Research and Development work in agrodiversity

Diversity in agriculture covers variability existing both in domesticated plants and animals. More than 150 crop species are cultivated in India and many of them are native to this country (Tables 1 and 2), which makes it extremely important to plan and conduct research on all the aspects of domesticated biodiversity which is also termed as *agrobiodiversity*.

Table 1. Cultivated crop species originated in India

Crop Group	Crops
Cereals	Rice, Little millet
Grain Legumes and Oilseeds	Black gram, Green gram, Moth bean, Red gram, Horse gram Sarson
Vegetables	Brinjal, Cucumber, Ridge gourd, Pointed Gourd, Snake Gourd, Round Gourd, Kundru, Arbi, Jimmikand, Leafy Mustard
Fruits	Citrus, Banana, Mango, Jamun, Karonda, Khirni, Phalsa, Bael, Wood Apple, Jack Fruit
Spices and condiments	Ginger, Turmeric, Cardamom, Arecanut, Black Pepper, Betel leaf, Cinnamon
Others	Sugarcane, Sunhemp, Tree Cotton, Jute, Bamboos, Tea, Dhaincha

Source: Gautam and Singh, 1998

Table 2. Cultivated crop species grown in India

Crop group	Number
Cereals	7
Legumes and Oil seeds	13
Vegetables	29
Fruits	22
Fiber and Fodder plants	18
Spices and Condiments	17
Medicinal and Aromatic plants	20
Others	42
Total	**168**

Source: Gautam and Singh, 1998

PART I. EXISTING RESEARCH SETUP ON DOMESTICATED BIODIVERSITY

National Agricultural Research System (NARS) comprising of Indian Council of Agricultural Research (ICAR) and State Agricultural Universities (SAUs) is the network of various organisations that are engaged in carrying out agricultural research. ICAR is a body which controls and directs major part of research work on domesticated biodiversity in the country. ICAR is a vast network of Institutes and Bureaus (Appendix 1), National Research Centers (Appendix 2) and Project Directorates (Appendix 3). Besides these research organizations, thirty one SAUs also exist (Appendix 4), which in turn cover

almost all parts of the country. To avoid duplication and to have proper linkage among researchers working in particular research aspects, crop/crops across the country, All India Co-ordinated Research Projects have been formulated (Appendix 5). In addition, many CSIR institutes and other centres are engaged in agricultural research directly or indirectly. Plant and animal breeding is one of the main activities in almost all the research centers. Plant breeding invariably needs base collection of germplasm from which the desired characters are brought together. Thus, each and every center working on breeding has at least a working collection of domesticated biodiversity.

Besides such collections, there are repositories of genetic material maintained by National Bureaus. There are three National Bureaus in the country taking care of domesticated biodiversity.

1. National Bureau of Plant Genetic Resources (NBPGR), New Delhi.
2. National Bureau of Animal Genetic Resources (NBAGR), Karnal, Haryana
3. National Bureau of Fish Genetic Resources (NBFGR), Lucknow, Uttar Pradesh.

These Bureaus act as nodal organizations in India to carry out planning, conducting, promoting, coordinating and leading all activities concerning collection, introduction, exchange, evaluation, documentation, conservation and sustainable management of domesticated biodiversity with a view to ensure their continuous availability for use of breeders and other researchers in the country. Besides their main centers/headquarters these bureaus also have regional stations. For instance, in case of NBPGR, the Bureau functions from the headquarters in New Delhi, with a network of 11 regional stations spread in different agro-ecological zones of the country. Indian National Plant Genetic Resource System operates through NBPGR with a strong linkage with 40 national active germplasm sites and 131 other cooperators.

Agrodiversity encompasses i) land races/local cultivars ii) wild and weedy relatives of domesticated crop and animals iii) wild species/underutilised crop species iv) Advanced cultivars and breeding materials generated by research organisations.

Research activity in agrodiversity can be mainly classified into i)Exploration and collection ii) Characterisation and evaluation iii)Conservation and iv)Utilisation of germplasm

1. Exploration and collection of germplasm

Germplasm exploration is done to

(i) equip on going crop improvement activities with novel genetic material.
(ii) collect the genetic diversity for future use.

Germplasm exploration, collection and evaluation is part of ICAR activities. Every year exploration work for collection of germplasm material takes place and germplasm is added to the existing collections. For instance, a list of germplasm collected from different parts across the country in the year 2000-01 is given below,

Crop group	**Collections**
Cereals	3535
Pseudo cereals	189
Millets and minor millets	775
Vegetable crops	2849
Oil seeds	1028
Pulse crops	1811
Horticultural Crops	279
Fibre and allied crops	98

Other groups*	2020
Total	**12584**

Source: DARE/ICAR annual Report 2000-01

*Medicinal and aromatic, underutilized species, spices and condiments, tree species and grass species

Apart from planned explorations, ICAR also responds to crisis by organising emergency explorations. For instance, from cyclone ravaged parts of Orissa, 1400 germplasm of various crops were collected by the NATP (Plant Biodiversity) rescue missions in 2000-01.

In addition, even the researchers of traditional universities and non agricultural research organisations undertake this activity to a limited extent. University Grant Commission (U.G.C.), Department of science and Technology (D.S.T), Council of Scientific and Industrial Research (C.S.I.R.) supported research schemes in non agricultural universities, and research schemes in Botanical Survey of India (BSI), National Botanical Research Institute (NBRI), Forest Research Institute (FRI) also take up plant exploration activity. At present there also exists a program on creation of biodiversity register with the nodal center at Indian Institute of Science. However, such activities concentrate on survey work and deal with species level diversity. Though, agrobiodiversity has more to do with variability existing within a species, the explorations carried out by these non-agricultural organisations act as benchmark to locate species rich regions and facilitate the utilisation of related species of domesticated crops.

2. Characterization/Evaluation of germplasm

Germplasm utilization mainly depends upon the evaluation process. This stage involves a logical chain of activities involving multiplication of collections, characterization, actual evaluation and documentation of morphological, physiological and developmental characters including some special features such as stress tolerance, pest and disease resistance etc.

