Conservation of forest genetic diversity in South Asia

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Introduction

The forests support, directly or indirectly and in various degrees, livelihood of millions of rural people in South Asia. For those who live in forests or have access to forests, the collection of various non-timber products and hunting of bush meat complement their subsistence, while in areas of limited forest resources, food production systems are often at least partly based on trees or other forest species. Timber and non-timber products, such as bamboo, rattan, medicinal plants, fruits and resin, also create employment opportunities and provide income that benefit both local communities and national economies. Furthermore, the remaining forests still harbour wild relatives of many agricultural crops and a large number of lesser-known plant and tree species whose usefulness for humankind has not been fully explored.

Trees are a major component in any forest ecosystem and they support the existence of many other plant species, animals and organisms. Trees also have ecological and economic importance in areas which are not classified as forests, such as open woodlands with low canopy coverage. In contrast to many other plant species, trees are long-lived perennials and they exhibit high level of intraspecific variation. Only handful of all tree species have been subjected to domestication or breeding efforts and due to the long life span, even domesticated tree species often have larger genetic variability as compared to most crop species.

Trees have been exposed to changing environmental conditions throughout their life histories and the high level of genetic diversity has enabled a continuous adaptation to the changing conditions. However, forest genetic diversity is facing increasing threat, which is contributing to massive changes in the patterns of distribution and the extent of variation. Climate change is modifying the prevailing environmental conditions in many parts of the world faster than trees can adapt to, owing to their long life span, while introduction of invasive species and atmospheric pollution are additional threats. However, forest fragmentation is probably the most important factor that is threatening forests. It has been predicted that changes in land use will have a much higher impact on biological diversity in the tropical terrestrial biome within the next 100 years as compared to the changes in climate, nitrogen deposition, biotic exchange or atmospheric CO_2 (Sala *et al.* 2000).

Conservation of forest genetic resources (FGR) is an urgent task especially in densely populated areas such as South Asia but it is also much more complex task than conservation of crop genetic resources. In many tropical tree species, the recalcitrant seed behaviour makes it difficult to maintain the long-term viability of seeds and thus the conservation of FGR has to depend mostly on conserving living trees in forest ecosystems. This approach is not straightforward as conserving FGR is often strongly dependent on complex interaction between trees and other organisms within a given ecosystem. Thus, long-term conservation of FGR requires information on phenomena and processes that are very complex in nature.

This paper, provides a short overview of conservation of forest genetic diversity and related capacity-building and research needs in selected South Asian countries. It presents some information on countries' forest resources and highlight their involvement and commitments to some of the international agreements that have relevance to forest sector. It also presents some examples of the work that has been carried out on conservation of forest genetic resources, including bamboo and rattan genetic resources, in the region.

Forest resources and commitments to forest-related conventions in South Asia

In 2000, the global forest area accounted for 3 869 million ha of which nearly 548 million ha was found in Asia, mainly in the southern, south-eastern and eastern parts of the continent (FAO 2003). The forest area in five South Asian countries, i.e. Bangladesh, Bhutan, India, Nepal and Sri Lanka, accounts for 74.2 million ha (Table 1). India has the largest area (64.1 million ha) under forests among these countries, while Bhutan has the highest forest cover of the land area (64.2%). The forests in the five countries are predominantly tropical, while in Bhutan and Nepal, considerable portion of the forests are subtropical due to their mountainous landscapes. Globally, only five per cent of all forests are plantations, while in Asia, 21 per cent of the forests are tree plantations, which account for 62 per cent of the global plantation, area (FAO 2003). In Bangladesh and India, approximately 50 per cent of the forests are tree plantations, whereas this figure is considerable lower in the other countries. As a result of intensive tree planting activities, forest cover was increasing in Bangladesh and India between 1990 and 2000, while the forest cover decreased considerably in Nepal and Sri Lanka during the same period (Table 1). However, although the total forest cover increased in Bangladesh and India during the past decade, conversion of natural forests into other land uses still continued and subsequently biological diversity in the remaining natural forests continued to erode.

