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Germplasm Conservation of Multipurpose Trees and their Role in Agroforestry for Sustainable Agricultural Production in Pakistan

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ABSTRACT

With increase in human and livestock population, worldwide increase in deforestation and land degradation has become the matter of global importance. Particularly in developing countries, productive forests and fertile lands are shrinking at an alarming rate making demand and supply relationship imbalanced. Another concern is the depletion of genetic resources of potentially important species either as a result of indiscriminate vegetation or insufficient efforts to preserve and maintain germplasm collections. Agroforestry (AF), as a complete farming system, has recently received attention recently and MPTS (multipurpose trees & shrubs) are considered as its integral component. They occupy prime importance for having potential and vital role in sustainable agricultural development. The importance of MPTS in meeting human needs for wood and its products and sustaining soil productivity is becoming increasingly recognized. Hundreds of species have been considered to have multiple uses. MPTS extremely vary for their natural distribution and variation, methods of exploration, collection and evaluation of their germplasm. In this paper, an attempt has been made to explore the role of MPTS in sustainable agricultural development and the strategies for germplasm acquisition, evaluation and preservation.

Key Words: Agroforestry; Multipurpose trees; Genetic conservation; Sustainable agriculture

INTRODUCTION

The world's forest resources are shrinking and disappearing at an alarming rate due to heavy harvesting and clearing woodlands for agricultural crops to meet the growing needs for food, fuel and fiber. The deforestation rate is extremely high in most of the developing countries. According to the summary report of the World Commission on Forests and Sustainable Development (1999), about 15 million hectares of productive forests are being cleared each year whereas only 10 percent area is brought back to forest vegetation on the global basis. The structural integrity of much of the forest that remains has deteriorated. Forests have virtually disappeared in 25 countries; 18 have lost more than 95% of their forests and another 11 have lost 90%. The highest current estimate of the world's remaining forests areas is about 3.6 billion hectares from an originally forested area of more than 6.0 billion hectares (WCFSD, 1999).

Wood has been among the basic human needs since the dawn of the civilization. In spite of the need in daily use, during the introduction and development of high input agriculture, trees were taken as a commodity of low priority in the farming systems of the developing countries. Adverse effects of severe food and fuel-wood supply can be foreseen today. According to National Research Council (1991) when forests decline or removed, trees are not all that is lost. The forest harbours many forms of animal and plant life that depend on its environment for survival. Many of these species, their potential use to society, and their ecological importance have yet to be discovered. The most important point to remember is once these species are gone, that knowledge, along with the potential benefits, is also gone. Another major concern is the genetic erosion of important plant species that used to be the part of our ecosystem (O'Neill *et al.,* 2001). Once the genes are lost, those are lost forever and there is absolutely no chance of bringing them back at any cost. According to Pathak (1992), woody perennials were among the essential components of the rural ecosystem since they catered to the multipurpose needs of the rural habitat. Recently, the local governments, national forest departments and international organizations have also realized the wood deficits and potential benefits of multipurpose trees in the farming system using agroforestry systems. It is, therefore, imperative to explore the MPTS germplasm to harvest its multidimensional benefits and their *in-situ and in-vitro* preservation. Therefore, this paper examines the role of multipurpose trees for developing

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sustainable farming system, identify problems of germplasm collection and formulate strategies to overcome these problems.

Multipurpose trees and shrubs (MPTS). MPTS are defined as trees grown deliberately or kept and managed for preferably more than one intended use, usually economically motivated major products and/or services in any multipurpose land use system, especially agroforestry systems (Von Carlowitz & Burley, 1984).

MPTS in a system approach. A multipurpose tree constitutes an essential component of agroforestry system or other multipurpose land use systems. Regardless of the number of its potential or actual uses, a multipurpose tree has to have the capacity to provide in its specific function (s) in the system a substantial and recognizable contribution to the sustainability of yields, to the increase of outputs and/or reduction of inputs and to the ecological stability of this system. Only a tree that is kept and maintained or introduced into an agroforestry system for one or more of these purposes qualifies as a multipurpose tree (Von Carlwolitz, 1984).