The specific evaluation depends on mandate of institute as well as crop and objectives of the research program. For instance, in case of cotton at Central Cotton Reseach Institute (CCRI), Nagapur, evaluation is done for yield and quality parameters such as fibre quality and seed oil. Evaluation is also being made for resistance to insects such as sucking pests and bollworms; for resistance to diseases such as gray mildent and bacterial blight. Unlike the evaluation done at CCRI, Nagpur, at Central Institute for Research on Cotton Technology, (CIRCOT) Mumbai, evaluation of cotton is concentrated on quality parameters. Thus, although both institutes work on same crop, the objective of germplasm evaluation varies from institute to institute.

At NBPGR, all major and minor crop groups collected from across the country are evaluated and catalogues are prepared. More than seventy catalogues have been prepared on number of crops including maize, soybean, okra, sesamum, guar, moth bean, mung bean, amaranth, sunflower, oats, barley, wheat, triticale, rice bean, cowpea, trigonella, ajwan, opium, sesbania, safflower, kodo millet, foxtail millet, forage sorghum, pearl millet, chickpea, lentil, linseed, methi, french bean, tomato, chillies, brinjal, banana, yam, greater yam and taro. Research acitivity at NBPGR also includes developing protocols for evaluation procedure. For instance laboratory evaluation protocols such as NMR and biochemical evaluation protocols of crops for oil content, protein, quality traits, phytochemical evaluation of medicinal and aromatic plants are optimized for routine use.

Germplasm evaluation helps in introduction of cultivars from one region to another. As a result of evaluation, so far more than 100 varieties comprising a range of crops are released across the country by direct selection and introduction method.

Besides morphological, physiological and quality evaluation, research efforts are also being concentrated on characterisation at molecular level. Finger printing of land races, varieties/hybrids developed becomes a point of reference for safeguarding the ownership over crop varieties. Thus, initiation is made for developing fingerprints of various crops. DNA profiling has been completed in several varieties of crop species. Number of varieties in different crop species where in fingerprinting is completed is given below,

Species	Number of cultivars
Rice	80
Wheat	96
Barley	50
Sorghum	30
Pulses	55
Oil seeds	42
Fibre crops	17
Hort. crops	30

Source: ICAR/DARE annual report 2000-01

At NRC on Mithun, Nagaland, DNA profiling of mithun and indigenous cattle indicated the difference between the two. Altogether, molecular genetic characterisation is going on in following indigenous breeds of animals,

Animal	Breeds
cattle	Shiwala
sheep	Garole, Nali and Chokla
goats	Barbari and Jamunapari
buffalo	Murrah, Mehsana, Nili-Ravi and Jaffarabadi
poultry	Nicobari and Miri fowls and also several indigenous and exotic
Pigs	Assamese pigs (Gouri), desi pigs of Haryana and Andamannese wild pigs

Source: ICAR/DARE annual report 2000-01

3. Conservataion:

Conservation is the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations, while maintaining its potential to meet the needs and aspirations of future generations (IUCN, 1980. World conservation strategy. Gland, Switzerland). In simple terms, conservation includes preservation, use, restoration and management of germplasm.

There are two basic approaches of conservation. *Ex situ* and *in situ* conservations. *In situ* conservation refers to maintaining the genetic resources in their natural condition. *In situ* conservation approach is mainly adopted for animal species and wild species of crop plants. Other than this, research efforts in agrodiversity in India is mainly concentrated on *ex situ* conservation.

3A. Plants

In broad terms *ex situ* conservation includes storage of seed and vegetative material in genebank. Those species which are propagated by seeds are stored in seed genebanks and those species which are vegetatively propagated through non-seed propagules such as cuttings, are maintained in field genebanks. Seeds are of two types, orthodox and recalcitrant seeds. Orthodox seeds are desiccation tolerant hence, can be dried and stored where as the recalcitrant seeds lose viability with drying and hence its difficult to store them over a period. Crops having recalcitrant seeds are conserved in field genebanks. For instance NBPGR regional stations maintain field genebanks of perennial crops belonging to the respective zones. Ranchi station has the field genebank for tropical fruits like bael, palash, jamun, jackfruit, anola etc; Jodhpur station maintains pomegranate, jojoba etc; where as regional station at Shimla operates as field genebank for temperate fruits such as apple, almond, apricot etc.

Agrobiodiversity is maintained as either base or as active collection under *ex situ* conservation. Base collection referes to conservation of germplsam for a longer period and is maintained in major genebanks and gene repositaries of National germplasm conservation centres. On the other hand, active collection referes to storage of germplasm for short to medium periods of time. Appendix 1,2,3,4 and 5 provides respectively the list of Institutes and National Bureaus, National Research Centers, Project Directorates State Agricultural Universities and All India Co-ordinated Research Projects where in active germplasm collections are being maintained.. Efforts on conservation of germplasm for short and medium term storage is being carried out in all these centres depending upon the region they are located and crops on which breeding programs are concentrated.

Germplasm conserved in each research center varies depending upon mandate of the center and nature of research work. As an illustration following examples are provided to indicate conservation activity taken up by few centers.

CAZRI (Central Arid Zone Research Institute) is an institute at Zodhpur, Rajasthan established to take care of the research needs of arid and desert region. Crop varieties required by the farmers of the region are different from other area. The crops have evolved in the desert region to withstand erratic weather parameters and poor soil physical as well as fertility conditions. The institute is maintaining the diversity in pearl millet, clusterbean, horsegram, moth bean, mustard and grasses. A large number of varieties, like Jalore, a seedless variety of pomogrante, local varieties of bael such as Dhara Road and Faizabadi, kanchan and Krishna of anola, have been identified and conserved by CAZRI that can be successfully raised even on marginal lands with certain conservation measures. Marwari and Magra breeds of sheep have been identified to be suitable for the desert tracts as these breeds can sustain if watered twice a week without any adverse effects on body weight.

CICRI (Central Institute for Cotton Research Cotton) at Nagpur has a National Gene bank on cotton, and a rich repository of cotton germplasm with more than 9700 accessions of 4 cultivated species of cotton and over 300 accessions of perennials including 24 wild species is being maintained, evaluated and utilized. Eco-friendly, naturally coloured and organic cottons also exists in the collection.

