TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES FROM DEVELOPED COUNTRIES TO DEVELOPING COUNTRIES

Background Document for the Ad Hoc Expert Group on Finance and Environmentally Sound Technologies

The Secretariat of the United Nations Forum on Forests

Prepared by
Esa Puustjärvi, Marko Katila and Markku Simula
INDUFOR

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The views expressed in the paper are of the authors and are not necessarily the view of the UNFF or its Secretariat.

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ABBREVIATIONS AND ACRONYMS

%	percent
a	per annum
ADIE	L'Association pour le Développement de l'Information Environnementale
AfDB	African Development Bank
AFTA	Association for Temperate Agroforestry
AHEG	Ad Hoc Expert Group
AIDC	automatic identification and data capture
AOX	absorbable organo-halogens
APAFRI	Asia pacific Association of Forestry Research Institutions
APCTT	The Asian and the Pacific Center for Transfer of Technology
APEC	Asia-Pacific Economic Cooperation
APFReN	Asia Pacific Forest Rehabilitation Network
AsDB	Asian Development Bank
BIG/CC	Biomass integrated gasification/combined cycle
BKNR	Bentuang Karimun Nature Reserve
BOT	build-operate-transfer
C&I	Criteria and Indicators
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza
CBD	Secretariat of the Convention on Biological Diversity
CBD	Convention on Biological Diversity
CCD	Convention to Comba t Desertification
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CESTT	Center for Environmentally Sound Technology Transfer (in China)
CHP	Combined heat and power
CIFOR	Center for International Forestry Research
COD	chemical oxygen demand
COP	Conference of Parties
CP	Cleaner Production
CPF	Collaborative Partnership on Forests
CSD	Commission on Sustainable Development
DESA	United Nations Department of Economic and Social Affairs
DTIE	Division of Technology, Industry and Economics
ECA	Export Credit Agency
EPA	US Environmental Protection Agency
ESCAP	Economic and Social Commission for Asia and the Pacific
EST	environmentally sound technology
ETFRN	European Tropical Forest Research Network
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign Direct Investment
FGEF	French Global Environment Facility
FMU	Forest Management Unit
FORAC	The Central African Forest Watch (Observatoire des forêts d'Afrique Centrale)
FORSPA	Forestry Research Support Program for Asia and the Pacific
FPEG	Forest policy and Environmental Group
FRA	Forest Resource Assessment
FSC	Forest Stewardship Council
GEF	Global Environment Facility

GFIS	Global Forest Information Service
GHG	Greenhouse Gas
GIS	Geographic Information System
GPS	Global Positioning System
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
ha	hectare
IBRD	International Bank of Reconstruction and Development
ICETT	International Center for Environmental Technology Transfer (Japan)
ICONS	Integrated Conservation Networking System
ICPIC	International Cleaner Production Information Clearinghouse
ICRAF	International Center for Research in Agroforestry
ICT	Information and Communication Technologies
IETC	International Environmental Technology Center
IFAD	International Fund for Agricultural Development
IFF	Intergovernmental Forum on Forests
IIED	International Institute for Environment and Development
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPE	Investment Promotion Entity
IPF	Intergovernmental Panel on Forests
IPGRI	International Plant Genetics Resource Institute
IPR	intellectual property rights
ISO	International Standards Organization
ITDG	Intermediate Technology Development Group
ITTO	International Tropical Timber Organization
IUCN	The World Conservation Union
IUFRO	International Union of Forest Research Organizations
LDC	Least Developed Countries
m^3	cubic meter
MEA	Multilateral Environmental Agreements
MNC	multinational corporation
MoF	Ministry of Forestry
NFP	National Forestry Program
NGO	Non-governmental Organization
ODA	overseas development assistance
ODI	Overseas Development Institute
OECD	Organization for Economic Cooperation and Development
OOF	Other Official Flows
OPIC	Overseas Private Investment Corporation
ORC	optical character recognition
PEFC	Pan-European Forest Certification
PID	programmable identification device
PPP	public-private partnership
R&D	Research and Development
RDFN	Rural Development Forestry Network
RECOFTC	Regional Community Forestry Training Center for Asia and the Pacific
RFID	radio-frequency identification
RIL	Reduced Impact Logging
SANet	Sustainable Alternatives Network
SFM	sustainable forest management

SFMP	Sustainable Forest Management Project
SME	Small- and Medium-sized Enterprises
SPDC	Special Programme for Developing Countries
STOA	Scientific and Technological Options Assessment
t	ton
TERI	Tata Energy Research Institute
TIFAC	Technology Information, Assessment and Forecasting Council
TRIPS	Trade-Related Aspects of Intellectual Property Rights
TSS	total suspended solids
TVE	The Television Trust for the Environment
UN	United Nations
UNCED	United National Conference on Environment and Development
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
UNFF	United Nations Forum on Forests
UNIDO	United Nations Industrial Development Organization
US	United States
USA	United States of America
USD	US Dollar
WARSI	Conservation Information Forum
WB	World Bank
WBCSD	World Business Council for Sustainable Development
WFEO	World federation of Engineering Organizations
WRI	World Resource Institute
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization

EXECUTIVE SUMMARY

This report has been prepared as a background document for the Ad Hoc Expert Group on Finance and Transfer of Environmentally Sound Technologies under the UNFF to support its deliberations at its meeting in Geneva in December 2003. It provides an overview of international processes and agreements relevant to environmentally sound technologies (ESTs) for sustainable forest management (SFM), including identification of barriers and potential technologies as well as recommendations on how to create enabling conditions for the successful and sustainable EST transfer. It also suggest approaches for improving EST transfer for SFM from developed countries to developing countries and identifies opportunities for cooperation among Collaborative Partnership on Forests (CPF) members, as well as relevant regional actors.

The study concludes that most international process for sustainable development and multilateral environmental agreements contain clauses with technology (EST) transfer. The most important multi-lateral environmental agreement with references to technology transfer in forestry is the United Nations Framework Convention on Climate Change (UNFCCC), which has direct implications for forest sector. Convention on Biological Diversity (CBD) and Convention to Combat Desertification (CCD) and various agreements of World Trade Organization also address technology transfer. IPF/IFF have prepared proposals for action related to transfer of EST in forestry sector, which are now being followed up by UNFF.

The framework adopted in this study emphasizes the need to view barriers to the successful transfer of EST using a demand-supply based systems approach. The analysis of barriers, including action aimed at improving the EST transfer should also make use of the division of barriers to those specific to EST in general, general barriers within forest sector, and general barriers outside forest sector. Regarding an enabling environment for EST transfer, most existing barriers are not specific to EST or the forest sector. Instead, they result from international agreements (e.g. WTO agreements) or the national policy or macroeconomic framework (e.g. import tariffs for technology) which are designed outside the forest sector. There can also be fundamental bottlenecks impeding EST adoption (e.g. lack of forest law enforcement capacity). The need to promote EST transfer is a contributing argument, but not a key driver for decisions to take action to eliminate such constraints. While one can and should attempt to influence these decisions from the perspective of EST transfer, it is likely that many of the barriers will prevail. Therefore, the strategies to promote EST transfer have to adapt and be designed so that they can function in an imperfect environment.

The key to successful EST transfer is that it is demand-driven. The user should have a strong motive for acquiring EST, such as reduced costs of environmental management, increased output of environmental benefits, or increased productivity with environmental benefits as a "by-product", etc. Transfer may take place government-to-government, but in order to ensure that demand is the driving force behind the transaction, it is desirable that they are carried out through the market mechanism between private actors or, as a second priority, involving public for-profit entities. The market mechanism does not guarantee that a technology produces environmental benefits, but it secures that the buyer/user perceives to gain from it, which is a precondition for continued EST use. Reliance on commercial transactions also ensures that both the technology seller and buyer have clear motives to make the transfer successful.

In the forest sector, market-based development is easiest in forest industries. In forestry, forests are mostly in state ownership. Low short-term returns of forestry, the restricted financial capacity of forest administration to purchase services from the private sector, large conservation areas in public ownership, etc. hinder private sector participation and leave the government with

significant responsibilities. EST transfer in forestry will continue to take place largely on a government-to-government basis, so enhancing its effectiveness constitutes an important development area. However, increasing attention must be paid to the role of private sector in EST transfer to make best use of the opportunities provided by privatization, development of timber concessions, and expansion of plantation forestry.

Market failures are the main weakness of the market-based transfer processes. Technology that has potential to yield environmental benefits may also be used in an unsustainable manner. The market mechanism does not automatically make the technology users pay for the negative externalities they generate. While encouraging commercial EST transfer, the governments should attempt to rectify market distortions. The most readily available approach is to introduce and enforce appropriate environmental regulations. Another option is to take advantage of markets for environmental services, which are aimed at internalizing the externalities into private sector decision-making. In the forest sector, the principal opportunity is the CDM mechanism under the Kyoto Protocol, which provides support to afforestation and reforestation projects contributing to carbon sequestration in developing countries.

Another shortcoming in market-based development is that markets tend to be insensitive to social issues. Market logic makes the private sector focus on commercial forest management and timber harvesting with large business volumes, neglecting the needs of the poor. Owing to this imbalance, one of the main duties of the public sector with respect to EST transfer is to support disadvantaged groups in gaining access to them. The same logic works also at the international level, where private investment flows and private sector-led EST transfer concentrates on a limited number of newly industrialized countries. Elsewhere, the potential for commercial EST transfer is limited, and providing ODA-based support is both necessary and justified. The primary target should be the least developed countries, where the forest sectors are highly dependent on external financing.

To make the impact of EST transfer sustainable, a broader set of activities going beyond the transfer of individual technologies is necessary. There are a number of measures both outside and inside the forest sector that would facilitate EST transfer but are not specific to it. These are related mainly to the macroeconomic, fiscal, legal and institutional framework Special attention must be paid to creating an enabling environment especially in the least developed countries. It is necessary to scope the transfer so that the existing constraints are taken into consideration. If the objectives are excessively ambitious, there is a risk to erode cost-efficiency and use resources wastefully. In particular, acquisition of "hard technology" has often taken place before there has been adequate training, institutional capacity, and infrastructure support to sustain the "hard technology". "Soft technologies" are especially important for sustainable forest management because of the large variety of forest management systems and forest conditions.

There are also a few actions that can be taken rather independently from other considerations and targeted especially at EST transfer in the forest sector. The most important ones among them are:

(i) Strengthening of R&D capacities
(ii) Establishment of intermediaries to facilitate EST transfer
(iii) Technology partnership programs
(iv) Applying environmental criteria in privatization processes, concession management contracts, public procurement, etc.
(v) Educating decision-makers about ESTs
(vi) Providing technical and financial support to transfer of specific ESTs
(vii) EST assessments
(viii) Integration of EST into national policies and e.g. national forest programs

1. INTRODUCTION

The need to accelerate transfer of environmentally sound technology (EST) as a means of promoting sustainable development was recognized and highlighted by the international community at the UNCED conference in Rio de Janeiro in 1992, and particularly in its Agenda 21 (Chapter 34). EST can provide many developing countries in the early stages of industrialization with an opportunity to leapfrog the "dirty" phases of technological development and also enhance their competitive position in the world markets by supplying goods and services that meet international standards. Since the Rio Conference, promotion of EST transfer has been incorporated in all relevant international environmental agreements, including the Convention on Biological Diversity (CBD), the Convention to Combat Desertification (CCD) and the United Nations Framework Convention on Climate Change (UNFCCC). In 2002, the World Summit on Sustainable Development (WSSD) in Johannesburg once again underlined the importance of technology transfer by including it in its Plan of Implementation.

With respect to the forest sector, the need to accelerate technology was recognized in Paragraph 11 of the Forestry Principles agreed at the Rio Summit. The issue was subsequently taken up by the Intergovernmental Panel on Forests (IPF) (1995-97) and the Intergovernmental Forum on Forests (IFF) (1997-2000) whose deliberations made a special reference to international cooperation in technology transfer. Since its establishment in 2000, the United Nations Forum on Forests (UNFF) has continued the work on the transfer of EST. Several international agreements and processes provide supporting initiatives with a bearing on technology transfer in the forest sector (UNFFCC, CBD, etc.).

This paper has been prepared as a background document for the Ad Hoc Expert Group on Finance and Transfer of Environmentally Sound Technologies under the UNFF to support its deliberations at its meeting in Geneva in December 2003. The main objectives of the paper are to (i) review the status and give an overview of environmentally sound technologies for sustainable forest management (SFM) from developed countries to developing countries, including identification of barriers and recommendations on how to create enabling conditions for the successful and sustainable EST transfer; (ii) assess approaches for improving EST transfer for SFM from developed countries to developing countries; and (iii) identify opportunities for cooperation among Collaborative Partnership on Forests (CPF) members[1], as well as relevant regional actors.

This analysis complements the background study "Transfer of Environmental Sound Technologies for the Sustainable Management of Mangrove Forests: An Overview" for the Government-designated Expert Meeting on Transfer of Environmentally Sound Technologies for the Sustainable Management of Mangrove Ecosystems in Latin America and the Wider Caribbean held in March 2003. While both studies address the generic issues related to North-South and South-South technology transfer, the approaches are complementary owing to their focus on different ecosystems. Additionally, the study on mangrove ecosystem

[1] Secretariat of the Convention on Biological Diversity (CBD), Center for International Forestry Research (CIFOR), Secretariat of the Convention to Combat Desertification (CCD), Secretariat of the UN Framework Convention on Climate Change (UNFCCC), Secretariat of the Global Environment Facility (GEF), Food and Agriculture Organization of the United Nations (FAO), International Center for Research in Agroforestry (ICRAF), International Tropical Timber Organization (ITTO), IUCN-The World Conservation Union, United Nations Department of Economic and Social Affairs (UN/DESA), United Nations Development Program (UNDP), United Nations Environment Program (UNEP), World Bank (WB).

emphasizes the Latin American and Wider Caribbean region, whereas this analysis has a global scope.

2. DEFINITIONS

2.1 Technology Transfer and Environmentally Sound Technology

The Intergovernmental Panel on Climate Change (IPCC 2000) has applied the following, rather broad definition to *technology transfer*:

> *Technology transfer is a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders such as governments, private sector entities, financial institutions, NGOs and research/education institutions. The broad and inclusive term "transfer" encompasses diffusion of technologies and technology cooperation across and within countries. It covers technology transfer processes between developed countries, developing countries and countries with economies in transition, amongst developed countries, amongst developing countries and amongst countries with economies in transition. It comprises the process of learning to understand, utilize and replicate the technology, including the capacity to choose and adapt to local conditions and integrate it with indigenous technologies.*

While the definition refers specifically to the UNFCCC, the basic concept is relevant to any transfer of EST. The above formulation is sound in that it draws attention to the multifaceted nature of technology transfer including know-how, experience and equipment. The IPCC definition is appropriate also in the sense that it highlights the importance of developing an enabling environment for technology transfer. It also points out the large number of parties involved in successful transfers ranging from governments and financial institutions to NGOs and research/education institutions, and the various flows of EST transfer among developed and developing countries. The need to ultimately establish self-sustaining capacity for technology transfer and development is also recognized.

The *concept of environmentally sound technology (EST)* can be defined in a number of ways. The most widely used and broadest definition of EST is provided in Chapter 34 of Agenda 21:

> *"Environmentally Sound Technologies protect the environment, are less polluting, use resources in a sustainable manner, recycle more of their wastes and products, and handle all residual wastes in a more environmentally acceptable way than the technologies for which they are substitutes."*

Furthermore, as argued in Chapter 34 of Agenda 21 (para 34.3.), ESTs are not just

> *"individual technologies, but total systems which include know-how, procedures, goods and services, and equipment as well as organizational and managerial procedures".*

This implies that when discussing transfer of technologies, the human resource development and local capacity building aspects of technology choices should also be addressed. ESTs should also be compatible with nationally determined socio-economic, cultural and environmental priorities.

It is not possible to provide a "watertight" definition of EST because of four main reasons. First, while introduction of ESR may potentially improve environmental performance, there is no guarantee for this to happen because of misuse of technology or lack of enabling environment. Broadly speaking there are two types of technologies that are considered to qualify as EST: (i) those that prevent, limit, minimize, correct etc. environmental damage e.g. by reducing pollution; and (ii) those, which use resources more efficiently (combination of the two is also possible). While technologies in the first group can without greater difficulty be qualified as environmentally sound, the evaluation of technologies in the second group is more complex. The very same technology can be used sustainably or unsustainably. For instance, improved technology for processing non-wood forest products may create incentives to excessive use of the resource base. This is an important issue, since nearly all technologies are aimed at productivity increases, i.e. more efficient use of resources.

Second, geographic and temporal factors may also influence the assessment; what is environmentally sound in one country or region, may not be in another, and what is environmentally sound today may not be it tomorrow (IECT 2003). Some technologies may be environmentally sound now, but may be replaced in the future by other technologies with even better environmental performance. With the present wording, the technologies that qualify for EST must have an environmental impact, which is an improvement compared to "technologies for which they are substitutes". Since the source technology to be substituted in developing countries is often old, it is possible that technologies that are already considered obsolete in developed countries would technically qualify as EST, because they bring about an improvement compared to the current situation in the developing countries. However, such technology "dumping" would most likely provide only a temporary relief, and could be harmful in the long run.

Third, environmental effects are generated not only when using the technology, but also when manufacturing, maintaining and disposing of it. As an example, installing an improved waste water treatment at a pulp mill reduces pollution, which is a tangible and measurable environmental impact. However, in order to estimate the total impact it would be necessary to carry out a life-cycle analysis, where the environmental costs and benefits of manufacturing, transporting and disposal associated with the applied waste water technology would be accounted for. This, however, is a complex task and can seldom be applied to individual projects unless relevant information is available.

Fourth, , the direct technology impacts may also be diffuse and work into opposite directions. For example, technology enabling more efficient use of harvesting waste may relieve pressure on the remaining forest, but at the same time continual removal of large quantities of biomass may deplete soil nutrient levels in the harvested areas. Assessing the "net" environmental benefit is difficult, because there is no common yardstick to estimate the impacts working into opposite directions.

As suggested by the above discussion, the definition proposed in chapter 34 of Agenda 21 suffers from many problems. Still, it is the most comprehensive formulation available, and it is difficult to provide a definition that would eliminate the current shortcomings. This study adopts the Agenda 21 definition of EST and the IPCC definition of technology transfer, keeping the above-mentioned caveats in mind.

3. INTERNATIONAL PROCESSES AND AGREEMENTS RELEVANT TO EST TRANSFER

3.1 UNCED

Technology transfer has been recognized as a key "means of implementation" of international processes for sustainable development. It is solidly rooted in Agenda 21 of UNCED and considered indispensable for making progress in implementing its recommendations. Several meetings of the Commission on Sustainable Development (CSD) have adopted recommendations on technology transfer. The major multilateral environmental agreements all contain significant clauses dealing with technology transfer. The Special Session of the General Assembly for the 5-year-review of the Rio commitments in 1997 reiterated the importance of technology transfer. The Report of the Secretary-General for the preparatory process of the World Summit on Sustainable Development, Implementing Agenda 21, identifies technology transfer as one of the ten key areas in which progress is needed. The same report estimates that since the Rio summit the progress in addressing the constraints to transfer of environmentally sound technologies has not been very encouraging (UN 2002).

3.2 IPF/IFF and UNFF

In the forestry sector, the global efforts to promote EST transfer has taken place under the IPF/IFF and UNFF processes. The IPF adopted technology transfer in its agenda early on, and relevant recommendations were included in the final IPF Proposals for Action. The work was continued under IFF, and a special report "Transfer of Environmentally Sound Technologies to Support Sustainable Forest Management" was commissioned and presented at the second IFF session in 1998. The report highlighted several key issues, and constituted a basis for further recommendations by the IFF. The report drew attention, *inter alia*, to the following issues: (i) available ESTs are not used aggressively enough; (ii) enabling policy environment plays an important role; (iii) there is insufficient awareness of the potential benefits of ESTs; (iv) many developing countries have weak capacities to assess the available and emerging ESTs; and (v) there is a need to promote EST transfer in a broad manner at national and international levels (IFF 1998).

The principal IPF/IFF Proposals for Action related to transfer or environmentally sound technology can be categorized under six clusters:

(1) Assessing technological requirements
(2) Enhancing co-operation and financing
(3) Facilitating capacity building within national forest programs, including supporting indigenous people and local communities
(4) Supporting developing countries to increase downstream and community-based processing
(5) Promoting dissemination and sharing of technologies with end users
(6) Strengthening education and training for women in community development programs

The UNFF has been made responsible for implementation of the IPF/IFF Proposals, including those related to technology transfer. The Plan of Action adopted by the UNFF includes 16 elements, one of which focuses on the "international cooperation in capacity building, and access to, and transfer of, environmentally sound technologies". To emphasize the issue the UNFF, at its third session held in Geneva from 26 May to 6 June 2003, agreed on the establishment of an ad-hoc expert group on finance and transfer of environmentally sound technologies (AHEG).

