# Transfer of Environmentally Sound Technologies for Sustainable Forest Management

## Framework and Applications

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# CONTENTS

## ABREVIATIONS AND ACRONYMS

| | |
|---|---|
| ACOPS | Advisory Committee on Protection of the Sea |
| AfDB | African Development Bank |
| AsDB | Asian Development Bank |
| AHEG | Ad hoc expert group established by ECOSOC to support the UNFF |
| AOX | Absorbable organo-halogens |
| APCTT | Asia and the Pacific Center for Transfer of Technology |
| BIG/CC | Biomass integrated gasification/combined cycle |
| BOT | build-operate-transfer |
| C&I | Criteria and indicators |
| CATIE | Tropical Agriculture Center for Research and Education |
| CBD | Convention on Biological Diversity |
| CDM | Clean Development Mechanism established under the UNFCCC |
| CERUPT | Certified Emission Reduction Unit Procurement Tender |
| CESTT | Centre for Environmentally Sound Technology Transfer |
| CHP | Combined heat and power |
| CICI | International Conference on the Contribution of Criteria and Indicators for Sustainable Forest Management |
| CIFOR | Centre for International Forestry Research |
| COD | Chemical oxygen demand |
| COP | Conference of the Parties |

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|---|---|
| CSD | Commission on Sustainable Development |
| CTFS | Center for Tropical Forest Science |
| COCATRAM | Central American Commission for Maritime Transportation |
| ECOSOC | Economic and Social Council of the United Nations |
| ERU-PT | Emission Reduction Unit Procurement Tender |
| ESCAP | United Nations Economic and Social Commission for Asia and the Pacific |
| EST | Environmentally sound technology |
| FAO | Food and Agriculture Organization of the United Nations |
| FDI | Foreign direct investment |
| FMU | Forest management unit |
| FRA | Forest Resource Assessment (prepared by FAO) |
| FSC | Forest Stewardship Council |
| GEF | Global Environment Facility |
| GESAMP | The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection |
| GHG | Greenhouse gas |
| GIS | Geographic information systems |
| IBRD | International Bank for Reconstruction and Development |
| ICETT | International Center for Environmental Technology Transfer |
| ICPIC | International Cleaner Production Information Clearinghouse |
| ICRAF | World Agroforestry Centre |

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|---|---|
| ICT | Information and communications technologies |
| IETC | UNEP's International Environmental Technology Centre |
| 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 Genetic Resources Institute |
| IPR | Intellectual property rights |
| ISO | International Organization for Standardization |
| IUFRO | International Union of Forestry Research Organizations |
| LDCs | Least developed countries |
| MEAs | Multilateral environmental agreements |
| MNCs | Multinational corporations |
| NFPs | National forest programmes |
| NGOs | Non-governmental organizations |
| ODA | Overseas development assistance |
| OECD | Organization for Economic Cooperation and Development |
| OPIC | Overseas Private Investment Corporation |
| PEFC | Pan-European Forest Certification |
| PPP | Public-private partnerships |
| R & D | Research and development |
| RIL | Reduced impact logging |
| SANet | Sustainable Alternatives Network |
| SFM | Sustainable forest management |

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|---|---|
| SME | Small and medium enterprises |
| STOA | Scientific and Technological Options Assessment of the European Parliament |
| STRI | Smithsonian Tropical Research Institute |
| TERI | Tata Energy Research Institute |
| TESTs | Transfer of environmentally sound technologies |
| TFP | Total factor productivity |
| TRIPS | Trade-Related Aspects of Intellectual Property Rights |
| TSS | Total suspended solids |
| UNCCD | United Nations Convention to Combat Desertification |
| UNCED | United Nations Conference on Environment and Development |
| UNEP | United Nations Environment Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UNFF | United Nations Forum on Forests |
| UNIDO | United Nations Industrial Development Organization |
| WBCSD | World Business Council for Sustainable Development |
| WTO | World Trade Organization |

## EXECUTIVE SUMMARY

In the intergovernmental policy formulation process, the transfer of environmentally sound technologies (TESTs) has been recognized as one of the principal means for the achievement of sustainable development. The Intergovernmental Panel on Forests (IPF) and the Intergovernmental Forum on Forests (IFF) addressed different aspects of TESTs for sustainable forest management (SFM) in detail and produced a comprehensive global policy agenda in the form of the IPF/IFF proposals for action. The United Nations Forum on Forests (UNFF) at its third session (Geneva, 26 May – 6 June 2003) agreed on the establishment of an ad-hoc expert group on finance and transfer of environmentally sound technologies. The ad hoc expert group convened in Geneva from 15 to 19 December 2003. Furthermore, a recent country-led initiative in support of UNFF, hosted by the Government of Nicaragua in Managua from 3 to 5 March 2003, focused on factors affecting technology transfer especially to mangrove forests.

This volume builds on the background documents prepared for those two meetings. *Transfer of Environmentally Sound Technologies from Developed Countries to Developing Countries* by Esa Puustjärvi, Marko Katila and Markku Simula of Indufor served as a background document for the Ad Hoc Expert Group on Finance and Transfer of Environmentally Sound Technologies. The background document, Transfer *of Environmentally Sound Technologies for the Sustainable Management of Tropical Forests* by the Center for Tropical Forest Science (CTFS) at the Smithsonian Tropical Research Institute (STRI), had a special focus on the tropical forests. *Transfer of Environmentally Sound Technologies for the Sustainable Management of Mangrove Forests: An Overview*, a background document prepared by COCATRAM as the Secretariat of the Antigua Guatemala

Convention for Cooperation in the Protection and Sustainable Development of the Marine and Coastal Environment of the Northeast Pacific served both the Government-designated Expert Meeting on the Transfer of Environmentally Sound Technologies for the Sustainable Management of Mangrove Ecosystems in Latin America and the Wider Caribbean, as well as the Ad Hoc Expert Group on Finance and Transfer of Environmentally Sound Technologies. Sincere gratitude is expressed to the individuals and organizations that have contributed to this volume.