Agroforestry. Agroforestry (AF) has been defined as an intensive land-management system that optimizes the benefits from the biological interactions created when trees and/or shrubs are deliberately combined with crops and/or livestock (Garrett *et al.*, 1994). It is also defined as a form of multiple cropping under which the following three fundamental conditions are met:

1. There exists at least two plant species that interact biologically
2. At least one of the plant species is a woody perennial and
3. At least one of the plant species is managed as fodder/annual or perennial crop.

However, in simple terms we can define agroforestry as the planned integration of agriculture and forestry. For instance Agrisilvopastoral system combines tree with agricultural crops, Silvopastoral system combines tree with livestock and Agrisilvopastoral system combines tree, crops and livestock on a unit of land area.

Role of AF in sustainable crop production. Agroforestry being an integrated land use system has the potential to address several environmental issues and overcome many ecosystems' problems. Almost all AF systems have specified functions and purposes for which they specifically are suited. These functions are matched to peoples' needs and capacities of land to sustain the agroforestry system to the possible extent. The agroforestry production functions lay emphasis on the production of food, energy, raw materials and cash outputs, however not diminishing the importance of environmental benefits and sustainability in any way. While production is stressed, it is the sustainability attribute that makes it different and unique from other approached to land and resources management (Ffolliott & Brooks, 1995).

AF systems are multipurpose and in general have both production and protection functions (Huxley & Houten, 1997). The protection functions of AF often contribute to production functions by sustaining and, at times, increasing the production of outputs through the amelioration of microclimates and the protection of soil and water resources (Ffolliott & Brooks, 1995).

MPTS as part of AF. Any definition of MPTS cannot be applied entirely to a certain set of species. Virtually every species of a tree or a shrub can be used for more than one purpose. However, the term appears to be used most commonly when a species is deliberately grown at one site and time to produce more than one product or benefit. Among the products, timber, fuel, medicines, human food and animal fodder, flowers for bees and leaves for silkworms are important whereas shade, shelter, soil conservation and improvement of soil fertility are other services of the MPTS. Moreover, the term should be used to cover species that may be grown for different purposes on different sites. For example, Silver oak (*Grevillea robusta*), an accepted timber tree would be considered multipurpose if it is grown for shade, mulch and honey (Burley, 1985).

Fast growing nitrogen fixing trees (NFTs) are subset within the category of MPTS. They are capable of fixing atmospheric nitrogen in the form that is otherwise un-available to plants, soil and animals. According to Brewbaker *et al.* (1984) most of the NFTs species fall under the *Leguminosae* family but there are more than 10 other families, known to fix nitrogen. NFTs are considered multipurpose because nitrogen fixation is a major service offered by them and the foliage is their minor product whereas their wood is another major product is also being used in the form of timber, poles and fuel etc. (Burley, 1985). Nevertheless MPTS (both NFTs & non-NFTs) happen to be an integral part and an important constituent of agroforestry systems.

Potential role and multiple benefits of MPTS in AF systems. MPTS grow under a wide range of ecological conditions, playing significant role in protecting natural resources, improving environment and providing numerous products and services (Baig *et al.,* 1997). AF with its multiple species, functions and products provides fairly wide range of social, economic and environmental benefits on a continuing basis. Also as a land use system, it has the potential to contribute substantially to the uplift of the impoverished rural dwellers that comprise 60-80% of the population of developing tropical countries (Vergara & MacDicken, 1990). Also Pathak (1992) maintains that the trees with numerous benefits are preferable and must be the first rate choice of scientists and the farming community than trees with only one benefit. Almost all trees can support rural and urban communities through their benefits of protective, productive and socio-economic roles. These functions are summarized and presented in Table I.

Present use of MPTS in AF systems of Pakistan. Although farmers in different parts of Pakistan integrate a variety of woody perennials in their crop and livestock production systems, depending upon the agro-climatic conditions and local needs, most of these practices are very site-specific and information on these are mostly anecdotal. Therefore, their benefits have remained mostly under- to unexploited. It has now been well recognized that AF can address major land use problems of the country. A great deal can be accomplished by improving the indigenous systems and by blending improved agroforestry techniques and using indigenous and exotic multipurpose and/or nitrogen-fixing trees and shrubs (Baig *et al.,* 1997).

In a national workshop held at the PFI, the following species are identified as priority species for different provinces of Pakistan (Khan, 1993).