3.3 Multilateral Agreements

3.3.1 UNFCCC

The most important multi-lateral environmental agreement with references to technology transfer in forestry is the United Nations Framework Convention on Climate Change (UNFCCC). Under the Convention, Annex II Parties shall "take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly to developing countries to enable them to implement the provisions of the Convention" (Article 4.5). Pursuant to this commitment, the Parties have taken decisions to promote the development and transfer of environmentally sound technologies at each session of the Conference of Parties (COP). For instance, at COP 4 (Buenos Aires, November 1998) the parties decided to establish a "consultative process" on technology transfer. At COP 6, an Expert Group on Technology Transfer was established.

Transfer of forest-related technology is promoted under the UNFCCC process. In terms of analysis, the most important contribution was the "IPCC Special Report on Methodological and Technological Issues in Technology Transfer" (2000) containing a special section on forestry. The potential of technology transfer to contribute to sustainable forest management in developed countries is constrained by the fact that the Clean Development Mechanism (CDM) - established to support actions in developing countries - restricts the eligible forestry activities to afforestation and reforestation.

3.3.2 CBD

The Parties to the Convention on Biological Diversity (CBD) have pledged to promote "technologies that are relevant to the conservation and sustainable use of biological diversity or make use of genetic resources and do not cause significant damage to the environment" (Article 16). To this end, the Convention has, *inter alia*, established a "clearing-house mechanism" promoting cooperation among Parties in six key areas, one of which is technology transfer. Notably, technology transfer and capacity building are to be major themes of the seventh Conference of the Parties of the Convention in 2004. With respect to forestry, the COP 6 adopted an Expanded Program of Work on Forest Biological Diversity. Technology transfer was identified as one of program activities, with particular references to development of information technology (remote sensing, GIS, data systems).

3.3.3 CCD

The Convention to Combat Desertification (CCD) commits the signatory parties, *inter alia*, to promote "transfer, acquisition, adaptation and development of technology" (Article 18). Transfer of technology does not appear to be a focal area of the convention but the issue is addressed under the thematic regional networks in Africa and Asia. Forestry-related technologies promoted under these CCD networks relate to monitoring of desertification and promotion of renewable energy sources and agroforestry (CCD 2003).

3.3.4 Impact of MEAs

The developing countries have strongly emphasized the view that, by signing international agreements, such as the Kyoto Protocol, CBD, CCD, etc., the developed countries have committed to facilitate technology transfer by providing financial support to it. The developing countries' view is that the implementation of agreed obligations by themselves is dependent upon the effective implementation by developed countries of the financial co-operation and transfer of technology provisions. The developing countries are demanding that the developing countries will make ESTs available on concessional and preferential terms, and use their financial resources to purchase EST patents and licenses to transfer them to developing countries on non-commercial terms as part of development cooperation for sustainable development (Hoffman 1999).

The developed countries have been reticent to accept this view and have, instead, stressed that ESTs are mainly in the hands of the private sector and that commercial transactions should be the primary vehicle for EST dissemination. In the developed countries' view, the available funding should be spent above all on removing constraints to trade and developing an enabling environment in the recipient countries. The latter is seen as a precondition for successful transfer. In general, the impact of MEAs on EST transfer is weak, and Hoffman (1999) concludes that they have not affected or influenced the prevailing contractual terms and conditions for technology transfer in open markets. As far as their capacity to mobilize funding, the record is unclear. All the MEAs except UNFCCC, which is a market-based instrument, essentially rely on existing global funds such as the Global Environment Facility (GEF), but there is little evidence that MEAs would have triggered an increased flow of financing to transfer of EST.

3.3.5 WTO

The Agreements of World Trade Organization (WTO) include a number of provisions to facilitate technology transfer. Developed countries are encouraged to assist the developing countries by providing technical assistance, and support to formulation and application of technical regulations and standards and establishment of regulatory bodies; facilitating access to technology-related information; providing subsidies to research conducted by firms or public institutions; etc. Of particular relevance for the forest sector is the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). It has specific provisions to prevent abuse of intellectual property rights in a manner that restrain trade or adversely affect the international transfer of technology. In the forest sector, the contents of the TRIPS Agreement may have importance for transfer of biotechnology, for instance, with respect to efforts to develop improved tree species. The issue is contentious and reviews are underway to assess, *inter alia*, how to deal with traditional knowledge, genetic material of species, and the rights of the communities from where these genetic resources originate (e.g. benefit sharing from inventions).

4. STATUS OF FOREST MANAGEMENT

The world has about 3 870 million ha of forests, of which 95% are natural forests and 5% are forest plantations. The largest proportion of the world's forests is in the tropical zone (47%), followed by the boreal (33%), temperate (11%) and subtropical (9%) zones (FAO 2000).

Tropical and subtropical dry forests are concentrated in Africa (containing 36% of the world total), South America (30%) and Asia (21%). The majority of tropical rain forests are located in South America (58%), but a large proportion (24%) is also found in Africa; most of the rest is in Asia (17%). Nearly all temperate and boreal forests are located in Europe, North and Central America and Asia (FAO 2000).

With respect to trends in forest condition, deforestation is perhaps one of the most telling indicators. It also one of the few indicators available for global comparisons. During 1990s, the net change in forest area was -9.4 million hectares per year, representing the difference between a deforestation rate of 14.6 million hectares per year of natural forests and an expansion of 5.2 million hectares per year of natural forests and forest plantations (Table 4.1). Most of the forest losses were in the tropics, where the net annual loss forests was 12.3 million ha. In non-tropical areas the forest area expanded annually about 2.9 million ha. The global rate of net change was slightly lower in the 1990s compared to the 1980s, due to a higher estimated rate of forest expansion in the 1990s (FAO 2000).

Table 4.1 Deforestation in Tropics and Non-tropics in 1990s

Domain	Deforestation	Increase in forest area	Net change in forest area
Tropics	-14.2	+1.9	-12.3
Non-tropics	-0.4	+3.3	+2.9
World	-14.6	+5.2	-9.4

Source: FAO 2000

The above difference is attributable to the fact that in relative terms, policy environments and forest management systems in non-tropics, especially in temperate and boreal forests, have been solid and systematic. Indicating this, in 2000 about 89% of forests in industrialized countries (mostly boreal and temperate forests) are being managed "according to a formal or informal management plan", and the situation has remained stable or improved over the last 20 years. The intensity of forest use in many countries is relatively high but usually well within sustainable limits. In the temperate and boreal zones, the annual fellings were 1 632 million m^3 accounting for 53% of net annual increment (FAO 2000). Most certified forests have been established in temperate, industrialized countries; at the end of 2000, about 92% of all certified forests worldwide were located in a handful of them (Eba'a & Simula 2002).

In tropical countries, forest management is still suffering from a number of constraints. Poore and Thang (2000) concluded in their review of the Member Countries of the International Tropical Timber Organization (ITTO) that the fundamental social and economic problems that impede sustainable forest management remain entrenched in many countries. Illegal logging and poaching are also serious problems in many tropical countries. However, substantial progress has also been made. Policy and legislative reforms have been carried out in almost all developing countries, and administrative reforms have been implemented. Still, there is not yet strong evidence that these reforms are taking effect.

Regarding conservation, the total extent of forests in protected areas was estimated at 479 million hectares, which is equivalent to 12.4% of the world's forest area. As shown in Table 4.2, temperate and tropical forests have the highest proportions of forests in protected areas, 16.3% and 15.2% respectively. In subtropical forests, protected areas account for 11.3% of total forest area. A relatively small proportion, 5%, of boreal forests are protected. However, this low figure is explained by the fact that boreal forest area is dominated by the vast forest areas in Siberia, the Russian Federation, which for the most part, are not officially protected (FAO 2000). The quality of protected area managed has not been comprehensively assessed, but the difference between tropics and non-tropics with respect to forest management is likely to hold for conservation areas as well. For instance, Poore and Thang (2000) estimated that the quality of protected area management in ITTO member countries was often inadequate.

Table 4.2 Global Protected Fore st Area by Ecological Domain

Ecological domain	**Forest area 2000**	**Forest in protected areas**	**Proportion of forest in protected areas**
	million ha		**%**
Tropical	1 997	304	15.2
Subtropical	370	42	11.3
Temperate	507	83	16.3
Boreal	995	49	5.0
Total	**3 869**	**479**	**12.4**

Source: FAO 2000

The focus of this study is on tropical countries because - as the above discussion suggests - the most threatened forests are found in tropical countries. In addition, the technology level in these countries is still low, and the policy, institutional and social constraints to technology transfer are severe in these countries. It is likely that the room for improvement and potential benefit of EST transfer for sustainable forest management is greatest in the tropical countries.

The potential to contribute to sustainable forest management through transfer of environmentally sound technology is substantial. The IPF (1996) has stated that the availability of ESTs is not a constraint, but rather the poor distribution of them. However, technology transfer is not a panacea, as the problem of sustainable forest management is only partly a technology issue. The reasons for unsustainable practices in the forest sector are numerous and only part of them can be addressed with improved technology. Usually, technology transfer can be successful only if certain preconditions are in place.

As an example, Roper and Roberts (1999) list the causes of deforestation in tropical forests dividing them into (i) predisposing conditions, such as population growth and poverty; (ii) indirect causes (e.g. inappropriate macro-economic policies, land tenure, market failures, etc.); (iii) direct causes, such as shifting cultivation, clearing for agriculture or pasture; and (iv) forest exploitation and plantation development (e.g., fuelwood collection, logging). It is obvious that ESTs can be useful in tackling the direct causes of deforestation, while they have limited use in addressing the problems with indirect causes and predisposing conditions.

5. REVIEW OF ENVIRONMENTALLY SUSTAINABLE TECHNOLOGIES

Opportunities to apply EST in the forest sector are abundant. With respect to wood production, they can be found in the entire processing chain, including forest management, utilization, and recycling or use of process waste. Bioenergy production, agroforestry and processing of non-wood forest products are other important areas for EST applications.

Conservation of biodiversity and other forest resources can also be made more effective using ESTs. One should also note that different forest types require different technologies.

The range of applications is too broad to be examined exhaustively here. The sample of ESTs described in the present review were chosen among those identified in the IFF report (1998) as ones having high potential to contribute to SFM (a more detailed account and examples of EST transfer projects are available in annexes 1 and 2).

5.1 Reduced Impact Logging in Tropical Forests

Reduced impact logging (RIL) is largely a "soft" technology that consists of planning, engineering and operating practices such as pre-harvest inventory, planning of roads, skid trails and landings; vine-cutting, directional felling; winching of logs to planned skid trails, reduction of waste, etc. (Dykstra 2001). Some elements of "hard" technology may also be introduced such as use of hand tools, high flotation tires, self-loading trucks, cable systems and aerial logging using helicopters.

The potential environmental benefits of RIL are substantial. Available studies indicate that compared to conventional logging systems RIL results in 41% less damage to residual stands, the area covered by skid trails is almost 50% less, the area damaged by road construction is about 40% less, overall site damage (compaction, exposure of soil, etc.) is less than half, canopy opening about one-third less, and the volume of lost timber is reduced by more than a third (Killmann *et al.* 2001). Unfortunately. RIL has not been widely adopted in the developing countries (FAO 2000).

5.2 Remote Sensing and GIS

The use of remote sensing and GIS has expanded in tandem with the development of computer and satellite technology, and forest sector has been quick to take advantage of the new opportunities. Remote sensing is routinely used in forest resource assessments, and GIS applications in forestry serve both operational and research purposes. Tropical countries use remote sensing widely for forest resource assessment. GIS has principally been used for research studies and only to a limited extent to formally support policy formulation, the planning process or management decisions (Apan 2000).

With respect to remote sensing the available applications range from such widely adopted systems as assessments of forest cover and timber volume to more recent innovations to monitor of forest fires, spread of invasive species, wildlife resources, grazing pressure, and illegal logging etc. (e.g. GIS applications 2003). The most common use of GIS is in planning of forest management, timber transport and timber harvesting schedules. Newer applications deal with fire prediction and response, ecological landscape planning, wilderness area design, predicting evapotranspiration and runoff, providing support to resolution of forestry/wildlife conflicts etc. Log tracking systems are a new innovation linked with GIS and use of GPS, and they are likely to spread rapidly in the near future (see Box 5.1).

The benefits of remote sensing and GIS are often obvious but difficult to assess in quantitative terms. With regard to environmental management they include, *inter alia,* better monitoring of forest condition, easier distribution of environmental data, improved coordination of productive and conservation activities, and enhanced capacity to analyze the environmental impacts of alternative courses of action.

Box 5.1 Log Tracking Techniques

The expansion of forest certificates and chain of custody certifications to prove the origin of products pose new demands for management and information systems in the organizations of the forest sector to provide verifiable evidence on the compliance with the certification. New technologies are needed to monitor and control the logistic chain to meet the requirements of chain of custody verification.

Technology development is challenged by the need for cheap, credible methods to identify timber in the various stages of the chain of custody. At present, the attachment of physical identification to individual logs – e.g. by marking or separation – is so expensive that it is feasible only with high-value logs. With other timber assortments (especially pulpwood), the identification is typically carried out on a lot basis, which can consist of anything between a bundle and a shipload.

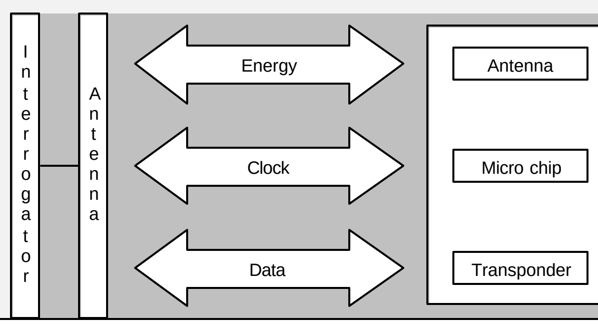
In addition to bar codes, programmable identification device (PID) would be one option to rationalize monitoring and controlling the chain of custody of timber. PID, together with GPS and GIS, would make it possible to attach information about the origin to the timber being extracted. Depending on the accuracy requirements, the information could be attached to a log, a wood bundle, a transportation unit (truckload), or a lot, and it could include the country of origin, logging site, or ultimately the map co-ordinates of the stump.

In its most developed form, PIDs would be equipped with automatic identification and data capture (AIDC) technology, which allows for the identification and/or collection of data into a computer system without using a keyboard. This eliminates errors and speeds up data collection. AIDC technologies include radio-frequency identification (RFID), optical character recognition (ORC), bar codes, smart cards, and emerging biometric technologies. RFID would be most readily adaptable to chain of custody monitoring, as it provides a means for obtaining information about an item without direct contact or a line-of-sight, which are its main advantages over other AIDC technologies.

RFID systems consist of two main components:

- transponder (or tag) located on the object to be identified
- interrogator (or reader), which allows data transfer to and from the transponder

The transponder is the actual data carrier, and it consists of an electronic chip and an antenna. Active transponders contain their own power source (battery) whereas passive transponders are powered wirelessly by the interrogator. The interrogator acting as an interface between software and the transponder, consists of a radio frequency module, a control and communication module, and an antenna.



Source: Indufor 2002

5.3 Bioenergy

In the developing countries biomass represents on average one third or fifth of the total energy consumption. The dominating use is firewood for cooking, space heating and hot water (Turkenburg *et al.* 2000). It is estimated that these technologies use 7-8 times more energy than "modern" ones (FAO 1998).

Among the "modern" ones, the most well-known products are improved stoves for cooking and heating. Many technologies are still in an experimental stage, but the following options appear to hold most promise for expansion and commercialization: (i) direct combustion of various types of biomass to produce heat, steam or electricity (CHP, dendrothermal power plants, co-combustion etc.); (ii) gasification of biomass for electricity generation, using technologies such as BIG/CC; (iii) production of liquid fuels (alcohol, ethanol, methanol, etc.) using hydrolysis and gasification (Turkenburg *et al.* 2000, FAO 1998).

Bioenergy production has a number of positive environmental effects. However, unless proper safeguards are applied, some negative impacts may also emerge. One of the main positive impacts is that biomass energy is considered carbon neutral when all biomass produced is used for energy. Also, increased availability of plantation wood for energy production, more efficient conversion of fuelwood and increased use of waste wood may relieve pressure to harvest natural forests. On the other hand, without appropriate precautions increased demand for wood-based fuels could encourage deforestation. Continual removal of large quantities of biomass may deplete soil nutrient levels. It should also be noted that the environmental impact of bioenergy production vis-à-vis other energy sources cannot be accurately determined unless full life-cycle is taken into account (Turkenburg *et al.* 2000, Sims 2002):

5.4 Pulp and Paper Production

In the developed countries the pulp and paper industry has been under substantial regulatory, social and market pressures to improve its environmental performance since the 1970s. These pressures were felt especially in the developing world where the industry responded by introducing new and improved technology such as (i) increasing the dry content of black liquor; (ii) incineration of odorous gases (in recovery boiler, lime kiln or separate furnace); (iii) filters for air emissions; (iv) biological and tertiary waste water treatment (activated sludge treatment); and (v) chlorine-free bleaching (Mickwitz *et al.* 2003). In recent times, the focus of technological innovation has shifted from traditional control and treatment technologies to pollution prevention at source (EPA 2002).

The introduction of new environmental technologies had a dramatic effect on pollution. For instance, owing largely to changes in bleaching techniques, the dioxin level of pulp and paper mill effluents in the United States decreased 90% between 1988 and 1993. In contrast, very few of these technologies were adopted in developing countries. For example in mid-1990s, less than one quarter of the world's pulp and paper-making capacity located mainly in the developing world was responsible for about three quarters of TSS (total suspended solids) emissions (IIED 1996).

5.5 Biotechnology

Over the last few decades industrial plantation forests have become a major source of supply of industrial wood. One of the main reasons for this change is the improved economics of planted forests through technological innovations. The vehicles of change have been tree breeding and – more recently – biotechnology. The characteristics that these techniques have sought to improve include *inter alia* (i) growth rates; (ii) disease and pest resistance; (iii) climate range and adaptability (tolerance to drought, cold, air and soil pollutants); (iv) tree form and wood fiber quality (straightness of the trunk, absence of large or excessive branching, amount of taper in the trunk, homogeneity of raw material), and (v) fiber characteristics that ease processing (break-down of wood fibers in chemical processing, reduced pitch or lignin content of trees) (Sedjo 2001)

The foreseen economic benefits are substantial. As an example, improved fiber characteristics could potentially increase valued added from pulping by 15-20%, and the benefit from reduced lignin content could be of same order of magnitude (Sedjo 2001). Potentially, the main environmental benefit is that low-cost wood from plantations provides an alternative source of wood supply reducing pressure to harvest natural forests. Some specific environmental applications are also in development (e.g. trees with ability to purify contaminated land) (Sykes *et al*. 1999).

However, in spite of these important opportunities biotechnology in forestry is still at an early stage of development, and no commercial production of transgenic forest trees has been reported (Owusu 1999).

It is acknowledged that biosafety aspects of genetically modified trees need careful consideration. One of the risks is that pollen from genetically engineered trees spreads to wild relatives giving birth to invasive species. Another concern is that because of the long generation time of trees, the full effects of biotechnology enhancement will not be known until at a very late stage (Botkin 2001).

The pulp and paper industry is also keen to take advantage of biotechnology to make the production process more efficient and environmentally friendly. A large number of experiments are underway, and a few applications have successfully been transferred to commercial production. Biotechnology is used to modify biologically based processes in a manner that produces more specific reactions and reduces environmentally harmful impacts. Biotechnology may also help in gaining energy savings and in developing alternatives for non-biological processes (Sykes *et al*. 1999).