The rate and direction of technological change largely determines the environmental impact of economic activities. New technologies may increase pollution and other environmental degradation while they can also efficiently mitigate the impacts of growing economic activities. Environmentally sound technologies prevent, limit or correct environmental damage such as pollution. They may also use resources more efficiently and thus be more environmentally friendly than the technologies they are substituting. Development of an appropriate policy and legal framework increases the likelihood that technologies are indeed used in an environmentally sound way. Environmental regulation itself can induce innovation of products and processes that are not only more efficient but also more environmentally friendly. Policies promoting development and diffusion of technologies are probably among the most important factors affecting environmental protection.

Moreover, technology transfer is one of the major factors shaping global income distribution. Since innovative activities are heavily concentrated in OECD countries, the ability of developing countries to catch up is largely dependent on their ability to import foreign technologies. International technology transfer has a significant potential to contribute to income convergence and sustainable development. Forces resisting the adoption of new technologies form a major development impediment.

International initiatives and processes since the Rio Declaration have given significant emphasis to technology transfer. Progress, however, has not been overwhelming. Technology transfer is failing to close the technology and income gap. Divergence, not convergence, some fear, might be the result of technological progress, fostered by the information and communications technologies (ICT) revolution. Access to technology is a major development issue and we need solutions to the obstacles for efficient global technology transfer.

The framework developed in this study emphasizes the need to view barriers to the successful transfer of environmentally sound technologies from the perspective of both supply and demand. This volume analyzes the obstacles and identifies approaches for improving TESTs. Especially it identifies ways through which the public sector and the international community could contribute to EST transfer.

Technology transfer for sustainable forest management and forest industries faces the same general constraints that prevail for other sectors. In addition to general challenges, the forest sector has a set of specific challenges. Technology transfer to forest industries requires different strategies compared to sustainable forest management. Transfer in the industry sector is largely a private sector activity, while the public sector role is pronounced in the area of management technologies. Low short-term returns of forestry, the restricted financial capacity of forest administrations to purchase services from the private sector, large conservation areas in public ownership, among others, hinder private sector participation and leave the government with significant responsibilities. Transfer of environmentally sound technologies to forestry will continue to take place largely on a government-to-government basis and 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.

There are barriers specific to TESTs within the forest sector and 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 national policies or the 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.

# PART I:  INTRODUCTION

## 1. TECHNOLOGY TRANSFER, ECONOMY AND ENVIRONMENT

### 1.1 What do we mean by environmentally sound technologies?

Environmentally sound technologies for sustainable forest management (SFM)) encompass a broad range of technologies, knowledge and policy instruments.  These can include scientific know-how, traditional forest-related knowledge, assessment and monitoring technologies, integrated information management systems, sustainable forest management practices, silviculture, harvesting and processing technologies, recycling of wood, fuel wood energy technologies, sound technologies for secondary wood products, economic instruments and mechanisms for SFM, certification and labeling approaches and forest-related climate change mitigation mechanisms (UNFF Secretariat 2003).

Technology is defined as the application of scientific and technical knowledge for practical uses in industry.  According to chapter 34 of Agenda 21, environmentally sound technologies 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.

In its report “Methodological and technological issues in technology transfer”, the Intergovernmental Panel on Climate Change (IPCC) also utilizes a broad definition or technologies in the forest sector.  These technologies can include genetically superior planting material, improved silvicultural practices, sustainable harvest and management practices, protected area management systems, substituting fossil fuels with bioenergy, incorporating indigenous knowledge in forest management, efficient processing and use of forest products and monitoring of area and vegetation status of forests. These technologies can meet several objectives, including conserving forest biological diversity and watersheds, enhancing sustainable forest product flows, increasing the efficiency of use of forest products and maximizing the resiliency of forest ecosystems to climate change, in addition to enhancing carbon sinks.

For the purposes of this study, environmentally sound technologies are often identified as "hard" and "soft" ESTs. The first refers to machinery and equipment more closely related to the harvesting, processing, transportation and utilization aspects associated with forest and manufacturing industries, while the latter relates more to the technological, technical and scientific know how associated with sustainable forest management, ranging from areas such as silviculture to management of protected areas to economic instruments and mechanisms. Soft ESTs usually consist of the application of scientific and technical know how for enhancing the management of forest resources without necessarily depending on the use of costly complex machinery and equipment. The distinction is important since much of the focus of this study is on financial and economic constraints affecting the transfer of environmentally sound technologies that fall under the category of hard ESTs.

## 1.2 Innovation, growth and environmental quality

The traditional ingredients of the neoclassical growth model of economics have difficulties explaining today's cross-country income differences: factor accumulation is not a sufficient explanation for their magnitude and persistence. A vital body of economic literature has emerged challenging the neoclassical view of economic growth and seeking explanations for the bulk of income differences that remain unexplained even when physical and human capital accumulation is accounted for (Barro and Sala-i-Martin 1992, Fagerberg 1994, Prescott 1998, Easterly and Levine 2002). Growth of total factor productivity (TFP) due to technological change, and barriers to it, many argue, should account for the unexplained part of income differences. Technological progress and productivity growth as a result of profit-motivated innovations and innovation stimulating economic incentives are seen as a major engine for growth (Grossman and Helpman 1991). While capital accumulation is essential for igniting economic progress -- education, for example, is indeed a necessary precondition for technological diffusion (Thomas et al. 2000) -- technological progress is a major factor shaping global income distribution.