MPTS in AF systems of Sindh province. In lower Sindh, farmers mostly plant *Acacia nilotica* (Babul) in the shape of woodlots, locally called "Hurries". A study focusing on the system of Babul block plantation practiced in Sindh province showed that its benefits the farmer by improving agricultural land and subsequent agricultural yields. The system also provides a financial return of about \$US 100 ha^{-1} yr^{-1} from the sale of the wood, with a cost/benefit ratio of 1: 1.72.

MPTS in AF systems of north west frontier province (NWFP). Poplar is planted in NWFP on the boundaries of agricultural fields to serve the purpose of shelterbelts or windbreaks particularly in Charsada, Mardan, Noshera and Mansehra districts. Poplar is used in wood-based industries, which generate millions of dollars and therefore contribute to the economic uplift of the area. The fact that the farmers of the area grow trees on their farms in conjunction with agricultural crops is a clear demonstration of the economic viability that recognizes the usefulness of trees. It also indicates that a great potential for agroforestry does exist under similar conditions and in other parts of the country. Wheat and sugarcane fields are protected with poplar windbreaks and this practice yields more financial benefits to the farmers in the Peshawar valley (Baig *et al.,* 1997). Poplar wood is used as a source of timber and wood fuel, whereas its leaves are used as fodder to feed various kinds of livestock. Being a fast growing tree species poplar is very much liked and preferred by the farmers as compared to other tree species.

MPTS in AF systems of Balochistan province. *Eleagnus hortensis* (Russian olive) are grown in Mastung valley of Balochistan on the borders of agricultural fields as shelterbelts or windbreaks. The desiccating effect of wind in dry and sandy areas that plays havoc with agricultural crops and orchards can be considerably reduced and even completely mitigated by shelterbelts and windbreaks. Planting of shelterbelts and windbreaks can enhance agricultural crop yields and food production in these areas (Akbar *et al.,* 1989; Baig *et al.,* 1997). Moreover, the seed of *Eleagnus hortensis* is used as fruit and for medicinal purposes.

In a sandy area of the Mastung valley in, the yield of wheat crop increased 8, 15 and 14% with one, two and three row shelterbelts (*Tamarix gallica; Tamarix gallica + Arundo donax;* & *Tamarix gallica + Arundo donax + Colligonum polygonoides*), respectively. This study also indicated that soil moisture in the 0-150 mm layer in plots protected by the belts was consistently 26% higher than in the unprotected plots.

MPTS in AF Systems of Punjab Province

Pothwar plateau. In Pothwar Plateau of the Punjab *Acacia nilotica* and *Zizyphus muritiana* (Ber) are raised sporadically in the fields to get fuel wood, timber, shade and fodder. *Eucalyptus Camadulensis* and *Leucaena leucocephala* are becoming popular as exotics and now are being grown on larger area of the plateau (Akbar *et al.,* 1989).

Irrigated areas. In irrigated areas of the Punjab province, *Dalbergia sissoo* (shisham) is planted for shade, timber and fodder production. Now-a-days, various species of *Eucalyptus* are also gaining popularity as these easily grow in irrigated as wells as arid areas receiving less than 300 mm average annual rain fall. For wood production in Pakistan, poplars and eucalyptus are excellent trees for planting on farmlands on short rotation. The average size of a farm in Pakistan is 5.3 ha and therefore farmers mostly prefer to plant short rotation tree species. Besides Shisham (*Delbargia sisso*) and Simal (*Salmalia malabarica*) are also planted in irrigated fields, alongside irrigation channels and along roadsides in central and lower Punjab. Simal is also a fast growing tree species and its wood is used in furniture industries, construction and in composite wood industries.

It has been estimated that on an average 12 trees could be planted per ha on each farm in the shape of windbreaks or along the water channels, paths or in small woodlots. If fast growing trees such as poplar or eucalyptus, are planted at 5 m x 5 m spacing on ten years rotation, an average minimum yield of 0.0425 m^3 tree-^{1} $year^{-1}$ can be obtained easily. This can give an additional annual production of 10.1 million m^3 of wood from 19.80 million ha of farmlands (Table III).

Desert areas. Shisham shelterbelts around wheat crops growing perpendicular to the prevailing wind in the Thal desert of the Punjab province benefited the farmer with a net increase of 100 kg ha^{-1} .Another study in the same desert region measured the effect of shisham on wheat yields with similar results. Successful demonstration of wheat sheltered by rows of Shisham in Mianwali region of Punjab and wheat sheltered with *Eucalyptus* in Tharparkar, Sindh has revealed the usefulness of tree for crops in terms of high economic return besides protecting the crop from heavy storms.

