COST OF CONSERVATION OF AGROBIODIVERSITY

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The cost of conservation of germplasm stored in gene banks i.e., *ex-situ* collections has been studied in other parts of the world to estimate direct and indirect contributions by various actors involved in conservation. This is the first study of its kind in India done in collaboration with National Bureau of Plant Genetic Resources, New Delhi. This was part of a sponsored research by Centre for Development Research, Germany. The limitations of this study are also listed so that future research in this regard can be pursued better. One of the costs not included is the cost of sharing data with local communities for enabling them to access germplasm in times of need. This is an important component of conservation and would require translation of gene bank and associated database in local language, making them available through public kiosks. This cost has not been included in any study on the subject so far. Separately, studies are underway to look at the conservation of germplasm under *in-situ* conditions.

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1. INTRODUCTION

Plant germplasm is a non-renewable natural resource indispensable for the sustenance of human life on this earth. Story of human civilisation is actually also a story of plant domestication and gender role differentiation. It is said that only after domestication the role of women started getting more and more differentiated. They have played the most pivotal role in selection, storage and *in situ* conservation of land races. It is important to appreciate that studies on the cost of conservation also capture in that sense, the hidden and unappreciated contribution women have made in this gigantic task. In this paper we will not be able to deal with this issue in detail because we are focusing essentially on the components contributing to the cost of *ex situ* conservation.

Biological diversity is used to describe the number, variety and variability of living organisms within each variety or species in a given ecosystem (Heywood and Baste, 1995). CBD and UNEP (1992) have defined this as the variability among living organisms from all sources including *inter alia* terrestrial, marine and aquatic ecosystems as well as the ecological complexes of which they are a part. Biological diversity is usually considered at three different levels: genetic, species and ecosystem diversity. Genetic diversity refers to the variety of genetic information contained in all of the individual plants, animals and microorganisms. Genetic diversity occurs within and between populations of species, and between species. Species diversity refers to the variety of living species. Ecosystem diversity relates to the variety of habitats, biotic communities, and ecological processes, as well as the tremendous diversity present within ecosystems in terms of habitat differences and the variety of ecological processes (Commonwealth of Australia, 1993).

Agricultural biological diversity, in short 'agrobiodiversity', refers to the variability among living organisms associated with cultivation of crops and rearing of animals along with the ecological complexes of which they are a part of (Convention on Biological Diversity, 1992). Agrobiodiversity focuses on that part of the biodiversity, which has undergone selection and modification over millennia by human civilisation to better serve the human needs (Wood, 1993). It has also been defined broadly as “the part of biodiversity which nurtures people and is nurtured by people”(FAO, 1995). The human cultures that have emerged and adapted to the local environment, discovering, using and altering local biological resources, over the course of time, have all contributed to its evolution. It is the interplay between human cultures and their biological diversity, which helps in articulating social preferences for different attributes of biodiversity. This is how the agrobiodiversity evolves as a direct consequence of social, cultural, and institutional conditions at a given place.

The domestication of wild biodiversity was necessitated due to emerging social structures requiring a stable supply of food and other biological materials. The emergence of agrobiodiversity in the regions where wild relatives abound was also a consequence of gender roles and socio-economic conditions.

1.1 Importance of biodiversity

Biodiversity provides a foundation for ecologically sustainable development and food security. There are four kinds of values for any given environmental resources:- option value, use value, exchange value and existence value. The unknown potential of genes, species and ecosystems is of inestimable but certainly high value. The ecosystems rich in biodiversity possess greater resilience and are therefore able to recover more readily from biotic and abiotic stresses such as drought, environmental degradation, pests, diseases,

epidemics *etc*. Hence, decline in biological diversity puts the functioning of ecosystems at risks.

The cultural value of biological diversity conservation for present and future generations is another important reason for conserving it today. Human cultures co-evolve with their environment, and the conservation of biological diversity can be important. Human cultures are shaped in part by the living environment that they in turn influence, and this linkage has profoundly helped to determine cultural values. The natural environment provides for many of the inspirational, aesthetic, and educational needs of people, of all cultures, now and in the future. Intangible values such as deep spiritual, social, protective and recreational significance of biodiversity are at this stage however, difficult to identify.

Agrobiodiversity has been slowly and naturally evolving since the beginning of life. Human existence (and that of most other organisms) is heavily dependent on primary producers, *i.e*. plants. Food security and self-sufficiency particularly in the marginal areas depends on the availability of crop genetic diversity. The adaptive complex of crop genetic diversity enables farmers to adopt crops suited to their ecological niches and cultural food production systems and practices. This wider environmental adaptability of diverse crops and varieties enables the farmers to use them as risk adjustment measure. Therefore, availability of agrobiodiversity enables farmers to attain food security in varied ecological regions by reducing their vulnerability to shocks or fluctuations in crop production. The challenge is to assess the amount of diversity farmers still maintain, economic costs and perceived environmental considerations.

The plant breeders and biotechnologists have the immense task of developing new crop varieties to overcome problems caused by pests, diseases and abiotic stresses. They are also confronted with newer challenges concerning sustainable agriculture, environment protection and satisfying the increasing demand for food, fodder, fibre and fuel. In the search for desirable genes in different crop species the plant breeders and biotechnologists depend upon the crop diversity as an immediate resource, to tailor the new varieties and hybrids or for reconstructing the existing genotypes in accordance with the requirements of time and space. Crop diversity contribute to the stability and sustainability of farming systems and are valued for providing important attributes including *inter alia* agronomic characteristics, biotic and abiotic stresses and other factors of cultural and socio-economic importance. In addition, the crop diversity contributes as a direct or indirect source of several products, *viz*., medicines, life-saving drugs, vitamins, minerals, various industrial products etc. The crop diversity also provide an insurance against unknown future needs/conditions as these are likely to hold still undiscovered cures for known and emerging diseases and is a fortune that can be tapped, as human needs change.

Apart from the above uses, the plant genetic resources may also act as the indicator of the ecosystem health. Hill and Ramsay (1977) demonstrated the use of various weeds as indicators of soil mineral properties, likewise certain varieties are suitable for very precise conditions of onset, duration and cessation of floods in humid and sub-humid areas. If due to siltation in certain low land micro-environment, the height of the water stand changes, the farmer may change specific land race for that location. In fact, Gupta (1995) has argued that by mapping local varieties one can also map the variability in the micro-environment because of the high correlation between the two.

Human activities also shape biodiversity. In the past when the earth's natural abundance seemed boundless, there was little concern over the effects of human activities on the world stocks of biological diversity. However, recently due to extent of natural destruction caused to the environment by human interference, the importance of biological diversity was felt.

1.2 Threats to biodiversity

Even in prehistoric times, humans had a considerable impact upon biodiversity. Many large animals and forest systems have been exploited to extinction. Man's impact (per time unit) was low in early times. It has gradually increased with growing technology, population, production and consumption rates in modern times. Biodiversity is currently decreasing at an unprecedented high rate (see, for example, the global biodiversity Assessment, 1995). The enormous genetic diversity is being lost mainly due to genetic erosion, genetic vulnerability and genetic wipe-out. These processes are not mutually exclusive, but are in fact, operating together driven by the demand of an increasing population and rising expectations.

Developmental pressures on the land resources, deforestation, changes in land use patterns, natural disasters are contributing to abundant habitat fragmentation/destruction, of the crops and their wild relatives. Social disruptions or war also pose a constant threat of genetic wipe-out of such promising diversity (OECD, 1996). Over exploitation and also introduction of invasive alien species are the other factors contributing for the loss of the genetic resources. More recently, the global warming and high degree of pollution have also been recognised as one of the causes for loss of biodiversity (Myers, 1994).

The traditional farmers, over the millennia, have given us an invaluable heritage of thousands of locally adapted genotypes of major and minor crops that have evolved because of natural and artificial selection forces. The quest for increasing food production and the ensuing success achieved in several crops has replaced the land races by uniform, true breeding cultivars or special hybrids of controlled parentage. This heritage is under threat because of recent developments and consequently the ancient patterns of variation are being obliterated (WCMC, 1992). The factors contributing to the erosion of agrobiodiversity are (a) increasing technological and financial support for high yielding varieties which will replace local varieties, (b) large scale modification of the medium upland farming condition may lead to faster diffusion of high yielding varieties, (c) high partitioning efficiency gives a comparative advantage to high yielding varieties that can perform often better even in the condition were local soil nutrition is below average and (d) The market preferences of consumers for uniform grains or vegetables or foods further contributes to the erosion of agro biodiversity.