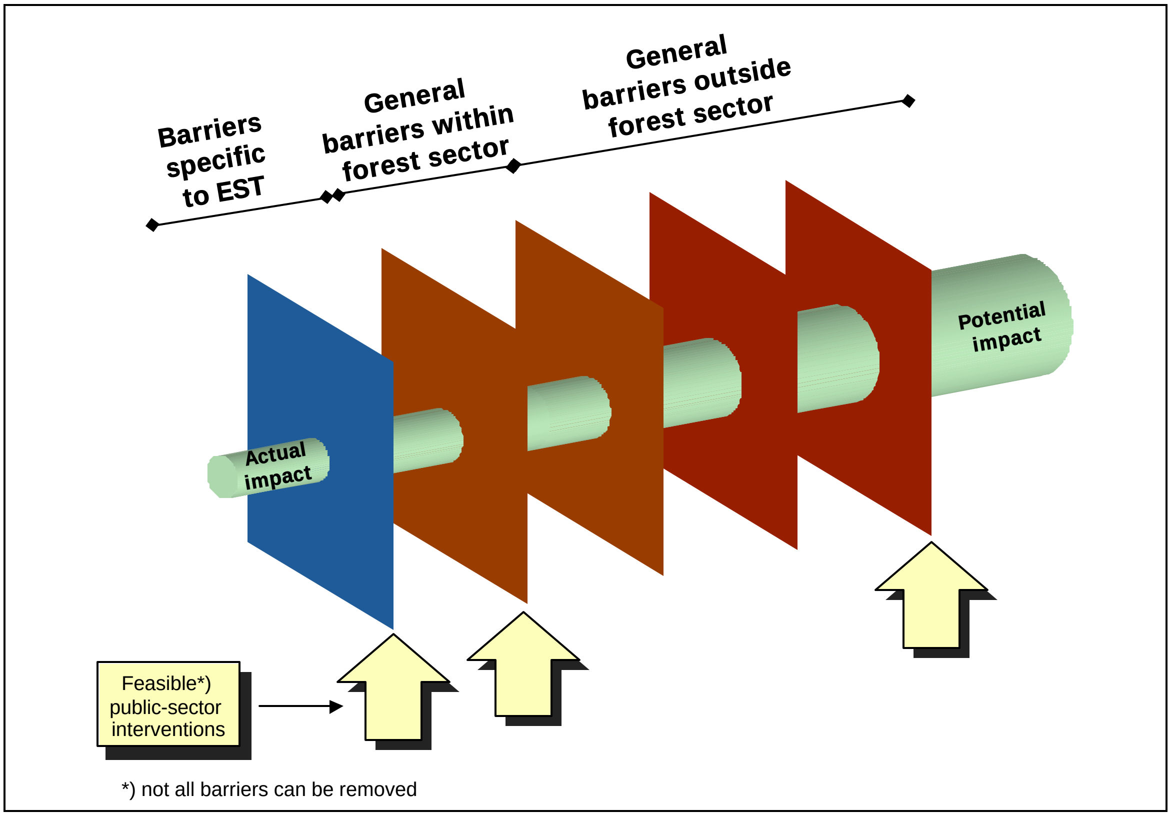
6. BARRIERS TO THE SUCCCESSFUL TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES

6.1 Overview

Transfer of ESTs has the potential to offer substantial benefits, but a variety of constraints hamper the process. Many of the impediments are common to all technology transfer, but a few barriers specific to the ESTs and the forest sector can also be identified. In Chapter 7.1 a general framework for EST transfer is presented. This framework looks at EST transfer from both a supply and demand perspective, and the mechanisms that are available in linking demand for and supply of EST. It has been quite common to analyze barriers to technology transfer largely from the perspective of the factors limiting developing countries' access to technology in the developed countries. The framework adopted in this study emphasizes the need to view barriers to the successful transfer of EST using a demand-supply based systems approach. The analysis of barriers, including making recommendations to improve the EST transfer (Ch. 7) and setting priorities (Ch. 8) makes also use of the division of barriers to those specific to EST in general, general barriers within forest sector, and general barriers outside forest sector (Figure 6.1).

Many of the barriers to the EST transfer are assessed in connection with measures to improve the transfer of ESTs. In this chapter some specific barriers are reviewed in more detail.

Figure 6.1 Type of Barriers Hindering EST Transfer



6.2 Economic Viability

In most sectors, the private sector is often seen to be the key agent for technology transfer. However, in the forestry sector of developing countries the role of public sector can be prominent. The public sector is often directly involved in sustainable forest management in addition to fulfilling its regulatory function. The short time preference of profit-oriented commercial ventures is an effectively barrier for private sector participation in forest management leaving the public sector with a large responsibility.

The bottom line for private enterprises in developing countries to embark on EST investments is their economic viability. However, these investments often struggle to provide acceptable returns in developing country conditions. Poor macro-economic conditions and undeveloped financing sectors increase risks and cost of financing while import tariffs and various other transaction costs represent an additional burden. The high upfront investment cost and long pay-back periods involved in EST investments in forestry are serious hurdles in an environment where access to funding is restricted and the required returns on investment are high (STOA 2001).

These problems are compounded in the SME sector, which dominates the forest industry structure in developing countries. For instance, in Asia SMEs constitute about 85% of the manufacturing establishments. SME enterprises lack economies of scale, and typically have weak balance sheets discouraging long-term investment and risk taking involved in adoption of new technologies. Commercial banks may also perceive investments in EST too risky. Additionally, the loans needed by many companies are often too small to interest the banking institutions. Banks tend to have a poor understanding on financing of SFM and its downstream operations (Thiruchelvam *et al*. 2003).

Even when investments are made, the SME owners tend to place more emphasis on capacity expansion than on environmental management. Adoption of new technologies carries significant transaction costs in the form of management effort, training and capacity building, and SME managers are reluctant to divert their attention to tasks that they do not see as critical for the company's performance (Thiruchelvam *et al*. 2003, IETC, undated). A survey carried out in the Asia-Pacific region among various industries, including pulp and paper, showed that most firms would not make substantial capital investment in cleaner production except when such elements can be incorporated in greenfield or other new production lines (cf. Llanto 2000).

In the developing countries, SMEs dominate not only in woodworking industries, but also the enterprises in the pulp and paper sector are often small. SMEs use most of the industrialized wood raw material and also provide most of the employment. SMEs are, however, often ignored when policies and strategies for the forest sector are drafted. With respect to forest management, the private sector has limited interest in investing in SFM because of high perceived risks and relatively low rates of return of SFM compared to other investments (including unsustainable forest management). For the same reason, foreign investors tend to be more interested in opportunities arising in the forest industries than in SFM.

Corporate and consumer awareness of environmental issues is not yet firmly rooted in developing countries, and there is only limited domestic market-based pressure to enhance environmental performance and introduce EST. Capacity to adopt voluntary environmental standards is limited and approaches suitable for SMEs are generally unavailable. Producer countries involved in exporting primary or further processed products to international markets are, however, increasingly experiencing consumer and buyer pressures to provide assurances that products originate from areas, which are sustainably managed and that the legal requirements are complied with.

Acquisition of ESTs by communities and farmers is constrained by lack of knowledge and limited access to capital, effective extension services, small-scale loan facilities are seldom available.

6.3 Policy and Legal Framework

Lack or inadequacy of environmental regulations and standards and the weak enforcement of existing regulations are major factors restricting demand for EST. The financial returns from investing in EST are often low because sales prices can be kept artificially low due to dominance of unsustainable environmental practices causing externalities that entail no cost to the technology user. The limited adoption of Reduced Impact Logging (RIL) techniques is a typical example of a situation, where the regulatory framework is lagging behind enabling unsustainable practices. While the environmental benefits of RIL would be significant, its implementation creates an additional cost for the producer. Given the limited or non-existent regulatory pressure, most operators choose to carry on with conventional techniques.

Distortions in the general economic framework and policies may also reduce demand for EST. In many countries timber prices are often set administratively, and if they are set too low below the market price, they reduce the profitability of SFM and the demand for EST. Agricultural and land policies reducing the relative profitability of SFM have the same effect. Lack of clear tenure arrangements reduces the incentives of forest users to invest in EST. Lack of coherent sectoral plans and policies increases uncertainty and makes it difficult to identify appropriate forest technologies and to develop strategies for their implementation and sustainable use. Moreover, technology issues are generally not dealt with in sectoral plans such as national forest programs (NFPs).

The forest sector in developing countries is often in chronic shortage of funds, both in terms of operational and investment finance. External funding is critical; an FAO survey (1997) revealed that 60% of responding countries relied on foreign sources for the greater part of their forest sector funding.

6.4 Capacity

Lack of capacity in developing countries to assess, select, import and adapt EST is effectively hindering technology transfer, and reducing its value. Local organizations suitable for these tasks, e.g. research institutions, do not have the necessary qualifications and resources. As a result, many existing technologies are under-utilized and transferred technologies seldom reach the designed operational efficiencies (TERI 1997).

Developing countries have also limited capacity to sustain the transferred technologies. Human constraints prevent upgrading and further development of ESTs, and without nation-wide access to service and repair functions (often carried out by private firms), geographically dispersed organizations such as forestry administrations have difficulty to keep their technologies operational, and the equipment often deteriorate fast.

6.5 Information

Local intermediaries able to facilitate EST transfer are often weak. Extension services have limited capacity and the potential of NGOs (including forest owner/producer organizations) to contribute to dissemination of information on ESTs is often not recognized or ignored. Both extension services and NGOs often have inadequate technical capacity and have inadequate focus on technology. The consulting sector remains weak owing to limited demand, and on the supply side, service-oriented R&D organizations or centers of technological knowledge are few and far apart. Their programs are frequently dissociated from the actual needs of forest owners and managers. Coordination and cooperation amongst forest producers and forest industry are often non-existent or inadequate, driven by short-term market interests.

Large-scale industries may be able to bridge the gap owing to their larger resources and international contacts, but SMEs have limited access to technological information, and are generally unaware of the opportunities and benefits offered by EST. They also lack scientific, engineering and technical knowledge to improve their own technologies, and access and adapt available better technologies (Thiruchelvam 2003, IETC undated). Lack of knowledge and information is a significant constraint since major improvements in environmental performance can often be achieved at low or no investment cost (cf. ICPIC 1997).

6.6 Research and Development

Forest-related research has usually limited capacity to contribute to EST development and institutions suffer from lack of qualified staff and other resources. The research institutions are usually too weak to enter into mutually beneficial co-operation projects with foreign research institutions or the private sector. There are, however, examples on effective cooperation when both domestic and external funding has been ensured.

R&D institutions in developing countries often suffer from inadequate capacity to access and adapt ESTs, which are in the public domain in the developed countries. Universities, research institutes, and government institutions also rarely have incentives to make the information available to potential beneficiaries in developing countries, because the transfer entails costs. Often, they also do not know about specific EST demand requirements originating from developing countries.

The R&D institutions in developed countries are not geared to address problems specific to developing countries. For instance, the pollution prevention technologies developed for pulp and paper mills in the developing countries are often incompatible with the outdated equipment used by small-scale mills in developing countries. Lack of appropriate technology would usually make it cheaper to build a new greenfield mill rather than upgrade an old one (IIED 1996).

There are also few ESTs meeting the needs of the poor in developing countries. In forest sector, new technologies are typically developed to benefit industrial plantations and operations in valuable tropical hardwood forests run by state forestry organizations and large companies. Supply of ESTs is much more limited for small-scale mass products such as improved stoves or for technologies suitable for commercially less attractive dry tropical forests. Innovations based on traditional forest-related knowledge or ESTs needed by disadvantaged groups, such as communities or women have not been considered when setting priorities for EST development.

7. APPROACHES FOR IMPROVING THE TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES

7.1 Framework for EST Transfer

In examining opportunities to improve EST transfer to the forest sector in developing countries, the focus is here given to identifying ways through which the public sector and the international community could contribute to EST transfer. The emphasis is on actions that policy-makers in government institutions directly responsible for public policies in forestry or forest industries can take. Policies in other sectors with relevance to EST transfer in the forest sector are also identified, but their analysis and respective recommendations are made with less detail.

The public sector is here treated as one block, even though in reality there is a host of organizational models involving different decision-making processes. For instance, forestry and forest industries are usually administratively placed under different ministries and are thus subject to different decision-making procedures. As regards the international community, the roles of bilateral and multilateral organizations are distinguished.

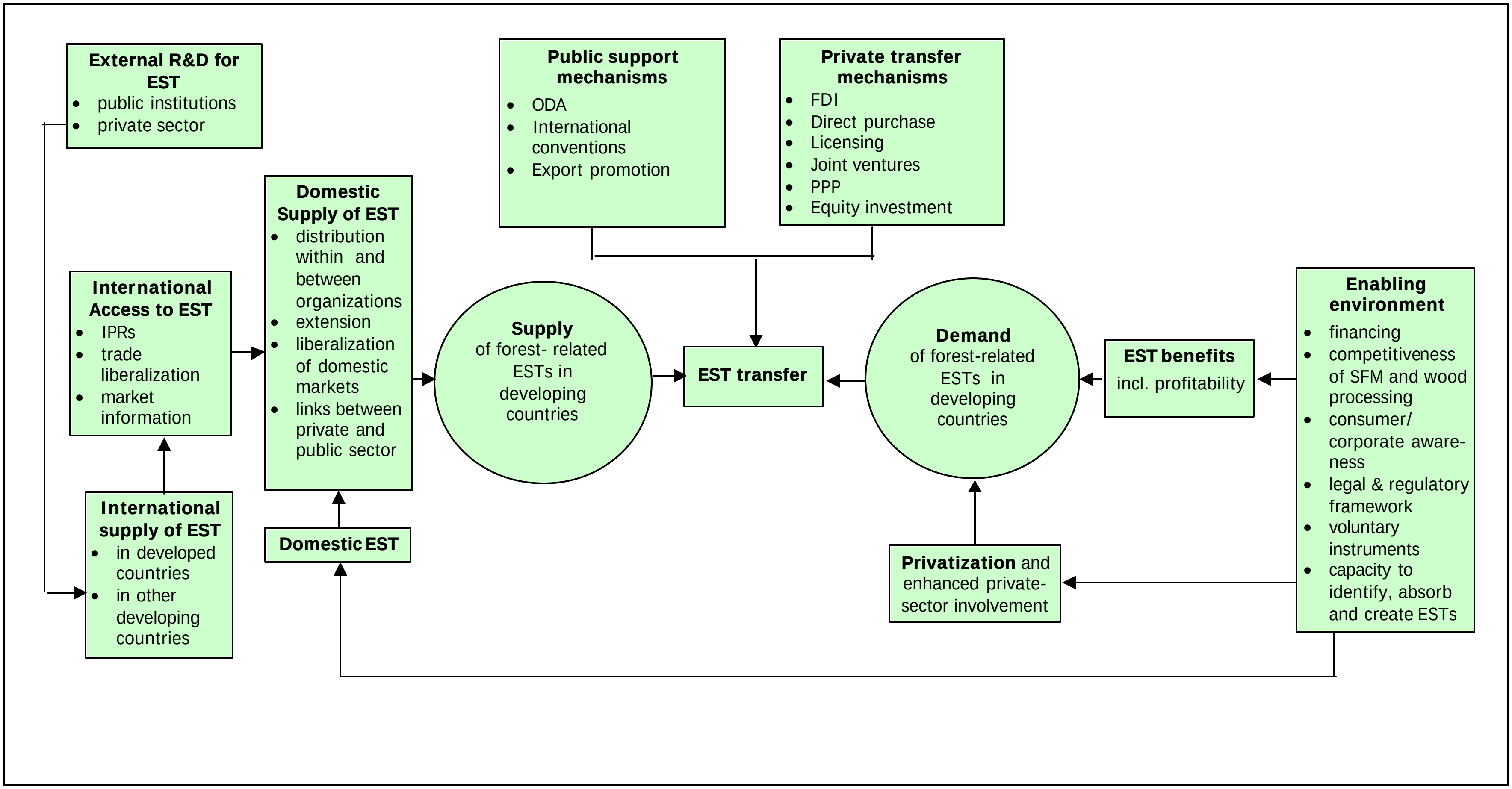
The transfer of EST is a result of demand and supply meeting specific needs. The promotion of EST transfer consists of various ways of influencing the factors behind demand and supply (Figure 7.1 Supply and Demand of Environmentally Sound Technology
. The rate of technology transfer is affected both by motivations that induce more rapid adoption of new techniques and by barriers that impede such transfers. Both types of factors can be influenced by policy (IPCC 2000). Typically, the impacts are interrelated, and the best effect is not reached by applying one single instrument but a combination of several instruments (UNFCCC 1998).

Many of the necessary measures are part and parcel of "ordinary" sectoral development, especially those that relate to development of enabling environment. Financing mechanisms, capacity building, regulatory environment, etc. are all well-known policy instruments, which can contribute to EST transfer. Research and development can also be specifically targeted at promoting EST transfer.

Transfer itself takes place through various mechanisms such as commercial purchases of EST, licensing, foreign direct investment, joint ventures, public-private partnerships (PPPs), equity investments, etc. The way in which these mechanisms work can be developed to contribute to EST transfer. International support mechanisms include overseas development assistance (ODA), concessional financing, export credits and international information and knowledge networks (North-South and South-South). The multilateral agreements agreed can have a direct or indirect bearing on EST transfer.

In general terms, the private sector is the primary agent for technology transfer within and between countries. The OECD estimates that more than three quarters of technology transfer takes place through commercial transactions (Xiliang undated). The dominance of the private sector stems from the fact that it is also the primary agent for developing technology and converting basic scientific research into applied technological products.

Figure 7.1 Supply and Demand of Environmentally Sound Technology



In forest industries, the private sector is the predominant actor for EST transfer. In contrast, forestry technology transfer is characterized by the non-commercial nature of the transfer of some technologies as well as low levels of involvement of commercial institutions. Currently technology transfer takes place largely from the government-controlled universities and research institutions to forest departments and farmers (IPCC 2000). Its impact in terms of enhanced productivity has been marginal and it is not geared towards EST transfer (cf. Ravindranath and Hall 1995 in IPCC 2000).

7.2 Creating Demand for EST

The basic condition for successful EST transfer is that there is local demand for the technology. Studies and experience show that the main driver behind EST investments in industries in the developing countries is the perception that they will yield an economic gain for private enterprises; in the absence regulatory pressure, the environmental benefits alone are not a sufficient impetus for investment. Large-scale adoption of ESTs is limited to those technologies that provide assured and immediate financial returns (Warshurst 1999, UNIDO 2003). In the public sector, financial returns are often more difficult to estimate, but improved performance defined in some other way is, or at least should be, the primary objective of EST acquisition.

The public sector can significantly influence demand by introducing appropriate environmental regulations and enforcing them effectively. Another contribution of public sector measures (e.g. with respect to macroeconomic framework) is that they reduce the risks and restrictions associated with the transfer of EST increasing the flow of technologies close to the commercial margin. The public sector can also apply instruments (e.g., tax breaks, subsidies) to make those ESTs that would provide a net social benefit but are not profitable economically viable.

Privatization is a major trend in developing countries and it is expected to give a direct boost to the demand for EST while opening new possibilities to finance the acquisition of technology. Converting public enterprises into private companies is a major feature of the economic restructuring of many developing countries. There is considerable scope for including EST criteria in the structuring, tendering, negotiating and financing of privatization programs. In the forest sector, this applies in particular to privatization of heavier industries such as pulp and paper mills, which are still in public ownership in some developing countries.

Private sector participation may also increase through other mechanisms than privatization. Public sector institutions can increase the purchase of various services from the private sector, including (i) operation on a day-to-day basis, (ii) maintenance of infrastructure, (iii) investments to maintain or improve the service, and (iv) revenue generation through fare collection or other forms of billing for services. All these type of contracts offer opportunities to include EST criteria.

According to some estimates the global market for environmental technologies is worth around USD 600 billion. However, the bulk is found in developed economies while the share of developing countries would be some 7% of the total (Commission of the European Communities 2002).

7.2.1 Competitiveness of Sustainable Forest Management and Wood Processing

EST transfer and related investment can take place in an environment where forest management and wood processing are economically feasible. Especially forest management suffers from low short-term profitability, which is a deterrent to investment. Coupled with the fact that ESTs often have a high initial capital cost, the basic framework for any technology transfer is challenging.

In addition, public policies often aggravate the problem. Agricultural subsidies applied in many countries increase the profitability of competing land uses and further reduce the interest to make investments in forestry. In energy production, the level of import duties on petroleum products (and related subsidies on the use of petroleum products) changes the relative cost of renewable and non-renewable energy technologies to the disadvantage of biofuels (STOA 2001). In some countries, forest policies are also contributing to low profitability of forest management. For instance, timber prices may be set administratively at a low level, or efficient functioning of timber markets is hindered by (state) monopolies or oligopolies. Lack of effective enforcement coupled with extensive illegal logging and trade also undermines the competitiveness of responsible producers. Removal of such distortions would favor EST transfer to forestry.

There are a number of R&D activities aimed at improving the productivity of forest management (increased tree growth, harvesting techniques, logging, waste reduction and efficiency in wood processing, etc.). However, these activities are mainly focusing on high-value forests subject to industrial forest management and harvesting. They represent only a limited portion of tropical forests, while a huge area of low-yielding forest (especially drylands) benefit only from very limited R&D inputs. For example, forest plantation productivity has increased spectacularly and average growth rates of 20-30 m^3/ha/yr are reached in operational activities. Still, with few exceptions, timber species grown on medium and long rotations have not benefited from these technological advances. They have limited appeal to commercial investors, who prioritize fast-growing species (Sayer *et al*. 1997).