Apart from driving economic growth, technological change has other important implications. New technologies may increase pollution and other environmental degradation while they can also efficiently mitigate the impacts of economic growth. Environmentally sound technologies prevent, limit or correct environmental damage such as pollution. They may also use resources more efficiently and thus be more environmentally friendly than the technologies they are substituting. The rate and direction of technological change, therefore, largely determines the environmental impact of economic growth (Jaffe et al 2000).

While technological progress stems predominantly from private research, public sector policies have important implications for private sector innovative activities (Porter and Stern). Also, alongside technological progress, development of an appropriate policy and legal framework ensures that technologies are indeed used in an environmentally sound way. Environmental regulation can induce innovation of products and processes that are not only more efficient but also more environment-friendly (Porter and van der Linde 1995). Trends in innovation represented by patenting have reflected regulation (Lanjouw and Mody 1996). Policies promoting development and diffusion of technologies are probably among the most important factors affecting environmental protection (Kneese and Schultze 1975). Different types of policy interventions have been designed to foster invention and diffusion of environmental technologies (Jaffe and Stavins 1995). Typically, policy decisions need to be taken in less than perfect conditions, under uncertainty and between complex choices (Foray and Grübler 1996). A wide range of policies are needed that, on one hand, enhance the generation of long-term solutions and environmentally sound technological alternatives, and, on the other hand, policies that control environmental impacts in the short-term. Regulation can either inhibit or foster technological change, depending on the choice and design of the instrument (Wiener 2004).

## 1.3 Technology transfer, environment and equality

Technological knowledge has important characteristics. First of all, technological knowledge can be used simultaneously by several users beyond the original ones, by different firms and in different countries (Kong and Keller 2003). Economists would say that technology is non-rival in consumption, unlike capital inputs -- both human and physical -- that can be used only at one place at a time. Second, the investment for creating new technology benefits not only the investor but creates also public benefits (Jaffe 1989).

The private return must be high enough to stimulate innovation, but spillovers, benefits to third-party actors, are very important for technology diffusion (Kong and Keller 2003) and raise the social rate of return on innovation. Along the lines of the Schumpeterian view on technological change, there are several steps required before full benefits of a new technology can be reaped. Invention and innovation – development and then commercialization of a new idea, the stage which very few inventions reach – are foundations of technological progress. However, it is diffusion – the speed and extent of the spreading of technology -- that finally determines the overall impact of a new technology. Like any other phenomenon in a world characterized by increasing international linkages, technology diffusion is faster than ever (Comin and Hobijn 2004). International technology spillovers are very important for the global economy (Bayoumi et al. 1999).

Why are these characteristics so important? Asymmetry characterizes the geographical distribution of inventions and innovations. Technology is developed by a few advanced countries, imitated by others, emphasizing the Schumpeterian view of three-staged technological progress (Barro and Sala-i-Martin 1997, Comin and Hobijn 2004). Potential for domestic driven technological innovations (Porter and Stern 2001) is limited in developing countries while a few OECD countries represent the bulk of global R & D spending.

The productivity of a country depends not only on domestic R & D but also on its ability to utilize technologies created in the rest of the world (Coe and Helpman 1995). Imitation increases the social return on investment and is cheaper than innovation (Barro and Sala-i-Martin 1997). Spillovers make it possible for developing countries to benefit from R & D investment in developed countries, both directly and indirectly, directly through learning new technologies processes, etc., and indirectly from imports of goods and services (Coe and Helpman 1995). International economic relations, particularly international trade but also FDI (Sinani and Meyer 2004, Blomstrom et al. 2000) are important avenues of technology transfer and foster productivity growth (Grossman and Helpman 1994, Cameron et al. 2004). Forces resisting the adoption of new technologies and increasing the costs become a matter of focus.

Technology imports indeed outnumber innovations in importance in developing countries (Zou 1995). The relative importance of foreign technologies in least-developed countries is 90 per cent or higher (Gong and Keller 2003). Technology imports are the major factor of technological change also in OECD countries (Eaton and Kortum 1999, Keller 2002), and, as a matter of fact, even 90 per cent of technology transfer takes place in the trade of North America, Western Europe, and Japan (Sandbrook 1995).

Diffusion - or technology transfer if you like - levels technological differences. International technology diffusion can either increase income differences or work for more equal income distribution depending on how uniformly technological flows spread and whether developing countries gain access to foreign technologies. Technology transfer has been given significant emphasis in international initiatives and processes, for example in the Rio Declaration. Progress, however, has not been impressive (United Nations 2002). Technology transfer is failing to close the technology and income gap (UNEP 2003). Divergence, not convergence, some fear, might be the result of technological progress, fostered by the ICT revolution if developing countries cannot fully participate. Diffusion of technology is a major development challenge and it is of crucial importance to identify the obstacles for efficient global technology transfer.

## 1.4 Why are innovations not adopted?

Diffusion is naturally a long process, typically characterized by diffusion rates that after a slow start gradually lead to a rapid expansion that finally slows down when approaching the saturation point, resembling the famous S-curve of technology diffusion (Mansfield 1963, Geroski 2000). This pattern is partly due to the decreasing cost of adoption. The early adopters reduce the cost and perceived risk of the later adopters, speeding up the diffusion (Gallaher and Delhotal 2005). Logically, lack of information also accounts for slow diffusion; information does not reach the potential users fast enough (Geroski 2000). Barriers to technology adoption such as regulatory and legal constraints and corruption increase the cost of technology adoption. Differences in these barriers, on their part, account for disparity in income across countries (Parente and Prescott 1994).