A list of institutes concentrating on various crops is given in Appendix-6 which invariably maintains the diversity available in these crops. There are 15 National Research centres working on various crops (Appendix 2). These NRCs take care of conserving all possible variability available in particular crop species. For instance, NRC for Banana at Trichy has a collection of 900 accessions; NRC for grapes at Pune has a collection of 265 accessions.

Long term storage:

In this approach, germplasm is conserved for a long period under very low temperature. Long term storage of seeds, pollen and plant parts require advanced infrastructure facilities and is taken up by major conservation centres.

Genebank at NBPGR holds the fourth largest *ex situ* collection in the world with more than two lakh accessions belonging to nearly 200 species as *base collections* at -20°C. It has a capacity to hold more than a million accessions with laboratory facilities to carry out research activities. NBPGR follows all international norms for seed conservation and monitoring of seed viability and health is a priority work. National Active Germplasm Sites spread over the country maintain *active collections* under medium term storage at 4°C. These National Active Germplasm sites concentrate on regeneration and restoration of germplasm work. A detailed list of conservation status made by NBPGR is presented in Apendix 7. National Active Germplasm Sites for various crops and their germplasm holdings is given in Appendix 8.

Long term storage requires development of suitable protocols. Some of the important aspects on which research work is going on at NBPGR is listed below.

- Basic research on issues related to seed storage behavior and factors that may influence the seed longevity with a view to cost reduction is being carried out.
- Seed weight-volume relationship in 26 crop species has been worked out to optimize the container size and storage space.
- Deleterious effect of fumigation on seed germination and seedling vigor in pulses such as chickpea and mungbean was observed indicating the need for an alternative protocol of pest free conservation in pulses.
- Effects of ultra-desiccation on the viability were investigated to generate information on its usefulness as a cost-effective seed storage strategy.
- Seed storage behavior of hitherto unexplored species has been worked out e.g. *Emblica officinale, Santalum album, madhuca indica* etc.

***In vitro* conservation**

More than a thousand accessions belonging to tuber & bulb crops, spices & industrial plants, fruits, medicinal & aromatic plants have been conserved.

- Development of conservation protocols to prolong subculture interval by optimization of low temperature e.g. 12 to 20 months for banana and ginger at 15°C; Use of osmotic agents such as mannitol e.g. 12-16 months in sweet potato at 25°C; Cytokinin in the medium e.g. 14 months in yams; Minor modifications in the media e.g. 20-24 months *Piper, Rauvolfia* etc.
- Detection and elimination of virus- Major glitch in the maintenance of clonal repositories is the perpetual presence of virus. Advanced ELISA based techniques and electron microscopy were used independently and in combination to detect virus and meristem culture was optimized to eliminate the virus. Eg. Sweet potato feathery mottle virus was for the first time reported to occur in India and meristem culture was used to eliminate the virus.
- Avoidance of browning- Establishment of cultures *in vitro* suffers from browning of the tissue especially in perennial species. A simple and economical approach of sealing the cut ends with paraffin wax to prevent browning has been a major contribution in the field.

Cryopreservation:

The NBPGR cryobank has the capacity to conserve more than 30,000 accessions. More than three thousand accessions belonging to 140 genera have been cryopreserved. These include orthodox, intermediate and recalcitrant species. This requires the development of successful protocols for the

storage of seeds, embryonic axis, pollen, shoot tips and meristem cultures. Biochemical and physiological aspects of seed recalcitrance were studied to develop successful protocols for cryopreservation of embryonic axes in tea, jackfruit and in an intermediate species almond.

***In vitro* holdings**

Crop group	Accessions
Tuber and bulb crops	468
Spices and industrial plants	251
Fruits	383
Medicinal and aromatic plants	65
Total	**1167**

Source: NBPGR: A compendium of achievements, Dhillon et al (2001).

Cryopreserved germplasm

Crop groups	Accessions
Cereals and millets	341
Legumes	419
Oilseeds	211
Vegetables	246
Fruits and nuts	269
Spices and condiments	51
Medicinal, narcotics and aromatic plants	433
Fiber and Fodder crops	19
Plantation crops and agro-forestry species	989
Total	**2978**

Source: NBPGR: A compendium of achievements, Dhillon et al (2001).

3B. Animals

Unlike in plants, approach for conservation of animal genetic resource is different. Its important that they have to be understood with their habitat for proper conservation. Research attempts are under progress for the same. Compared to plants *in situ* conservation is given more importance in animals. Under a Network Project of ICAR on Animal Genetic Resources, indigenous cattle, buffallo, goat and poultry were studied under their home tracts. Its interesting that research personnels have taken care of not just the diversity of races of animals but also the feed and related information. For instance RAU, Bikaneer has made a socio-economic survey of the goat keepers which indicated that small flock size (1-5, 6-10) were predominant in the field area. Role of women in goat management was found significant under field conditions. A data information system on the feed and animal resources of India was developed under a Net work Project on Animal Genetic resources.

Unlike the concentration of research effort in plant genetic resources to make *ex situ* collection, research in animal genetic diversity concentrates on understanding the diversity available in different eco-systems and possible attempts for *in situ* conservation. Assessment of Ichthyo-diversity in central Himalayan river system revealed 30 species. An assessment of ichthyo diversity in the drainage system in Central Himalayas was conducted. 25 species in Garhwal region and 16 species in Kumaon region were recorded. NBAGR, Karnal is engaged in field surveys, physical characterisation, sustainable utilisation and conservation of indigenous livestock and poultry breeds. Systemic field surveys were undertaken to assess the population status of the breeds, socio-economic condition of the farmers, production performance and interaction of local ecology with the breeds. A systematic and scientific evaluation has been made for the local breeds of animals. The breeds and the area where the study was undertaken is listed below.