Recommended action:

- Remove perverse incentives reducing the relative profitability of SFM and undermining the demand for EST investments
- Support research to increase the competitiveness of sustainable forest management outside the high-yielding commercially attractive forests

7.2.2 Legal and Regulatory Framework

One of the main reasons for low demand for EST in developing countries is the lax or non-existent regulatory framework for environmental protection. The negative environmental effects (externalities) caused by unsustainable practices are not internalized to capture the environmental and social costs. Appropriate regulatory framework can, however, be an effective instrument in promoting demand for EST. Stronger regulations and improved enforcement would increase the cost of non-compliance and strengthen the demand for EST. Generally speaking, the most efficient policies are those, which set targets for the private sector and leave them the freedom to choose how to meet those targets.

Finland, among many other developed counties, established an environmental permit system, which was crucial in reducing industrial pollution in the pulp and paper industries. The permit regulations speeded up the adoption of advanced techniques and created a market for environmentally friendlier solutions (Hildén *et al*. 2002). In developing countries, a study commissioned by UNIDO (2002) on EST adoption in the pulp and paper industries of selected countries suggests that regulatory pressure is the single most important driver for EST investment. For instance, in Brazil the strict limits imposed by environmental regulators were found to be strong drivers for innovation and the adoption of EST. Similar results were found in a survey carried out by the United Nations Economic and Social Commission for Asia and the Pacific among environmental oversight bodies and commercial companies in developing countries (ESCAP 2001, cf. IETC undated).

Despite their potential effectiveness, regulations are often politically controversial. Governments may be reluctant to introduce them, because they fear that they will reduce the competitiveness of domestic industries and fiscal revenue potential for the government and earnings of logging companies (IPCC 2000). The overall policy and institutional environment is also important. For firms operating in free market conditions in Brazil and India regulatory pressure was the most important reason for EST investments. In socialist economies of China and Vietnam, the reduction in and raw material costs was the key driver. However, even in the latter case regulations were the second most important reason for adopting ESTs (UNIDO 2002).

Most of the available examples on the impact of regulation are from forest industries as industrial activities are easier to control than forest management. Production is concentrated on a few locations, and performance indicators are rather straightforward (e.g., emission levels). The environmental impact of forest management is often more diffuse, regulation is more complex and enforcement has to be extended over large areas. There are also considerable difficulties to establish unambiguous indicators for the environmental performance in widely varying forest conditions. For instance, the very limited use of Reduced Impact Logging in tropical countries is at least partly attributable to the difficulty of enforcement.

From the forest sector's perspective, it is important that introducing and enforcing regulatory instruments are largely a sectoral responsibility – in contrast to many other instruments proposed for promotion of EST transfer (e.g., financing). In spite of the fact that legislative and resource allocation decisions are made on higher levels, the forest sector is responsible for preparatory work and implementation. Regulations and enforcement are also important in the sense that the potential effect is very high. In practice, the weaknesses in the institutional framework and inadequate resources often erode effectiveness of regulation, but the potential is so high that the improvements in this area should be given a high priority.

Among other legal provisions, those that regulate land tenure have the largest bearing on EST transfer in forestry. The acceptance or rejection of a technology will depend on who owns, controls and manages the resources both legally and in practice. Insecurity created by unclear property rights or conflicting claims (e.g., state ownership vs. traditional rights) deter investment. In Thailand it was found that farmers were more likely to make capital and technical improvements on their holdings if their land ownership was secure (IPCC 2000).

Recommended action:

- Introduce appropriate environmental regulations and strengthen the capacity to enforce them effectively
- Promote independent auditing and certification as voluntary measures to compliance with environmental regulations
- Where necessary, clarify property rights related to forest land and introduce effective and secure land tenure as a precondition for EST investment

7.2.3 Capacity Building

EST transfer is a highly complex undertaking requiring strong implementation capacity at all stages. Capacity building is a slow and multi-faceted process needing long-term commitments on the part of the various stakeholders. Many of the requirements are cumulative and involve tacit knowledge that can only be acquired through an incremental learning process (Barnett 1995 in IPCC 2000). Capacity building needs vary greatly from country to country, but in general terms the ultimate goal of capacity building should not be just applying a particular technological solution, but to build an autonomous capacity to acquire, adapt, and further develop technologies. This is a matter of enhancing the overall technological capabilities, rather than pursuing actions related to specific environmental technologies (Parikh 2000).

Training

EST transfer is a continuous and broad process extending far beyond the transfer of individual technologies. With respect to capacity development, the transfer should encompass (i) knowledge and competence necessary to operate and maintain the technologies transferred; and (ii) knowledge, competence and experience to simulate, create and lead technology change and development in the recipient country (TERI 2000). To enhance these capabilities improvements are needed both in training and research and development.

Successful transfer of ESTs requires the existence of basic technical skills among the recipients. The immediate need is for operational and maintenance skills, which both technology buyers and sellers usually focus on. Technology sellers often help with long-term training packages. Still, transferred technologies are often running much below their operational capacity suggesting that all shortcomings in the basic educational level cannot be overcome with short-term training. Enhancing skills related to specific technologies cannot fully address the fundamental problems, such as gaps in the basic education. As one response to this problem, new forms of technology transfer are emerging in the forest sector. As an example, improved forest auditing and log tracking systems are being offered to developing countries using the build-operate-transfer (BOT) approach where the supplier designs the systems, sets it up, recruits and trains local staff to run the system for an initially period, and then transfers the operations to the recipient when the system has been well established and operates smoothly. The BOT approach and its variants have been successfully used in production and their application is now broadening to other areas to overcome the difficulties of the technology transfer process. In spite of higher costs, these approaches substantially increase the probability of successful transfer addressing the problem of the recipient organization's capacity constraints.

Another specific problem is lack of skills in Information and Communication Technologies (ICT), which in many cases are in close relationship with the capacity to use ESTs (cf. TERI 1997). These technologies are gaining an increasingly important role in forest management planning and monitoring, forest law enforcement, wood procurement, organizations and forest industries.

Foreign investment has the potential to serve as an effective vehicle for transferring capacity, but it does not automatically lead to it, and special measures are needed to ensure the development of local capacity. There are short-term incentives both for the technology supplier and the recipient that work against it. For instance, the supplier's wish to maintain control over the transfer process and the recipients' tendency to minimize expenditure on capacity building by employing foreign consultants on an "as-needs" basis (Warhurst 1997). The acquisition investment should be considered in the systemic context where the expected outputs are weighed against all the necessary elements of a successful EST transfer. Such a holistic analysis covering all the ancillary costs is rarely done in forest management investments and improved technologies remain unutilized due to inadequate capacity building in the organizations.

Environmental management and addressing the social issues related forest operations are a key area of sustainable forest management. In these two fields, operators in developing countries have also limited capability. Insufficient consideration of these aspects in the investment process has often led to environmental damage and social conflicts. These issues tend to be considered peripheral from the traditional investor's point of view. A holistic approach within the context of sustainable forest management is therefore called for investment planning.

Insufficient capacity is apparent at many different levels of the technology transfer process from decision making about appropriate technology to establishment of appropriate management practices for ESTs. Especially the SMEs are affected as they are often unable to acquire external assistance. The issue is partly related to limited resources allocated to education and training, but in part also to inadequate coverage of environmental and social aspects of SFM in the curricula of existing educational institutions in forestry.

In many countries the forestry curricula of educational institutions have been revised to address the broadening scope of future skills in SFM. However, the flow of EST-related information to industries and practitioners in the forest sector is still inadequate and affect the educational sector as well. The efforts to disseminate information on ESTs often pay little attention to the educational sector. In addition, weak links to logging organizations and industry often prevent demonstration on the use of existing ESTs.

Another often neglected area of capacity building is the education of decision-makers of the opportunities and limitations of ESTs in the forest sector. There is evidence that, e.g., remote sensing and GIS applications are often underutilized because the decision-makers in the sector are not aware of their full potential. The objectives of EST transfer may also be set too high considering the overall conditions in the sector.

Recommended actions:

- Raise awareness among decision-makers on the capacity building methods related to EST transfer as well as the potential of new transfer mechanisms to overcome capacity constraints (e.g., build-operate-transfer)
- Strengthen environmental curricula in educational institutions for forestry and forest industries highlighting EST applications as well as management of environmental and social impacts and risks of forestry operations
- Facilitate the flow of information on ESTs to forest-related educational establishments by developing links to information networks, and by strengthening cooperation with enterprises and public institutions using ESTs

Research and Development

The main challenge regarding knowledge transfer is to create sufficient capacity for EST transfer and development of indigenous technology. This will ensure that the transfer process does not become a one-off event without having replicative and trickle-down effects on the economy. Enhancing the quality of research and development (R&D) plays a key role to this effect. The significance of R&D has been accentuated by the shorter commercial life-cycle of products (Hoffman 1999) but it is equally important for SFM and utilization of forest products and services due to rapid change in the operating environment of the forest sector and accumulating scientific knowledge.

Adaptive research needs to be carried out in support of EST transfer. The ultimate aim should be, however, to move to technology development, because this is the area in which the domestic value added is the highest. In developing countries, this is possible within many fields, particularly where indigenous knowledge on the natural resources is crucial. Setting overambitious targets should be avoided and many smaller countries with weak R&D institutions may better focus on limited niche areas where a critical mass can be created while drawing on the results generated elsewhere in other areas. The Japanese experience from the past decades shows that the ability to develop technology in an efficient manner usually follows on from first having mastered existing technologies developed by others. Stepwise progress towards more ambitious targets ensures that research efforts will produce tangible results within reasonable timeframe (Parikh 2000).

In addition, government-to-government aid mechanisms have often proved to be inefficient in facilitating the flow of technologies to the developing countries. To the extent feasible the private sector should be involved in such cooperation either as a direct beneficiary or as a potential intermediary "packaging" and distributing the research findings to their users. One of the main weaknesses of research in developing and developed countries alike is that research findings do not reach the potential users. Involving a private enterprise in the co-operation arrangement ensures that there is a motivation to use or find a user for the information.

Developing the capacity of developing countries to adapt existing technologies to local conditions is especially important in the forest sector, where conditions (e.g., climatic, micro-climatic, soil, species) vary dramatically from region to region and even from site to site. Unfortunately, the status of forest research in developing countries is not encouraging in any discipline, including ESTs (Szaro *et al.* 1999). Apart from a few exceptions, research institutions in developing countries rarely have adequate capacity to effectively participate in international research projects, and to adapt and transfer results of the research to the local level. Research on forests has not only suffered from a lack of resources; it has not been sufficiently interdisciplinary to provide an integrated view of forestry (FAO 1997 in IPCC 2000). Forestry research is often an undervalued and under resourced activity with limited external support. For instance, only 2% of the ODA in forestry is spent on research (OECD 2000). For comparison, in agriculture the allocation for research may have been as high as 10% (IPCC 2000).

Forestry research and technical training institutes in developing countries have traditionally been linked more to serve state forestry and public sector organizations rather than the private sector. Several countries are reducing public sector funding of research because of economic constraints. This is being partially offset by increasing private sector investment in R&D by large forest companies, but their focus tends to be on short-rotation industrial species and on processing technologies while little effort is spent on developing ESTs (Szaro *et al.* 1999). Expansion of multinational companies brings additional resources to developing countries, but their impact on local research capacity may be limited, because R&D activities are managed at corporate level. Few institutions, public or private, have used their capacity to develop ESTs for the poor forest-dependent people, disadvantaged groups, such as women, or on commercially less attractive forests. Research efforts to build on traditional forest-related knowledge have been negligible.

Because low-yielding forests often harbor significant environmental (e.g., biodiversity, watershed functions) or social values (e.g., fuelwood production), the public sector has a special responsibility to ensure that technological development benefits also these areas. Commercial development of ESTs suitable for these conditions is likely to remain limited in developed countries. Instead, companies in developing countries can find a niche market in this area, and therefore South-South EST transfer holds particular promise in this regard. As an example, an improved stove designed after a model developed in Thailand has become a mainstay on the commercial market in Kenya (IPCC 2000).

Escalating R&D costs have encouraged and enhanced collaboration among enterprises and governments to promote technological innovations. However, with the exception of the electronics industry (in few countries in Southeast Asia), this development has so far not extended to developing country firms to any significant extent (Hoffman 1999). In the forest sector, the situation is highly similar at least with respect to development of ESTs. However, the emergence of collaboration arrangements is highly desirable, and any initiatives in this regard should be strongly supported.

As the first step, the capacity of the public forest research institutions to participate in R&D must be strengthened. Apart from providing training and increased resources, one of the most promising avenues is sub-regional and regional networks of research institutions (e.g., CIFOR, IUFRO, CATIE, ICRAF, IPGRI, etc.). In addition to benefits in information sharing, networking provides opportunities for exploiting synergies. So far, research institutions in developing countries have not been able to fully participate in these networks which are often supported by donor funding or run by NGOs.(see Annex 3). The problem lies in the limited capacity to take advantage of the opportunities rather than not having access to networks.

Recommended actions:

- Expand funding to public forest research; and where feasible, provide support to development of public-private partnerships
- Provide support for training and research programs focusing on adaptation of ESTs to recipients' contexts; pay special attention to identifying opportunities to support South-South collaboration; shift focus gradually to efforts to creating new ESTs
- Provide support to research programs targeted at identifying, refining and extending indigenous ESTs that can be used to incorporate and preserve traditional forest-related knowledge
- Where necessary, redesign training and research programs to focus on development of SFM-related technology, including ESTs suitable for the poor, disadvantaged groups such as women, and commercially less attractive forests, as well as ESTs based on traditional forest-related knowledge
- Provide support to strengthening the cooperative networks of research institutions in developing and developed countries and among those in developing countries; particular attention should be paid to enhancing the developing countries capacity to take advantage of the existing and emerging opportunities

7.2.4 Information Management and Monitoring

Because of its public good characteristics, the technology infrastructure required to generate new knowledge and information may lack direct economic value to one firm, and thus individual firms rarely serve adequate incentives to build technology infrastructure on their own. This points to an important role for governments to create the necessary information assessment and monitoring capacity. Also, there is a need to support private sector actors and communities in seizing the available opportunities. At the same time, the roles of governments and private actors are changing. Private information networks are proliferating through specialized consulting and evaluation services and over the Internet. Increasing foreign direct investment (FDI) also demonstrates that ESTs can diffuse rapidly without direct government action suggesting that the governments' role could often be focused on the facilitation of this process (IPCC 2000).

Many developing country enterprises are unable to effectively exploit the diversity of available technologies. Repeatedly, companies in developing economies indicate that they do not have adequate information on the availability of technologies. Insufficient awareness of alternative technologies has been a major obstacle to improving corporate environmental performance in developing countries. One of the main impediments to information flow is the high transaction cost involved in active market search Also, there are only limited specific support structures to facilitate technology transfer (IETC undated).

However, the past experience suggests that the demand for general data, e.g. in technology data bases is limited (e.g., FAO in logging). Instead, the enterprises require specific, needs-based information on ESTs and, often, on financing. These services are usually best provided by an intermediary through an interactive process with the enterprise searching for information. In general, it is important to provide information fast with access points close to the end-users. Other functions an intermediary may have is to act as local agent for potential licensers, locate potential that users, purchasers, or licensees for ESTs, and facilitate licensing or investment arrangements between buyer and seller etc. (e.g. TERI 1997, UNIDO 2000). In some instances, they may also help commercialization of local technologies (e.g. CESTT in China). In the forest sector, such intermediaries are not well developed which led to the conceptual development of the Investment Promotion Entity which, however, could not take off due to lack of public sector support (Salmi *et al.* 2001).

Intermediaries are typically specialized private consultants, public sector or public/private institutions or non-governmental organizations. All types exist, but in slightly different environments and serving different needs. For instance, in the pulp and paper sector, companies in open, market-based economies, (e.g. in Brazil and India) rely to a large degree on private consultants. In socialist economies (e.g. in China and Vietnam), there is often a heavy reliance on public sector institutions. Experience in India suggests that to enable a proactive role for the intermediary, it would be necessary to combine the information service with a financing facility. Adoption of technology by SMEs hinges often on the availability of financing, and to ensure smooth implementation of plans to transfer ESTs, easy access to financing plays a key role (TERI 1997).

In the forest industries, one of the most promising mechanisms for enhancing EST supply is the partnership between industries and farmers, where the industries provide the technology (and possibly credit) to farmers growing trees in return for establishing a business relation with the company. Both the industry and the farmers are driven by profit motive (IPCC 2000). However, since the resources available to industries are much larger than to farmers, public sector support and regulation are often needed to ensure that the partnership remains balanced.

Relatively simple technologies (e.g. improved stoves) can be disseminated through the extension service or the mass media. In many cases, however, forestry extension service is poorly developed and alternative approaches are to work through NGOs or producers' associations (e.g. farmers' or industry organizations). For instance, in India there is an NGO driven large-scale revegetation program, and in Brazil, two industry associations are an important source of technological information for the local pulp and paper industries (IPCC 2000, UNIDO 2002).

With respect to the performance of public and private intermediaries, case studies indicate that the Brazilian pulp and paper firms relying on private sector consultants were generally satisfied with the available external support. The companies in China and Vietnam depending on public sector intermediaries found the quality of services low (UNIDO 2002). While this does not mean that services provided by the public sector are necessarily ineffective, the findings support the view that market-based approaches tend to be more effective. The main weakness of a market-based strategy is that it does not necessarily reach the large SME sector or communities, leaving the public sector a large responsibility in this regard.

In order to the public sector intermediaries work more effectively, they could be made responsible for marketing ESTs and the financial benefits to their staff would depend on the results of their work. The approach holds a lot of promise, but there is little experience of it. The potential weaknesses are the difficulty in maintaining neutrality of the service; avoiding concentration of marketing efforts in the more developed, "easier" locations; and ensuring that the most appropriate technology is used. Possible remedies include guidelines, regular reviews, etc. to avoid misconduct. Transactions in more difficult conditions could be rewarded with higher incentives. For such a system to work appropriately careful design and experimentation stages are needed.

The international information networks and clearinghouses that provide advice and training are often necessary to support country-level intermediaries. A number of bodies already exist that can be relevant to the forest sector ,including

- FAO Forestry Program
- UNFCCC Technology subprogram
- UNEP/DTIE International Environmental Technology Center (IETC),
- UNEP International Cleaner Production Information Clearinghouse (ICPIC)
- UNIDO Cleaner Production (CP) Program
- International Center for Environmental Technology Transfer (ICETT) (Japan)
- The APEC Virtual Center for Environmentally Sound Technology Exchange (APEC-VC)
- The Asian and the Pacific Center for Transfer of Technology (APCTT)
- The Center for Environmentally Sound Technology Transfer (CESTT) (China)
- SANet supported by GEF and UNEP (see Box 7.1)

Box 7.1 Sustainable Alternatives Network (SANet)

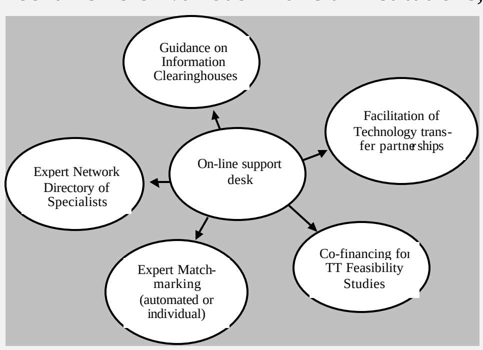
The Sustainable Alternatives Network (SANet) is a partnership between the United Nations Environment Program (UNEP) and the Global Environment Facility (GEF). Contributing partners are the World Federation of Engineering Organizations (WFEO), the International Federation of Consulting Engineers (FIDIC), and a number of sector-oriented organizations. SANet's objective is to develop a cross-cutting communication mechanism, and related information infrastructures that can help address the knowledge management and dissemination needs of technology transfer practitioners whose work affects the implementation of the different MEAs.

The following lessons learned from UNEP's previous projects underpin SANet activities:

- Information only starting point: interaction of people is what makes a difference
- Clear communication strategy and target group are instrumental for success
- Technical solutions are only half the story – viability is key across all sectors
- Environment is not the primary driver of technology transfer, but contributions to economic goals

SANet helps business experts overcome technology transfer challenges by offering online resources and financial incentives, thereby enabling local experts to strengthen their advisory capacity and effectively market their services. Business experts can use SANet to find up-to-date information and tools that have practical value in assessing investment feasibility. Using SANet, specialized and experienced expertise can also be found. SANet acts as a broker of information and expertise for business experts in companies, consulting firms and financing institutions.

The SANet web site contains an array of knowledge and useful information resources designed to help business experts prepare financing decisions about cleaner technology transfers. The planning tools directory provides guided introductions to databases and interactive planning tools, most relevant to investment decision-making. The directory of case briefs helps experts generate ideas or crosscheck them with real-life business successes in which cleaner technologies were used profitably. The case directory is linked to the expert directory, which offers a database of experts with track records in bringing clean technology investments to success, both in terms of economy and environment. In addition, the finance directory, which will exhibit mechanisms of various financial institutions, is being planned.