Technology adoption is a complex process that is affected by several factors, such as human capital and trade openness (Comin and Hobijn 2004). There can be lack of awareness and information, prevailing economic and financial constraints, technical risks, institutional and regulatory barriers, market failures and behavioral factors (Reddy and Painuly 2004). When technologies are available, costly local adaptation may be the inhibiting factor. Costs, such as licensing fees, training of personnel and adaptation may exceed the benefits and discourage demand (Stoneman 1983, Detradiache 1998). It is not enough that technologies are environmentally sound they need to be also economically viable.

Technology transfer uses numerous avenues and involves a number of stakeholders. Transaction types are numerous and several economic, social, operational and other factors motivate transfer (see, e.g., Reisman 2004.) Some of the transfer takes place between government agencies or within vertically integrated firms. Technology flows in the form of knowledge, capital, goods and services through trade, FDI, licensing, joint ventures, exchange of personnel, training and government aid, just to mention some of the most commonly cited examples (IPCC 2000). The avenues have been classified to government-driven, private-sector-driven and community-driven pathways but, however, technology transfer depends increasingly on co-ordination and co-operation of multiple organizations. Partnerships between stakeholders are increasingly important (IPCC 2000).

The private sector represents 90 per cent of all technology transfer (Sandbrook 1995). However, the role of governments is pronounced when technologies are not immediately economically viable. These include high risk and longer term projects, which the private sector is more reluctant to finance. Environmentally sound technologies fall many times into this category.

Forces resisting technology diffusion or technology transfer pose a serious challenge. Unsuccessful transfer of technologies is another, at least equally persistent one. Why does technology transfer fail? Challenges for successful transfer depend on the circumstances; different types of technologies, applications, suppliers and recipients need tailored approaches. Environmentally sound technology is context specific. What is environmentally sound in one place or at specific point in time may not qualify as environmentally sound in another location or another moment. The choice of technology is a crucial element of the technology transfer process. Selected technologies should respond to the needs, circumstances and capacities of the recipient (UNEP 2003). Recipients and users need capacity to choose the most appropriate technology given the prevailing constraints.

## 1.5 Framework for improving technology transfer

Policies aiming at promoting technology transfer face a complex situation. The technology transfer process involves several stages that need to be addressed, including identification of needs, choice of technology, assessment of conditions of transfer, agreement and implementation, evaluation and adjustment to local conditions and replication (IPCC 2000). Barriers may emerge in any of these stages.

Policies for technology diffusion need to address both supply and demand factors (Tsoutsos and Stamboulis 2004; see also Hausmann and Rodrik 2003 and Rodrik 2004). To elaborate this important fact it is perhaps useful to briefly review the discussion on and around the term technology transfer. The term itself has left many with an understanding of a passive one-way process. There have been arguments that, in technology transfer, technology is seen as an object and transfer as a one-time transaction that maintains the dependency of the recipient (IPCC 2000, Heaton et al. 1994). The negative associations with the concept of transfer have prompted proposals to use alternatives such as technology cooperation (Martinot et al. 1997) and technology diffusion (Grouble and Nakicenovic 1991). As Mathews (1995) argued, there is a risk that "technology transfer" is understood as a donor/receiver relationship, where the recipient is given only a passive role. In his opinion, this does not reflect the important role of the technology importer in creating an institutional framework capable for absorbing, adapting and improving the imported technology. This is a valid concern and a balanced demand-supply framework should be an answer to this confusion. There are only equal partners in a successful technology transfer. Technology diffusion that is frequently cited in the scholarly literature may not reinforce the attitudinal bias that is often connected to the term technology transfer.

The IPCC definition for technology transfer is a fruitful starting point. This broad definition overcomes the problems associated with the narrow interpretation and provides a basis for a balanced framework:

> *"The broad and inclusive term "transfer" encompasses diffusion of technologies and technology co-operation 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, utilise and replicate the technology, including the capacity to choose it and adapt it to local conditions and integrate it with indigenous technologies."*

The framework developed by Puustjärvi et al for this volume emphasizes the need to view barriers to the successful transfer of ESTs using a demand-supply based systems approach. Is a global framework for improving EST transfer at all possible or meaningful? It is. This volume analyzes the obstacles and identifies approaches for improving TESTs. In particular, it identifies ways through which the public sector and the international community could contribute to EST transfer.

The forest sector faces the same general constraints that characterize the operating environment in other sectors. In addition to those, it has a set of its own challenges, thanks to its peculiar nature. Very different logic governs the technology transfer for forest industries compared to that of sustainable forest management. Transfer in the industry sector is largely a private sector activity while the public sector role is pronounced in management technologies. 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 the private sector in EST transfer to make best use of the opportunities provided by privatization, development of timber concessions, and expansion of plantation forestry.

## 1.6 Structure of this study

A short description of international processes and agreements that are central to international technology transfer is provided in the following chapter. Chapter three analyzes the constraints inhibiting technology transfer process. It sets forth a fundamental argument that many of the impediments for EST transfer come from outside the forest sector. International agreements, national policy and macroeconomic frameworks shape the environment for EST transfer like for any other sector. Therefore policies for promoting EST transfer need to be designed for an imperfect environment.

Small and medium-size enterprises are dominant and lack finance and interest in investing in EST. Inadequate environmental regulation and enforcement restrict demand for EST. Unsustainable practices are more profitable. An enabling policy framework should also contemplate clear land tenure arrangments, appropriate resource pricing and coherent sectoral plans and policies.

Lack of capacity to assess, select, import and adapt ESTs and limited access to information hinder technology transfer. Research and development institutions often lack capacity to access and adapt ESTs. Interestingly chapter three also concludes that priorities for EST development do not adequately address the needs of the poor.