A recent study has shown that there was a decline of about 16 per cent to 100 per cent (that is total extinction) of area during 1989 to 2001 under indigenous varieties of various crops in three villages of flood prone parts of Eastern India. The decline was maximum in rice (about 85 per cent to 100 per cent) and minimum in chick pea (16 to 65 per cent), maximum in the plots of medium high land type and belonging to small farmers compared to marginal or large farmers (Gupta*, et al*, unpublished). Without remedial action, genetic erosion will inevitably increase and the costs of replacement of diversity needed in future by the community will be much greater. These costs can be reduced by strategic and timely conservation actions (Commonwealth of Australia, 1993).

The decline of the agrobiodiversity has made the food system extremely vulnerable. The possibilities of insects, pests or disease spreading over vast area have increased because of genetic uniformity. The agrobiodiversity therefore contributes directly to the containment of such risks.

This loss in the diversity is taking place at a time and speed when new tools of biological research enable scientists to focus as much on the diversity of genes as on the diversity of genotypes. Future progress in the improvement of crops largely depends on immediate conservation of genetic resources for their effective and sustainable utilisation. To date India retains extensive reservoir of ancient diversity in farmer's fields in many parts of

the sub continent, but especially in mountainous, drought and flood prone and tribal areas wherein the inherent physical, ecological or sociological barriers have impeded adoption of modern technologies.

In view of the above, the developing programmes on biodiversity conservation and for their sustainable use in food and agriculture, has been a major concern both at national and international level. Since most species are interdependent for their survival, conservation strategies have to take into account all elements of biodiversity.

2. CONSERVATION STRATEGIES

The choice of conservation strategy depends mainly on the nature of the material to be conserved i.e. the life cycle, mode of reproduction, size and the ecological status (OCED, 1999). Two major approaches for crop diversity conservation are: (i) *In-situ* and (ii) *Ex-situ* (Figure 2).

2.1 *In situ* conservation

In-situ conservation means the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings, where they have developed their distinctive properties (UNEP, 1992, 95). The Convention on Biological Diversity has given highest priority to this approach of conservation which includes species protected in the wild as well as landraces (*i.e.,*cultivars adapted to the local climate, soil, pests as well as satisfy the taste of local people; Primack, 1993) and other cultivated forms maintained by farmers. This also includes the preservation of indigenous knowledge (social, cultural and religious status), agro-ecosystems and other wild cultivars (CBD, 1992).

In situ conservation enables to preserve evolutionary processes that generate new germplasm under conditions of natural selection, maintain important field laboratories for crop biology and biogeography. It also serves as a continuous source of germplasm for *ex situ* conservation. Further, for those countries, which have abundant crop germplasm resource, it provides an important option for conservation with a wider participation.

Four basic kinds of multidisciplinary research are required to successfully run the *in situ* conservation (FAO, 1996).

a) Ethnobotanical and socio-economic research to understand and analyse farmers' knowledge, selection/breeding and utilisation and management of plant genetic resources with the approval of the involved farmers with applicable requirements for protection of their knowledge and technologies.
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.*).
c) Crop improvement research in mass selection and simple breeding without significant losses in local biodiversity.
d) Extension studies for lesser-known crops including their seed production, marketing and distribution.

The criteria for site selection for *in situ* conservation with in the study areas are (a) wide range of diversity of a single or few crop species within a given site, (b) ecological heterogeneity, (c) possibility to control or monitor the site and (d) easy access for monitoring and management (Tan and Tan, 1998).

However, the germplasm maintained under *in situ* conservation are highly vulnerable to the threat posed by (a) genetic drift, (b) inbreeding, (c) habitat loss, (d) competition from exotic species and (e) pest infestation. Beside these factors the inability to readily provide crop germplasm to the breeders is the major limiting factor of this approach in contrast to *ex situ* conservation.

2.2 *Ex situ conservation*

Ex- situ conservation refers to the conservation of germplasm away from its natural habitat. This complementary approach for conservation had begun on a wide scale about three decades ago and is now practised, to some extent, in almost all countries as a means to conserve crop species diversity for posterity. This strategy is particularly important for crop gene pools, and can be achieved by propagating/ maintaining the plants in genetic resource centre, botanical gardens, tissue culture repositories or in seed gene banks (OCED, 1999).

Notwithstanding the advantages of *ex situ* conservation, there are limitations of relying only on this approach:

a) Many important species are under-represented because of the recalcitrant nature of the seeds,
b) Genetic shifts or alterations cannot be ruled out due to inappropriate storage conditions,
c) Since the crops are grown with external application of fertilisers and pesticides, and use of heavy machinery, the plants slowly get accustomed to more congenial conditions, the roots architecture and assimilatory properties get modified since nutrients are easily available and availability of porous well ploughed soil.
d) *Ex situ* conservation does not maintain evolutionary processes that created the crop germplasm. The genetic resources are not exposed to natural or artificial pressure and therefore no chance exist for further evolution or adaptations.

Various approaches are employed for the *ex situ* conservation depending upon the mode of reproduction and nature of plants to be conserved. Seed genebanks deals with the conservation of seeds with 'orthodox' seed behaviour (which can withstand drying below a certain moisture level). Apart from seed gene banks, *in vitro* repositories or cryobanks are also widely employed for the conservation of germplasm where either the seeds are unable to withstand drying below a certain moisture level *i.e*., 'recalcitrant seeds' or seeds are not produced at all *i.e*., vegetatively propagated plants (OECD, 1999). The details of these strategies have been discussed latter in the text.

3. NEED OF CALCULATING THE COST OF CONSERVATION

During the past one and a half-decade, with the increase in the activities of conservation the costs involved in such activities have been in debate. Various studies for estimating the costs of conservation have been carried out adopting different methodologies Jarret and Florkowski 1990; Epperson *et al.*, 1997, Pardey *et al.*, 1998, 1999). The cost of conservation is highly crop and location specific (Virchow, 1999), therefore, it is imperative to calculate it for estimating the capital required for conserving the germplasm in the given region. Such studies also draw attention towards the critical components, for efficient conservation and would also lead to guide the future conservation strategies as well as in formulating cost-effective approaches. The estimation of cost of conservation helps the International Communities to allocate the appropriate financial assistance to the country for conserving its natural resources.

The conservation of agro-diversity contributes to the food security by providing sources of such genes which might hold clue for increasing production in future or for providing specific biochemicals used in drugs or other such products. It is well recognised that productivity of land races is generally lower than the high yielding varieties. Therefore, whenever a new high yielding variety becomes available, the pressure for the extinction of the existing land races becomes higher. The study of cost of conservation helps us to appreciate requirement of resources for conserving agro-biodiversity, which on its own may not be conserved by the farmers without external incentives. The cost of conservation study also helps in allocating scarce resources among competing crops wanting to be covered under the conservation programmes.

The overall cost of conservation is broadly made up of fiscal/momentary costs and opportunity costs. The fiscal costs represent the cost that have to be budgeted and invested either on national and international level for planning, implementing and running of *ex situ* and *in situ* conservation activities. These are determined by specific conservation activities, depreciation costs for investments and the costs for institutional and political regulation for the access to the germplasm. Additionally, the cost for compensation and incentives paid for maintaining the collected germplasm are also included. The opportunity costs on the other hand reflect the foregone benefit for the country by maintaining the diversity of genetic resources in the field (Bretting & Duvick, 1997).

4. METHODOLOGY

In the present study an attempt has been made to give a brief account of the cost components involved in the various activities listed in the figure1 for efficient *ex situ* conservation. These activities have been drafted following discussions with the cross-section of Scientists and Administrators engaged in the activities of conservation and management of germplasm in India. The authors would like to acknowledge Dr P L Gautam Director, National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India for his valuable suggestions and guidance in finalising the various components involved in conservation of germplasm and contributing to the costs. Further the relevant information and suggestions provided by Dr Anuradha Agrawal, Ms J Radhamani, as well as other scientists of NBPGR are also duly acknowledged.

4.1 Test crops

The components of costs involved in the conservation have been discussed in the present study by taking the examples of five crops, *viz.* paddy, sorghum, cowpea, banana and tea. The rationale behind selecting these five crops is the differential modes of reproduction and the storage techniques.