Source: Rittner 2003

The key problem does not appear to be the distribution of information at the international level, but having the capacity at the country level to use the available EST-related information in a systematic manner and being able reach out to those who are unable to access it. Training of local intermediaries is a key activity.

Another possibility is to subsidize the services of the private sector consultants to make them more accessible to SMEs. There is some experience on this, but such arrangements tend to produce lower quality services than a pure market-based mechanism. The consultancy sector could also become a significant driver for EST transfer (cf. TERI 1997). A potential weakness is that the cost of using international consultants is usually prohibitive for a public subsidy system. In many countries it would be difficult to find a sufficiently large body of domestic consultants to ensure adequate quality of service and competition between the service providers.

Recommended actions:

- Where appropriate and feasible, provide support to the development of private consultancy capacity to implement intermediary functions in EST transfer in the forest sector
- Enhance the capacity of public intermediaries relevant to EST transfer in the forest sector by providing them with training and financial assistance; if possible, provide them with access to a financing facility; explore the possibility of introducing output-related incentives for staff in public intermediaries
- Strengthen the capacity of the NGOs with respect to facilitation of EST transfer, and fully tap their capacity to contribute to the efforts carried out by the public sector
- Develop the interface between international information networks and clearinghouses and country-level intermediaries to ensure that the existing information flow is in full use

7.2.5 Consumer and Corporate Awareness

High awareness of environmental issues among consumers is a major driver for EST use in developed countries. In developing countries consumer awareness is often low, and it influences mainly those companies that export their products to environmentally sensitive markets. For instance, in Brazil the pulp and paper industries' environmental performance was found to be linked to pressure from customers demanding ISO 14001, forest certification and environmental labeling. This situation particularly characterized exporting companies selling environmentally friendly products (chlorine free paper) in niche primarily in Europe. In addition, pressure on firm image is important especially for multinational companies, which do not want to be seen as impacting negatively on the environment (e.g. Chudnovsky & Lopez 1999).

As regards natural forest management, buyers and consumers in importing countries have concerns related to legality and sustainability of tropical timber products. These concerns have led to the emergence of forest certification systems and independent auditing of legal compliance. Developing countries have perceived these demands as yet another hurdle to theri market access, which should be discussed in the context of non-tariff barriers to trade. Unilateral measures to restrict tropical timber use for these reasons are another area of concern. It appears that these requirements (legality and sustainability) are gradually becoming baseline requirements in public procurement driving the demand of ESTs in logging as well as management and information systems.

In general, corporate awareness is on the rise and it is not obviously limited to concerns about the world's forests. For instance, the World Business Council for Sustainable Development (WBCSD) representing major industry groups has announced plans to promote development and expansion of new markets for innovative climate-friendly technologies, in particular, by providing a mechanism for companies in developing countries to acquire new ESTs (IETC undated).

The overall impact of consumer awareness on the forest sector in the developing countries is, however, quite limited and largely confined to key exporting countries. Only a minor portion of roundwood or processed timber traded in developing countries goes to environmentally sensitive markets, and the certified forest area in developing countries is still modest (see Ch. 4). Increasing globalization in the forest product markets will create increasing incentives for firms in developing countries to adopt SFM innovations, leading to derived demand for EST. The certification process itself often involves transfer of soft ESTs and helps change practices by diagnosing forest operations and identifying gaps for improvement to achieve SFM. The learning process that is achieved through certification is especially effective in transferring technologies to small and medium enterprises (Vertinsky & Vertinsky 1998).

The pressure to improve corporate environmental performance is real, and the companies need tools to demonstrate that they act responsibly and in an environmentally sustainable manner. Establishment of environmental management systems as one of the tools toward SFM is desirable because their adoption entails an indirect, but significant incentive for EST transfer. Independent verification of performance and related communication, including on-product labeling, can provide market advantage for creating demand for EST.

Recommended action:

- Support the establishment of relevant and appropriate environmental management systems in private enterprises in developing countries
- Promote voluntary certification of sustainable forest management

7.2.6 Voluntary Instruments

The importance of, and the need for, technical standards and codes of conduct have been well recognized by the technical community. Were standards and codes absent, transaction costs would increase because each buyer must ascertain the quality and functionality of potential technologies individually. Technology risks can increase because of the uncertain quality of technologies (IPCC 2000).

The existence of quality and environmental standards is an essential element in the dissemination of ESTs. The objective of EST transfer is to provide an environmental benefit, and, in order to verify this benefit, it has to be measured. Standards provide a common framework, which makes it possible to measure and demonstrate the positive impact of ESTs (STOA 2001).

The International Standards Organization (ISO) has prepared a number of standards related to several sectors of economic activity. Two series of standards have special importance for ESTs: (i) ISO 14000 series, which relates specifically to the environment; and (ii) ISO 9000 series, which relates quality management systems for products and services. These ISO standards do not describe particular measurements of quality or environmental impacts (for instance emissions standards). Rather, they are management system-oriented, and aim to secure adequate documentation permitting ex-post verification on the appropriateness of management actions. Further, the implementation of the 14000 series is considered to be complex and its application is presently limited rather exclusively to very large firms. Therefore, there is ongoing work within the ISO to create a “subset” of the 14000 standard applicable to smaller companies (STOA 2001).

In the forest sector, ISO 14000 series has been applied in forest industries as well as in forest management organizations (particularly state forests) in developed countries. A recently developed conceptual framework, Criteria and Indicators (C&I) for Sustainable Forest Management, constitute an additional tool, but one that is specific to measuring the sustainability of forest management. While the existing C&I sets differ somewhat in their national application, they commonly include indicators for all key elements of SFM (CICI 2003). The C&I, which are applicable at the Forest Management Unit (FMU) level can be used for assessment of EST and its impacts. C&Is have a comprehensive scope which renders them somewhat cumbersome in assessing the impact of individual EST, but a sub-set of full C&I may be used to overcome this problem. On the other hand, the benefit of a comprehensive framework is that it enables a systematic assessment, and draws attention not only to direct impacts but also to indirect ones, which may easily be overlooked (e.g. social effects). Development of appropriate monitoring systems is an integral part of C&I development.

Both ISO standards and the C&I for SFM list indicators but they do not define performance requirements. Such requirements are set in forest certification standards such as those of the Forest Stewardship Council (FSC) and the Pan-European Forest Certification (PEFC). As noted earlier, these standards have proven controversial because the developing countries have expressed concerns that they may constitute barriers to trade (see Ch. 7.2.5). This issue can be overcome if forest management standards are developed nationally within relevant regional or international C&I framework for SFM. As some type of environmental (and social) standards are necessary to enable measurement of the impact of ESTs, forest industries and forest managers, such as timber companies, state forest enterprises, communities and forest owners should be supported in adopting such standards.

It is also necessary to develop technology performance benchmarks to enable assessment of the impact individual technologies. This is particularly relevant for ESTs in forest industries. For instance, the findings of a study on waste reduction in industrial sectors in Asia, including pulp and paper, showed that the benefits of cleaner production were difficult to measure (cited in Llanto 2000). The availability of benchmark information would be a significant advantage for efforts to market ESTs as it would dissipate much of the uncertainty surrounding EST investments. Risk aversion has been found to be a major barrier to adoption of ESTs in forest industries (Thiruchelvam *et al.* 2003).

Recommended action:

- Develop national C&I sets for SFM within relevant regional/international frameworks and adjust existing ones to make them suitable for assessing the impact of ESTs; develop appropriate monitoring systems
- Provide technical assistance to enterprises embarking on certification of industrial activities or SFM
- Develop technology performance benchmarks for ESTs used in the forest sector, especially in forest industries and wood harvesting

7.3 Supply of EST

The supply of ESTs to developing countries filters through barriers that are found both at the international and national level. To enhance the supply the international community and the national decision-makers need to take action. Most hindrances are market-related and dependent on international or macro-economic policies. Few impediments are specific to the forest sector, but in some cases effective action can be taken within the sector. This applies in particular to domestic barriers. The following discussion deals with factors affecting the international availability of ESTs, and as well as domestic barriers.

7.3.1 Internationally Supplied ESTs

Currently, the bulk of internationally available ESTs come from developed countries. The supply is concentrated in few countries, and even in few enterprises in the case of pulp and paper engineering technology. Supply from developing countries is slowly emerging along with improved technological skills in the few countries displaying rapid economic development and sectoral growth. Most of this supply goes to domestic market, but part of it is exported (e.g. genetically improved species from Mexico and Brazil, logging and wood-working machinery and equipment form Brazil and China, etc.) (cf. IPCC 2000). South-South transfer of ESTs is likely to become increasingly important because of similarities in ecological and socio-economic conditions. It holds, therefore, a great promise and provides support to the emerging initiatives may yield high returns.

The research on ESTs in the developed countries is geared towards servicing the market in developed countries. Governments in the North encourage R&D investment by a variety of means, including: (i) direct spending (e.g. funding government programs and R&D contracts); (ii) provision of scientific and technological assistance at less than market prices; (iii) tax credits; (iv) direct subsidies to R&D establishment; (v) support of infrastructure development; and (vi) public training programs (Vertinsky & Vertinsky 1998).

These programs could be modified to encourage EST development, specifically targeted at developing countries. Such programs could involve cooperation between private companies, universities and research institutions in developed and developing countries. Fostering the emergence of capacity to carry out autonomous R&D in developing countries would have to be an important part of these programs.

These activities would require additional financing, because they would probably not fit within the "ordinary" mandate of R&D institutions in developing countries. The most logical source of funding would be ODA, but some financing could possibly be provided as a compensation for the global benefits that improved environmental management through EST brings about. However, the current financing mechanisms for instance under the Kyoto Protocol, require that supported activities contribute directly to the reduction of greenhouse gas (GHG) emissions, and indirect means such as development of appropriate technology cannot be financed. Adjustment of existing technologies, however, could qualify as part of large projects.

In some developed countries publicly funded R&D represents a substantial portion of all R&D related spending (up to 40%). Governments often either transfer or license the patents of the publicly funded technologies to the private sector, who then use them like any other private IPRs (IPCC 2000). However, those transferred to government institutions often stay in the public domain. In forestry, the significant role of the public sector entails that there is an ample supply of ESTs in the public domain, especially "soft" or "softish" technology (e.g. silvicultural models, GIS systems, computer models, etc.).

Most of these technologies are not, however, readily marketable. In forestry, commercialization of research technologies is made particularly difficult by the large variety of forest conditions. Needs are highly location and context-specific, and it is often difficult to develop "products" that could be transferred from one developing country location to another without major modifications. In addition, the public sector organizations do not have an incentive to transfer them to developing countries.

Providing financial support to implement the necessary modifications and the actual transfer may be sufficient in a simple transfer from one government organization to another. However, if the EST in question is intended for larger distribution, it usually has to take place through the market and government institutions do not have capacity to get involved in such activities. This requires private sector involvement and, as a rule, co-financing from them. The low cost of acquiring the basic technology naturally facilitates private sector involvement, but it is not the main consideration. The key question is whether it can be commercialized The high transaction costs may discourage the participation of the private sector, but having them involved early on, and learning on their opinion is at any rate valuable. As there are few alternatives for the involvement of the private sector, their interest can also been seen as a lithmus test to verify whether the undertaking is feasible or not.

Recommended actions:

- Provide bilateral and multilateral funding for research projects to develop ESTs for the forest sector in developing country conditions; the projects should preferably involve partners from developing and developed countries as well as from public and private sectors; opportunities to encourage South-South transfer should be seized; special attention should be paid to transfer of research capacity to developing countries
- Explore and tap funding opportunities for EST development arising under international conventions
- Encourage dissemination of forest-related ESTs in the public domain
- Provide support to adjusting EST to developing country conditions and promote the involvement of private sector in their development and distribution.

7.3.2 International Access to ESTs

Trade liberalization is a major trend in the international markets. Reduction of tariffs on technology (machinery and equipment) and removal of other trade barriers will increase the supply of ESTs to the developing countries. In some instances, however, it may have a reverse effect. In the past, companies in the developed countries could not export their products to developing countries with import restrictions and were therefore prepared to transfer technology to enter the market. With the removal of import restrictions they are now able to export their products directly (Hoffman 1999).

At the same time, trade liberalization will expose domestic production of ESTs in developing countries to tougher competition. Domestic production is often nascent and highly dependent on the protected home market. Overall trade liberalization will provide the domestic producers with new opportunities, but on the other hand they will face a tough challenge in trying to survive in the competition (e.g., Juma 1994). The developing country governments have often limited resources to support domestic production. However, governments often have opportunities to foster of public-private partnerships, which can help with mobilizing additional resources and technological know-how and improving productivity. Efforts to establish these partnerships would benefit from technical assistance and financial support from the international community.

The intellectual property rights (IPRs) are a particularly important issue in the context of technology transfer. Two differing views on the impact of IPR protection have been put forward: (i) strict protection of IPR provides incentives for technology transfer as well as for the growth of local R&D capacities, and (ii) relaxing IPR protection encourages dissemination (transfer) of existing technology since developing countries and their companies have limited resources to purchase licenses. The great majority of patents are owned and continue to be generated by the industrialized world. Not surprisingly their governments and companies tend to be a proponents of strong IPR protection. Developing country governments often hold the opposite view. For instance, in the discussions under UNFCCC process, the G77 countries have been concerned about the negative impacts of overly strict IPR protection. One of the concerns is that under strict protection they would be unable to acquire the ESTs needed to meet the international requirements on reasonable terms (Hoffman 1999).

In the forest sector, the degree of protection may have highest relevance in forest industries and bioenergy production, where technological innovation is a key competitive factor. In forestry, technologies are often "soft", and they generally do not have protection. Strict protection and continued innovation is probably most important for biotechnology, where the benefits of forestry related innovations is large. At the same time, because many innovations could be based on forest resources in developing countries (e.g. tree seeds biotechnology), it is highly important to ensure that arrangements for benefit sharing are appropriate. Ensuring equitable division of benefits from application of traditional forest-related knowledge could also be subject to IPRs (Box 7.2).

Recommended actions:

- Remove trade barriers to increase the flow of ESTs
- Provide support to EST producers in developing companies to enable them to survive and benefit from opportunities provided by easier market access

- Ensure that WTO regulations on IPRs enable appropriate benefit sharing (e.g. when forest-related resources from developing countries are used as a basis for IPR-protected innovations in biotechnology)

Box 7.2 Intellectual Property Rights with Respect to Traditional Medicines; Case Study in Zimbabwe

In 1995, the University of Zimbabwe, in partnership with the Swiss University of Lausanne, undertook a study of Zimbabwe's medicinal and poisonous plants. The two academic institutions signed an agreement that any commercial success resulting from the project would be shared. Samples of many different plants could be supplied to the project, including the bark of the *Swartzia* tree used by traditional healers.

The research scientists at the University of Lausanne discovered that *Swartzia* bark contains one of the world's most powerful anti-fungal agents. Used as a medicine, it can cure yeast and microbial infections. It was anticipated that *Swartzia* bark would have a potential for huge commercial success.

However, a legal wrangle between the universities ensued. According to the scientists from the University of Zimbabwe, the University of Lausanne took out a sole patent on the substance, and sold the license for further development and manufacture to a US drugs company. The Lausanne University maintains that the University of Zimbabwe was fully informed of the deal which allowed for 0.75% of net sales to go to each university in the event of a commercial success. The University of Zimbabwe claims that the Swiss university broke the agreement by registering the patent alone and not jointly. They settled their differences by re-filing for a joint patent but the research into commercializing *Swartzia* bark compounds was eventually halted due to toxicity problems (TVE 2003).

It has been pointed out that the traditional healers were not part of this agreement. However, in an another case their rights have been recognized. The University of Lausanne has reportedly patented an anti-malarial derived from a plant indigenous to Southern Africa. The plant was submitted by the healers to the University of Zimbabwe, which later passed this to Lausanne. To give due credit to the healers, the Zimbabwe National Traditional Healers Association has been given the right to share any future profits from this drug (TIFAC 2001).

7.3.3 Domestic Supply of ESTs

The issues related to diffusion of ESTs within developing countries have drawn much less attention than barriers to EST transfer at the international level. However, domestic impediments are often a serious handicap, and reduce the effectiveness of EST transfer.

In part, the same barriers impeding international transfer of EST constrain domestic diffusion. These include weaknesses in macroeconomic framework, high initial cost of EST investments, lack of information, etc. One barrier that often is specific to domestic markets in the developing countries is the poor functioning of the market mechanism. The markets are often small in size and the number of players is limited. Combined with lack of appropriate regulation, this situation easily leads to emergence of monopolistic or oligopolistic structures, which can be a serious hindrance to the supply of ESTs.

There is a tendency for individual companies to restrict the spread of ESTs rather than to promote it. This because the companies usually acquire EST to gain competitive edge and are unwilling to share their experience with others. Thus, while FDI is an effective mechanism for bringing EST to developing countries, it may have a limited impact in terms of distributing the ESTs within the country. In particular, the demonstration effect from successful use of

ESTs may not be achieved. Still, any EST transfer will eventually lead to information "trickling-down" down to other players in the sector through staff turnover, collaboration and sub-contracting arrangements with local partners, etc. Promotion of joint ventures and any form of public-private partnerships could enhance this effect.

Distribution within large organizations is often hampered owing to limited staff and other resources to use and maintain the EST. Training and resource needs may have been underestimated, and qualified staff and sufficient resources are often available only in one location, usually the central office in a major city. With limited geographic distribution, the opportunities offered by EST cannot be fully taken advantage of. The problem affects both private companies and government institutions, but it is more severe for the latter, because they often receive initial funding from external sources, and once financial resources are exhausted, the organization's own resources are inadequate to maintain the operation. For instance, in the forest sector computer-based applications are often installed only in the forestry administrations' headquarters and not in district offices. Besides lack of resources in the organization, hardware and maintenance services for hardware are often unavailable in remote locations. This seriously hampers one of the main strengths of computer systems, which is to enable organization-wide decentralized communication, data collection and use.

Recommended actions:

- Eliminate monopolies and other market failures that hamper the functioning of market mechanism for EST diffusion in developing countries
- Encourage private companies in developing countries to demonstrate success stories in EST use
- Support public sector organizations in developing countries to design appropriate EST transfer programs
- Explore how joint ventures and other public-private partnerships could be provided a preferential status among foreign investment to promote EST adoption

7.4 Financing

Financing is a pivotal aspect of technology transfer. Financial assistance and transactions conducted on favorable terms are considered critical by developing countries in furthering the transfer of ESTs (ESCAP 2001). Also, a survey conducted by the UNFCCC secretariat as well as the Korean experience with climate-relevant technology have distinguished the non-availability of adequate financing means as a main barrier to technology transfer (UNFCCC 1998, TERI 2000, cf. IETC undated)

Apart from the sheer size of EST investments, their cost structure is a challenge for financing. High capital investments and low operating costs generally characterize ESTs. As an example, renewable energy for rural areas and energy efficiency are often among the least-cost options on a life cycle basis. However, because individual projects tend to be of a small unit size and are considered to be of high risk offering returns mainly in the long term, they are extremely difficult to finance (STOA 2001).

Efforts to develop financing for the EST transfer are focused on increasing the flow both on the supply and demand side and developing efficient delivery mechanisms. However, while these are necessary measures, they may constitute too narrow an approach Financing should not focus only on increasing the funding volumes, but also on how the existing flows can be made to work in support of sustainability objectives. There is not an automatic connection between increased financing and increased transfer of ESTs.

7.4.1 ODA

The overall amount of public funds to developed countries has fluctuated substantially in recent years. While the volume of bilateral grants has remained steady around USD 30 billion per year, the credits from official sources (WB, IMF, etc.) have oscillated in the wake of financial crises in Asia and Latin America. Compared to the private sector, the public flows are clearly more limited. Between 1997-2003, the private sector flows were 3-8 times higher than those from the public sector. However, public sector flows are still significant for the economies of the poorest developing countries. In regional terms, Middle East and North Africa, South Asia and Sub-Saharan Africa show highest dependence on public sector flows (World Bank 2003).

The amount of ODA to forestry rose until 1980s but has since then modestly fallen; the current amount is around USD 0.5 billion per year, which accounts for about 1% of total ODA. About two-thirds of the estimated total goes to afforestation projects, with the remainder spent on policy, administration, research, training and fuelwood and charcoal projects. Official loan funding to forestry is quite limited. Bilateral donors provide very few credits to the sector. IBRD lending to forestry is on the average USD 50 million a year and stable over time. AfDB and AsDB have reduced financing to forestry projects (OECD 2000).