Chapter four develops a framework for EST transfer. In this framework, transfer is conceptualized as a result of demand and supply meeting specific needs of the stakeholders involved. It identifies public and private transfer and support mechanisms. Promotion of EST transfer consists of influencing factors affecting both demand and supply.

The competitiveness of SFM, the legal and regulatory framework and capacity building are analyzed among other factors creating demand for ESTs. Local demand is emphasized for successful EST transfer. Economic gain is a crucial driver behind EST investment, especially when regulatory pressure is not strong. Stronger regulation and improved enforcement increase the cost of non-compliance and, therefore, increase the demand for ESTs. Regulation should be a sectoral responsibility.

Privatization is expected to increase the demand for ESTs. However, the public sector has an important role in reducing the risk related to EST transfer and increasing the flow of ESTs close to the commercial margin. However, the economic viability of

ESTs is challenging and often public policies, even forest policies, contribute to low profitability. Support to research increasing competitiveness and removal of perverse incentives is recommended.

Insufficient capacity is hindering EST transfer at all levels of the process. Due to the specific nature of forestry, capacity to adapt existing technologies to local conditions is highlighted. However, the ultimate goal should be to build an autonomous capacity to acquire, adapt and further develop technologies. This contributes to general technological capabilities and is not specific to any particular technology.

Chapter four also discusses international and domestic supply of ESTs. It states that most hindrances to the supply of ESTs are market-related and dependent on international or macroeconomic policies. It discusses trade liberalization and intellectual property rights in a situation where the great majority of patents are owned by the industrialized countries. Needs in forestry are highly location and context-specific and not easily transferred without substantial modifications. South-south transfer is likely to become more important because of similarities in ecological conditions. The same barriers impeding international transfer constrain domestic diffusion. Specifically, at the domestic level, poor functioning of market mechanisms, the small number of players and monopolistic structures hamper TESTs.

Financing is a crucial element of the transfer of ESTs, which are typically characterized by high capital investment and low operating costs. While efforts to increase flows are necessary, it is pointed out that increased financing does not necessarily lead to increased transfer of ESTs. Attention should also be paid to the existing flows to make sure that they support ESTs.

There is evidence that FDI brings along environmentally sound practices. However, the share in forestry of private investment is most likely small and FDI is concentrated in a handful of countries. The forest sector has basically indirect measures at hand to increase the flow of FDI. Adding ESTs criteria in loans is also suggested.

Chapter five states that the assessment of country and sector-specific conditions should be the basis for policies aimed at supporting EST transfer. Proper technology assessment, including identification and selection of ESTs, is a crucial step in policy formulation and has often been neglected in the past. The ability to contribute to solving environmental issues, sustained impact, social implications and cost-effectiveness are key elements affecting the choice of technology. Compatibility with indigenous technologies is also important.

Constraints to technology transfer exist both outside and inside the forest sector and the actual impact of ESTs are often below their potential. Barriers that directly impede TESTs should be the priority area for action. The international community should focus on the least developed countries. Initially, mechanisms that encourage the adoption of existing technologies are the priority area, but the long term objective should be an autonomous capacity to create new technology.

Chapter six reviews some of the central environmentally sound technologies and chapter seven illustrates an important example of a special situation for technology transfer in the case of mangrove forests. One of the important lessons of the analysis by COCATRAM is that South-South transfer of ESTs is becoming increasingly important but still very limited. Chapters eight and nine conclude and give a summary of the recommendations.

# 2. THE TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES IN INTERNATIONAL PROCESSES AND AGREEMENTS

## 2.1 International processes

Technology transfer is a cross-cutting issue addressed by a number of international processes, including several multilateral environmental agreements. It is a priority area particularly for developing countries and a critical element for securing their participation in these processes.

*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).

*IPF/IFF and the United Nations Forum on Forests*

In the forestry sector, the global efforts to promote EST transfer have taken place under the ad hoc IPF/IFF processes and the United Nations Forum on Forests. 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 the transfer of environmentally sound technologies 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 UN Forum on Forests has been made responsible for the implementation of the IPF/IFF Proposals, including those related to technology transfer. Its Plan of Action 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 UN Forum on Forests 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).

The ad hoc expert group met in Geneva from 15 to 19 December 2003. Decision IV/1 of the UNFF establishes that the recommendations contained in the report of the meeting are to be taken into account in the future work of the Forum of finance and transfer of ESTs. These recommendations serve as the basis for the recommended actions provided in this study.

Subsequently, a country-led initiative on transfer of ESTs and capacity building for SFM was hosted by the Government of the Republic of Congo in Brazzaville from 24 to 27 February 2004. This meeting took into account the comprehensive nature of the work of the ad hoc expert group of the UN Forum on Forests. It continued discussions on key issues of key importance, particularly to African countries.

## 2.2 Multilateral Agreements

*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" (2002), 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.

*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 were 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, geographic information systems and data systems).

*UNCCD*

The United Nations Convention to Combat Desertification (UNCCD) commits the signatory parties, *inter alia*, to promote the "transfer, acquisition, adaptation and development of technology" (Article 18). The 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 UNCCD networks relate to monitoring of desertification and promotion of renewable energy sources and agroforestry (UNCCD 2003).

## 2.3 Impact of MEAs

The developing countries have strongly emphasized the view that, by signing international agreements, such as the Kyoto Protocol of the UNFCCC, CBD, UNCCD, 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 developed countries 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 have triggered an increased flow of financing for the transfer of ESTs.

## 2.4 WTO

The Agreements of the 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 the formulation and application of technical regulations and standards and the 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 the 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).

