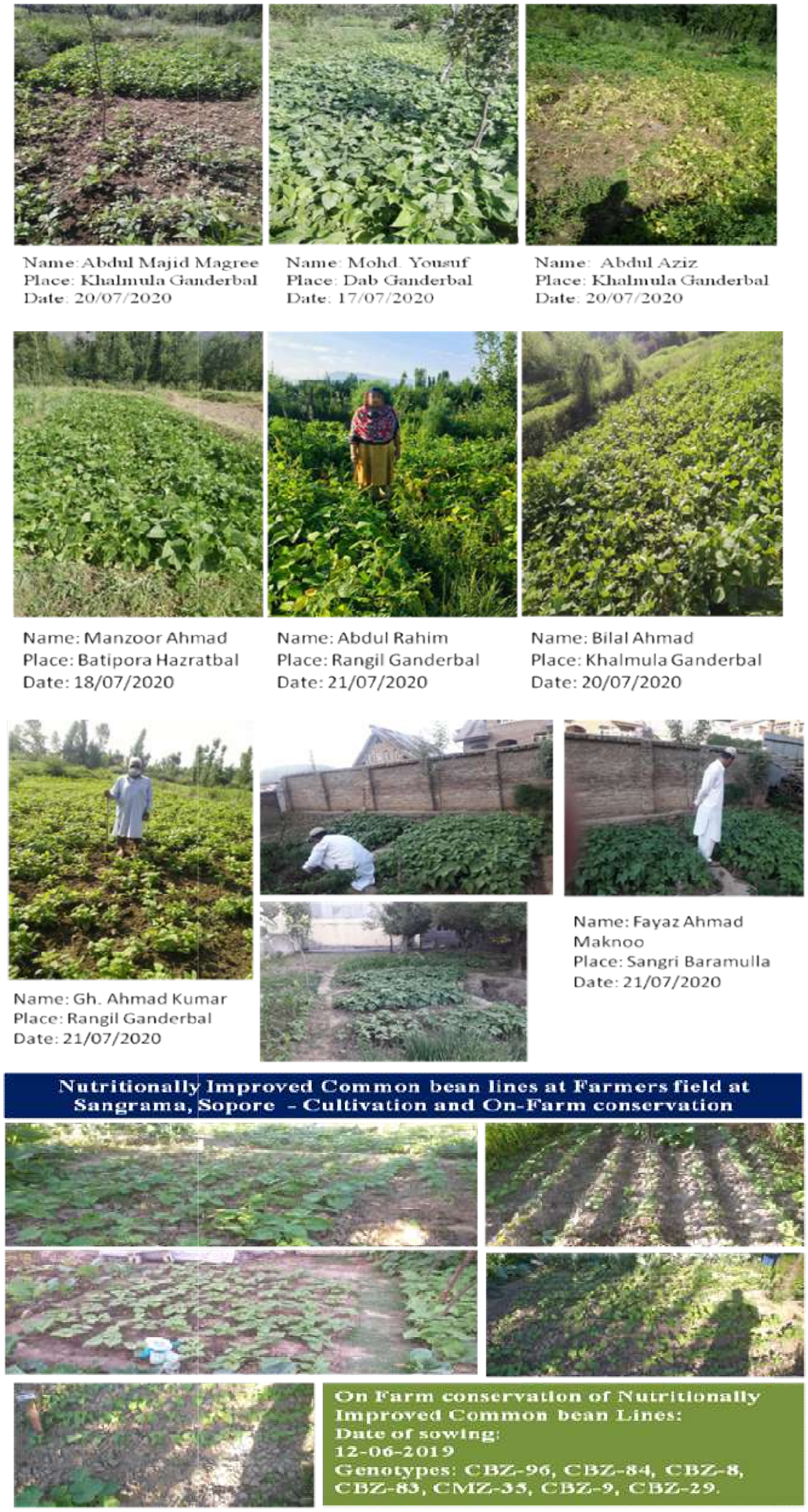

Plate 5: Adaptation of nutritionally superior genotypes of common bean by farmers by cultivating on their farms

8

CONCLUSIONS AND RECOMMENDATIONS

In order to multiply the productivity of agriculture in India, it is pivotal to augment the treasure of agro-biodiversity of the country. According to FAO, about 75 percent of world's crop diversity has been lost irreversibly over the 20th century. Moreover, with the introduction of modern agriculture, many landraces were replaced with high-yielding and genetically uniform advanced varieties. For instance, about 30,000 rice varieties were once grownin India, which has been drastically reduced as many landraces either are replaced with the modern cultivars or are restricted to small areas. This has posed serious threat to landraces in terms of genetic base, which has become tapered due to the loss of landraces, which in turn has caused loss to the biodiversity.In our global production system, loss of agro-biodiversity is a seriousconcern as predicted by the Rio Convention on Biological Diversity and the Sustainable Development Goals of the United Nations. When we lose agricultural biodiversity, simultaneously our option of having healthier diets and making our food systems more sustainable and resilient is also lost. To promote sustainable use and conservation of landraces, government should initiate following tasks on priority:

1. **To assist community seed banks development and the multiplication of the seeds available in these seed banks:**
   Crop diversity preserved by farming communities will be conserved by this initiative, which will also facilitate farmers timely, and easily with locally acclimatized and diverse seeds. Besides, it will also facilitate education and training and contribute to related income opportunities and probably to seed ownership.

2. **To address the need to maintain and regenerate seed collections in many gene banks:**
   It is essential to provide facilitated access, conserve and maintain crop landraces in geographic and national gene banks. This will safeguard the cultural heritage of a region or country, and provide access to important characteristics food production and for future agriculture.

3. **To strengthen and develop the sustainable use and conservation of crop diversity globally:**

   To complement traditional seed banks, other methods that include cryopreservation, *in-vitro* tools and techniques and in-situ conservation of crop wild relativesis required. Further, the information systems related to manipulating, storing genomic data and digital crop diversity is required.