Animal breed	Study area

Spiti horses	Kaja sub division of Lahaul and Spiti districts, Hangrang tehsil
Beetal Goats	Gurdaspur, Amritsar and Ferozeput districts of Punjab
Nili-Ravi Buffaloes	Ferozzepur and Amirtsar districts of Punjab
Sahiwal cattle	Amritsar and Ferozepur districts of Punjab
Kodi Adu goats	Tamil Nadu
Tharparkar bulls	Suratgarh
Barbari goat	Agra, Aligarh and Etah districts
Double humped camels	Nabhra valley, Kashmir
Jamunapari goats are being conserved in their home tract	By Central Institute for Research on Goats, Mathura, U.P

The *in situ* conservation models for different species were developed for implementation. Superior germplasm incase of Barbari goat was identified at Etah district and the farmers are advised for conservation of these animals in their native tract. Under network project the following sheep and goat breeds are being improved at the following stations and invariably these research stations will be having all the possible variability within them.

Sheeps: CSWRI, AvikanagarChokla sheepArid Region Campus of CSWRI, BikanerMarwari sheepCIRG, MukhdoomMuzaffanagri sheepMPKV, RahuriDeccani sheepANGRAU, PalmneerNellore sheepRAU, BikaneerMagra sheepTNUVAS, KattupakkamMadras Red sheep

Goats: CIRG, Mukhdoom, Mathura, U.P,

- Jamunapari Goats NDRI, Karnal , CIRG, Mukhdoom, Mathura, U.P,
- Jamunapari, Barbari and Sirohi Goats: All India Co-ordinated Research Project (AICRP) on Goat improvement takes care of Jamunapari, Barbari and Sirohi breed of goats.

Pigs: AICRP on pigs has its centres at IVRI, Izatnagar, AAU, Khanapara, ANGRAU, Tirupati, KAU, Mannuthy, TNUVAS, Kattupakkam and JNKVV, Jabalpur. The objective is to produce lean type pigs with faster growth, high prolificacy and excellent feed conversion ability. As a breeding project the centres involved invariably holds the landraces.

Fishes: The data base on fish diversity of India has been developed. The database is targeting at images of fishes along with karyotypes and gel images. The database includes conservation status and endemicity of fishes in specific rivers. Assesment of ornamental fish resources at Lakshdweep revealed nearly 165 fish species of 20 families. River Sutlej was surveyed for ecology,biodiversity and fishery.

Fowls: Research work on conservation and utilization of indigenous fowl mainly Aseel Kagar, Aseel Peela Kadakanath and Dahlem Red is in progress. At the Central Avian Research Institute, Izatnagar, UP some of the best germplasms of avian species in the country are maintained.

Mithun: NRC on Mithun, Nagaland has collected 4 strains of mithun from Mizoram, Manipuri, Aunachala and Nagaland.

Cattle: The Project Directorate on Cattle, Meerut has been engaged in conservation and genetic improvement of indigenous cattle breeds, viz., Hariana, Ongole, Gir and Tharparkar in their native tract through Associated Herd Progeny Testing Programme.

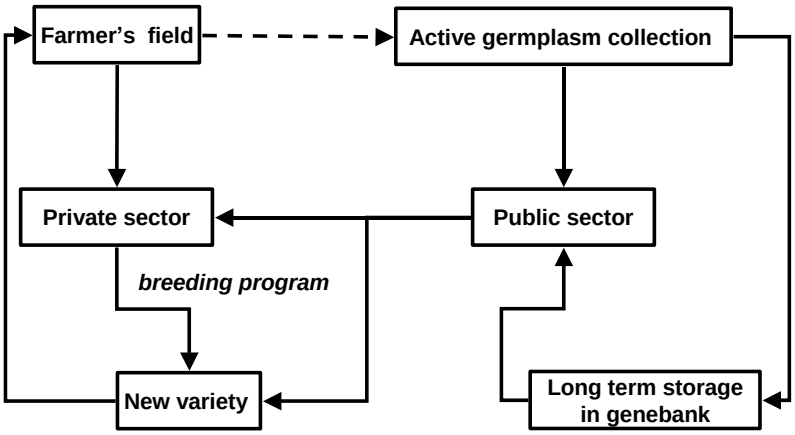
Long term storage: Under preservation of animal genetic resources program, a technique for obtaining primary cell culture from ear tissue of goats was standardised.

Part II. GAPS, STRATEGY AND ACTION PLAN

Conservation and utilisation of plant genetic resource is done by researchers. It is important to realise that these diversity in domestic genetic resources have evolved in farmers fields with their direct or indirect

involvement. The resource is collected with a good will of returning to him or his fellows in improved format. Thus genetic resource is from him and for him. However, in the whole process his role is passive. And if there is any active involvement is there, then it is in the form of making payment ironically enough, payment is made by the farmer to the seeds which might have been taken from him but coming back in different form. Infact, genetic resource collected is used in breeding programs to release it straight as a named variety or will be utilised to incorporate its characters in some other genetic background.

Plant genetic resource is always considered as a 'means' for some other 'end' and never as an end in itself. Though they have become means for achieving economical returns for the outsiders, it could not generate anyting for its stake holders. Thus the domesticated biodiversity in its natural state is considered as 'means' for the outsiders. Land races have evolved in farmers's field where in lifetimes of generations and almost all their resources have gone into. There is no economic returns made when these land races are collected from their site of origin. But they become payers for the commercial product which is derived from their own material.



Broken arrow: The crucial step for the whole cycle; however, no economic returns to the persons/organisation from where it is collected.

Solid arrow: Researchers involved are paid. Economic activity exists.

With the recognition of farmers right over varieties by CBD, it is time to reconsider the value of these genetic resources. Reconsideration has to be done not just for the utility value to outsiders but for the returns that it can generate for the stake holders. Thus, when the agrodiversity becomes both 'means' and 'end' it should be able to generate income and also will be able to sustain itself. For this to happen a) Economic cost involved in maintenance and evolution of landraces have to be realised b) Economic utility value of genetic resource have to be highlighted c) Mechanisms should be generated for value addition and for validating the agrodiversity d) Instead of considering agrodiversity as a common and public property, outsiders should be made to pay a price for any sort of utilisation of this resource e) Farmers right have to be validated on par with plant breeders' right.

Commercial varieties are advocated for their high potential under optimum conditions which inturn are replacing the landraces. Unlike commercial varieties which have high productivity and hence has an appeal for the growers; characters of land races are more of hidden nature. A comparative list of land race and commercial variety is provided for appreciating the value of both.