# PART II: IMPROVING THE TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES

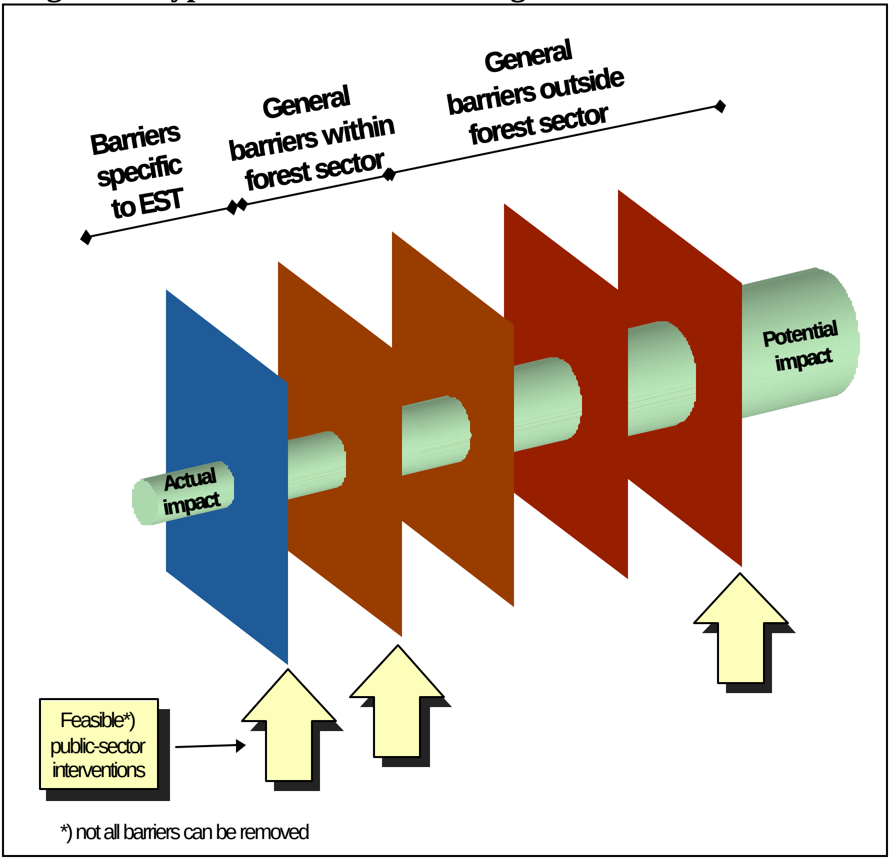
## 3. BARRIERS TO THE SUCCESSFUL TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES

### 3.1 Overview

The 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 4.1 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 ESTs. 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 ESTs using a demand-supply based systems approach. The analysis of barriers, including making recommendations to improve EST transfer and setting priorities also makes use of distinctions between barriers specific to ESTs in general, general barriers within the forest sector and general barriers outside the forest sector (Fig. 1).

Many of the barriers to 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 1. Type of Barriers Hindering EST Transfer**



## 3.2 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 the 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 effective 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 the 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 ESTs 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 of 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 developing countries, SMEs dominate the woodworking industries; oftentimes enterprises in the pulp and paper sector are also 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 ESTs. 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 that are sustainably managed and that the legal requirements are complied with.

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

## 3.3 Policy and Legal Framework

The lack or inadequacy of environmental regulations and standards and the weak enforcement of existing regulations are major factors restricting the demand for ESTs. The financial returns from investing in ESTs are often low because sales prices can be kept artificially low due to the 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 ESTs. 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 ESTs. 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 ESTs. 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.

### 3.4 Capacity

Lack of capacity in developing countries to assess, select, import and adapt ESTs 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.

## 3.5 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 an 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 ESTs. 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).

## 3.6 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 of 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 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 developed 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 the 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.

# 4. IMPROVING THE TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES

## 4.1 Framework for EST Transfer

In examining opportunities to improve EST transfer to the forest sector in developing countries, the focus here is on 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 the respective recommendations are made with less detail.

The public sector is here treated as one block, even though in reality there are 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.