Table 1. Forest resources in selected South Asian countries (FAO 2003)

Country	Total forest area in 2000 (million ha)	Percentage of land area	Forest types (% of forest area)		Forest plantations in 2000 (million ha)	Annual change between 1990-2000 (%)
			Tropical	Subtropical		
Bangladesh	1.3	10.2	100	0	0.60	1.3
Bhutan	3.0	64.2	69	31	0.02	n s
India	64.1	21.6	95	5	32.60	0.1
Nepal	3.9	27.3	58	42	0.10	-1.8
Sri Lanka	1.9	30.0	100	0	0.30	-1.6

Table 2. Status of ratification of selected international conventions and agreements, national forest programmes, and criteria and indicators for sustainable forest management in South Asian countries (FAO 1999, 2001, 2003)

Country	Status of ratification of selected international conventions				ITTA 1994 (ITTO members)	National forest programmes		Criteria and Indicators (process)
	CBD	FCCC	Kyoto Protocol	CCD		Starting year	Type	
Bangladesh	X	X	X	X	-	1989	MP	DFAs
Bhutan	X	X	-	-	-	1989	MP	DFAs
India	X	X	X	X	X	1992-93	NCS/NEAP/NFAP	DFAs/ITTO
Nepal	X	X	-	X	X	1984	MP	DFAs
Sri Lanka	X	X	X	X	-	1983	MP	DFAs

CBD=Convention on Biological Diversity, FCCC=UN Framework Convention on Climate Change, CCD=UN Convention on Combating Desertification; ITTA=International Tropical Timber Agreement, ITTO= International Tropical Timber Organization; National forest programmes: MP=Master Plan, NCP=National Conservation Strategy, NEAP=National Environmental Action Plan, NFAP=National Forestry Action Plan; Criteria and Indicators: DFA=Regional Initiative for the Development and Implementation of National Level Criteria and Indicators for the Sustainable Management of Dry Forests in Asia.

At political level, five South Asian countries have indicated strong commitments to various international conventions and agreements related to forests (Table 2). All countries have ratified the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change. Furthermore, the countries have also ratified, to various degrees, the Kyoto Protocol (developed as part of the FCCC process) and the United Nations Convention to Combat Desertification (CCD). The role of forests is important for all of these Conventions but this role is crucial for CBD and FCCC in particular. After CBD was signed at the United Nations Conference on Environment and Development (UNCED) in 1992, the global interpretation for sustainable forest management was extended to cover biodiversity and other environmental services of forests. By ratifying CBD and FCCC, the South Asian countries have also committed themselves to the global efforts to conserve and sustainably use biological resources, including forest genetic resources (FGR), and to mitigate the negative effects of climate change.

After UNCED, the international dialogue to enhance sustainable forest management continued through the Intergovernmental Panel on Forest (IPF, 1995-1997) and subsequently Inter-governmental Forum on Forest (IFF, 1997-2000). Sustainable forest management has been defined as a process of managing permanent forest land to achieve multiple objectives to produce desired forest products and services without undue reduction of future productivity and without undue undesirable effects on the physical and social environment (ITTO 1992). Currently, the United Nations Forum on Forests (UNFF, 2000-2004) continues this dialogue but so far these efforts have not generated any specific actions on conservation and management of FGR. However, the international dialogue has promoted sustainable forest management at policy level and this has also benefited indirectly conservation and management of FGR, while several international agencies have actively developed operational guidelines for sustainable forest management. The International Timber Trade Organization (ITTO), established following the International Tropical Timber Agreement in 1994, has published various guidelines to promote sustainable forest management and conservation of biological diversity in tropical production forests (ITTO 1990, 1992).