In the desert of Cholistan, MPTS like *Prosopis cineraria, Salvadora oleoides, Callygonum polygonoides, Haloxylon recurvum, Capparis aphylla, Tecomella undulata* and many other are commonly found, which are often grazed by livestock. Among other prominent tree species, *Acacia, Albizzia, Moringa oleifera, Azadirachta indica* are commonly found in irrigated areas.

Salt-affected areas. Various studies have been conducted on salt tolerant trees, shrubs and grasses, growing in salt-affected areas of the country. Results show that the common indigenous salt tolerant plant species of Pakistan includes *Sesbania aculeata, S. sesban, Tamarix aphylla, Prosopis juliflora, P. cinararia, Albizzia lebbek, Leucaena leucocephala, Acacia nilotica, Azadirachta indica, Pakinsonia aculeate. The exotic Atriplex spp and Eucalyptus spp.* from Australia has proved very useful because of other beneficial attributes also.

MPTS as source of food and medicine. Trees and forests add variety to our diets in providing essential vitamins, minerals and proteins. Leaves, fruits, nuts, gums, roots and mushrooms are collected as edible foodstuff either from naturally growing forests or cultivated farmlands. They also provide the habitat for many common wild animals, livestock and fish. Forest tree products like nuts and fruits are used as snacks during the whole year. Forest trees and their leaves and fruits are considered rich in vitamins A and C. Quite a variety of fruits including *Zizyphus mauritiana, Capparis decidua, Salvadora oleoides and Date palm* come from tropical thorn forests. Plants like wild mango, Jaman, figs, bamboo shoots coconuts are viewed as food from forest origin (Mohammad & Joyia, 1989; Ashraf, 1990). Most of the precious medicines are prepared from various parts of trees and shrubs. Seed and fruits of many wild trees, leaves, root; flowers and barks of others are also used in preparing various medicines.

Need for Exploring MPTS Germplasm to Strengthen Agroforestry. Different roles of MPTS, wide range of climate, priorities for lands to be brought under afforestation, number of objectives and systems for managing trees, imply that a large number of MPTS species must be explored. As we know that no single species can grow well at all sites, respond to management practices, nor can result all types of services and products. It is also known that all the species are not necessarily suitable for multiple purposes (Burley, 1985). The associated multipurpose tree food species (MPTFS) occurring in different ecological zones are also important for food security and many of these are either extinct or endangered in their native habitats (Khan, 1998). Given the economic potential of the MPTS as source of food, medicines, fiber, wood fuel, timber and other environmental benefits warrants to explore and preserve the germplasm suited to a variety of climatic and edaphic conditions. Since neither a single species can grow well at all sites nor respond to management practices, or provide all types of services and products, it is essential to resort to collecting germplasm of a variety of MPTS.

MPTS are now being extensively planted outside traditional forest areas to provide not only timber and fuel wood but also a wide range of other products and services. The high importance of these additional roles of trees has already been recognized by international organizations like World Bank, FAO and Asian Development Bank etc. (Burley, 1985). It is encouraging that emphasis in development programs has been shifted from commercial forestry plantations to forestry for local development. The concepts of bringing the forest on the farm i.e., AF are increasingly becoming popular in both the developed and the developing countries (Baig *et al.,* 1997).

MPTS and associated problems. Analysis of the overall changes of emphasis in global forestry, the potential of small farmlands to supply multifarious products to meet our requirements and a large number of MPTS have greatly increased the interest in multipurpose tree germplasm in a short time. However, limited supplies of appropriate germplasm cannot meet the current demand of a nation like ours for suitable MPTS. The requirements of the nations are high and they are facing severe problems in receiving huge quantities of seed of MPTS from properly identified sources from the international research organizations. On the other hand, huge quantities of unknown MPTS and unknown provenances are also being exchanged worldwide without considering the consequent results. It is very unfortunate where seed collection is properly done; appropriate sampling procedures are employed or often overlooked. Genetic erosion of species and depletion of genetic resources is a matter of serious concern that needs immediate attention (Burley, 1985; O'Neill *et al.,* 2001). Large number of species having potential for planting in one or more environments, by one or more systems and for several purposes is the general problem associated with MPTS whereas the specific problems are:

1. Methods for deciding appropriate species to test
2. Determining appropriate methods of exploration and evaluation and
3. Locating suitable sources of germplasm when the optimum species and population are known.