4.1.1 Paddy

India has abundant resources of wild species of paddy particularly *O. nivara, O. officinalis* and *O. granulata*. The wild species of paddy can be found in many different natural habitats, from shade to full sunlight, and can be either annual or perennial in nature. Some wild species occur as weeds in and around paddy fields and even hybridise naturally with the cultivated forms. This complex association between cultivated and wild forms can enhance the diversity of paddy crop in traditional agriculture systems, where farmers often grow mixtures of varieties, to provide a buffer against the risk of complete loss of the crop due to biotic and abiotic stresses (Sharma *et al.*, 1988; Jackson *et al.*, 1997). According to an estimate, about 50,000 land races of paddy are expected to exist in India.

The full spectrum of paddy germplasm thus includes:

- Wild *Oryza* species and related genera
- Natural hybrids between the cultigen and wild relatives and primitive cultivars of the cultigen in areas of paddy diversity.
- Germplasm generated in the breeding programmes including pureline or inbred selections of farmers varieties, F1 hybrids and elite varieties of hybrid origin, breeding materials, mutants, polyploids, aneuploids, intergeneric and interspecific hybrids, composites etc.
- Commercial types, obsolete varieties, minor varieties and special purpose types in the centres of cultivation

The exploration and collection activities for indigenous paddy cultivars were initiated around the turn of the century. However, the systematic explorations were initiated only during 1955-60 by the Jeypore botanical Survey in South Orissa and adjoining areas of Madhya Pradesh. Since then numerous explorations have been carried out resulting in acquisition of nearly 66,745 accessions from the various parts of the country (Singh *et al.,* 2000).

4.1.2 Sorghum

Sorghum is believed to have originated from wild species in Western, Eastern and Eastern-Central Africa. India is considered to be one of the centres of diversity for sorghum. About 30,000 accessions of sorghum are believed to exist in India. Ethiopia, Indonesia, Myanmar, Philippines and India are the high priority for collection of diversity in sorghum (Stenhouse *et al.*, 1997).

4.1.3 Cowpea

Cowpea is an ancient crop and has been domesticated since Neolithic period throughout the world. African gene centre especially Ethiopia is considered as the primary centre of diversity for cowpea. While South East Asia mainly India and China as the secondary centres of the origin. Five subspecies of *Vigna unguiculata*, i.e. *dekindtiana, sesquipedalis, unguiculata, cylindrica* and *mensensi*s play an important role in the evolution of the cultivated type (Ng and Singh 1997).

In India, cowpea is widely distributed from the foothills of Himalayas to Southern peninsula. The species is endowed with the diversity in two forms *viz. V. unguiculata* var. *unguiculata* and *V. unguiculata* var. *biflora*. The occurrence of *V. unguiculata* var. sesquipedalis is sporadic. According to estimate about 3000 accessions of cowpea are available in India (Ng and Singh 1997).

4.1.4 Tea

The cultivated population of tea has been categorised into three types on the basis of their morphological, anatomical and biochemical characteristics. These are (i) Assam type (*Camellia assamica*), (ii) China type (C. *sinensis*) and (iii) Cambod type (*C. assamica* ssp. *lasiocalyx*). Yunnan provenance of South West China is considered to be centre of origin for the genus *Camellia.* However, North East India bordering Burma harbours maximum diversity and wild relatives of *C. assamica* (Singh 1988).

The germplasm of tea in India have been collected from North East India, Burma, China, Kampuchea, Sri Lanka, Vietnam and USA. The collection of germplasm of tea was initiated in 1823. About 3000 accessions of tea are assumed to exist in India centre. The

germplasm of tea is lost at an enormous rate due to the uprooting of old stocks and replacement of these with few selected ones (Singh 1988).

4.1.5 Banana

South East Asia and Malayan Archipelago are the centres of origin for *Musa*. The Indian gene centre extending to South East Asia is believed to be one of the centres of origin and diversity for edible banana (*Malus acuminata* X *M. balbalisiana*). Several species such as *M. acuminata, M. balbisiana,* their interspeciifc hybrids along with wild types occur in India (Harry *et al.*, 1997).

The probable areas for exploration in India are Assam, North Eastern hills, Western Ghats, Chotannagpur, Orissa and Kerala. More than 300 landraces of banana and plantain are found in diverse habitats throughout India (Iyer and Subramanian 1988).

4.2 Procedure Adopted

The cost figures involved in the different conservation activities for these crops have been calculated as:

Cost (US$/acc./yr) = cost figure (in Rs.) x 1/conversion factor x 1/no. of acc. collected per year

The cost figures involved in the various activities were initially calculated in Indian Rupees (Rs.), which were subsequently converted to US $ employing a conversion factor of 44. The number of accessions collected per year varies with the crop species as it depends on the extent of genetic diversity within the species (details are in section 6). In addition to this, the cost figures in the tables (Table 2-7) have also been expressed, when distributed over the duration of the activity (as discussed later in the text).

The manpower required for each activity has been allocated at three levels (a) scientist (@ Rs. 2,50,000/yr), (b) research associate (@ Rs. 1,25,000 /yr), (c) technical person (@ Rs. 1,25,000/yr) along with the semi-skilled help on contractual basis as per the requirement of the activity. To account for the depreciation and replacement costs the total expense required for the equipments in a particular activity has been distributed over a period of five years to get the per year cost.

5 THE COMMON COSTS

There are certain pre-requisites for initiating any type of conservation activity. In the present study they have been grouped under common cost which refers to the sum total costs involved in establishment of basic infrastructure, human resource development, salaries of the engaged staff members as well as for other administrative activities including institutional overhead charges etc.

The space cost has been computed including the land and construction costs for the farms and buildings, which are imperative to have a proper infrastructure. Since the establishment once created would serve for a long period, these costs have been distributed over a period of 50 years. The germplasm conservation activities can effectively be carried out by involving various stake holders hence setting up of efficient network and communication facilities is an important activity that shall contribute substantially to the common cost. Keeping in view the rapid advancement in the information technology, these facilities would require regular replacement and upgradation, thus these costs have been

distributed over a period of five years. The security of the collections is of prime importance and the institutions involved would have to make annual expenditures for this activity.

To organise any collection mission and develop appropriate conservation strategy it is essential to acquire adequate information about the nature of the crop (mode of reproduction, flowering season ethnobotanical information, etc.), areas harbouring the diversity and details about the region to be explored (topography, climatic conditions, traditions and culture *etc.* (Clay 1991; Fingleton 1993; Martin 1995). These information are usually gathered through libraries, Internet as well as by co-ordinating with the concerned institutes. It is essential to establish a library in the institute, which would require financial resources for subscription fee to the journals, cost of the books, establishment and maintenance of the suitable database, salaries to the concerned staff members as well as in other miscellaneous expenses. The establishment of infrastructure for these facilities has been assumed to be a part of the space cost, however, annual maintenance charges towards library costs have been taken into account.

It is essential to keep the staff members engaged in the conservation activities abreast with the latest developments in their field and to achieve this various training programs would have to be organised periodically in the advanced centres within the nation and in certain cases in other countries. In organising such programs the expenditure is mainly incurred due to the travelling and daily allowances of the trainee's as well as the experts and also towards bench fees, transportation, stationary, consumables *etc*. Usually suitable honorarium is given to the invited experts for their services. The total expenses allocated for organising such training programmes has been calculated on the yearly basis.

In the changing global scenario where the implementation of IPR related the issues would gain tremendous importance a provision towards legal cost has been provided for carrying out activities like, filing of patents, checking piracy, and benefit sharing *etc*. every year.

The proper utilisation of the germplasm collected can only be ensured if it is made available to the interested persons. Expenses would have to be incurred for different activities associated with the transaction of the germplasm (handling of the germplasm, request for acquisition and dissemination of the material. In addition expenditure for developing material transfer agreements for transaction of the germplasm from field gene banks (for local communities), active sites (national and local) and base collection (national and international) would has been accounted in the transaction cost

In the present study the expenditure towards the technical manpower required for the various components of the conservation, has been accounted for, in the respective activity. However, as the administrative staff engaged in the maintenance of the accounts and for record keeping would assist all the components provision has been made in the common cost for this.