Table 3. Comparative values of a land race and a commercial variety

	Land race	**Commercial variety**
Uses	Hidden /unexpressed and unrealised	More visible and market oriented
Cultural need	For religious cermonies and social	Nil

	functions land races with particular characters are needed	
Taste factor	Tasty	Less valid
Culinary factor	Postivie attributes	Less valid
Weather changes	Easily Adaptable	Becomes vulnerable
Suitability	Well suited for agro-ecological niche	Well suited for uniform and optimum condition
Marketability	Least considered	Highly valid
Productivity under optimum conditions	Less	High
Demand of external inputs	Low	High

Commercial activity of varietal development has always neglected the hidden value of landraces and had always become subject of exploitation by outsiders. Hence, we would like to present here strategy and action plan as a self sustainable development model where in genetic resource can become income generating mechanism able to sustain itself.

1. Germplasm exploration and conservation

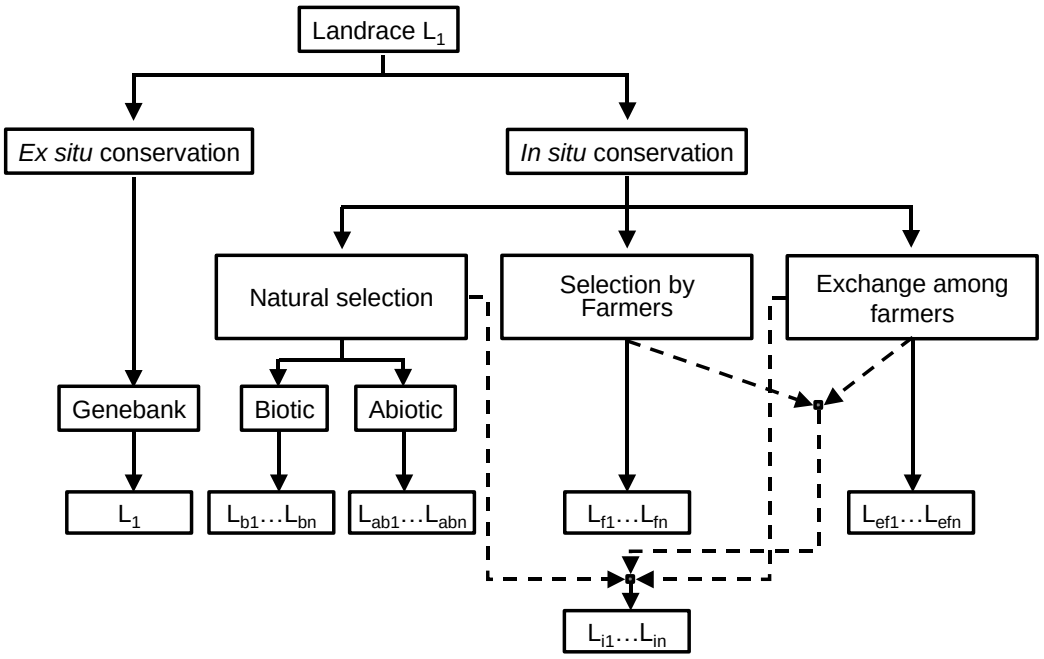
Gaps

1. So far, the exploration activitiy is done by outsiders. However efficient an explorer is, components of diversity could be left out to a certain extent either because of constraint due to time viz., non availability of a variety during the time of visit or due to accebility viz., certain variety may be available in backyard of some particular house which might never come to notice of an outsider. More over it is important to realise that exploration for collecting genetic resource in domesticated diversity is entirely different from collection of wild species. Many a time its only local people who are aware of the existing diversity and location of exact farm or backyard where it exists.

2. It is important to understand that domesticated diversity is valid when its hidden values are realised. So, its not just seed, besides seed, a lot of information also have evloved with it. It may be related to cultivation, conservation, food preparation, taste and several such other things. Hence, it is important that these information have to be collected along with the seed. Thus along with indigenous varieties it is important to make a record of indigenous knowledge.

3. For the ease of management and study, traditionally ‘components’ of diversity are conserved and ‘functional interactions’ between crops, varieties are ignored e.g. seeds of varietal mixtures, mixed cropping are neglected which are crucial for continuous evloution of varieties. Since *ex situ* conservation can not handle such situations, the variety gets freezed stopping all possible evloution process. On-farm approach to conserve land races together with the potential interactions between co-evolved components needs examination. The following figure tries illustrate the case of insitu conservation over ex situ.

Fig.2 Evolutionary process of land race under *in situ* conservation over ex situ conservation.



L_1 = Existing Land race
$L_{b1}..L_{bn}$ = Land races evloved in response to biotic stress
$L_{ab1}…L_{abn}$ = Land races evloved in response to abiotic stress
$L_{f1}…L_{fn}$ = Land races evloved in response to farmers' selection
$L_{ef1}..L_{efn}$ = Land races evloved in response to exchange among farmers
$L_{i1}…L_{in}$ = Land races evloved in response to interaction effect

With conclusion of the CBD and Agenda 21, and the adoption of Global Plan of Action by the participating countries, a significant emphasis has been given to *in situ* conservation. Following are the four basic kinds of multidisciplinary research pointed out as required to successfully run the *in situ* conservation (FAO, 1996 FAO 1996 Report of the International technical Conference on Plant Genetic Resources, Leipzig, Germany. 17-23 June 1996).

a) 'Ethnobotanical and socio-economic research to understand and analyse farmers' knowledge, selection/breeding, utilisation and management of plant genetic resources with the approval of the involved farmers with applicable requirements for protection of their knowledge and technologies'.

Ethnobotany is an improtant aspect to be researched. However, it is important to evolve a mechanism to safeguard these informations as a private property of the people. It's a known fact that the farmers and even the region which is rich in genetic diversity is poor in terms of economic consideration. The main reason behind this being lack of maximum production parameters in these varities though many of the varieities are sustainable in terms of prodcution over time and over varying weather condition and has all the hidden values as listed in table 3. Thus, low yield and lack of marketable factor inturn leads to lower economic returns.

b) 'Population and conservation biology to understand the dynamics of the local landraces and farmer's varieties (population differences, gene flow, degree of inbreeding and selection pressure etc.)'.