It is not known to what extent the ODA flows contribute to EST transfer, but it is likely that projects focusing on EST transfer are few. On the other hand, EST transfer is an essential component of most bilateral or multilateral development projects. For instance, nearly all projects funded by the Global Environmental Facility (GEF) include technology-related elements (El-Ashry and Martinot 2001). A parallel initiative by the French Government, the French Global Environmental Facility, has a similar approach

In the forest sector, ODA supported activities have rarely focused on EST transfer *per se*; but EST transfer has been an integral component of many forestry projects. This may in broad terms have been the proper approach since EST transfer is necessarily a part of a broader development effort, especially with respect to EST investments in sustainable forest management (SFM). Use of ODA to support EST transfer in forest industries has been limited apart from the establishment of targeted financing for SMEs in some cases and large-scale forest industries in the 1970s.

Increased attention should be paid to proper identification and formulation of EST-specific projects or project components. In particular, attention should be paid to supporting research and development, development of intermediaries to facilitate EST transfer at country level, and technology partnerships, which would directly impact on the transfer mechanisms (see Ch. 7.2.3).

Box 7.3 **French Global Environmental Facility as an Instrument for EST Transfer**

The French Global Environment Facility (FGEF) was set up in 1994 to encourage efforts to protect the global environment in developing countries and countries in transition. It is France's bilateral complement to the multilateral Global Environment Facility (GEF). It provides resources in the form of grants to investment projects with a beneficial impact in terms of the global environment. These resources are intended to cover the incremental costs arising out of measures taken to protect the global environment. The FGEF was launched with resources of 440 million francs for the period 1994-1998. It was renewed in 1999 for a further four years.

In 2000, FGEF had a portfolio of forestry projects worth EUR 6.5 million with an average contribution of 10% of total project cost. There are two broad areas of support: (i) biodiversity conservation and (ii) forest management with participation of local population. Regarding EST investments FGEF is interesting in the sense that it provides funding, *inter alia*, to physical investments, training, inventories and monitoring. Also, forest management planning is considered a key activity, the basis of sustainable forest management.

The FGEF contributes to the financing of sustainable forest management plans in Morocco, Mali, Gabon, and Chile. The approach is focused on biodiversity and carbon sequestration , and emphasizes local involvement in the planning process. New projects with a similar approach are being planned in Congo, Cameroon, and Georgia. There are also two projects aiming to enhance the use of wood energy by transforming coal-fired boilers into boilers using fuelwood (Russia), and by improving the energy effectiveness of Turkish steam baths (Morocco).

Source: FGEF 2003

Owing to limited private sector involvement, most cooperation has taken place between governmental organizations in developing and developed countries, and between government forestry organizations in developing countries and bilateral and multilateral organizations in developed countries. Privatization programs, increased use of concession contracts, etc. have already started to increase the role of the private sector and may represent an untapped opportunity to use ODA support for promoting EST transfer in the forest sector. EST criteria could be incorporated in various stages of these delivery processes, but the governments are generally unfamiliar with such procedures.

As a special use of ODA, the developing countries have demanded that developed countries purchase patents and licenses on commercial terms for transfer to developing countries on non-commercial terms for sustainable development. These countries have also suggested that special fiscal and other incentives should be created to encourage the transfer of privately owned ESTs from developed countries. The justification for these measures would be based on the MEA commitments made both by developed and developing countries (Hoffman 1999).

The principal problems with these measures are that (i) it is difficult to target them at ESTs, and (ii) desired impacts may not be reached if a proper enabling environment is not in place. The definition of EST is still vague and, potentially, all technologies could qualify somehow (cf. Ch. 0). However, an adequate definition could probably be developed by excluding technologies that have an environmental impact only through increased productivity. Only the ones with preventive, corrective, mitigating, etc. function in terms of negative environmental impacts would be included in the definition. Examples of these technologies include pollution prevention and waste reduction technologies in forest industries.

Regarding the enabling environment, there may be minimum preconditions that have to be fulfilled for the EST transfer to be successful, but it does not mean that the environment has to be flawless. EST transfer can accelerate development in a satisfactory manner even if some of the barriers remain. Introduction of targeted financial incentives could be considered justified, if the impact from EST transfer is likely to be significant and sustainable. General incentives are, however, likely to be inefficient and very costly and would have to be analyzed carefully on a case-by-case basis to avoid distortions. It is probable that most of the opportunities would arise in forest industries, where the business environment is "simpler" and more supportive than in forestry.

Recommended actions:

- Identify opportunities for EST transfer as part of broader development projects in forestry
- Increase ODA allocation to EST-specific activities
- Incorporate EST criteria in privatization and other processes increasing participation of the private sector in forestry activities
- Consider providing technology-specific financial support to EST transfer on a case-by-case basis paying special attention to opportunities arising in forest industries; support should be conditional on not causing significant market distortions

7.4.2 Commercial Lending and Incentives

Large corporations in developing countries have usually satisfactory access to investment funding either locally or internationally, and capital availability is not necessarily a major constraint for EST investments. In contrast, reaching to SMEs is one of the main challenges for efforts to promote EST transfer. The small size of SMEs and their isolated nature makes influencing their behavior difficult, particularly with regard to technology investment.

The major concern of SMEs is their emphasis on short-term financial profitability, which for the majority of ESTs is not attractive, because the benefits tend to accrue over a long period of time. There is, however, a large number of ESTs that can be implemented at low or no cost. For example, a project assessing clean production options for a medium-sized Chinese paper mill identified 38 options, of which 22 were no or low-cost options (ICPIC 1997). In such cases the constraint is much less financing than unawareness of ESTs, and the problem could be best addressed by information dissemination or by establishing appropriate advisory services.

Enhancing SMEs' access to funding is a broad topic not specific to the forest sector or not necessarily even for EST transfer. In theory, it is possible to incorporate EST criteria in loans, leases, etc. funded by multilateral development banks. To the extent they are disbursed through local banks, the capacity constraints and the cost of screening projects for their potential for EST transfer may reduce the feasibility of this option.

At macro level, there are both financial instruments (e.g. grants and direct subsidies) and fiscal measures (tax allowances or tax incentives) that could be used to improve SMEs' access to financing with regard to EST investments. For instance in Thailand, there are financial incentives for energy conservation-related technology transfer. Capital financing is provided to eligible projects as well as subsidies, if the rate of return is below commercial standards. However, such measures can be expensive and bureaucratic and their use should be carefully controlled, preferably only to "kick-start" EST markets (cf. CSD 1996). It is also difficult to target such measures on single sectors such as forestry. Targeting could be possible, were the provision coupled with an advisory component.

Recommended action:

- Explore the possibility to include EST-related conditions on loans given to SMEs or to apply fiscal or financial incentives to EST investments
- Promote the involvement of financial specialists with special knowledge on forest-related ESTs in advisory bodies for SMEs and financing institutions responsible for delivery of financing to SMEs

7.4.3 Micro and Mini Finance

A few ESTs in the forest sector, such as improved charcoal kilns and stoves, are targeting individual producers or consumers in developing countries. The conventional financing instruments are usually inaccessible to them and the small size of investments makes them also uninteresting to commercial banks. However, there are successful micro-financing initiatives that are available to poor people such as the Grameen Bank, and purchase of simple, low-cost ESTs would fall within their scope. The development of these schemes would probably be conducive to increased uptake of ESTs as long as transaction costs related to promotion of EST transfer are not excessive. Efforts to promote small-scale ESTs in the forest sector should concentrate on product development.

Recommended action:

- Collaborate with existing micro-credit schemes to raise awareness on the benefits of adoption of forest-related ESTs.

7.4.4 Public-private Partnerships

Public-private partnerships can be an effective, complementary way of financing the transfer of ESTs. The aim of these partnerships is to facilitate cooperation between private and public sectors which often involves a public intermediary covering part of the transaction costs. A publicly funded framework for cooperation can also catalyze partnerships in forestry investments. Public funding support can encourage investment in ESTs which may not be competitive from business standpoint, but which should be subsidized for public interest reasons. In the short term, the aim of public-private partnerships is to mobilize private capital and harness market forces for EST transfer (IETC, undated).

Investment funds

Examples of public-private partnerships that could be relevant to the forest sector include publicly sponsored investment funds that focus on ESTs or at least identify them as a priority investment area. Sector-specific funds can be established only with difficulty, since the amount of financing to make them economically viable is substantial. For instance, the idea of establishing a global Investment Promotion Entity (IPE) for sustainable forest management has been discussed, but the main hurdle is to raise the necessary amount of seed capital (Chipeta & Joshi 2001; Salmi *et al.* 2001).

On the other hand, forestry investments qualify under several funds that have a broader scope. The main opportunity in the forest sector is the Clean Development Mechanism (CDM) mechanisms under the Kyoto Protocol (Box 7.4). The CDM is essentially a market mechanism and offers opportunities mainly for the private sector within the facilitation of the public sector. In the forest sector, funding will be available for reforestation and afforestation. The CDM does not target ESTs *per se*, but there are special provisions to encourage their transfer. Facilitation by public sector could also contribute to this end. There are already several such funds, including Prototype Carbon Fund, Community Development Carbon Funds, Biocarbon Fund, CERUPT, and ERUPT. The first three funds are managed by WB and the last two ones by a Dutch government organization. These funds also act as intermediaries.

Box 7.4 Clean Development Mechanism as Funding Source for Forest-related ESTs

The Kyoto Protocol was conceived in 1997, whereby 37 developed countries and economies in transition made binding commitments to reduce their GHG emissions. The Protocol approves the use of three "flexibility mechanisms" for facilitating the achievement of these GHG emission reduction targets. Of these, the Clean Development Mechanism (CDM) allows for the creation of Certified Emission Reduction (CER) credits in developing countries.

CDM is considered to be of particular importance for the diffusion of ESTs in developing countries. The advantages of the CDM are to

- Favor the diffusion of ESTs in developing countries which do not wish to subscribe to national targets on GHG emissions
- Accelerate R&D on ESTs particularly appropriate for developing country conditions
- Raise awareness of climate change considerations among technology decision-makers at all levels, in both developed and developing countries

During its brief existence CDM has shown capacity to be able to mobilize a substantial amount of funds. It is estimated that commitments by institutional purchasers to acquire carbon credits will reach over USD 1 billion by the end of 2003.

For the forest sector, an important output of the Kyoto Protocol was the signal that forestry activities will be considered valid options for accomplishing the emission reduction targets agreed by parties. The main limitation is that the CDM mechanism under the UNFCCC restricts eligible activities in the forest sector to afforestation and reforestation for the first commitment period between 2008-2012. Future expansion to cover forest management is possible but this will be decided as part of the negotiations on the second commitment period.

The establishment of CDM opens up a new avenue for financing in the sense that its basic concept is to enable payments for environmental services. According to available estimates, full use of the CDM mechanisms in the forest sector would enable annually the establishment of an additional one million hectares of tree plantations. Other similar opportunities in the forest sector are watershed and biodiversity services, but so far the markets for these services have been limited (Katila & Puustjärvi 2003).

The involvement of the private sector implies that the investment flows will be heavily concentrated on the most attractive areas in terms of investment climate and growth conditions for trees. It is likely that most forestry-related investments under the CDM will be made in tropical countries in Asia and Latin America. There are estimates that African countries' share of CDM markets will be only about 3% (Davidson 2001).

Intermediaries

Publicly funded intermediaries for EST transfer are another important category of partnership. They aim to help in the development of projects oriented towards transferring ESTs by providing pre-investment support such as funding feasibility studies, finding partners and preparing bankable proposals to mobilize private capital, as well as matching potential buyers with sellers (see also Ch. 7.2.4).

Regarding financing, the intermediaries have basically two strategies (i) to find financing for selected environmental problems, and (ii) to identify (a) a pool of potential financiers, and (b) projects in a selected sphere that meet the financiers' investment criteria (CSD 1996). Both of these approaches could be relevant in the forest sector. However, it may be difficult to reach a "critical" mass of business opportunities, if the advisors concentrate on one single sector such as forestry. Depending on the importance of various funding sources, it may be advisable to pool resources either cross-sectorally or across several countries regionally. This would be more attractive from the financiers' point of view, who would have access to a larger business volume. Especially in the latter case, the international community could provide focused assistance to the forest sector and the ESTs.

Technology partnerships

Technology partnership programs are another form of cooperation between private and public sectors. It involves collaboration between government agencies and institutions, the private sector and science and technology institutions. They are typically mutually beneficial long-term arrangements involving capacity-building and aiming to stimulate the development, transfer and dissemination of ESTs. The arrangement is highly suitable for the forest sector as well. The main hurdle is the weakness of public science and research institutions in the developing countries (see Ch. 7.2.3), weakening the basis for mutually beneficial relationship.

Recommended actions:

- Collaborate with the private sector to ensure that the full potential of instruments such as CDM to support EST transfer in the forest sector will be effectively used
- Ensure that public sector intermediaries to enhance financing to private sector will contribute to EST transfer in the forest sector; the possibility to establish regional intermediaries targeting specifically at the forest sector and ESTs should be explored
- Where feasible, provide technical and financial support to the establishment of technology partnership programs between public and private sector entities in the forest sector; and strengthen the capacity of public entities to contribute to such partnerships

7.4.5 Inflow of Private Investment Funds

Foreign Direct Investment (FDI) is a major source of financing for capital investment. According to the World Bank in 2003, the private sector is expected to provide a net funding of USD 158 billion to developing countries. Of this, nearly 90% is FDI, the rest being portfolio equity flows. In general, FDI is placed very selectively, and it is typical that even within one region there is large variation between individual countries. In East Asia and the Pacific, China receives over 90% of the entire FDI inflow, and in Latin America and the Caribbean, Brazil and Mexico together account for more than 70%. Overall, these three countries received 58% of all FDI in developing countries in 2002. In contrast, the whole Sub-Saharan Africa was able to attract only 5% of the total (World Bank 2003).

The amount of FDI in the forestry sector is not known. It is probable that most of it is recorded under industrial projects including forestry components (e.g. timber harvesting, plantation establishment). Global estimates on FDI in forest industries are unavailable, but it was estimated that in 1998 the combined FDI of the US and Finnish forest industries reached USD 30 billion (Uusivuori & Laaksonen-Craig 2001). Only part of these investments was made in developing countries, but the order of magnitude indicates that FDI represents a much larger source of funds than ODA or official loan funding. It is apparent that also in forest sector the FDI flows are highly concentrated in few selected countries. Also, the portion going to forestry is probably quite small with capital investments in wood processing taking the lion's share. Especially highly capital-intensive pulp and paper industries benefit from FDI.

There have been concerns that FDI and especially multinational corporations (MNCs) would take advantage of lower environmental standards and their lax enforcement in developing countries. However, while not all FDI brings along environmentally responsible practices, there is increasing evidence that foreign-owned or joint ventures tend to have higher environmental standards than local firms. One reason is that that they use the usually higher standards and technology adopted by the overseas parent company. Another impetus comes from the fact that they export to environmentally sensitive markets, and do not want to tarnish their reputation (Panayotou 1997 in IPCC 2000, Chudnovsky & Lopez 1999).

In the forest sector, many European, Japanese, Korean and US private forest products companies are introducing more efficient sawmilling and plywood technologies to Siberia, Southeast Asia, West and Central Africa, and Latin America. Other improved technologies widely exported include nurseries, alternative logging techniques (like reduced impact logging to Malaysia, Indonesia, and Latin America), software for forest management and planning, harvesting and processing equipment, operational monitoring systems, and fire management (IPCC 2000). In the pulp and paper industry, evidence on positive correlation between FDI and improved environmental practices has been found, for instance, in Chile (Chudovsky & Lopez 1999). This is often due to the fact that when constructing state of the art modern large-scale pulp and paper mills, EST is usually not a separate investment. It is transferred as "part of the package" which is competitive in global scale and which should meet the needs of future environmental regulation.

The forest sector alone has somewhat limited opportunities to increase its attractiveness for FDI. Factors such as macroeconomic framework and economic policy regime are beyond the sector's competence and capacity to influence. Within the sector, the means to attract FDI are mostly indirect. A sound policy and institutional framework would be a positive signal for foreign investors, as well as an adequate "absorptive" capacity of the sector. Timber prices are key factors as well as clear rules for access and harvesting. However, to make sure that the enterprises behave responsibly and that the investments include EST, strong regulatory framework has to be in peace (see Ch. 7.2.2). If necessary, independent auditing or certification could be introduced as a control instrument. It may also be possible to collaborate with other government agencies to make FDI conditional on the use of environmentally friendly technologies.

Joint ventures and private equity from strategic investors are a particular type of FDI. Investors are often large multinational corporations and the conditions that attract them are largely the same as for any other FDI. The benefit of joint ventures over direct FDI is that capacity building and technology diffusion in the host country can be more effective (see Ch. 7.3.3). Global Environmental Fund is an example of an equity fund making private equity investments in companies contributing to environmentally sustainable development. Sustainable forestry and forest products is one the identified areas of investment, and the fund has acquired a stake in a forest product company in South Africa (Global Environmental Fund 2003).

The main weakness of these types of arrangements is that they target only the largest developing country corporations; SMEs are rarely involved in these schemes. Venture capitalists are more willing to provide funding for SMEs, but they tend to prioritize "new" sectors (e.g. IT and biotechnology) with high expectations on return. The perception that forestry and environmental ventures yield low profits has discouraged their interest. A study of 60 international venture capitalists showed that a high proportion of them were skeptical about the relevance of ESTs; lack of information appeared to be one of the main constraints (CSD 1996). International collaboration could be useful in dissipating the uncertainty about ESTs in the forest sector. However, because investors are rarely interested in one single sector in one single country, penetration into their awareness would probably require cross-country or cross-sectoral cooperation.

Recommended action:

- Create enabling conditions attracting FDI to the forest sector and, possibly, to make FDI conditional on application of environmentally sustainable practices
- Promote independent auditing and certification as a means to create demand for EST

7.4.6 Export Credits

The largest source of public sector support for cross-border finance is trade finance in its various forms, where a government agency provides a guarantee on loans to support exports. Export credits are the most common type of trade finance, and their volume is large, annually USD 100-200 billion, which is several times higher than the total volume of ODA. National export credit schemes can prioritize investments, which focus on improving environmental performance. Trade finance is significant in that it is usually combined with funding from commercial financing institutions, and, for example, has often a major role in supporting project finance. The main weakness considering EST transfer is that most agencies running these schemes do not have environmental policies, and that there is no mechanism to provide special support to EST transfer (cf. IPCC 2000, Goldzimer 2003). The issue is anchored to the overall trade policy of the country, but improvements in this regard (e.g. a preferential treatment or special allocation for ESTs) could substantially boost EST supply. Some agencies (e.g. OPIC in the USA) have special provisions, which can promote transfer of forestry EST (OPIC 1999).

Recommended action:

- Adjust export credits and other similar instruments to incorporate provisions favoring ESTs

8. SETTING PRIORITIES

8.1 Technology Assessment at National Level

Formulation of public policies in support of EST transfer should be based on a proper assessment in the country and sector-specific conditions. Technology assessment, i.e. identification and selection of ESTs, is a crucial step in the process of formulating public policies targeted at EST promotion. In the past, this has often been a grossly neglected area. There has been a tendency to rely on technological information from those supplying the technology. Tied aid and linkages between the suppliers and those providing finance has often prejudiced the choice in the past (Juma 1994).

Defining priority ESTs for promotion of transfer involves a complex weighing of contributing factors. Several of them can only be assessed in qualitative terms and subjective views and values unavoidably influence the assessment. The key elements underlying the choice include: (i) ability to contribute to resolving priority environmental issues, (ii) the sustained impact that can be achieved considering the existing constraints and the extent to which they can be removed, (iii) social implications, and (iv) cost-effectiveness in achieving the impact. In addition, attention should be paid to compatibility with indigenous technology and practices. The aim should be to supplement rather than supplant indigenous capabilities.

Ability of ESTs to address priority environmental issues is of high importance. Even a minor contribution to resolving priority problems can be more significant than major strides in an area that is considered to have only marginal relevance, or where measures cannot be targeted appropriately. For instance, the impact of introducing improved stoves to reduce fuelwood consumption and deforestation may be seriously reduced unless there is remote sensing technology allowing the identification of “hot spots” of deforestation. It should be noted that social considerations may change the priorities set only on environmental grounds. For instance, the distribution of above-mentioned stoves may be prioritized for social reasons. The reduction in the workload of women who collect fuelwood may be considered to justify the distribution of stoves across all regions without specific priorities.