Prior to UNCED in 1992, several countries through out the world had already initiated various national efforts to improve sustainability of their forest sector for economic development and to improve overall management of natural resources. These efforts included various strategic frameworks, such as national forestry action plans, forestry sector master plans, forestry sector reviews, national biodiversity strategies, national environmental action plans and national conservation strategies. These various approaches have later developed towards a broader forest sector planning process and intersectoral policy dialogue as the efforts are based on similar principles and approaches. Currently, the term 'national forest programmes (NFPs)' is commonly used when referring to this strategic planning process.

Most of the South Asian countries had initiated their NFPs already in the 1980's and also India initiated similar activities in early 1990's (Table 2). In theory, NFPs should be a continuous, participatory national level forest policy formulation and implementation process but in many countries, the efforts have been carried out as a project-type activity with little continuity and implementation. Furthermore, conservation and use of forest genetic resources are often poorly integrated into NFPs. This is due to the fact that national programmes on FGR are very weak or does not even exist, as compared to similar programmes on agricultural sector that relatively well established. Thus, national FGR programmes and their linkages with NFPs need to be strengthened not only in South Asia but also in other countries in the Asia-Pacific region.

Conservation of important tree species in South Asia

A number of species-oriented networks are already operating in the Asia Pacific region.

These include the International Teak Network (TEAKNET), the International Network on *Leucaena* Research and Development (LEUCANET), the International Network on Bamboo and Rattan (INBAR) and the International Centre for Research and Training on Seabuckthorn (ICRTS). These networks work with a single species or group of species and their emphasis is on tree improvement instead of conservation of FGR. Coordinated efforts on genetic resources in natural tropical forests in the region are scarce although these forests provide raw materials for many economically valuable goods and products.

Information on the status of forest genetic resources is still fragmented and reliable data, if available, are seldom gathered according to common objectives or standard methodologies. Information may accumulate under various local or national programmes, and is available in national reports on plant genetic resources for food and agriculture, biological diversity status and action plans, forest inventory publications and so on. Although some countries have developed mechanisms to conserve forest genetic resources, up-to-date information for most developing countries is available only at the regional level. Such information which can be obtained through FAO Panel of Experts on Forest Genetic Resources has not been well coordinated for effective utilization in managing and conserving forest genetic resources.

In Bangladesh, it has been estimated that 25 tree species, 9 rattan species and 4 gymnosperms are considered as endangered species. In view of this, the government has increased conservation efforts for forest genetic resources *via* various strategies such as *in situ* and *ex situ* conservation, forest genotype conservation through plantation development and others (Sirajul Islam 2003). In India, conservation of some economically important forest tree species have been possible through efforts of the state forest departments as gene banks, *in situ* and *ex situ* conservation sites. National parks and other protected areas such as biosphere reserves and wildlife sanctuaries have been regarded as important for the *in situ* conservation and management of forest genetic resources at the species level (Katwal 2003). In Pakistan, the forest genetic resources are mainly confined to the mountainous areas of the north. Many tree species have been used with little efforts towards conservation or use of quality planting stock. Hence, there is an urgent need to address the conservation of several species including *Abies pindrow*, *Acacia* spp., *Pinus gerardiana* and others (Khan 2003). The forest genetic resources conservation activities in Sri Lanka are mainly linked to *in situ* and *ex situ* strategies having a focus on the more economically valuable species such as acacia, eucalyptus, mahogany, teak, *Pinus patula*, *P. caribaea* and a few other species. (Murashinghe 2003). Forest genetic resources in Nepal are conserved *in situ* in National Parks and Wildlife and Hunting reserves whereas for *ex situ* conservation community forestry is the viable approach used. Some of the more economically important but threatned trees species that are given attention include *Acacia catechu, A. nilotica, Dalbergia latifolia, D. sissoo*, *Alnus nepalensis, Pinus patula, P. roxburghii* and others (Tamrakar 2003). The priority species identified by some of the South Asian countries for forest genetic resources conservation and management are shown in Table 3.

Country-based data was compiled based on consultation feedback by Bangladesh Forest Research Institute, Indian Council for Forestry Research and Education, Department of Forest Research and Survey (Nepal), Tree Improvement and Silviculture Component (Nepal) and Sri Lanka Forest Department.