Problems associated with exploration and collection. The optimum choice for using plant species and populations for a given site and specific objectives obviously opens new research and development avenues. We are aware of the fact that not all individual countries or institutions have the capacity to carryout all the functions and take steps towards exploration, collection and taxonomic observations of MPTS germplasm. Also it would be the wastage of resources if all countries wishing to receive germplasm to grow particular species and could be intolerable and undue burden on the host institution and donor country. Tree and shrubby vegetation requires a very longer period of time to produce seed and therefore makes it difficult for the breeders to select plus trees for seed production. Moreover, lack of adequate seed processing and certification facilities are other problems associated with the propagation of the MPTS germplasm.

Lack of trained field staff. Lack or shortage of trained field staff is serious constraint in the collection of MPTS germplasm. On the other hand, if the collection of germplasm is done by the experienced and knowledgeable staff on behalf of the potential planting countries would save the resources and overcome many problems likely to arise later (Burley, 1985).

Little information on distribution and extent of geographic distinction. Insufficient information is available on the distribution and extent of geographic distinction between populations within natural range, making field exploration a costly venture. To overcome this shortcoming, professional field staff and local rural population need to be identified as resource persons. Burley (1985) suggests that for indigenous species, scientists should encourage their staff to observe and record locations of the species whereas for exotics, one should consider the problem of exploration below sampling.

Lack of information on phenology. Lack of prior information on seasonal periodicity, little or no knowledge on the annual fluctuations in flowering and seed production and leaf phenology is seen as problems in exploring and collecting MPTS germplasm. For successful collections, it is necessary to have this kind of information beforehand to collect the seed at a suitable time without wasting time and resources (Burley, 1985).

Seed collection during low production years. Seed collection during low seed production should be avoided. According to Burley (1985) it is preferable to collect seeds in a year when it is produced abundantly. Heavy and surplus production of seed not only offers more freedom and choice of stands but also increases the possibility of more seed.

Limited resources and sampling. Burley (1985) suggests collecting samples from widely scattered points across the entire range at least during the first year, in case limited resources and insufficient information is available. Further it is advised to complete sampling later to get additional needed information because for both evaluation and conservation, it is desirable to capture optimum potential genetic variation within a population.

Local land races and derived provenances. During the process of evaluation of a multipurpose tree species within the natural range, environmental variability and human interference are important factors to consider. Because this kind of interference may move population genotype away from what natural selection could result (Burley, 1985). He further reports that when trees are planted within the natural range but on the farms, in some case, a low level selection would result in the development of local land races. On the other hand, Jones and Burley (1973) emphasized that when exotic species are planted out of their natural range, local selection by nature or by man creeps in as opposed to natural provenance, changing the population genotype. Such populations are considered and known as derived provenances.

Problems associated with evaluation. Evaluation of MPTS Germplasm is a complex process and difficult task to accomplish. For accurate evaluation, the design of the experiment is an important factor. Analysis and interpretation of comparative trials of different seed sources (species & sources) are crucial points in evaluation process. Careful consideration to taxonomic and ecological studies must be given during evaluation process.

Experimental design. For achieving precise and accurate results, it is imperative that experiments are carefully designed and planned, employing appropriate and exact designs for analytical and evaluation purposes. However, Burley (1985) experiences following three general problems associated with experiments on MPTS:

Lack of information. Burley (1985) observed that generally insufficient information exists or available with the scientists on variation between and within populations, creating difficulties for researchers.

Complex design. It has been observed that some experiments may include many species or Provenances, requiring more complex designs such as lattices for more precision. However, it is true that such designs are difficult to employ and layout. Management measures and analytical procedures are difficult to adopt due to the involvement of many species (Barnes *et al.*, 1982).

Too many sources of germplasm. In case, MPTS germplasm is coming from many sources, it may be at different stages of development, may have different breeding system and of course, variance. Burley (1985) presenting the example noted that one or two bred varieties of Leuceanea could be compared with bulked, wild type collections of other species not previously tested.