This research can be ideally developed to fix up a minimum plant population that can be maintained with minimum resources.

c) 'Crop improvement research in mass selection and simple breeding without significant losses in local biodiversity'.

Particiaptory plant breeding activity can be strengthened to enhance and supplement the existing genetic resources. Introduction of lines from outside to the farm in turn would also direct the course of evolution of existing land races in the farm giving a chance for farmer to widen his base for selection.

d) 'Extension studies for lesser-known crops including their seed production, marketing and distribution'.

There is a need to create a demand for the local crops and land races which can be achieved through value addition process by highlighting the positive value in them. Ideal way of postharvest handling and preservation proceadure has to be worked out properly for each one of them. For instance, in case of jackfruit and local varieties of mango, certain regions are rich in terms of diversity and production. But these areas are remoted and the crop looses it marketable value due to short post harvest life span. Certain indigenous preparations can be standardised for long shelf life and marketing. There is a lack of commercialisation approach for these productus. There is a wide gap between existing diversity and economical returns, which has to be filled with value addition.

Strategy:

a) Involvement of locals:

To address efficient collection process, it is important to involve local people to a maximum in exploration and collection activity. Since, the value of crop varies with i) men - who normally concentrate on value of a variety from the point of cultivation and ii) women - who concentrate on culinary and taste aspects; it is important to involve both men and women while identifying varieties for collection.

b) *In situ* conservation for continuous evolution of varieites:

Unlike other plant genetic resources at a species level, that exists in wild where its possible to set aside areas for their insitu conservation, these domesticated diversity exists in farms so it is difficult to make *in situ* conservation. Growing of land races can always be sustainable but when short term benefits and needs are considered, its economical to grow improved high yielding varieties which has high remunerative value mainly because of high productivity. Thus, there exists a trade off between hidden values, conservation of diversity vs. economical returns. There is a need to highlight the benefits of cultivating landraces and there is a need to evolve a mechanism for realising economical returns from domesticated diversity.

c) *In situ* conservation and economic viability:

Stratigies have to be developed to take care of *in situ* conservation and at the same time to make it an economically viable proposal for the cultivators.

d) Decentralisation of research activity:

Being alienated from field, cultivation, consumption or usage of land races, researcher within formal research set up would never be able to understand landraces in their true potential. Alternatively, its either NGOs or locals and even extension workers who work with people and are in field will have more understanding about the diversity its true potential. Involvement of these people inturn would enrich the research activity. There is a need to combine scientific knowledge with community approach. Even at the research setup, decentralisation of conservation activity to regional stations is more advisable concentrating on few issues at central research organisations. Self sustainable seed conservation process

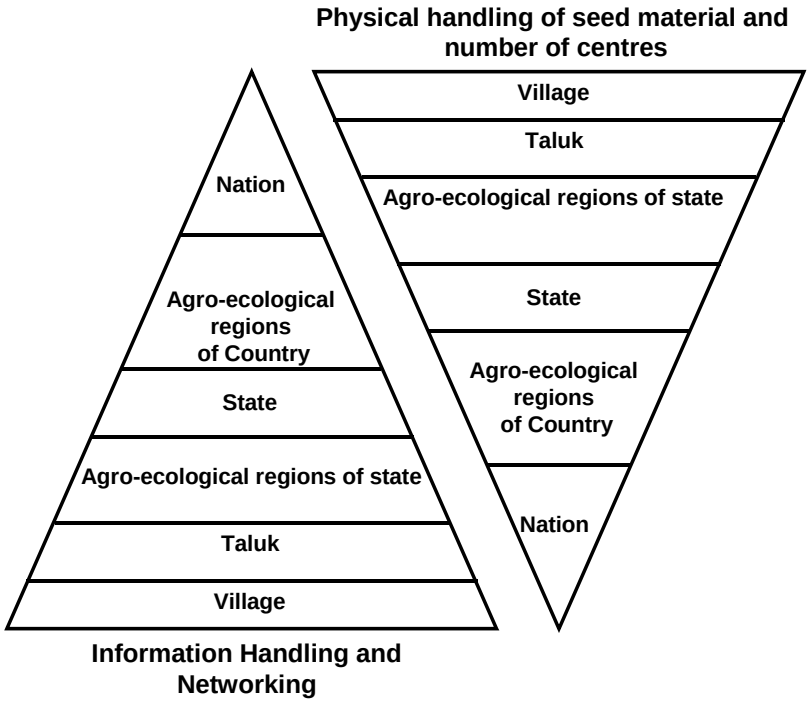
has to be developed. Linking of conservation activity with information technolgy has to be evolved to facilitate accessibility of genetic resource across centres and for facilitating the recommendations of CBD to honor Farmers' rights on par with plant breeders' rights.

Action plan:

Conservation of Domesticated diversity can be encouraged by
i) Supporting cultivation of land races by providing inputs in subsidised price ii) Fixing up higher procurement price for land race iii) Conservation at a village level in an economical pattern either through community or through individual approach. The first two would always demand resource from outside the system and hence is not advocative over long term. Where as the 3rd approach is more self sustainable.

Exploration and collection activity is devided to two major components.

i. Handling of genetic material.
ii. Handling of information associated with the material.



Major portion of physical handling of landraces can be left with local areas with the local people. However, all the detailed information regarding the characters along with available quantity can be linked across the country with the central linking point lying with National gene banks. A proper record has to be maintained for each one of these varieties. There can be chain of links from village to national level (as represented in the model)

A. Physical handling:

a)Exploration and collection activity can be decentralised and can be handed over to regional research stations of SAUs and that of ICARs. These research stations in turn should co-ordinate the exploration and conservation process at each village level and should act as a point of cross reference for exchange of varieties across regions/states.
b)Existing system and centers can be utilised for gathering information on agrodiversity, to build registers, short term storage of varieties and for developing seed banks. Several Krishi Vijnana Kendras (KVK)

exists under each research institutes. The National Agricultural Technology Project (NATP) has supported Institution village linkage programme (IVLP) which aims at achievements of technology assessment and refinement through IVLP at 44 project centres covering over 36194 farmers in 151 villages. There are 40 Agricultural technology Information centers (ATIC) which are bing implemented by 25 state agriculatural Universities and selected 15 ICAR research institutes. All these can be roped in together for conservation activity of genetic resources.

b)Local agricultural, horticultural and veterinary officers who act as one way channel of taking improved varieties from lab to land can be involved in conservation of existing landraces. Horticultural Departments have their own farms which can be used as conservation sites. School grounds can act as repository of landraces.

d)seedfarms can be established in cluster of villages or at Panchayat levels.