Conservation of important bamboo and rattan species in South Asia

Bamboo and rattan are two economically important non-timber forest products (NTFP) of South Asia. One of the pressing needs in conserving these NTFP are studies on patterns of genetic diversity within gene pools. Another area of importance is seed production, which in many species is often rare or non-existent. Studies on storability of seeds would facilitate *ex situ* conservation of seed material of those species for which such storage and increased

Table 3. Priority species identified by four South Asian countries in an APAFRI-IPGRI consultation carried out in 2002 for the Asia Pacific Forest Genetic Resources Programme (APFORGEN)

Species	Country				FAO panel
	Bangladesh	India	Nepal	Sri Lanka	of experts
Acacia nilotica		X			X
Ailanthus excelsa		X			X
Albizia lebek		X	X	X	
Albizia procera	X	X	X		
Artocarpus heterophyllus	X	X	X		X
Azadirachta indica		X	X	X	X
Bamboo		X			X
Bambusa vulgaris	X				
Calamus erectus	X				X
C. longisetus	X				X
Cassia siamea	X		X		X
Casuarina equisetifolia	X	X	X		X
Chloroxylon swietenia				X	
Chukrasia tabularis	X			X	
Dalbergia bariensis		X			X
D. latifolia		X	X		X
D. sissoo		X	X		X
Diospyros ebanum				X	
Dipterocarpus turbinatus	X				X
Eucalyptus spp.		X			X
Gmelina arborea	X				X
Heritiera fomes	X				
Lagerstroemia ovalifolia		X	X		
L. speciosa	X				
Prosopis cineraria		X			X
P. juliflora		X			X
Pterocarpus indicus		X		X	X
P. marsupium			X		X
Rhizophora spp.	X				X
Samanea saman	X				
Santalum album		X			X
Schima wallichii			X		X
Shorea cochinchinensis		X			
S. robusta	X	X	X		
Syzygium grandee	X				
S. cumini			X		
Tectona grandis	X	X	X	X	X
Terminalia chebula		X	X	X	X
Toona ciliata			X		
Xylia dolabriformis	X				
X. xylocarpa		X			

Source: FAO 2002

viability are possible. Induction of flowering in young bamboo and rattan plants will greatly influence the use of genetic resources at a later stage (Ramanatha Rao 1998). It is impossible to carry out studies for all species and hence, a list of priority species has been identified according to a set of criteria for the Asia Pacific region (Rao *et al.* 1998). The species from the list that are found in South Asia are listed in Table 4.

Table 4. Priority species of bamboo and rattan found in South Asia (Rao *et al.* 1998)

Bamboo	*Rattan*
Bambusa balcoa	*Calamus adamanicus*
Bambusa bambos	*Calamus nagbettai*
Bambusa polymorpha	*Calamus ovoideus*
Bambusa tulda	*Calamus zeylanicus*
Bambusa vulgaris	*Calamus palustris*
Cephalostachyum pergracile	*Calamus inermis*
Dendrocalamus asper	*Calamus nambariensis*
Demdracalamus giganteus	
Dendrocalamus latiflorus	
Dendrocalamus strictus	
Melocanna baccifera	
Ochlandra spp.	
Thyrostachys siamensis	
Arundinaria sp.	
Bambusa nutans	
Dendrocalamus hamiltonii	
Dendrocalamus hookerii	
Gigantochloa albociliata	
Schizostachyum sp.	

Some species that are popular and are economically important are threatened and hence, the need for intensifying the conservation of these plants are vital. For example, in Bangladesh, *Dendrocalamus hamilotonii, Melocalamus compactiflorus* and *Neohouzeaua dullooa* are regarded as threatened species (Banik 1992). Similarly in India, about 28 species of bamboo have been classified as threatened (Banik 1994).