Problems associated with assessment. As the word multipurpose indicates these species are supposed to have multiple uses and characters, which are required to be assessed. Some or all of these parameters may not be familiar to agricultural and forest scientists. For example, usually foliage, fruit yield and foresters do not measure nitrogen-fixing capacity of species whereas woody biomass, fuel wood and charcoal yield and properties are not familiar topics to agricultural scientists. Therefore, lack of such information may lead to a variety of problems associated with the selection, preservation and propagation of the MPTS germplasm.

Sampling methods and laboratory techniques. Sampling methods, laboratory and field measurement procedures and analytical techniques still have to be developed for some of the traits of MPTS. Time, cost and skill are regarded as simple problems experienced during assessment process (Burley, 1985). To him, the prominent among the complex problems for assessing the multiple characters, is their compilation into an overall index, reflecting the gross socio-economic value of each seed source for each experimental site.

Little knowledge causes management problems. Some countries are stimulated to observe the remarkable successes of other countries operating under a different set of socio-economic, environmental and ecological factors. However, they may like to work on some of these exotic MPTS, not previously researched by their local institutions. Any organization wishing to replicate the success story of a foreign country without having experience of actually growing these trees, would indulge into the management

Table I. Role of MPTS in protection and productive system and uplift of socio-economic situation

Protective role of MPTS
Stabilization of environment
Soil improvement
Live fences
Wildlife habitat
Pest and weed control Watershed protection and rehabilitation of degraded lands.
Productive role of MPTS
Wood - timber, building material, pulp, paper etc.
Bark - raw as fuel, dyes, and tannins.
Energy Raw - wood fuel Processed - charcoal, gases or liquid fuels, resin, oil paint, varnishes
Leaf - fodder, oil, silk, medicines, dyes, food
Root - fiber, fuel wood, dyes, chemical extractives.
Socio-economic benefits
Improved human and animal nutrition and health
Employment opportunities and income generation
Foreign exchange and import substitution
Rehabilitation of degraded lands
Counter seasonality, year along products and employment
Risk reduction and lobour saving

Source: Pathak, 1992

Table II. Priority species for afforestation in different provinces of Pakistan

NWFP*	Punjab	Sindh	Balochistan	AJK & NA**
Pinus wallichiana	*Dalbergia sissoo*	*A. nilotica*	*Acacia Victoriae*	*P. roxburghii*
P. roxburghii	*A. nilotica wallichiana*	*E.camaldulensis*	*Acacia albida (exotic)*	*Pinus*
Cedrus deodara	*Bombax ceiba*	*Conocarpus Lancifolius*	*Pinus halepensis (exotic)*	*Robinia*
Eucalyptus	*P. deltoids*	*Albizia procera*	*E. camaldulensis*	
Camaldulensis				*Ailanthus altissima*
Acacia nilotica	*E.camaldulensis*			
Populus deltoides				*Sapindus mukorossi*

Source: Khan, S.R. 2003

*North-west Frontier Province

AJK & NA** Azad Jammu Kashmir and Northern areas

Table III. Some suitable combinations of trees and agricultural crops

Agricultural crop		Tree species
Wheat	+	Poplar + Shisham + Acacia +Ipil Ipil + Ber
Rice	+	Willow
Cotton	+	Simal
Sugarcane	+	Simal + Poplar
Fodder	+	Poplar + Sesbania + Acacia + Mulberry Shisham +Ipil Ipil
Vegetables including peas	+	Poplar + Sesbania
Irrigation channels	+	Simal + Shisham + Acacia
Field borders	+	Simal + Shisham + Poplar
Fruit gardens borders	+	Eucalyptus + Shisham + Simal

Source: Baig et al., 1997; Punjab Forest Department, 1998

problems. Burley (1985) considers that these management constraints arise due to lack of knowledge on seed treatments, nursery techniques, mycorhizal or inoculation applications and field operations.

The problem of seed source reliability. Seed source reliability must receive due attention and has been considered as one of the major problems in Germplasm evaluation trials. Burley (1985) views seed sources classification and guarantee of the reliability and authenticity of the two separate issues in Germplasm studies.