Composition of the cost may vary with the magnitude of the conservation activities undertaken as well as with the site of conservation, but components attributing to the total cost would remain the same. Initially, acquisition cost will be higher with low maintenance cost while in subsequent years, maintenance cost would be higher (at the end of 10 years). Although the acquisition cost will be zero, however, this will act as replacement cost in case of any calamities/natural disaster (5 per cent of the total cost). A provision of 10 per cent of the total annual cost has been accounted as institutional overheads for expenditure towards the annual maintenance and depreciation. In the present study, while calculating the total common cost, the cost figures have been distributed for 2,00,000 accessions, assuming it to be the total diversity of the five test crops to be collected and conserved as active or base collections (Table 1).

6 COST FOR ACQUISITION OF GERMPLASM

The germplasm is mainly collected from the regions harbouring the maximum diversity of the crop. During the exploration emphasis is laid on the collection of local landraces along with their wild relatives. Broadly, two kinds of exploration are planned based on (a) priority of crops, *i.e*. crop specific, and (b) area/region surveyed *i.e*. region specific. However, in cases of severe threats due to natural calamities (cyclones, droughts, floods etc.) and other forms of human interference (building up of dams, infrastructure development etc.), mission-oriented explorations are also undertaken to conserve the germplasm diversity of the specific regions in an urgent time-bound manner. The cost incurred for the crop specific explorations is generally expected to be more than that required for region specific explorations, while the cost involved in the mission explorations are still higher. The duration of the exploration trip as well as the number of the accessions collected per trip will depend upon the germplasm to be collected. The exploration trips focusing on the collection of the germplasm in crops with 'orthodox' seed behaviour are generally of longer duration compared to those aimed for the collection of 'recalcitrant' crops or 'vegetatively propagated' crop species. The germplasm of the latter categories are perishable in nature and remain viable for a very short duration, hence needs to be processed and transported to the conservation site rapidly. Thus less number of accessions for recalcitrant and vegetatively propagated crops can be collected per trip compared to the orthodox seed producing crops.

Passport data information regarding the habitat, nature of the plant, its growth behaviour, socio-economic values, ethnobotanical informations, *etc*. are recorded at the time of collection of the germplasm. This information generally accompanies the germplasm to the genebank, where they are entered in the database for its analysis. This information not only facilitates in setting up the priorities for conservation (Nabhan 1996), but also is helpful in monitoring the changes in the diversity of the crop through time and consequently estimating the risks of its genetic wipe out (Brush 1991; Belon 1996). The generation of the standard formats for the passport data sheets requires thorough discussions with the experts. The expenditure in this activity is attributed in organising meetings, discussions, and in imparting adequate training to the explorer to record such information.

Women have a profound knowledge of plants and their environment. Traditionally women have been using a variety of indigenous plants, trees and animals, and they have a direct stake in the preservation. Studies have revealed that the women have greater interest in preserving and conserving crop plants, forests and other natural resources for perpetual use. Men on the other hand, are more often concern with converting these resources into cash. In addition, women are traditional caretakers of genetic and species diversity in agriculture. Their knowledge of the necessary growing conditions and nutritional characteristics of various species gives them a crucial fund of experiences in seed selection and plant breeding. This enables them to maintain the genetic diversity required to adapt to intermittent changing parameters and to ensure the survival of these traditional crops adapted to local conditions and taste. It is therefore important to collect the gender-based knowledge of the locals about the crop as this plays an important role in agrobiodiversity conservation and management especially in the era of increasing adoption of monoculture (Krishna 1998). However, it is being realised through participatory breeding programme as well as work on local knowledge that domestication of different species is also accompanied by development of cultural institutions. Which kinds of grains/pods or parts of plants are used in various ritual or food recipes is to some extent shaped by the socio-cultural tradition in a given community. Sometimes the importance of a genuine germplasm cannot be appreciated without looking at the associated knowledge system about its place and the social life. The interaction between ecosystem variability and genetic variability also needs to be studied carefully for designing conservation programme. The variability in the topography, soil texture and structure, micro environment condition and existing ecological communities

shape or define the range within which biological evolution may take place. However, the pressure of social preference modifies the bio-evolutionary pressure by shaping the choice of characteristics in the agro-biodiversity in the given context.

The team for carrying out an exploration mission would include plant explorer, crop researcher and extension worker along with the local guide. Usually, at the collection site help of contractual labours is also required. The exploration team needs to be equipped with the important accessories (such as exploration kits, camera, GPS, computers/data logger, vasculum etc,) required during the tour along with a proper means of transportation. For organising such trips the components attributing to the cost are the expenditures to fulfil the basic requirement and accessories/equipments needed for the purpose along with the travelling and other allowances given to the team members. Sometimes to collect the primitive and rare cultivars incentives are also given to the farmers or the locals for collecting the germplasm as they maintain these in their fields along with the other prevalent varieties.

At the base campsite the collected accessions are properly processed (dehusking, threshing *etc*.), cleaned and packed in the appropriate containers seeking the help of contractual labours. Subsequently, they are transported to the genebank after packing them in the appropriate containers. The labour cost and the miscellaneous expenditure incurred in the transportation of the collected germplasm to the genebank from the site of collection contributes to the variable cost.

The cost of augmentation of the germplasm of the test crops is mainly attributed through various activities such as presurvey activities, co-ordination with the collaborators, developing formats for recording of the passport data information as well as the expenditure incurred during the organisation of exploration trips including the processing cost and the manpower required for these activities.

The acquisition cost of paddy has been calculated assuming that 50,000 samples are to be collected. Experience shows that in exploration trips of 15-20 days about 250 accessions can be collected, thus requiring 20 explorations per year to collect 50,000 accessions in 10 years (@ 5000 accessions/year) with an expenditure of Rs. 40,000 per exploration. Since the activity of exploration is season specific therefore it has to be done in collaboration of other scientists hence a provision of 2 human years for fulfilling this requirement has been assumed. Once collected and sent for long-term conservation the accession, it need not be collected again. In view of tropical conditions in the gene rich and resource poor countries, the costs of collection of the accession has been distributed over 50 years. The total expenditure on the acquisition of single accession of paddy amounts to US $ 0.486 per year (Table 2).

The acquisition cost of sorghum has been calculated assuming that 30,000 samples are to be collected. Experience shows that in an exploration trip of 15-20 days about 200 accessions can be collected, thus requiring 15 explorations per year to collect the entire germplasm in 10 years (@ 3000 accessions/year) with the expenditure of Rs. 40,000 per exploration. Once the collected the accession is frozen and need not be collected again. The costs of collection of the single accession have been estimated to be US $ 0.622 per year, when distributed over 50 years (Table 2).

The acquisition cost of cowpea has been calculated assuming that 3,000 samples are to be collected. Experience shows that in an exploration trip of 15-20 days about 75 accessions can be collected, thus requiring 4 explorations per year to collect all the diversity in 10 years (@ 300 accessions/year) with the expenditure of Rs. 40,000 per exploration. The total cost of acquisition when distributed over 50 years has been estimated to be US $ 1.468 per accession per year (Table 2).

The germplasm of tea is collected through seeds, which are perishable and have to be processed within 10 days. Due to the shorter duration of the exploration trips, a sum of Rs. 20,000 has been allocated per trip in the present case. However, few additional trips are required prior to the collection of the germplasm for marking and selection of elite trees. Experience shows that in an exploration trip of 7-10 days about 30 accessions can be collected, thus requiring 100 explorations in 10 years (@ 300 accessions/year). Once collected the accession is frozen through the technique of cryopreservation and need not be collected again. The cost in this case has been distributed over 50 years and is estimated to be US $ 2.983 per accession per year (Table 2).

The acquisition cost of banana has been calculated assuming that 300 samples are to be collected. The collection trips for banana are of short duration, as the vegetative propagules are perishable in nature. The total expenditure incurred per exploration trip has been assumed to be Rs. 20,000. Experience shows that in an exploration trip of 7-10 days about 15 accessions can be collected, thus requiring an average of 2 explorations per year to collect the entire diversity in 10 years (@ 30 accessions/year). The vegetative propagules collected for banana are conserved employing the technique of tissue culture. In the tissue culture repositories, a high risk of survival exists. It is assumed that the same accession would be required to collect again, therefore the costs of collection of banana is US $ 23.922, when distributed over 25 years (Table 2).