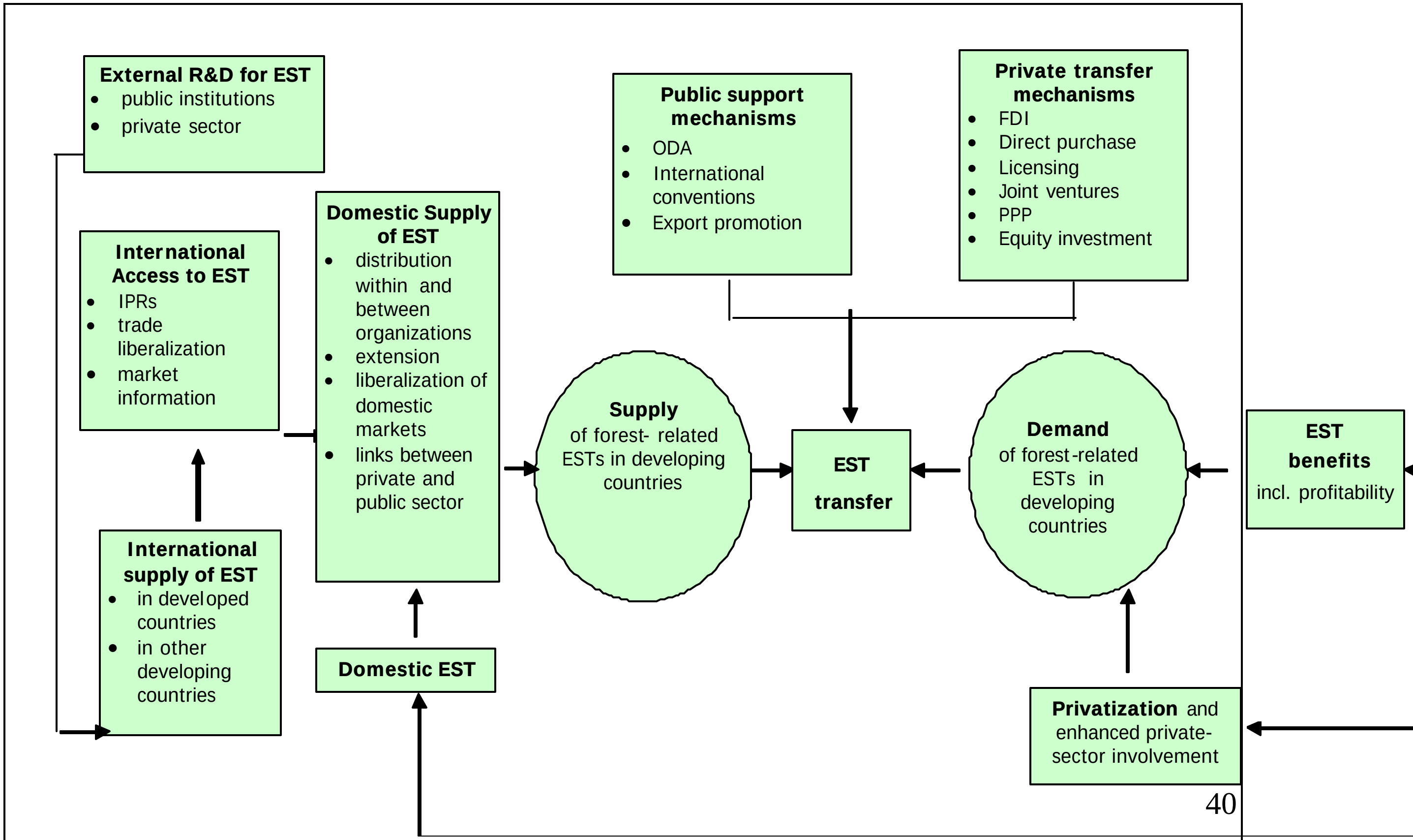
The transfer of ESTs is a result of demand and supply meeting specific needs. The promotion of EST transfer consists of various ways of influencing the factors behind demand and supply (Fig. 2). The rate of technology transfer is affected both by motivations that induce more rapid adoption of new techniques 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 an 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 ESTs, 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 can also 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 2. Supply and Demand of Environmentally Sound Technologies**


External R&D for EST
public institutions
private sector
International Access to EST
IPRs
trade liberalization
market information
International supply of EST
in developed countries
in other developing countries
Domestic Supply of EST
distribution within and between organizations
extension
liberalization of domestic markets
links between private and public sector
Domestic EST
Public support mechanisms
ODA
International conventions
Export promotion
Private transfer mechanisms
FDI
Direct purchase
Licensing
Joint ventures
PPP
Equity investment
Supply of forest- related ESTs in developing countries
EST transfer
Demand of forest-related ESTs in developing countries
EST benefits incl. profitability
Privatization and enhanced private-sector involvement

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).

## 4.2 Creating Demand for ESTs

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 developing countries is the perception that they will yield an economic gain for private enterprises; in the absence of 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 2002). In the public sector, financial returns are often more difficult to estimate, but improved performance defined in some other way is, the primary objective of EST acquisition, or at least it should be.

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 the macroeconomic framework) is that they reduce the risks and restrictions associated with the transfer of ESTs, increasing the flow of technologies close to the commercial margin. The public sector can also apply instruments (e.g., tax breaks and subsidies) to make those ESTs more attractive that would provide a net social benefit but are not profitable or economically viable.

Privatization is a major trend in developing countries and it is expected to give a direct boost to the demand for ESTs, 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 US$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).

### 4.2.1 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. Forest management especially 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 forests (especially drylands) benefits 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 actions:

- 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.

### 4.2.2 Legal and Regulatory Framework

One of the main reasons for low demand for ESTs 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. An appropriate regulatory framework can, however, be an effective instrument in promoting demand for ESTs. Stronger regulations and improved enforcement would increase the cost of non-compliance and strengthen the demand for ESTs. 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 countries, 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 ESTs. 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, the fiscal revenue potential for the government and the 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 the socialist economies of China and Vietnam, the reduction in 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, since industrial activities are easier to control than forest management. Production is concentrated in 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 the promotion of EST transfer (e.g., financing). In spite of the fact that legislative and resource allocation decisions are made at 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 actions:

- 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.

### 4.2.3 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 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 1999). 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 to 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. SMEs are especially 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 on the opportunities and limitations of ESTs in the forest sector. There is evidence that, for example, 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 end. The significance of R&D has been accentuated by the shorter commercial life-cycle of products (Hoffman 1999). It is equally important for SFM and the 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 of natural resources is crucial. Setting overambitious targets should be avoided, and many smaller countries with weak R&D institutions would be better off focusing 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 from first having mastered existing technologies developed by others. Stepwise progress towards more ambitious targets ensures that research efforts will produce tangible results within a 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 generally 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). In comparison, the allocation for research in agriculture 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 the 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 and 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 a 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 the development of ESTs. However, the emergence of collaboration arrangements is highly desirable, and any initiatives in this regard should be strongly supported.

As a 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 the work in this area by 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. 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 the 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.