Conservation of MPTS genetic resources. Forest biodiversity is under serious threat due to both habitat loss and degradation of forest ecosystems, as confirmed by the key studies such as the State of World's Forests (FAO, 2007). To meet present day and future needs, it seems appropriate to conserve natural resources and the concepts are now widely receiving appreciation (Baig *et al.,* 1997) However, un-fortunately, only rarely are genetic studies available (Thomson *et al.,* 2001). Therefore, it is the need of the day to conserve natural resources and national and international institutions are making serious efforts. FAO (1981) has outlined the strategies for *in-situ* conservation of forest genetic resources. Unfortunately, concerted efforts have not been made to conserve the genetic resources of MPTS.

Problems associated with *in-situ* conservation. *In situ* conservation of trees typically refers to conservation in undisturbed nature reserves, managed nature reserves and national parks (NRC, 19991) whereas has the advantage of conserving ecosystem's functions (Thomson *et al.*, 2001). In principle we agree that conserving an ecosystem (*in-situ*) obviously implies to conserve the species and their genetic resources. However, it is believed for both exotic industrial and multipurpose populations and species are more important to conserve than conserving the entire ecosystem. It has been suggested that if some species or populations are identified in a comparative trial, then it is imperative to decide which genetic populations need to be conserved (Burley & Namkoong, 1980; Burley, 1985). NRC (1991) mentions that the design of in-situ conservation schemes is still primitive.

Problems associated with *ex-situ* conservation. *Ex-situ* conservation is important for maintaining genetic variation in high-priority tree species or populations. It deals with sampling and maintaining genetic variation within and among populations of target species. But such efforts have targeted a limited number of species of commercial importance (Rudebjer *et al.*, 2007). It implies the conservation of genetic resources through the storage of pollen or seed storage and tissue culture (Wilkins *et al.*, 1982; NRC, 1991) or growing plants in conservation stands, which continuously evolve themselves (Roche, 1975; Burley, 1985). Important features of an ex-situ conservation programme reported by Amaral and Yanchuk (2004) are:

- Acts as a backup measure to *in-situ* conservation.
- Ensures that the wide range of diversity in a species is conserved
- Manages the regeneration of the species outside the natural range.

Burley (1985) noted that *ex-situ* conservation is done by organizations having interest in species from the areas where environmental conditions or management techniques are feasible and favorable. According to (Theilade *et al.*, 2004) the lack of knowledge of target species' distribution, genetic variation, ecology and reproduction and seed biology can be significant constraints for *ex-situ* conservation. However it is very disappointing to report that appropriate techniques for many of the MPTS are unknown.

Strategies for improving MPTS germplasm. For an effective selection, preservation, storage and propagation of the MPTS, it is important to devise suitable strategies to address all those problems associated with these parameters.

Recognizing the importance of MPTS and their germplasm, Thompson *et al.* (2001). Consider the following as essential requirements in collection and maintenance of plant genetic resources:

1. Representation: Genetic diversity (large population)
2. Prevention: Genetic erosion (no selection)
3. Preservation: Genetic integrity (no gene flow)
4. Retention: Gene frequencies (no distortion to breeding pattern)
5. Conservation: Long-term security (low energy input).

In addition, they have also advised to avoid the following actions as much as possible to capture maximum genetic resources:

1. Small proportions: (collected or maintained)
2. Selection: (random or directed)
3. Hybridization: (gene flow)
4. Unnatural breeding patterns: (level of heterozygosity)
5. High risk survival factors: (individual enthusiasms, cultivation in greenhouses).

Both *in-situ and ex-situ* conservation procedures are useful under limits and have advantages as well. However, in practice, a comprehensive genetic conservation programme will require some combination of *in -situ* and *ex- situ* conservation (Amaral & Yanchuk, 2004). To achieve this, a national strategy, developed with participation of all relevant stakeholders, would be required.

The process includes the following logical steps (Kjaer & Graudal, 2001; Graudal *et al*., 2004):

1. Setting overall priorities and identification of priority species based on potential socioeconomic value and conservation status.
2. Assessment of their genetic structure and variation.
3. Assessment of level of protection of the target species.
4. Identification of conservation requirements or priorities, at population level for single species and at ecosystem level for groups of species.
5. Choice of conservation strategies and measures.
6. OrganiZation and planning of specific conservation activities, including identifying implementing partners.
7. Provision of management guidelines.