7 COSTS FOR MANAGEMENT OF ACTIVE COLLECTIONS

The value of collected and conserved germplasm can only be realised only after proper characterisation and evaluation, complemented by biosystematic studies of the wild species. The responsibility of evaluation, supply for utilisation and maintenance of the germplasm for medium term are entrusted with the "active sites" and the collections are called as active collections.

The germplasm in the active sites are used for agronomic, biochemical, for special traits, gender based knowledge and molecular evaluations as well as for regeneration.

7.1 Evaluation of the germplasm

Evaluation and characterisation of genetic resources is of prime importance in making a large collection available for wide use. The past experiences have amply demonstrated how enormous diversity of crops has been utilised in solving the current food problems. The evaluation of germplasm collected in the past has resulted in identification of have contributed significantly in the crop improvement programs owing to their various agronomic, genetical and biochemical traits. Evaluation of genetic resources involves recording of morphological, physiological, genetical and biochemical traits. Besides these, the need for evaluation for the authenticity of the gender based knowledge collected from the locals while acquisition of germplasm has been felt recently.

The germplasm is raised in the fields for agronomic evaluations. The cost components attributing for this activity would include the cost of land as well as the farm equipments (tractor, row-disk bedder, seed spreader, harvester etc.) contributing to the fixed cost. The manpower required for various farm practices as well as the inputs in the form of pesticides, insecticide, fertilisers etc.) are the components of the variable cost. Once the crop is established in the field various agronomic traits (viz*.,* plant height, branching pattern, leaf size, vigour, flora features etc.) listed in the plant descriptors are recorded. The generation of such descriptors requires thorough discussions with the crop curators, for which various meetings, seminars as well as discussions are organised. The organisation of all these as well as the training imparted to the concerned people to record the details

accurately contributes further to the cost. The recording of these details would also require equipments (leaf area meter, balances, seed counters etc.), miscellaneous items and manpower that add up to the cost further. The number of plants that can be raised in a unit area also contributes significant differences in the cost component, which depends on the growth pattern of the crop, e.g., in a given area more number of plants of paddy than that of banana can be raised. The total cost required for the agronomic evaluations for all the crops when calculated per accession is least for paddy as compared to that for other crops as the number of accessions are more for the former (Table 3).

Detailed evaluation would require evaluation of biochemical parameters as well as some special traits (palatability, fodder value, nutritional aspects, *etc.*). The biochemical evaluation requires setting up the laboratory with various sophisticated equipments (spectrophotometer, balances, lyophilizer, centrifuge etc.) to increase the efficiency and authenticity of the results and to carry out any other associated supportive research, the cost of which contributes to the fixed cost. While the variable cost for a biochemical laboratory includes the expenditure for chemicals, glasswares and manpower.

The need of evaluation of molecular characters *viz.* their genetic homogeneity as well as stability during storage is also felt and it is being used routinely at many sites of conservation. The molecular evaluation of the germplasm is a sumptuous exercise as it requires very sophisticated equipment (spectrophotometer, flourimeter, PCR, electrophoretic apparatus, *etc.*) and expensive chemicals though the basic set up of the laboratory and requirement is similar to that of the biochemistry laboratory. Although the cost for developing protocols for different crops would vary the cost of molecular evaluation has been assumed to be Rs 5000 per accession irrespective of the crop.

The evaluation cost for paddy, sorghum, cowpea and tea for agronomic, biochemical and special traits is distributed over a period of 10 years, as these would be repeated with each regeneration cycle. However, for the molecular traits these would be evaluated only once therefore the cost is distributed over a period of 50 years. The crops maintained in *in vitro* have to be established in the field after about ten cycles of sub-culturing. In banana assuming that the sub culturing is to be done after one year the cost involved in the evaluation activities has been distributed over a period of 10 years. Since the chances of alteration in molecular traits is very high under *in vitro* cultures in banana the molecular evaluations has been calculated for each regeneration cycle ie., every 10 years (Table 3).

7.2 Regeneration of Germplasm

The germplasm are regenerated to maintain the safety duplicates as well as to increase availability of seed quantity of the germplasm maintained in the ‘active sites’ when the percentage germination falls below 85%. To regenerate the germplasm in the fields the routine agricultural practices are followed, however, proper crop specific strategy is to be followed to maintain the genetic integrity of the accession. The regeneration cost depends on the reproduction behaviour of the crops as the cost of regeneration of cross-pollinated crops is more than that for the self-pollinated ones, as the former requires elaborate arrangements and manpower for manual pollinations category to maintain the genetic integrity to the original collection (Breese 1989, Porceddu and Jenkins 1991).

The cost of land as well as the farm equipments (tractor, row-disk bedder, seed spreader, harvester etc.) contribute to the fixed cost while the manpower required for various farm practices as well as the agrochemicals (such as pesticides, insecticide, fertilisers etc.) are the components of the variable cost. These costs for regeneration would be similar as for seed multiplication, however these have not been separately accounted for assuming that the fresh collections will not need regeneration.

7.3 Germplasm Health Evaluation

The crop plants and the pests attacking them have evolved together, through a long and continuous association. Before sending the germplasm to the genebank, it is imperative to evaluate the health of the seeds for effective and safe conservation. To make sure that the collected germplasm is free from the contaminants, they are subjected to different types of examinations. The generalised tests, required for detection of superficial contaminants make use of common laboratory instruments and chemicals however, the specialised tests, required for the detection of the hidden infestations require sophisticated instruments and diagnostic kits (Ram Nath 1993). In some cases, where the infestation is detected in the seeds, the valuable germplasm is salvaged employing various techniques, viz. chemotherapy, thermo-therapy, mechanical cleaning or meristem tips culture. The salvaged germplasm are subsequently raised in isolation in the glasshouse.

Common laboratory equipments, the specialised instruments and the establishment of glasshouse facility contribute to the fixed cost component. The glassware, chemicals and the manpower contribute to the variable costs. The health of the germplasm is to be evaluated once that is prior to sending the germplasm to the genebank, therefore in this case the total cost is distributed over a period of 50 years (Table 4).

Banana requires thorough indexing for viruses and other microbes, as these multiply rapidly under cultural conditions and their presence posses a great threat for efficient conservation the costs involved in this activity are more. Moreover, this activity needs to be carried out after every 10 years as the accessions conserved through *in vitro* techniques are transferred to the fields after ten cycles of sub culturing (approx. one cycle/yr). Therefore, the total cost involved in the evaluation of health has been distributed over a period of 10 years in case banana in contrast to other crops (Table 4).

7.4 Maintenance of Active Collections

The active collection sites for crops with 'orthodox' seed behaviour are medium term storage modules, while for the 'recalcitrant' or 'vegetatively propagated' plants are the field gene banks.

7.4.1 Medium Term Storage

The active collections for paddy, sorghum and cowpea are effectively stored in the medium term storage modules, maintained at 4^{o}C temperature and 35% relative humidity. The seeds, after proper drying are stored in various types of containers such as cloth bags, metal cans or glass jars and kept in the storage racks of the modules. The establishment of infrastructure would include the storage module, having components like insulating panels, cooling system, dehumidifier, electrical panel *etc*. Since the facilities are to be operated at full efficiency and any break down would result in spoilage of the germplasm, therefore it is essential to have built-in redundancy of important components in the system. Similarly to circumvent the ill effects of power failure an efficient backup supply is to be ensured.

In addition to the modules, associated equipments for seed processing, seed drying, sealing, documentation etc. are also required. The consumables (baskets, containers etc.), manpower, the running cost of the module including the energy cost along with the maintenance cost for the equipments contribute to the variable cost component. The accession once kept in the medium term module can maintain its viability of 10-15 years hence the total cost incurred for the storage of germplasm in the active collections can be distributed over the period of 10 years (Table 5).

7.4.2 Field gene bank

The active collection sites for the vegetatively propagated plants such as banana as well as for the recalcitrant crops like tea are the field genebanks. Germplasm maintained in the field genebanks fall in two categories. Type I species (such as tea) include woody and herbaceous perennials that require only periodic maintenance. Type II species (such as banana) include annuals, biennials and perennials that require frequent maintenance. The cost for maintenance of Type II species is more than to that for Type I species (Jarret & Florkowski, 1990).