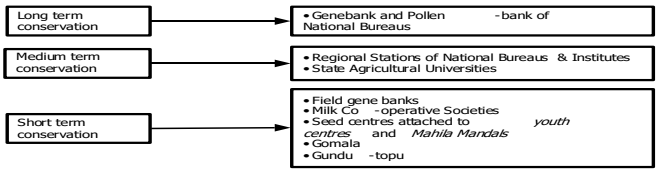
e) seed mulitplication by local youth clubs as well as Mahila mandals have to be encouraged and a link with seed companies and NSC as well as seed corporation of states, state department of agriculture and horticulture can be established for making it a self sustainable economic process.

f) Agricultural graduates can be encouraged to start seed farms in villages in accordance with establishment of farm clinics. These seed farms can act as repository of all possible intraspecific diversity of important crops of villages surrounding. These can also act as advisories for addressing and tailoring the specific needs of farm family.

g) Conservation sites of fruit crops and perennials at road sides can be aimed and rights can be alloted over that to local individulas such as landless laborers or local groups making it self sustainable. For eg. fruit trees such as mango, tamarinds, jackfruits can be remunerative for those who maintain it.

h) Common lands of the villages can be used for cultivation of unique fruit trees of the village

Conservation activity



Handling of information:

Data banks should be built up in each research stations.

a) Information technology should be utilised for linking of information generated at various centres and can be exchanged according to the need of the other regions.

The data base can be made available for commercial seed companies and breeders on payment basis.

b) Kiosks can be provided to village seed centers and all information regarding existence of different varieties, seed availability, characteristics of the varieities can be fed to this.

c) Opensource operating systems and softwares being developed under Linux can be strengthened as that would reduce the overhead charges for the govt. And such activities have to be supported for the public interest.

d) Effort for the same can be supported with research grants to local centers involving local high school and colleges.

e) A link between ICAR and UGC can be made for supporting and strengthening such activities. Even the NGO in the region can be involved in these networks of the region.

f)Highly sophasticated, high resource involved activities can be left with main research stations, and bureaus such as National Bureaus of plant/animal/fish genetic resources.

Research organisations can concentrate on items such as methods of conservation for long term

g) Research stations can concentrate on cryo preservation and gene banks at DNA level. Carrying out cryobiological studies and development of protocols for bringing in more species in cryobank have to be concentrated upon.
h) Development of protocols for monitoring genetic stability; storage and distribution using slow growth in economically important indigenous crops hitherto not established in *in vitro* culture eg. Emblica, Morus etc have to be addressed.
i) Its important to evaluate the alternate methods of storages and chepaer methods of storages for a longer period. Cheaper tecnologies for preservation have to be evolved for conservation in village seed banks.
j) Seed storage behavior and factors that may influence the seed longevity with a view to cost reduction has to be concentrated upon.

2. Characterisation and Evaluation:

Gap:

Hitherto evaluation always aimed at those characters, which can be brought for mass production. However, it is important to realise that need of farmer varies with ecological location, cultural habits and socio-economical conditions. Evaluation of land races for their culinary and nutritive values is never given sufficient importance. Its important to concentrate on hidden values (Table 3).

Strategy:

Effective utilization of conserved germplasm entirely depends upon the efficiency of evaluation. It is difficult to handle a large population of different crops in a single centre taking into account the breeding behavior, and to maintain genetic identity and integrity of the material. India has got a large network of agricultural research system (Appendix 9).

1. Networking involving various ICAR institutions, State Agricultural Universities and projects for multi-location evaluation of various crops may provide effective utilisation of time and resource of research stations.

2. Its important to note that there are several research centres which have their own germplasm collection in accordance with the need of their research mandates. And they do take multiplication of their genetic resources depending upon the viability of the crop species. This can be utilised for exchanging and passing on the information and seed material across the country. In general evaluation is done by breeders. And as highlighted earlier it's the mass production and ideal cultivation conditions are aimed at by the researchers. However, the way a plant is looked at for its value differes with researchers and growers. Infact, with this idea the concept of participatory plant breeding has come in. The same priniciple can be used for evaluation of germplasm in research station. Infact, during Krishimeals organised by the universities evaluation of germplasm by growers can be a part. Farmers can be invited to research stations during growing periods of crops and during critical stages of crop growth and can be involved in evaluation of germplasm procured from outside the region and also in evaluation of breeding lines under developement. Its also important to look at genetic resource from different angles of women, tribals and growers of different regions. Hence, care has to be taken to bring them for evaluation or to send the material for evaluation by various centres across the country.

3. Indigenous knowledge about the land race existing in the region is a result of evaluation made over generations. Its important to record these information which may be existing in the form of folklores, riddles, proverbs, stories and songs.
4. Evaluation activity can be turned as a value addition process by which market value of land races can be enhanced.

Action plan:

Evaluation activity can be partitioned into mainly three components.

i. Evaluation of existing land races by the stake holders and cultivators

Many of cultural characters of land race and culinary properties of these varieties have been tested over generations. A source of such indigenous knowledge base exists and efforts are needed to build in data base of such local knowledge developed over generations which has evolved with its practical utility. Its important to record all these information. The indigenous knowlede associated with the crops such as its adaptibility, performance, cultural requirements, culinary methods, taste paprmeters, even the susceptibilito pest and disease attack have to be recorded. A comparative performance for yeild and related characters can be taken up in the seed farms of villages.

ii. Evaluation of genetic resource for introduction into new area. The breeding material developed by research stations can also be considered under this component.

The process of germplasm conservation should be evolved to interactive process. That demands introduction of interesting germplasm from outside. Identified persons from the regional stations along with the farmers and state depratment officials can visit different regional stations during the right time of crop growth and can be given a chance to pick up the desired type for their region which can be added to the existing collection.

iii. Evaluation of resource towards value addition process.