It is also important to distinguish between the potential and actual impact of EST. The actual impact under prevailing constraints may be substantially less that the potential one achievable only under ideal conditions (Figure 6.1). Constraints are found both outside and inside the forest sector, and it is realistic to assume that only part of them can be removed. Often, inadequate resources or low overall priority accorded to issues relevant to EST transfer impede action. In many cases, the possibility to facilitate EST transfer in the forest sector may only be a contributing motive, not the decisive argument for taking necessary measures. For instance, macroeconomic decisions such as removal of import tariffs or lowering interest rates are not sector-specific issues. Decisions to allocate funds for forestry extension are made based on the entire spectrum of extension needs in forestry, not only the need to promote EST transfer which is just one tool to promote SFM. On the other hand, there are also barriers that directly impede EST transfer in the forest sector such as lack of R&D capacity, technology intermediaries, technological partnerships, etc. Owing to their direct impact on EST transfer, the removal of these barriers should be considered priority actions.

The relationship between the cost of implementing the support strategy and the expected impact will determine the cost effectiveness. As an example, the acquisition cost of the EST is not a public cost, but one of the factors determining the uptake and eventual impact. Instead, any costs (e.g. R&D) incurred to reduce the acquisition cost would be taken into consideration when estimating the cost-effectiveness of public measures.

Formulating a policy for EST transfer should be a broad effort involving all relevant stakeholders. A participatory process is necessary to reduce the bias caused by subjective assessments, business or political interests involved in EST transfer. The most suitable framework for formulating an EST-related policy would be within comprehensive sector strategies, such as national forest programs (NFPs), the key features of which are broad-based participation and fostering consensus among parties. A national set of C&I for SFM as a reference point would provide a sound basis for decision-making. Integrating EST promotion as a comprehensive sector policy also provides a firm foundation for the international funding agencies to target their EST-related activities.

Forestry organizations should also attempt to influence prioritization made at higher political levels, which may bring additional resources to the sector. As an example, Indonesia and China have included forestry among the priority sectors for EST promotion (TERI 2000).

8.2 Global Agenda

The selection of priority technologies for R&D is highly dependent on the local context, and especially in forestry there is great variation between locations. At the national level the local forest and socio-economic conditions are the natural starting point for decisions to promote EST transfer. The priorities set by the international community will have an impact on the broader regional and global levels, and this should to some extent be reflected in their agendas. Admittedly, defining regional or global priorities is at best highly subjective so the following viewpoints should be regarded only as ingredients to the discussion.

The international community and the private sector should work in concert to complement each other's activities. The private sector will be guided by the market mechanism, which implies that activities that are not viable from a business perspective will be paid less attention to. There are nevertheless activities that are not commercially viable but merit support on environmental and social grounds, and the international community - having essentially the character of public sector – should attempt to fill these gaps.

Increasing the number of commercially used tree species. Deforestation is one of the main forest-related environmental problems in forestry and technologies that help in arresting should be considered priority. In humid tropical forests the main opportunity is to increase the number of commercially utilized species. Currently, only a minor portion of available timber is harvested, but if a higher portion could be used, the pressure to open up new areas for harvesting would be reduced. This is a key activity since the main conduit for deforestation is not direct conversion of forest into agricultural land; instead, conversion usually takes place only after the forest area has been made accessible through logging. Developing processing capacity for lesser-used species is therefore one of the priority areas for EST development. As long as there is room to expand harvesting areas, the private sector alone may have little incentive to develop such technologies.

Enhancing the competitiveness of sustainable forest management. In many forest areas the difference between financial returns from agriculture and forestry is often so large that marginal improvement in the profitability of forestry will not have an impact in terms of arresting deforestation. A better opportunity would probably be to increase the competitiveness of forestry in areas that have marginal value for agriculture such as grazing areas and bare lands. This may not necessarily reduce deforestation but enable expansion of forest cover in areas where it did not exist. Tree breeding and biotechnology enabling higher yields appear to be the main opportunity to increase the competitiveness of forestry in marginal areas. In absolute terms, the returns would probably remain much below those achieved in commercial plantations established by private enterprises, which is a major disincentive for their participation.

Enhancement of the qualities of multi-purpose trees. Improving the yield from multi-purpose trees would be highly desirable both from a social and environmental perspective. In areas, where land availability is the main constraint for productive activities, agricultural production is necessarily the main land use for small holders owing to their overriding need to generate short-term benefits. Forestry activities are usually limited to planting small tree plots often with the objective of spreading the risks of production and ensuring a restricted supply of timber for household use. Enhancing the qualities of multipurpose trees to provide increased short-term benefits would probably enable farmers to expand their production, which would bring both social, economic and environmental benefits. Tree breeding and biotechnology play a key role in this endeavor. The participation of the private sector relevant R&D is unlikely owing to the limited purchasing power in the potential market i.e. among small holders.

Reducing cost of forest monitoring. Lack of relevant and up-to-date information on the forest resource is a major constraint for formulation of appropriate policies. Lack of adequate monitoring systems is also a significant impediment for efforts to draw benefit from carbon trade. One of the main constraints to adoption of appropriate remote sensing systems is the high cost of acquiring and maintaining necessary hardware. Development of low-cost solutions to reduce the initial investment cost would be conducive to their increased uptake. It should be noted that this does not do away with the need to remove institutional and social constraints to their adoption and effective use. The private sector will probably contribute to solutions suitable for use at enterprise level, but the technology needs for assessments at the national level are slightly different and often context specific, which reduces the private sector's interest to participate in R&D.

Expanding the use of bioenergy. Regarding bioenergy, there is huge potential to increase its use owing to substantial amounts of waste generated in connection with timber harvesting and processing. The private sector is participating in technology development and has recently made available e.g. small-scale biopower plants suitable for tropical countries (Kuitunen 2003). The need for support from the international community should therefore focus on fostering public-private partnerships. The private sector has probably less interest to participate in the development of products for use by individual such as improved stoves, and support from the public sector would be justified. However, the past experience shows that the main barrier to the adoption of improved stoves is not necessarily their cost, but free access to fuelwood, which makes the users less appreciative of increased energy efficiency. One should therefore carefully analyze, to what extent and where product development can overcome such constraints.

The support provided by the international community should be targeted primarily on the LDCs, which currently have trouble benefiting from market-based EST transfer. In the first phase, the emphasis should be placed on developing mechanisms that encourage the adoption of existing ESTs. One of the key measures is to support the development of intermediaries to facilitate transactions between the EST providers and users. The long-term objective, however, should be to develop capacity for creation of new technology. In countries, which have moved along this path and already possess more developed capacities for R&D, the international community should focus on fostering the development of public-private partnerships as a means to mobilize resources.

9. RECOMMENDATIONS

The most important measures that would facilitate EST transfer but are not specific to it include the following:

Outside the forest sector

(i) Adjusting export credits to incorporate conditions favoring EST transfer
(ii) Stabilizing the macroeconomic framework; strengthening legal institutions
(iii) Creating enabling conditions to attract FDI; promoting joint ventures with EST
(iv) Removing import tariffs and other trade barriers related to EST (hardware, software, services)
(v) Contributing to development of appropriate regulations for IPRs
(vi) Enhancing SMEs' access to investment financing with priority on EST
(vii) Exploring the opportunities to introduce fiscal and financial incentives for private enterprises to adopt EST
(viii) Establishing micro-credit schemes linked with EST available to communities
(ix) Removing monopolies, oligopolies and other market imperfections restricting the domestic supply of EST

In the forest sector

(i) Improving the legal and regulatory framework for environmental management to internalize externalities
(ii) Making forest environmental law and enforcement effective
(i) Establishing secure land tenure and resolving conflicts over land rights
(ii) Eliminating policies reducing the relative competitiveness of forestry as a land use
(iii) Increasing consumer and corporate awareness on SFM
(iv) Promoting adoption of environmental and social standards by public and private entities
(v) Improving education and training on environmental management and social issues in forest management

However, there are a few actions that can be taken rather independently from other considerations and targeting especially at EST transfer in the forest sector. The most important ones among them are:

(ix) *Strengthening of R&D capacities.* This would contribute directly to facilitating EST transfer. Lack of capacity to assess, select, and adapt ESTs is one of the major impediments to successful transfer. Investment in R&D also represents a possibility to reduce the cost of ESTs and enhance their competitiveness, which in all circumstances is conducive to increasing transfer and adoption. Special attention should be paid to encouraging the development of EST with social and environmental benefits that cannot be captured through the market mechanisms.

(x) *Establishment of intermediaries to facilitate EST transfer.* Lack of information is a major impediment to EST transfer, especially among SMEs and communities. Past experience suggests that enterprises require information for highly specific needs, and that it is best delivered by locally-based intermediaries with access to a financing facility. Support could be provided to private sector consultants, research institutions, technology centers, public extension services, farmers' associations and NGOs to provide these services through contracting and project funding.

(xi) *Technology partnership programs*. These can be fostered in conditions where government institutions and science and technology centers are sufficiently strong to form a balanced and mutually beneficial partnership with private enterprises (e.g. research institutions with private enterprises in product development, and with forest industries and farmers in tree growing). While these partnerships should eventually develop and operate independently, public sector support is often necessary to establish the basic framework for collaboration.

(xii) *Applying environmental criteria in privatization processes, concession management contracts, public procurement etc.* The ongoing process whereby the private sector is assuming a larger role in forest sector activities provides several opportunities to enhance the adoption of EST. Incorporation of environmental criteria in agreements made between the public and private sectors provides substantial incentives to increase EST transfer.

(xiii) *Educating decision-makers about ESTs.* Decision-makers in the forest sector are not fully aware of the opportunities provided by EST transfer or of the demands its places on the capacity of the public sector to support it. Increased awareness would increase the support to EST transfer.

(xiv) *Providing technical and financial support to transfer of specific ESTs*. The main vehicle for supporting EST transfer in the forest sector will be projects integrating EST as one of the tools to promote SFM, which requires increased attention to identifying all relevant opportunities to enhance EST transfer. Additional, activities that directly support EST transfer (see above) should receive adequate technical and financial support. Direct financial support (e.g. subsidies) to transfer of specific ESTs may be considered in individual cases where the enabling environment is adequate to secure a successful transfer. These opportunities are likely to arise especially in forest industries and plantation development.

(xv) *EST assessments*. To define a public policy for EST promotion and relevant support strategies for effective transfer requires a broad analysis of issues – often in qualitative terms - and value judgements. To reduce the possible bias due to subjective views on business and political interests, it is advisable that such processes are carried out in a participatory and transparent manner involving all relevant stakeholders.

(xvi) *Integration of EST into national policies*. Policies for EST transfer should be formulated as part of comprehensive sector strategies such as national forest programs (npfs) enabling broad-based participation and balancing of conflicting objectives. The commitments emanating from relevant MEAs serve as an overall framework for policy formulation, and as a justification for the international community to provide support to its implementation.

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REVIEW OF SELECTED ENVIRONMENTALLY SOUND TECHNOLOGIES

1. REDUCED IMPACT LOGGING IN TROPICAL FORESTS

1.1 Technology

The term reduced impact logging (RIL) refers mainly to harvesting in tropical countries, but many of these practices were developed in temperate countries, where they are widely applied. RIL is largely a "soft" technology that consists mainly of planning, engineering and operating practices; some elements of "hard" technology are also involved.

Although it varies somewhat with the local situation, RIL in tropical forests generally requires the following (Dykstra 2001):

- pre-harvest inventory and mapping of individual crop trees;
- pre-harvest planning of roads, skid trails and landings to provide access to the harvest area and to the individual trees scheduled for harvest, while minimizing soil disturbance and protecting streams and waterways with appropriate crossings;
- pre-harvest vine-cutting in areas where heavy vines connect tree crowns;
- construction of roads, landings and skid trails so that they adhere to engineering and environmental design guidelines;
- the use of appropriate felling and bucking techniques including directional felling, cutting stumps low to the ground to avoid waste, and optimal crosscutting of tree stems into logs in a way that maximizes the recovery of useful wood;
- the winching of logs to planned skid trails and ensuring that heavy skidding machines remain on the trails at all times;
- where feasible, using yarding systems that protect soils and residual vegetation by suspending logs above the ground or by otherwise minimizing soil disturbance; and conducting a post-harvest assessment in order to provide feedback to the concession holder and logging crews and to evaluate the degree to which RIL guidelines were successfully applied.
- improved harvesting recovery (reduction of waste) by better use of existing equipment

The "hard" technology that may contribute to RIL include

- hand tools
- use of high flotation tires in ground-based skidding machines
- self-loading trucks
- large skidder vehicles to reduce the need for crawler tractors
- (radio-controlled) cable systems
- aerial logging using helicopters

Unfortunately, RIL has not yet been widely adopted. The FRA report (FAO 2000) concluded that there was very little evidence of implementation of low-impact logging or other model harvesting practices in the tropics.

1.2 Environmental Effects

When properly applied, RIL can have dramatic results. A recent review of 266 studies and articles on RIL and conventional logging in tropical forests revealed the following environmental benefits from RIL (Killmann *et al*. 2001):

- On average, RIL results in 41% less damage to residual stands when compared with conventional logging systems.
- The area covered by skid trails in RIL operations is almost 50% less than in conventional logging.
- The area damaged by road construction is about 40% less with RIL than with conventional logging.
- Overall site damage (compaction, exposure of soil, etc.) in RIL operations is generally less than half that in conventional logging.
- Canopy opening is generally about one-third less in RIL compared with conventional harvesting practices (16% versus 25%).
- The volume of lost timber (i.e. merchantable logs that have been prepared for extraction but not found by skidder operators) is reduced by more than a third in RIL operations.
- Logging costs are reduced thanks to more detailed planning of operations

1.3 Barriers

Despite considerable effort to promote RIL, it is still practiced by a small number of logging operators. Major barriers to its widespread adoption include (Durst and Enters 2001):

- The high relative costs of implementing RIL is a key deterrent for commercial operators; while sustainable timber production applying RIL can produce acceptable financial returns, unsustainable practices are even more profitable at least over the relatively short periods of time considered by most private investors. Costs are also high compared to widespread illegal practices that do not bear full costs
- Lack of awareness and appreciation of the benefits of RIL at decision-making levels in governments and corporations
- Lack of security of tenure; since many financial benefits of RIL are only realized at the time of future harvests, forest managers have little incentive to log forests carefully if they anticipate that the forest will be occupied, taken over, or damaged by others.
- One of the key barriers is lack of trained and experienced personnel to use both “soft” and “hard” RIL technology; constraints include both unavailability of appropriate trainers and high cost of training
- Inadequate government policies and incentives to practice RIL; while laws and regulations are often adequate their lax enforcement eliminates incentives to practice RIL, especially if adherence to regulations is perceived to reduce profits.
- Reduction of overall logging volumes caused by RIL owing to exclusion of many areas from harvesting due to steep terrain, wet conditions, protection of wildlife habitat and cultural features, etc.); this may limit supply of wood to processing units, which usually is the overriding concern for timber companies.

2. REMOTE SENSING AND GIS

2.1 Technology and Its Use in Tropical Countries

The use of remote sensing and GIS has expanded in tandem with the development of computer and satellite technology, and the forest sector has been quick to take advantage of the new opportunities. Remote sensing (using areal photos, satellite imagery, laser, video) is routinely used in forest resource assessments, and GIS applications in forestry serve both strategic and operational purposes. The various applications are numerous and diverse; the following list provides selected examples of technologies in use: (e.g. GIS applications 2003).

Remote sensing

Mapping and monitoring of changes of

- Forest (stand) characteristics (volume, biomass, carbon sequestration, species composition, growth, vegetation site, basal area etc.)
- Potential threats to forest (deforestation, forest degradation, desertification, fragmentation, spread of invasive species)
- Forest damage (fire, pest and disease infestation, wind damage, pollution)
- Wildlife resources
- Grazing pressure, and shifting cultivation, end clearing for agriculture
- Logging impact
- Extent of road network
- Extent and location of illegal logging

GIS applications (often in combination with remote sensing)

- Land use and ecological landscape planning
- Forest management planning (strategic and operational)
- Planning of protected area management
- Planning of timber harvesting schedules and timber transport
- Planning of fire response and predicting fire behavior
- Planning of forest access and road design (including scenic roads)
- Planning of biodiversity conservation strategies and ecosystem management (e.g. identification of areas suitable for habitat protection and wildlife corridors, ecological landscape planning)
- Planning of wilderness areas (e.g. development of recreational trails)
- Estimating recreation value and tourism potential
- Predicting evapotranspiration and runoff
- Supporting the resolution of forestry/wildlife conflicts.

Tropical countries use remote sensing widely for forest resource assessment. GIS has principally been used for research and only to a limited extent to formally support policy formulation, the planning process or management decisions (Apan 2000). In contrast, in developed countries GIS applications are routinely used as an operational decision-making aid suggesting that the potential for transfer of GIS technology to developing countries is substantial.

2.2 Environmental Effects

The benefits of remote sensing and GIS are often obvious but difficult to assess in quantitative terms. General benefits include, *inter alia*, increases in productivity, cost reduction, information security, improved decision-making, improved customer service, improved modeling and planning, etc. The fact that most commercial timber companies in developing countries are applying at least GIS is a strong indicator of their usefulness.

The benefits specific to environmental management include, *inter alia*, better monitoring of forest conditions, easier distribution of environmental data, improved coordination of productive and conservation activities, and enhanced capacity to analyze the environmental impacts of alternative courses of action.

2.3 Barriers

GIS and remote sensing have been substantially promoted in the developing countries, but the results have been rather mixed. The available evaluations show that apart from the well-known problems with capacity and human resources, institutional and organizational constraints constitute a significant hindrance. There is also a considerable under-utilization of the existing data. The identified impediments in developing countries include the following (cf. Eastman & Toledano 1996, de Gier *et al*. 1999):

- restricted access for policy-makers and practitioners to existing data owing to
  - inadequate data distribution mechanisms
  - lack of structures for decentralized data management
  - restrictions on free access to information for strategic, political, economic or other reasons
  - lack of international/national data standards rendering data sets incompatible
  - lack of mechanisms/protocols to integrate and share data
- restricted institutionalization of GIS projects in the public sector owing to
  - weak links to decision-makers and their data needs
  - lack of incentives for professional GIS staff (salaries, career opportunities)
  - lack of funds enabling continuation of externally supported projects
- high costs of computer hardware and most GIS software
- lack of commercial markets for remote sensing data owing to high data acquisition and processing cost and restricted utility for timber companies (e.g. valuable tree species cannot be identified separately)
- lack of raw data to input to the GIS, and lack of "digitized" infrastructure (e.g. digitized road maps in support of transport applications)
- lack of technical skills to operate and manage GIS as well as to conceptualize and independently manage GIS development projects
- lack of adequately equipped and staffed training institutions
- restricted capacity to support remotely located units (in-house & commercial services) making it difficult to reach "critical mass" of data users

3. BIOENERGY

3.1 Technology

Biomass contributes significantly to the world's energy supply, accounting for about 9-13% of the total. It is particularly important in the developing countries, where it represents on average one third or fifth of the total energy consumption. The dominating use of wood is fuelwood for cooking, space heating and hot water. In contrast, in the industrialized countries biomass-based energy production accounts for only 3% of the total consumption (Turkenburg *et al.* 2000).

"Modern" bioenergy conversion technologies classified by production type include (Turkenburg *et al.* 2000)

(1) Heat production
  (a) Improved stoves for cooking and heating (in developing countries)
  (b) Domestic biomass-fired heating systems (in Nordic countries, Austria, Germany)

(2) Heat and electricity production
  (a) Combustion
  (b) Combined heat and power (CHP) (e.g. in sawmill factories)
  (c) Standalone
  (d) Co-combustion (e.g. natural gas and coal with biomass)
  (e) Gasification
  (f) Combined heat and power (CHP) (diesel or gas turbines)
  (g) Biomass integrated gasification/combined cycle (BIG/CC)
  (h) Digestion

(3) Fuel production
  (a) Pyrolysis (bio-oil, charcoal production)
  (b) Hydrothermal upgrading (biocrude)
  (c) Fermentation (ethanol)
  (d) Hydrolysis (ethanol, possibly electricity)
  (e) Gasification (methanol, hydrogen, electricity)
  (f) Syngas conversion processes (methanol, hydrogen)

"Traditional" technologies such as using fuelwood in cooking and domestic heating or in small-scale industries (bakeries, brick-making, etc.) are still the most prevalent ones in developing countries. It is estimated that "traditional" technologies use 7-8 times more energy than "modern" ones (FAO 1998). Many of the latter are still in an experimental stage, but the following technological options appear to hold most promise for expansion and commercialization (Turkenburg *et al.* 2000, FAO 1998):

- Direct combustion of various types of biomass to produce heat, steam or electricity (CHP, dendrothermal power plants, co-combustion etc.);
- Gasification of biomass for electricity generation, using technologies such as BIG/CC;
- Production of liquid fuels (alcohol, ethanol, methanol, etc.) using hydrolysis and gasification

Scenarios investigating the potential of all renewable energy sources indicate that they could contribute 20-50% of energy supplies in the second half of the 21st century (Turkenburg *et al.* 2000).