Maintenance of plants in field genebank is labour-intensive and expensive. Along with this the chances of loss of the germplasm are very high due to insect/pest attack, disease outbreak and natural calamities. To avoid loss of vigour as well as to prevent the incidences of attack by pests the plants have to be replanted routinely, and this adds up to the cost further. The costs of land and farm equipment (tractor, row-disk bedder, seed spreader, harvester etc.) contribute to the fixed cost. The manpower required for various farm practices is allocated depending on the nature of the crop, and number of accessions to be handled further the expenditure incurred for various agrochemicals (such as pesticides, insecticide, fertilisers etc.) have been included as miscellaneous expenditure. While calculating the total cost of conservation of germplasm the storage and maintenance cost in the field genebank has been distributed over a period of 50 years (Table 5).

8 COSTS FOR MANAGEMENT OF BASE COLLECTIONS

In the base collections the germplasm are conserved employing three approaches (a) seed gene bank: for orthodox seeds, (b) tissue culture repositories for of vegetatively propagated plants and (c) cryo-banks: for recalcitrant seeds as well as the aseptic cultures maintained in the tissue culture repositories.

8.1 Seed Gene Bank

The seed for the base collections are stored in the long-term storage modules maintained at -20^{o}C temperature. The accessions when received in the genebank are screened to remove the under sized, shrivelled, diseased and immature seeds the clean and healthy seeds are subjected to the seed germination test, following the recommendations of IBPGR (now IPGRI, Ellis *et al*., 1985). The accession having shows more than 85% viability are transferred into muslin cloth bags and are allowed to equilibrate at 15^{o}C temperature and 15% RH in the seed dryer to attain a moisture content in the range of 3 to 7 per cent. The dried seeds are hermetically sealed in a tri-layered aluminium foil pouch. These pouches are transferred to the long-term storage modules after appropriate labelling indicating the crop, genus, species, accession number, identification number, germination percentage, moisture percentage, storage date and source.

The various components contributing for the fixed costs are the storage module, arrangements for alternative power supply, seed germinators, incubators, analytical balances, seed dryers, sealing machine, *etc*. While the man power and the expenditure on the miscellaneous items *viz.* germination paper, baskets, labels, glasswares, aluminium foil pouches, muslin cloth bags *etc.* contribute to the variable cost component. The cost involved in the conservation of seeds with orthodox seed behaviour has been distributed over a period of 50 years (Table 6).

The seed genebank aims to store good quality seed and maintain viability of the accessions above 85%. Therefore, approximately 10% of the accessions kept in the long-term storage are randomly monitored periodically, after every 10 years. If on test it is found

that the viability has fallen below 85% a request is sent to the active site to regenerate the accession for replacement in the base collection.

8.2 Tissue Culture Repositories

Conservation of germplasm through tissue culture is a costly exercise and requires expensive equipments and skilled staff. Raising of aseptic cultures, employing shoot tip, nodal segments, zygotic or somatic embryos, is a pre-requisite for this activity. For the conservation, emphasis is laid to slow down the growth of the tissue in cultures to extend the subculture interval. Slow growth under *in vitro* conditions is accomplished by adopting various strategies, *viz*. (I) maintenance of cultures on the minimal media, (ii) reduction in sucrose quantity in the culture media, (iii) incubating the cultures at low temperatures (iv) use of osmotic agents (sorbitol, mannitol), and (v) use of growth retardant (ABA, maleic hydrazide *etc*.; Mandal *et al*, 2000).

The conservation activity begins with the standardisation of protocols, which contributes to the cost substantially. The required equipments *viz.,* stereomicroscope, autoclaves, laminar flow cabinets, refrigerators, growth chambers, weighing balances, contribute to the fixed costs while the manpower, miscellaneous items and the contingency for the maintenance of equipments and facilities contribute to the variable cost. The maintenance of germplasm requires frequent sub culturing, which adds up further to the cost involved in their maintenance (Epperson et al. 1997). For banana and tea, the total cost is calculated on annual basis, as frequent subculturing is required to maintain the viability of the germplasm. The tissue culture activity related to tea germplasm has recently begun with the standardisation of protocols. At present it is not practically employed for conservation purposes but offers a promising potential to be used in future (Table 6).

8.3 Cryopreservation

This technique involves the conservation of germplasm at ultra low temperature of -196 ^{O}C using liquid nitrogen. The small sized recalcitrant seeds are preserved as whole seeds, while in large sized seeds (like tea) the excised embryonic axes are conserved. The *in vitro* raised cultures can be cryopreserved employing encapsulation/dehydration, vitrification or freeze injury methods (Chaudhary and Radhamani 1993).

The cost incurred in standardisation of protocols contributes to the total cost substantially. The cost involved in conservation of banana (conserved in the form of cultures) is more, as it is a prerequisite to establishment of aseptic cultures, while in case of tea the excised embryonic axes can be conserved.

The setting up the cryopreservation facility requires expensive equipment's like cryo-tanks, cryo-cans, laminar flow, autoclave, analytical balances, stereomicroscopes, analytical balances, etc. It is a highly labour intensive activity and the manpower, general laboratory glasswares, liquid nitrogen and chemicals contribute to the variable costs.

The cost components involved in the cryopreservation have been distributed over a period of 50 years (Table 6), as the accessions once kept in cryotanks are believed to remain viable for an indefinite period. The cryopreservation activities related to banana germplasm have recently begun with the standardisation of protocols. At present it is not practically employed for conservation purposes but offers a promising potential to be used in future.

9 EPILOGUE

In the present study, the cost of conservation has been calculated keeping in account all the activities involved in it in a holistic manner rather than laying emphasis only on the mode of storage as dealt in some earlier studies. The cost of conservation has found to be highly dependent on the crops to be conserved its mode of reproduction and storage as well as the extent of diversity (Table 7). Among the five test crops, the cost of conservation is least for paddy, which is due to its self pollinating nature, orthodox seed behaviour as well as large number of accessions, which can be handled in the same infrastructure. The various conservation activities require specialised personnel and basic infrastructure therefore the cost effectiveness of the conservation centre will be determined by the number of accessions and the strategy adopted for its conservation.

There are however various limitations encountered in calculating cost of conservation:

- The activities associated with the conservation of plant genetic resources are highly inter-linked and the research institutions involved do not find it easy to maintain their internal accounts either commodity wise or activity wise. A sense of hesitation in sharing the accounts also exists as it is looked upon by the institutions as an auditing of their activities. Thus one has to impute the commodity wise expenditures by working out unit cost of each activity and this calls for making assumptions based on the experiences of the concerned scientists.

- The cost of characterisation has in past included primarily the agronomic and biological characterisation using generally the standard descriptors based on the requirements of breeding programmes, mainly aiming at increase in production, and the costs are calculated for these aspects. There is a need for characterisation of germplasm based on social and local knowledge and for specific requirements of communities. This has implications for cost calculations, as this requires as compiling this data for the accessions during collection missions and characterising both existing and newly acquired germplasm. It shall also require expenditure for capacity building and reorienting of the germplasm explorers about this dimension of characterisation.

- The passport data sheets will also need to be redefined and new parameters will have to be included, with changing times, for instance food processing quality which is becoming an important criterion of global economy as well as national economy, have not been included in existing formats. The cost of identifying such characteristics will be very high in the absence of local knowledge. Initial expenditure for the modification of the passport data sheets and collation of this knowledge may be high and needs to be accounted for in the future.

- The scientists are using the latest techniques such as in vitro cultures, cryopreservation etc., for conservation of germplasm and this requires costs for protocol development and associated basic studies as well. The costs in the present studies have been calculated using existing models for the crops for which these have been developed. But one has to treat these estimates as tentative since actual costs may be high depending upon the technique employed and nature of the germplasm to be conserved.

- The cost of sharing data with local communities for enabling them to access the same in times of need has not been calculated in this study. However, one must note that access to the information as well as germplasm kept in ex situ gene banks must also be provided to the local communities as and when they need the same, this would be a very potent incentive for them for sharing their information and material. This will require the translation for genebank associated database in local languages, making it available on

web for access through public kiosks etc., all of which will be quite costly given the size of germplasm holdings in the genebank. Though this cost has not been included in the present analysis, but this is a cost which will have to be included at some stage to make gene bank-people relationship ethically accountable and sustainable in the long-term.