Capacity-building and research needs

The FAO Panel of Experts on Forest Gene Resources (FGR) has long played a major role in providing recommendations and priorities on management of forest genetic resources at global level and continuously highlighted the importance of forest genetic resources and their conservation. The Panel has recommended that capacity of national institutions to carry out work on FGR should be strengthened and that this work should be closely linked to planning and implementation of National Forestry Programmes (NFPs). National FGR programmes can provide the operational linkage to NFPs and enhance the conservation and sustainable use of FGR. In South Asia, however, national FGR programmes are not well established and this situation is causing considerable bottlenecks to conservation and management of FGR in the countries concerned. Hence, there is a need for concerted efforts in increasing the capacity and skills in the various fields of FGR conservation and management for countries in region. These upgrading efforts would invariably be linked to the research needs of the countries concerned. Hence, there is a vital link for capacity building and research needs to be in synchrony with the FGR conservation needs of the countries.

There is a need to address conservation with a wider social, political and cultural framework. This is reflected in an increasing concern with *in situ* conservation, an interest in a larger number of useful plant species and the recognition of the importance of FGR conservation within production systems. The need to consider economic issues that have impact on FGR conservation is a concern that has to be given much attention as well. Two aspects of research activities are needed. The one focusing on strategic research is necessary to advance the knowledge and to improve conservation and use of technologies (Ramanatha Rao and Koskela 2001). The applied research aspect will constitute the bulk of FGR research in most South Asian countries that will derive benefits from it.

Some areas of strategic research will include developing methods for surveying, sampling and assessing diversity, research in ethnobotany and socio-economics in relation to local communities in conservation, development of improved *ex situ* conservation methods, improved methods of access and usage of FGR conserved, germplasm health and safe exchange and others. Some areas of applied research will include selection and screening germplasm, breeding and genetic improvement of forest trees, collation on local knowledge concerning specific types of plant or landraces, etc.

Discussion and conclusion

Conservation of forest genetic resources is not an independent activity from forest management and utilization for human needs (Finkeldey 1996). Further, conservation of endangered and endemic forest species is neither an independent effort from FGR conservation in general. Endangered species will be conserved if their economic values are recognized. One way to do this is to obtain more basic information not only on the biological and ecological features of the species but also their present and potential uses. Often especially the uses are poorly documented and increasing the collection of traditional knowledge from local people could fill this gap. Once it is better known what can be lost, it is easier to justify urgent and possibly high-cost conservation measures while setting priorities.

Although the importance of FGR conservation is recognized in many countries in the region, establishment of national FGR programmes has been hampered by lack of policy-makers' commitment and limited national capacity to conserve and manage FGR. Therefore, national efforts on FGR are weak as compared to respective activities on agricultural sector to conserve and manage crop genetic resources. Also, national efforts on FGR are not very well integrated into national forest programmes and policies. There is a need to create a formal national mechanism and bring together various stakeholders so that they can together discuss and develop conservation strategies and action plans for conservation and sustainable use of FGR. Strong national FGR programmes can increase policy-makers' awareness and increase their long-term commitment and support to carry out FGR conservation. This will also facilitate development of national capacity to conserve and sustainably use FGR.

A regional programme with a holistic scope to conservation and management of FGR can alleviate these obstacles in the region. Through networking, it is possible to avoid duplication of efforts and to gain synergy among collaborating countries, institutions and other stakeholders. Regional collaboration promotes partnership and more efficient use of limited resources. Networking can enhance the dialogue between scientists, managers and users, and increase interaction between different sectors at national level that is a necessary pre-condition before sustainable forest management can be operational in its true meaning. It is in this context that the Asia Pacific Forest Genetic Resources Programme (APFORGEN) has been proposed. IPGRI together with APAFRI (Asia Pacific Association of Forest Research Institutions) will soon initiate APFORGEN with an inception workshop to he held in July 2003. All together, 12 countries in South Asia, Southeast Asia and East Asia have indicated interest in participating in the programme. Through APFORGEN, it is anticipated that conservation and management of FGR in South Asia could be better coordinated and focussed.

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