Based on existing information, efforts should be made for value addition. For instance, certain land races are known to have superior nutrititve value, are tastier compared to high yielding varieties and are also supposed to have medicinal prpoperties. There is a need to validate all these information and to give a scientific explanation so that the information can be utilised for commercial exploitation by govt. organisations or by private agencies.

- Biochemical and phyto chemical evaluation for value added traits such as presence of high curcumin content in turmeric; papine in papaya is needed. Estimation of aroma concentrate in flowers such as jasmine or rose varieties can all give a commercial value for local varieities. Involvement of private sector from pharmacutical and aromatic industry can be encouraged to give economically sustainable remunerative activity in village.
- Institutes such as CFTRI and NIN should be involved in nutrition estimation process as well as in developing suitable products based on consumer preferances. Many of the underexploited crops and land races are rich in their nutritive value. There is a need to systematise and validate these informations. And the technolgies have to be evolved for preservation and marketing. For instance, NIN, Hyderabad has evaluated the Nutritive value of minor fruits. Similarly, Small millets center at the CFTRI, Mysore has developed fingermillet malt based infant foods. These are superior to malto-dextrin bsed infant foods in physiochemical and nutritional characteristics. The centre has also reported that Fox tail millet rice (dehusked and debraned) could be used in the preparation of more than 30 traditional recipes. Such research efforts have to be supported.
- State Agricultural Universities should be encouraged to take up such research activities.

- Institutes under CSIR system such as CFTRI and NIN, homescience colleges under state agricultural universities under purview of ICAR and traditional universities coming under the purview of UGC, Mahila mandals under development departments of state govts can be interlinked for research activity interms of food processing. Particularly such Research schemes that can result in technologies for small scale industries in rural areas for food processing have to be encouraged. This network activity involving UGC, CSIR and SAUs of ICAR can be encouraged to involve private food processing industries.

Like the process in the Germplasm exploration and collection, evaluation also consists of two components viz., physical evaluation and handling of information. The extent of work and volume in both are like reversed complementary triangles.

Germplasm collection centres	Main Evaluators	Other evaluators to be involved				Genetic resource	Evaluations of characters
		Researchers	Non-Researchers	Govt. deparments	Others		
National Bureaus	Researchers	Researchers from SAU and National Res. Stations	NGOs	-		Evloving breeding material , few germplasm & Land races of special features	Evaluation for optimum condition and commercial cultivation Characterisation at molecular level
National research stations	Researchers	Researchers from SAU	NGOs	-		Evloving breeding material , few germplasm & Land races of various states with special features	Evaluation for optimum condition and commercial cultivation Characterisation at molecular level
SAU	Researchers	Researchers Regional Stations		State depts. of Agric., Hort., and Vet.	Home Science Colleges, Food and Nutrition Dept., Institutes on Postharvest handling Commercial Food Chains	Evolving breeding material, & Land races of various districts within the state and introduced material from other states with special features.	Evaluation for optimum condition and commercial cultivation. Evaluation of physiological parameters
Regional stations	Researchers		Resource rich and poor Farmers, women and tribals	State depts. of Agric., Hort., and Vet.		Breeding lines from various stations and land races collected form different villages along with introduced material from SAU	Morphological and culitvation aspects for agroecologicah niche and local requirements and For value addition
Village seed centres	Locals		High school and College botany teachers, Women, youth	State depts. of Agric., Hort., and Vet.	Postharvest and food processing industries for marketability of land races		Morphological and cultivation related evaluation for yield and related characters. For hidden values For value addition

Components and Process of Participatory Germplasm Evaluation Process

3. Policy Research

Suggested action plan:

a) Considering PGR as national resource it is important to identitfy the beneficiaries for hither to existing landraces. There is a need to evolve a fool proof system for assigning rights to individual farmers, villages, communities, or regions.
b) Support price mechanism does not assign any special weightage to land races. There is need to validate the need of it.
c) Henceforth seed with the farmer and knowledge associated with it are made available to public free of cost. With the development in PBR and patents it is important to safeguard this information.

d) There is a need to organize debates and workshops involving all the stakeholders to generate views on various key issues including,

- Supply of germplasm to private sector with appropritate IP attached
- Generation of funds to support to future PGR programmes

e) Complementary comprehensive conservation approach is the order of the day. Any decision-making in this regard requires comparison of the costs, advantages and drawbacks of each method case by case. It is important to make a comparative soci-economical studies as a support for policy decisions.

f) Germplasm registration offers a form of soft IP. There is a need to build registers. Few attempts which have been made to develop biodiversity registers have concentrated on diversity at species level. It is important to realise the intraspecific diversity existing in domesticated plant and animal species. The problems of rewarding farmers rights lies in the basic fact of non avilability of authoritative and authenticated information on the source of these land races. Developement of local data banks and registers in local regions would inturn facilitates this

g) PGR awareness has been spreading. NBPGR has imparted a number of training programmes designed for different sections of the PGR workers. Additions such as multimedia documentations on importance of every step of conservation activities would be beneficial for the whole process.

h) Educational programmes such as UGC telecasts need to be prepared since next step is to inspire the future generations.

i) There is a need to create of skilled and committed work force with sound knowledge of leagal issues along with background of genetic diversity.

j) NBPGR has generated a vast information for already collected seed material. In addition to documentation of the information, dissemination is also very important. Ways and means should be worked out to provide the people these information.

k)There is a need to build a give and take policy between farmers and research institutes interms of genetic resources.

l) There is a need to initiate studies on impact of multiple cropping, varietal mixtures, fallowing and rotation, organic amendments, flooding, burning, mulching, raised beds, site selection, manipulating shade etc vis-à-vis PGR conservation and management.

m) Productivity of land races have to be assessed over years under farm condition to assign it proper weightage unlike those studies taken up in research stations with optimum condition. Accordingly definite and different needs of resource poor farmers and regions can be addressed with the exchanged of material suitable for them.

Conclusions:

More conservation is not the answer to the problems of genetic uniformity in crops. Value of agrobiodiversity lies is in its use than in conserved form. All the future research efforts in domesticated biodiversity may be channeled to achieve “CONSERVE THROUGH USE”.