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Table 1. Common Costs Involved in the Conservation of Germplasm

Common Cost	Details	Rs. (,000)	US $ (,000)	$/acc/yr
Space Cost	Building (50 years) and Land farm cost	150000	3409	0.341
Security Cost	for buildings, farms and gene banks at places	200	4.54	0.023
Networking	Data entry & Information Mgt Consumables,	500	11.36	0.057
	Equipment Vast, Initial networking cost	1000	22.73	0.00228
	Manpower: 1 Scientists, 2 TA, Contractual labour	1000	22.73	0.114
	Miscellaneous (including maintenance contracts for equipment's)	1500	34.09	0.171
Library Cost	Books, Journals *etc.,*	1500	34.09	0.171
H. R. D.	National Training's	1500	34.09	0.171
	International Training's	500	11.36	0.057
Legal Costs* and benefit sharing	For checking piracy, filing and challenging patents Manpower, Manager(1) TA(1)	500	11.36	0.057
Transactions Costs	Handling cost Request of material, acquisition and dissemination cost Cost of developing Material Transfer Agreements (MTA)	200	4.54	0.023
Administrative Staff	Accounts maintenance and records up keep	1500	34.09	0.171
Total				1.35828
Institutional overheads	10 % of the annual common cost			0.136
Total		159900	3633.98	1.49

Table 2: Estimated Costs Involved in the Acquisition of Germplasm

Apportioned Cost Head	**Paddy**			**Sorghum**			**Cowpea**			**Tea**			**Banana**		
	Rs. (000)	US $ (,000)	$/Acc/yr	Rs. (000)	US $ (,000)	$/Acc/yr	Rs. (000)	US $ (,000)	$/Acc/yr	Rs. (000)	US $ (,000)	$/Acc/yr	Rs. (000)	US $ (,000)	$/Acc/yr
Pre-survey activities a) Library, Review, Communication/ Internet time (to be met from common costs)															
b) Co-ordination with prospective collaborator(s), Developing Formats Miscellaneous	500	11.36	2.272 **(0.046)**	400	9.09	3.028 **(0.061)**	100	2.27	7.567 **(0.153)**	200	4.54	15.12 **(0.306)**	100	2.27	75.667 **(3.027)**
Documentation and Validation (Physical,Social religious,Culi-nary characters)	100	2.27	0.454 **(0.009)**	100	2.27	0.757 **(0.015)**	50	1.14	3.783 **(0.077)**	50	1.14	3.783 **(0.077)**	50	1.14	**37.633 (1.514)**
Exploration, germplasm & passport data collection Processing of material(clean-ing,drying,etc) collection/active Collection, Documentation,Consumables	1000	22.73	4.544 **(0.092)**	700	15.91	5.299 **(0.106)**	150	3.41	11.367**(0 .230)**	200	4.54	15.12 **(0.306)**	200	4.54	151.234 **(6.054)**
TA/DA	1000	22.73	4.544 **(0.092)**	600	13.64	4.542 **(0.091)**	160	3.64	12.131**(0 .242)**	500	11.36	37.867 **(0.767)**	40	0.91	30.330 **(1.213)**
Equipments	500	11.36	2.272 **(0.046)**	400	9.09	3.028 **(0.061)**	100	2.27	7.567 **(0.153)**	100	2.27	7.567 **(0.153)**	50	1.14	37.633 **(1.514)**
Manpower	1700	38.64	7.768 **(0.155)**	1500	34.09	11.363 **(0.227)**	300	6.82	22.734 **(0.460)**	400	9.09	30.300 **(0.607)**	250	5.68	189.330 **(7.573)**
Contingency	500	11.36	2.272 **(0.046)**	400	9.09	3.028 **(0.061)**	100	2.27	7.567 **(0.153)**	500	11.36	37.867 **(0.767)**	100	2.27	75.667 **(3.027)**
Total	5300	120.45	24.126 **(0.486)**	4100	93.18	31.045 **(0.622)**	960	21.82	72.716 **(1.468)**	1950	44.30	147.62 **(2.983)**	790	17.95	597.49 **(23.922)**

Table 3: Estimated Costs Involved Evaluation and Characterization of Germplasm

Apportioned Cost Head	Paddy			Sorghum			Cowpea			Tea			Banana		
	Rs. (000)	US $ (,000)	$/Acc/yr	Rs. (000)	US $ (,000)	$/Acc/ yr	Rs. (000)	US $ (,000)	$/Acc/y r	Rs. (000)	US $ (,000)	$/Acc/y r	Rs. (000)	US $ (,000)	$/Acc/ yr
Agronomic Evaluation / Seed Multiplication / Regeneration Characterisation (based on known descriptors), consumables	500	11.36	2.27 **(0.227)**	300	6.82	2.27 **(0.227)**	150	3.41	11.37 **(1.137)**	200	4.55	15.17 **(1.517)**	50	1.14	38 **(3.800)**
Manpower	1500	34.09	6.82 **(0.682)**	1250	28.41	9.470 **(0.947)**	150	3.41	11.37 **(1.137)**	400	9.09	30.30 **(3.030)**	250	5.68	189.33 **(18.933)**
Contingency	500	11.36	2.27 **(0.227)**	400	9.09	3.03 **(0.303)**	100	2.27	7.57 **(0.757)**	100	2.27	7.57 **(0.757)**	300	6.82	227.33 **(22.733)**
Equipments (farm and lab.)	250	5.68	1.14 **(0.114)**	200	4.55	1.52 **(0.152)**	100	2.27	7.57 **(0.757)**	100	2.27	7.57 **(0.757)**	50	1.14	38 **(3.800)**
Total	2750	62.49	12.5 **(1.25)**	2150	48.87	16.29 **(1.629)**	500	11.36	37.88 **(3.788)**	800	18.18	60.61 **(6.061)**	650	14.78	492.66 **(49.266)**
Biochemical and special traits evaluation Preparation of samples, consumables, chemicals and glasswares	1500	34.09	6.82 **(0.682)**	1000	22.73	7.58 **(0.758)**	500	11.36	37.87 **(3.787)**	500	11.36	37.87 **(3.787)**	100	2.27	75.67 **(7.567)**
Equipments	1000	22.73	4.55 **(0.455)**	700	15.91	5.30 **(0.530)**	300	6.82	22.73 **(2.273)**	300	6.82	22.73 **(2.273)**	50	1.14	38 **(3.800)**
Manpower	700	15.91	3.18 **(0.318)**	500	11.36	3.78 **(0.378)**	150	3.41	11.37 **(1.137)**	200	4.55	15.17 **(1.517)**	100	2.27	75.67 **(7.567)**
Contigency	1000	22.73	4.55 **(0.455)**	500	11.36	3.78 **(0.378)**	200	4.55	15.17 **(1.517)**	200	4.55	15.17 **(1.517)**	100	2.27	75.67 **(7.567)**
Total	4200	95.45	19.1 **(1.91)**	2700	61.36	20.44 **(2.044)**	1150	26.14	87.14 **(8.714)**	1200	27.28	90.94 **(9.094)**	350	6.95	265.01 **(26.501)**
Genetic Diversity/ Molecular Evaluation / Genetic purity / Stability @ Rs 5000/sample.			113.63 **(2.27)**			113.63 **(2.27)**			113.63 **(2.27)**			113.63 **(2.27)**			113.63 **(11.36)**

Table 4: Costs involved in the germplasm health evaluation

Apportioned Cost Head	Paddy			Sorghum			Cowpea			Tea			Banana		
	Rs. (000)	US $ (,000)	$/Acc/yr	Rs. (000)	US $ (,000)	$/Acc/ yr	Rs. (000)	US $ (,000)	$/Acc/ yr	Rs. (000)	US $ (,000)	$/Acc/ yr	Rs. (000)	US $ (,000)	$/Acc/ yr
Consumables	500	11.36	2.27 **(0.046)**	300	6.82	2.272 **(0.046)**	200	4.55	15.167 **(0.306)**	200	4.55	15.167 **(0.306)**	300	6.82	227.33 **(22.733)**
Equipments	1000	22.72	4.54 **(0.092)**	700	15.91	5.30 **(0.160)**	400	9.09	30.30 **(0.607)**	300	6.82	22.72 **(0.460)**	800	18.18	606.00 **(60.600)**
Manpower	1500	34.09	6.82 **(0.136)**	750	17.05	5.68 **(0.113)**	150	3.41	11.36 **(0.230)**	200	4.55	15.167 **(0.306)**	250	5.68	189.33 **(18.933)**
Contingency	200	4.55	0.91 **(0.018)**	200	4.55	1.517 **(0.031)**	100	2.27	7.567 **(0.153)**	100	2.27	7.567 **(0.153)**	300	6.82	227.33 **(22.733)**
Miscellaneous (including maintenance contracts for equipments)	300	6.82	1.36 **(0.027)**	100	2.27	0.757 **(0.015)**	100	2.27	7.567 **(0.153)**	100	2.27	7.567 **(0.153)**	200	4.55	151.23 **(15.123)**
Total	3500	79.54	15.9 **(0.319)**	2050	46.6	15.526 **(0.310)**	950	21.59	71.961 **(1.444)**	900	20.46	68.188 **(1.374)**	1850	42.05	1401.22 **(140.12)**