3.2 Environmental Effects

Bioenergy production has a number of positive environmental effects. However, unless proper safeguards are applied, some negative impacts may also emerge. The main considerations include (Turkenberg *et al.* 2000; Sims 2002):

- Biomass energy can be considered carbon neutral as released CO_2 was first sequestered for the atmosphere by trees.
- Increased availability of plantation wood for energy production, more efficient conversion of fuelwood and charcoal and increased use of waste wood may relieve pressure to harvest natural forests. On the other hand, without appropriate precautions increased demand for wood-based fuels could encourage deforestation.
- Replacing traditional uses of biomass with "modern" technologies could reduce indoor and outdoor air pollution and reduce health risks.
- Fuelwood plantations could reduce erosion, if they replace annual crops or are established on degraded or bare land.
- The impact of large plantations with fast growing species on water supply is unclear, but in some instances groundwater resources could be reduced.
- Use of pesticides can have negative effects, but experience with wood crops (e.g. poplar, eucaluptys) indicate that strict environmental standards can be met.
- Biomass plantations display low biodiversity as they support a much narrower range of biological species than natural forest. However, if plantations are established on degraded lands or on marginal agricultural lands, the restored lands are likely to support a more diverse ecology.
- Continual removal of large quantities of biomass may deplete soil nutrient levels; on the other hand, energy farming with short rotation forestry requires less fertilizer than conventional agriculture.
- Large plantations may significantly change land use, crops and landscape evoking resistance from the local population
- The environmental impact of bioenergy production vis-à-vis other energy sources cannot be accurately determined unless full life-cycle is taken into account

From a social viewpoint, it is worth noting that biomass power generation is far more labor-intensive than conventional power generation.

3.3 Barriers

There are several barriers, either real or perceived, that can obstruct implementation of modern biomass energy applications. These barriers may be technical, financial, economic, institutional or a combination of them. The financial, economic and technical barriers are generally influenced by the following factors (FAO 1998, Sims 2002):

- Biomass energy projects suffer from not having a level playing field in competition with conventional energy sources (i.e. tax policies, power-purchase agreements, etc. often favor conventional energy projects).
- Bioenergy production requiring large land areas may not be able to compete with alternative land uses in densely populated areas, where the demand for land is high.
- Biomass-based energy projects may have competition for their fuel source from higher-value applications such as the furniture industry, especially in the case of wood.
- Available biomass energy technologies do not offer sufficiently high returns or they may not be sufficiently mature to represent an acceptable risk to private-sector investors.

Besides these, there are also institutional constraints, which vary from country to country and over time, depending on prevailing conditions. These can be summarized as follows (cf. FAO 1998):

- Current energy policies are often biased against renewable energy sources; energy prices do not reflect external social costs such as the effects of air pollution or GHG emissions.
- Taxes and subsidies often encourage fossil fuels, favoring operating costs over long-term investment.
- Cooperation between developers/researchers, manufacturers and potential users is not well coordinated.
- Technology transfer of mass products, e.g. improved stoves, is often too focused on fuel efficiency and direct cost; however, acceptance is strongly influenced by indirect costs and social factors, such as simplicity of operation and maintenance, availability of materials, cultural preferences and patterns, and the mechanisms to promote the new stoves.
- Market creation is often difficult; biomass producers may not be willing to plant energy crops unless they are assured of a market for their output. At the same time, the power utilities may not be willing to build bioenergy power facilities unless they have assurances that fuel will be available.
- Widespread implementation of afforestation programs is often constrained by economic and social factors.

4. PULP AND PAPER PRODUCTION

4.1 Technology

The pulp and paper industry has been under substantial regulatory, social and market pressures to improve its environmental performance since the 1970s. These pressures were felt especially in the developing world where the industry responded by introducing new and improved technology. The environmental technologies adopted by the pulp and paper industries in the past three decades include the following (Mickwizt *et al.* 2003).

- Increasing the dry content of black liquor
- Incineration of odorous gases (in recovery boiler, lime kiln or separate furnace)
- Filters for air emissions
- Biological and tertiary waste water treatment (activated sludge treatment)
- Chorine-free bleaching

Unfortunately, very few of these technologies were adopted in developing countries. In mid-1990s, less than one quarter of the world's pulp and paper-making capacity (in Asia excluding Japan, Russia, Eastern Europe and all of Latin America) is responsible for about 75% of TSS (total suspended solids) emissions, and 49% and 38% of COD (chemical oxygen demand) and AOX (absorbable organo-halogens), respectively (IIED 1996).

At the same time technological development has made rapid progress in developed countries swifting focus from traditional control and treatment technologies to pollution prevention at source. Some of the most recently adopted pollution prevention techniques applied at pulp and paper facilities in the United States include (EPA 2002):

- *Extended delignification*, *oxygen delignification* and use of *anthraquinone catalysis* to reduce the need for bleaching chemicals
- *Ozone delignification* (ozone bleaching) to eliminate the need for chlorine in the bleaching process.
- *Improved black liquor spill control and prevention*.
- *Enzyme treatment of pulp* to decrease in chlorinated compounds and use of chemicals
- *Improved brownstock and bleaching stage washing* and *improved chipping and screening* to reduce use of bleaching chemicals and the associated chlorinated compounds as well as conventional pollutants.
- *Oxygen-reinforced extraction and peroxide-reinforced extraction processes* to reduce the amount of elemental chlorine and chlorine dioxide needed in the bleaching process
- *Improved chemical controls and mixing* to avoid the formation of chlorinated organics

The use of these technologies has expanded rapidly. For example, it is estimated that up to 80% of mills in the United States are currently using oxygen-reinforced extraction. The use of peroxide extraction is also increasing. As of 1987, it was estimated that only 25% of domestic mills were using peroxide extraction (EPA 2002).

4.2 Environmental Effects

The introduction of new environmental technologies has had a dramatic effect on pollution. For instance, owing largely to changes in bleaching techniques, the dioxin level of pulp and paper mill effluents in the United States decreased 90% between 1988 and 1993 and at the end of the period 90% of the mills produced unmeasurable levels of dioxin. A survey of Canadian pulp and paper industries in 1995 indicated that dioxin levels were non-detectable in all but one. On the other hand, during the same period only few mills in Asia and Latin America and none in Africa had replaced their chlorine bleaching technologies (IIED 1996).

The recently introduced pollution prevention technologies hold substantial potential to improve the environmental performance of pulp and paper industries. To mention just one an example; oxygen delignification can reduce the lignin content in the pulp by as much as 50% resulting in a potentially similar reduction in the use of chlorinated bleaching chemicals and chlorinated compound pollutants (EPA 2002).

4.3 Barriers

Environmental investments in pulp and paper sector typically require substantial capital inputs. Many of the barriers are therefore related to the weakness of the financing sector in general. Foreign direct investment (FDI), which is a major vehicle for technology transfer, may be constrained by unfavorable economic environment. Typical problems in developing countries include

- Capital availability from the banking sector is limited (cost of capital for domestic enterprises generally in the range of up to 30-40%) owing to
  - high inflation rates
  - unstable and poorly capitalized banking sector
- Inflow of foreign capital is hindered by
  - restrictive national trade and investment policies
  - lack of sufficient infrastructure
  - risk of social and civil disruption

Attracting FDI is constrained further, if the country in question (a) has small market size, (b) lacks of skilled or well-trained human resources, and (c) has limited stock of natural resources of commercial interest.

Constraints specific to environmental investments in the pulp and paper sector in the developing countries include the following:

- Environmental investments have high relative cost; it would less expensive to build large greenfield mills using state of the art environmental systems, rather than to attempt to renovate old and small mills (e.g. in China in mid-1990s there were 8 000 mills with a capacity under 1 000 t/a); much of the modern equipment and systems are unavailable for small-scale mills and is incompatible with the obsolete equipment used in many older mills (IIED 1996).
- Import tariffs increase the investment cost and encourage imports of used industrial equipment lacking appropriate environmental technology.
- Weak regulatory framework for intellectual property rights discourages technology transfer by foreign companies.
- Pulp and paper industries in developing countries are often focused on market expansion and perceive limited returns from environmental investments.
- Inadequate environmental legislation, low environmental standards, and lax enforcement reduce incentives to make environmental investments.
- Lack of consumer awareness limits market-based pressure to enhance environmental performance.
- There is a shortage of trained managers and technical personnel, lack of appropriate training institutions.
- Lack of publicly funded R&D effectively bars small and medium-sized firms from having access to any broader knowledge infrastructure that would facilitate technology adaptation and reduce adaptation cost.

The relevance of these factors varies over time and from one country to another.

5. BIOTECHNOLOGY

5.1 Technology

Over the last few decades industrial plantation forests have become a major source of supply of industrial wood. One of the main reasons for this change is the improved economics of planted forests through technological innovations. The vehicles of change have been tree breeding and – more recently – biotechnology. The characteristics that these techniques have sought to improve include, *inter alia* (cf. Sedjo 2001),

- *Growth rates*
- *Disease and pest resistance*
- *Climate range and adaptability*; tolerance to drought, cold, air and soil pollutants
- *Tree form and wood fiber quality:* straightness of the trunk, absence of large or excessive branching, amount of taper in the trunk, homogeneity of raw material
- *Fiber characteristics that ease processing:* break-down of wood fibers in chemical processing, reduced pitch or lignin content of trees

The foreseen benefits are substantial. As an example, improved fiber characteristics could potentially increase valued added from pulping by 15-20%, and the benefit from reduced lignin content could be of same order of magnitude. Introduction of herbicide resistant gene in the seedlings is estimated to reduce the initial establishment of cost of eucalyptus plantations by 40% (Sedjo 2001). However, biotechnology in forestry is still at an early stage of development. There has been no reported commercial production of transgenic forest trees, although 116 field trials in 17 countries and involving 24 tree species have been reported (Owusu, 1999).

The pulp and paper industry is also keen to take advantage of biotechnology to make the production process more efficient and environmentally friendly. A large number of experiments are underway, but applications that have successfully transferred to commercial production include the use of (Sykes *et al.* 1999)

- xylanases for bleach boosting
- cellulases for improved drainage
- lipases for pitch removal, and
- cellulase-hemicellulase mixture for deinking

These technologies are seen as cost-effective alternatives to complement rather than totally replace traditional technologies They were first introduced in Nordic and Canadian pulp and paper industries, later followed by industries in the United States (Sykes *et al.* 1999).

5.2 Environmental Effects

While the adoption of biotechnology in forestry appears to be driven mainly by hopes for economic gain environmental benefits can be provided *parallel* to this pursuit. Most importantly, low-cost wood from plantations provides an alternative for wood from natural forests, and expanded production could substantially reduce pressure to harvest natural forests.

Additionally, biotechnology could be used to develop specific tree qualities that provide desired environmental services. For example, modified trees could survive and provide environmental services in conditions previously unsuitable for them. Arid and degraded lands or those in cold climates could benefit from erosion control and watershed services provided by trees. Biotechnology could be used to enhance capacity of trees for phytoremediation, i.e. cleaning up toxic waste sites. Biotechnology also provides the potential to restore species severely damaged by pests and disease, such as the American chestnut. Further, forests' ability to sequestrate carbon and other GHG to mitigate the build-up of atmospheric green house gases could be enhanced through biotechnology (Sedjo 2001).

However, it is acknowledged that biosafety aspects of genetically modified trees need careful consideration. One of the risks is that pollen from genetically engineered trees spreads to wild relatives giving birth to invasive species. Another concern is that because of the long generation time of trees, the full effects of biotechnology enhancement will not be known at a very late stage (Botkin 2001).

In pulp and paper industry biotechnology can be used to modify biologically based processes in a manner that produces more specific reactions and reduces environmentally harmful impacts. Biotechnology may also help in gaining energy savings, and in developing alternatives for non-biological processes (Sykes *et al.* 1999).

5.3 <u>Barriers</u>

The impediments to transfer of biotechnology to the forest sector in developing countries include:

- Insufficient human and institutional capacities at all levels
  - Lack of modern institutions for technology development and adaptation
  - Inadequate training capacity
  - Unawareness and lack of experience among policy makers of developing appropriate policy and regulatory environment
  - Inefficient and inexperienced public institutions to regulate and promote biotechnology
  - Lack of technical knowledge in enterprise sector
- High initial cost of biotechnology development and adoption; poorly developed networks and public-private partnerships able to pool resources (financing and knowledge)
- Poorly formulated or enforced legal framework concerning intellectual property rights discouraging technology transfer from abroad as well as private sector involvement in R&D
- High front-end costs of investments based on biotechnology and lack of access to investment capital among industrial companies and forest owners
- Inadequate or poorly enforced environmental regulations that do not constitute an incentive for the business sector to make investments in biotechnology providing only environmental benefit
- Public policies that accord low priority for environmental investments not yielding parallel productive gains
- Public opinion concerned about negative environmental impacts of biotechnology; these concerns are aggravated by inadequate policy and legal frameworks for biosafety

SELECTED EXAMPLES OF EST TRANSFER PROJECTS

Even though EST transfer appears to take place mostly as part of larger development projects, there is also a large number of projects focusing specifically on EST transfer. The projects are too numerous to be exhaustively listed here, but a few selected samples are summarized (Table 1).

The experience gained in Kenya with the rural stoves project as well as with the promotion of technology to process coconut trees in the Philippines highlight the need for demand-based approach in the transfer. The Clean Technology project at a Chinese pulp mill as well as the project promoting conservation-oriented agroforestry in Lesotho show the critical importance of economic viability of ESTs for their diffusion. Similarly, in Indonesia it was found that the acceptance of a conservation area management plan essentially depends on its contribution to economic and social development in the area. In Malawi, the process to establish an environmental monitoring system applying remote sensing and GIS showed the importance of addressing non-technological barriers – social, institutional and cultural – in the context of EST transfer.

Table 1 Selected examples of EST transfer projects

Type of Project/Country	Supported by	Objectives	Lessons learned
Upesi Rural Stoves Project (Kenya)	Intermediate Technology Development Group (ITDG) 1995	Production and commercialization of improved stoves	Rural stoves can be commercialized, but process can be tedious and expensive; people with free access to fuelwood do not necessarily put a lot of emphasis on energy efficiency; introduction of subsidies may have slowed down commercialization (Njenga 2001)
The use of GIS and Remote Sensing Technologies in Environmental Monitoring (Malawi)	Clark Labs, Clark University (1993-1998)	Enhance the capacity of GOM agencies and departments to evaluate and monitor national environment using GIS and Remote Sensing	Adoption of non-technological approach critical to transfer process; apart from increased techniques and technology training or increasing the amount of data used, institutional, social, and cultural barriers must be addressed (Toledano 1998)
Support to the implementation of Reduced Impact Logging in a private forest concession in East Kalimantan (Indonesia)	Indonesian-German Technical Cooperation Project SFMP-GTZ-MoF	Adoption of RIL on an operational scale in company activities	Successful implementation requires (i) commitment for implementation by top management; (ii) investment in human resources and, if required, superior technologies; (iii) intensive and reliable internal control systems; (iv) possibility to apply 'learning by doing' approach; and (v) allowing sufficient timeframe for the process — about two years (Hinrichs & Ruslim 2001)

Type of Project/Country	Supported by	Objectives	Lessons learned
Rationalization of the Production Process in Pulp and Paper Production in Zhejinang Province (China)	National Cleaner Production Center 1997	Achieve Cleaner Production by process modification and good housekeeping	Opportunities for Cleaner Production are often low or no cost and the main barrier to their implementation is lack of information. High-cost options can be implemented if they are economically viable. In the mill in question the pay-back periods ranged from six months to one year (ICPIC 1997).
Soil and Water Conservation and Agroforestry Program (Lesotho)	IFAD 1989-1998	Key objective was to promote soil and water conservation measures as part of the farmer's normal agricultural activities	Project evaluation concluded *inter alia* that farming systems most likely to be adopted are those which offer farmers within one season of adoption a sustainable increase in net income from a cash/food crop; as long as adoption of conservation techniques does not result in a quick felt benefit to the farmer, adoption will not take place (IFAD 1998).
Technology Transfer/ Commercialization Of Selected Cocowood Utilization Technologies (the Philippines)	ITTO 1994-1998	Objectives were *inter alia* to promote selected cocowood utilization and to commercialize / encourage adoption of selected cocowood utilization technologies.	The evaluation report concluded *inter alia* that the success of technology transfer is critically dependent on the demand for specific products or services produced with the corresponding technologies; A market-oriented approach/market-driven selection of technologies is necessary (Fink 2003).
Development of Bentuang Karimun Nature Reserve as National Park (Phase I) (Indonesia)	ITTO 1995-1999	To develop BKNR as a National Protected Area for biodiversity conservation; one of the key activities is to develop a comprehensive management plan	One of the key findings of the post-evaluation report was that the effectiveness of a management system critically depends on effective cooperation with local stakeholders (institutional and rural) for co-management and the management system's contribution to economic and social development (Umali & Seibert 2002)

FOREST-RELATED RESEARCH AND INFORMATION NETWORKS

L'Association pour le Développement de l'Information Environnementale (ADIE) has a mission to support various public, private and collective entities involved in the management of natural resources in Central Africa. Together with other partners ADIE has developed FORAC - the Central African Forest Watch (Observatoire des forêts d'Afrique Centrale).

The Association for Temperate Agroforestry (AFTA) is a private, nonprofit organization formed in 1991. The mission of AFTA is to promote the wider adoption of agroforestry by landowners in temperate regions of North America. Agroforestry practices combine trees and shrubs with crops and/or livestock to increase and diversify farm and forest production while conserving natural resources.

Asia Pacific Association of Forestry Research Institutions (APAFRI). is an association of forestry research institutes in the region. FORSPA assisted in setting up this association to strengthen regional research networking and collaboration. At the moment APAFRI has over 55 member institutions, including NGO's and private institutions

Asia Pacific Forest Rehabilitation Network (APFReN) has been established by FORSPA in collaboration with the Forest Research Institute Malaysia. The objective of the network is to facilitate the sharing of information, experience, expertise and technology, as well as to support human resource development and to facilitate collaborative research in rehabilitation of logged– over forests

The European Tropical Forest Research Network (ETFRN) is a forum for communication between European organizations, researchers, EU institutions and others concerned with (sub-)tropical forest research.

FACT Net was an international network of community groups, development workers, tree breeders, researchers, students, and farmers. FACT Net closed in 1999 after operating for almost 20 years as a successful international network. Winrock International's Forestry and Natural Resource Management Program maintains a web site as an on-line resource

Forestry and Society Network is a Chinese community forestry network funded by the Ford Foundation and executed by Chinese Academy of Forestry.

The Forestry Research Support Program for Asia and the Pacific (FORSPA) is a regional project funded by the Netherlands government and executed by the Food and Agriculture Organization of the United Nations (FAO). Its main objective is to build capacity in national forestry research systems.

Forest to Customer (FORAC) is a research consortium involving partners from the forest product industry, the high tech sector, and both public and private organizations dedicated to research and development. The consortium is concentrated on the management of value creation networks and maximizing the potential of Web-based resources.

Global Forest Information Service (GFIS) is an information network under development with the support of IUFRO-SPDC.

The Integrated Conservation Networking System (ICONS) is an information management system designed to meet the needs of non-government, rural and indigenous organizations and individuals working in developing countries.

Network on Ethnoforestry is a peer group of concerned foresters, scientists, international agencies, and NGOs working for documentation, dissemination and integration of indigenous knowledge on forest management with formal forestry, in various cultures and indigenous peoples across the globe.

Pulp and Paper Net is designed to be an information and communication resource for the pulp and paper industry.

La Red Forestal Amazónica (Amazonian Forestry Network) is a virtual entity consisting of various public, private and community organizations promoting exchange of information and experiences in SFM in the Amazon Region)

The Regional Community Forestry Training Center for Asia and the Pacific (RECOFTC) offers a range of consulting and advisory services to community forestry project, programs and organizations throughout the region.

The Rural Development Forestry Network (RDFN) is a component of the outreach program of the Forest Policy and Environment Group (FPEG) of the Overseas Development Institute (ODI)

TEAKNET's objective is to strengthen interaction among all those concerned with conservation and sustainable management of teak-bearing forests and plantations through sharing of information and promoting collaborative efforts to deal with common problems.

Tree Nutrition Research South Pacific is collaborative research project 'Nutrition of Tropical Hardwood Plantation Species in the South Pacific' involving the Departments of Forestry in Fiji and Samoa and funded by FORSPA

WARSI (Conservation Information Forum) is an organizational network established in January 1992, with membership made up of twelve NGOs from four provinces in Sumatra (South Sumatra, West Sumatra, Bengkulu and Jambi), whose focus is biodiversity conservation and community development.