Some other Strategies to be Adopted

Develop national, international programs and centrally coordinated organization. There is a need to strengthen national Germplasm programs and their capabilities. The cooperation and coordination between national and international organization can save the resources while bringing the necessary information among the users (World Bank & FAO, 1981; Burley, 1985). A centrally coordinated organization is suggested by Burley (1985) with the following functions to perform:

1. To collect samples and data and to conduct research on topics of common interest
2. To distribute seed of different origins, assist in experimental designs to analyze and compare the performance of trials in different countries
3. To recommend uniform assessment procedures for comparative trials
4. To assist with national analyses if required and perform combined analyses of the over all sites and to estimate species/provenances stability or genotype-environment interaction
5. To compile manuals and monographs on individual taxa based on global results of collaborative trials
6. To give advice on the place of such introduced trial material in breeding programs.

Establish professional ties and links. In case, it is hard to establish international coordination, two or more national organizations working on the species of common interest can work together in the areas of their interest. This sort of cooperation would help in avoiding duplication of research efforts, thereby saving national wealth.

Focus of research on plant type, species geography and environment. It is observed that some organizations work only on a single species or on a common set of species. For example, NFT Association is an institution with its scientists working only on nitrogen fixing tree species. The other classical example is the Neem Tree Institute, working on a sole species (Burley, 1985). Some institutions work on environmentally specific areas like arid zone. Mckell (1975) and Burley (1985) report that forage shrubs in arid zone needs particular group attention. We are aware of the fact that with such a large number of MPTS available, setting priorities for different environments is very laborious assignment.

Develop good working relationship to get taxonomic support. Exploring species in their natural range requires a good knowledge and practical experience of taxonomy. Taxonomic support is also desired at the evaluation process of exotic species. For accurate assessment, good collaboration among herbaria staff, foresters and agriculturists would be helpful.

Need for standardized methods. International organizations like International Center for Research in Agroforestry (ICRAF) and (ICF) have published some of the needed characters for evaluating MPTS, however, much attention needs to be paid to formulate standard methods for evaluating MPTS.

Development of standard data and information management systems. To develop standard formats for data collection and compatible methods for computer-based data exchange, dedicated efforts are to be made to minimize variations and errors for germplasm studies. For the ready use of information on MPTS, research papers, review articles, bibliographies etc. should be published on a regular basis.

Actions for the conservation of threatening species. Conserving the threatened species and populations is an area of interest for many national and international organizations. For achieving an effective MPTS germplasm conservation, *in-situ* or *ex-situ* procedures are needed.

Genetic improvement and conservation measures. It is imperative to identify the species of prime importance. After completing identification process, breeding programs at the national institutes can be good option to be adopted. For conserving improved genetic resources through international cooperation and coordination, practical steps must be taken.

Avoid duplication. Since MPTS cover a wide range of species and populations and produces a variety of products, therefore, it would be appropriate to develop and publish a directory of MPTS and institutions engaged in such research. Information on the activities carried out by them, principal species and their products should widely be publicized so as to avoid duplication and minimize the wastage of resources.

Development of professionals. Developing countries are not only severely deficient in trained manpower but also face the problem of brain drain. Imparting in-service and specialized training through various training courses at university and other institutional level could mitigate shortage of trained professionals and technical staff.

Developing a seed bank to meet demands for germplasm. Burley (1985) suggests creating the national and international seed banks to meet the Germplasm supply and demand relationship.

Clonal propagation. Some organizations have restricted themselves to the rooted cuttings. Burley (1985) has advised them to broaden their area of interest by including MPTS.

CONCLUSION

The present scenario of agriculture and forestry sectors in the developing countries warrants the development of an efficient production system. There is a considerable potential to raise MPTS with a view to get increased wood and food production from the AF techniques, which implies integration of agricultural crops with perennial trees on farmlands. It is assumed that MPTS play protective and productive roles in safeguarding vital qualities of agricultural lands and their production. They provide numerous food products and services to farmers on sustainable basis. Suitable combinations of MPTS and agricultural crops, derived through known germplasm, appropriate for various agro-ecological zones can greatly help in increasing food, fuel, forage, wood and crop production. Their conservation aims at sustainable development of the natural resources essentially required to meet the needs of the future generations. Both *in-situ and ex-situ* conservation procedures have their advantages. However, in practice, a comprehensive genetic conservation programme will require some combination of *in -situ* and *ex- situ* conservation. To conserve genetic resources, a national strategy, developed with participation of all relevant stakeholders, would be required.

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