Table 5: Estimated Costs Involved in the Storage of Germplasm in the Active Collection

Apportioned Cost Head	Paddy			Sorghum			Cowpea			Tea			Banana		
	Rs. (000)	US $ (,000)	$/Acc/ yr	Rs. (000)	US $ (,000)	$/Acc/ yr	Rs. (000)	US $ (,000)	$/Acc/ yr	Rs. (000)	US $ (,000)	$/Acc/yr	Rs. (000)	US $ (,000)	$/Acc/ yr
Seed Genebank															
Processing cost consumables	1000	22.73	4.545 **(0.455)**	800	18.18	6.06 **(0.606)**	150	3.41	11.36 **(1.136)**						
Equipments	750	17.05	3.409 **(0.341)**	500	11.36	3.78 **(0.378)**	300	6.82	22.72 **(2.272)**						
Manpower	700	15.91	3.18 **(0.318)**	500	11.36	3.78 **(0.378)**	150	3.41	11.36 **(1.136)**						
Miscellaneous (including maintenance contracts for equipments)	500	11.36	2.272 **(0.227)**	500	11.36	3.78 **(0.378)**	100	2.27	7.567 **(0.757)**						
Contingency (including energy charges and emergency backup power supplies)	1000	22.73	4.545 **(0.455)**	500	11.36	3.78 **(0.378)**	100	2.27	7.567 **(0.757)**						
Total	3950	89.78	17.951 **(1.796)**	2800	63.62	21.18 **(2.118)**	800	18.18	60.574 **(6.058)**						
Field Genebank															
Land cost										200	4.55	15.167 **(0.306)**	100	2.27	75.667 **(1.53)**
Farm equiments										100	2.27	7.567 **(0.153)**	100	2.27	75.667 **(1.53)**
Man power										400	9.09	30.30 **(0.607)**	200	4.54	151.23 **(3.06)**
Miscellaneous										100	2.27	7.567 **(0.153)**	100	2.27	75.667 **(1.53)**
Total										800	18.18	60.606 **(1.212)**	500	11.35	378.23 1 **(7.59)**

Table 6: Estimated Costs Involved in the Storage of Germplasm in the Base Collection

Apportioned Cost Head	Paddy			Sorghum			Cowpea			Tea			Banana		
	Rs. (000)	US $ (,000)	$/Acc/ yr	Rs. (000)	US $ (,000)	$/Acc/ yr	Rs. (000)	US $ (,000)	$/Acc/y r	Rs. 000)	US $ (,000)	$/Acc/y r	Rs. (000)	US $ (,000)	$/Acc/ yr
Seed Genebank															
Consumables	600	13.64	2.728 **(0.055)**	500	11.36	3.787 **(0.076)**	200	4.55	15.167 **(0.306)**						
Equipments	800	18.18	3.63 **(0.073)**	500	11.36	3.787 **(0.076)**	300	6.82	22.720 **(0.460)**						
Manpower	700	15.91	3.182 **(0.064)**	500	11.36	3.787 **(0.076)**	150	3.41	11.367 **(0.230)**						
Miscellaneous	1000	22.73	4.545 **(0.092)**	500	11.36	3.787 **(0.076)**	100	2.27	7.567 **(0.153)**						
Contingency	1000	22.73	4.545 **(0.092)**	500	11.36	3.787 **(0.076)**	100	2.27	7.567 **(0.153)**						
Total	4100	93.19	18.63 **(0.376)**	2500	56.8	18.935 **(0.38)**	850	19.32	64.388 **(1.302)**						
In Vitro repository															
Preparaing cost										300	6.82	22.720	50	1.14	38.000
Equipments										300	6.82	22.720	300	6.82	227.200
Manpower										200	4.55	15.167	150	3.41	113.670
Miscellaneous (maintenance of culture room, equipments)										100	2.27	7.567	50	1.14	38.000
Contingency (consumables, galsswares & chemicals)										100	2.27	7.567	50	1.14	38.000
Total										1000	22.73	**75.741**	600	13.65	**454.87**
Cryopreservation															
Preparaing cost										300	6.82	22.727 **(0.460)**	50	1.14	38.000 **(0.767)**
Equipments										300	6.82	22.727 **(0.460)**	300	6.82	227.200 **(4.600)**
Manpower										200	4.55	15.151 **(0.306)**	100	2.27	75.667 **(1.530)**
Miscellaneous(maintenance of cryo-bank, equipments)										100	2.27	7.575 **(0.153)**	50	1.14	38.000 **(0.767)**
Contingency (consumables, galsswares & chemicals)										100	2.27	7.575 **(0.153)**	50	1.14	38.000 **(0.767)**
Total										1000	22.73	75.755 **(1.515)**	550	12.51	416.667 **(8.331)**

Table 7: Total Cost Estimated Involved in the Conservation of Germplasm of Five Crops

Apportioned Cost Head	Paddy			Sorghum			Cowpea			Tea			Banana		
	Rs. (000)	US $ (,000)	$/Acc/yr	Rs. (000)	US $ (,000)	$/Acc/yr	Rs. (000)	US $ (,000)	$/Acc/yr	Rs. (000)	US $ (,000)	$/Acc/yr	Rs. (000)	US $ (,000)	$/Acc/yr
Acquisition of germplasm	5300	120.45	24.126 **(0.486)**	4100	93.18	31.045 **(0.622)**	960	21.82	72.716 **(1.468)**	1950	44.30	147.62 **(2.983)**	790	17.95	597.49 **(23.922)**
Evaluation and characterisation of germplasm															
Agronomic	2750	62.49	12.5 **(1.25)**	2150	48.87	16.29 **(1.629)**	500	11.36	37.88 **(3.788)**	800	18.18	60.61 **(6.061)**	650	14.78	492.66 **(49.266)**
Biochemical and for special traits	4200	95.45	19.1 **(1.91)**	2700	61.36	20.44 **(2.044)**	1150	26.14	87.14 **(8.714)**	1200	27.28	90.94 **(9.094)**	350	6.95	265.01 **(26.501)**
Molecular			113.63 **(2.27)**			113.63 **((2.27)**			113.63 **((2.27)**			113.63 **((2.27)**			113.63 **(11.36)**
Storage of germplasm in active collection	3950	89.78	17.951 **(1.796)**	2800	63.6	21.18 **(2.118)**	800	18.18	60.574 **(6.058)**	800	18.18	68.201 **(1.212)**	500	11.35	378.231 **(7.59)**
Storage of germplasm in base collection	4100	93.19	18.63 **(0.376)**	2500	56.8	18.935 **(0.38)**	850	19.32	64.388 **(1.302)**	1000	22.73	75.755	600	13.65	454.87
										1000	22.73	75.755 **(1.515)**	550	12.51	416.667 **(8.331)**
Germplasm health evaluation	3500	79.54	15.9 **(0.319)**	2050	46.6	15.526 **(0.310)**	950	21.59	71.961 **(1.444)**	900	20.46	68.188 **(1.374)**	1850	42.05	1401.22 **(140.12)**
Common cost	159900	3633.98	1.49	159900	3633.98	1.49	159900	3633.98	1.49	159900	3633.98	1.49	159900	3633.98	1.49
Total cost	183700	4174.88	**223.33 (9.89)**	176200	4004.39	**238.54 (10.863)**	165110	3752.39	**509.69 (26.53)**	167550	3807.84	**702.19 (101.754)**	165190	3753.22	**4121.268 (723.456)**