### 4.2.4 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 have 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 role of governments could 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, past experience suggests that the demand for general data, for example, in technology databases is limited (e.g., FAO in logging). Instead, enterprises require specific, needs-based information on ESTs and frequently 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 include acting as a local agent for potential licensers; locate potential users, purchasers, or licensees for ESTs; and facilitating licensing or investment arrangements between buyer and seller. (e.g. TERI 1997, UNIDO 2000). In some instances, they may also help in the 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 an "Investment Promotion Entity" that unfortunately did not take off due to a 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 operate in slightly different environments and serve 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 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 extension services or the mass media. In many cases, however, forestry extension services are poorly developed, and an alternative approach would be 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 for the public sector intermediaries to 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. This approach holds a lot of promise, but there is little experience in this area. The potential weaknesses are the difficulty in maintaining the 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:

- The FAO Forestry Program
- The UNFCCC Technology subprogram
- The UNEP/DTIE International Environmental Technology Center (IETC),
- The UNEP International Cleaner Production Information Clearinghouse (ICPIC)
- The UNIDO Cleaner Production (CP) Program
- The International Center for Environmental Technology Transfer (ICETT) (Japan)
- The APEC Virtual Center for Environmentally Sound Technology Exchange (APEC-VC)
- The Asia 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 1.)

**Box 1. Sustainable Alternatives Network (SANet)**

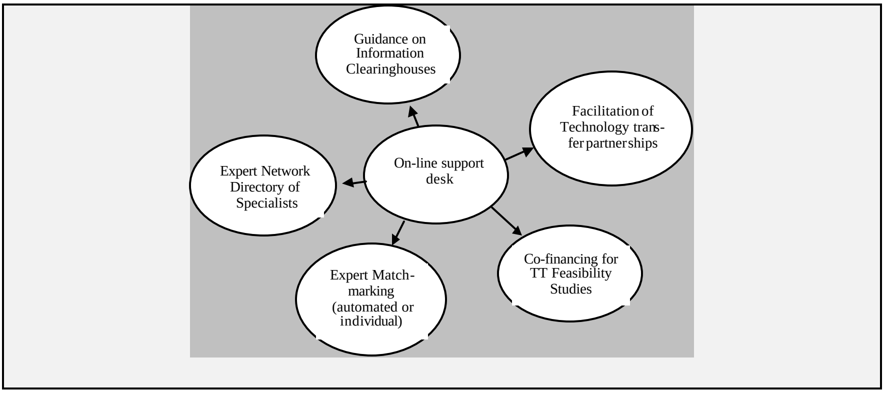
The Sustainable Alternatives Network (SANet) is a partnership between the United Nations Environment Program (UNEP) and the Global Environment Facility (GEF). Contributing partners are the World Federation of Engineering Organizations (WFEO), the International Federation of Consulting Engineers (FIDIC), 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.

### 4.2.5 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) primarily in Europe. In addition, pressure on the image of a firm 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 their 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 obviously not 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 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. 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 ESTs. 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 ESTs.

Recommended actions:

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

### 4.2.6 Voluntary Instruments

The importance of, and the need for, technical standards and codes of conduct have been well recognized by the technical community. Where standards and codes are 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) the ISO 14000 series, which relates specifically to the environment; and (ii) ISO 9000 series, which relates to 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 ESTs and their impacts. C&Is have a comprehensive scope which renders them somewhat cumbersome in assessing the impact of individual ESTs, 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 developing countries have expressed concerns that they may constitute barriers to trade. This issue can be overcome if forest management standards are developed nationally within relevant regional or international C&I frameworks 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, including 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 of 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 actions:

- 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

## 4.3 Supply of ESTs

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 analysis deals with factors affecting the international availability of ESTs, and as well as domestic barriers.

### 4.3.1 Internationally Supplied ESTs

Currently, the bulk of internationally available ESTs come from developed countries. The supply is concentrated in a 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 the 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, great promise and provides support to emerging initiatives that may yield high returns.

The research on ESTs in 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 created by improved environmental management using ESTs. 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 about their opinion is at any rate valuable. As there are few alternatives for the involvement of the private sector, their interest can also be seen as a litmus 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 the public and private sectors; opportunities to encourage South-South transfer should be seized; special attention should be paid to the 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 ESTs to developing country conditions and promote the involvement of the private sector in their development and distribution.

### 4.3.2 International Access to ESTs

Trade liberalization is a major trend in international markets. Reduction of tariffs on technology (machinery and equipment) and removal of other trade barriers will increase the supply of ESTs to developing countries. In some instances, however, it may have a reverse effect. In the past, companies in 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 the competition (e.g., Juma 1994). Developing country governments have often limited resources to support domestic production. However, governments often have opportunities to foster 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.

Intellectual property rights 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 is owned and continues to be generated by the industrialized world. Not surprisingly, their governments and companies tend to be proponents of strong IPR protection. Developing country governments often hold the opposite view. For instance, in the discussions under the UNFCCC process, the Group of 77 and China countries has 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 the application of traditional forest-related knowledge could also be subject to IPRs (Box 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 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 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).

### 4.3.3 Domestic Supply of ESTs

The issues related to the 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 the international transfer of ESTs constrain domestic diffusion. These include weaknesses in the macroeconomic framework, the high initial cost of EST investments, lack of information, etc. One barrier that often is specific to domestic markets in 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 the 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. Companies usually acquire ESTs to gain a competitive edge and are unwilling to share their experience with others. Thus, while FDI is an effective mechanism for bringing ESTs 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” 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 ESTs. 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 ESTs 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 mechanisms 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 investments to promote EST adoption.

## 4.4 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 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.

### 4.4.1 ODA

The overall amount of public funds for developing 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. From 1997 to 2003, the private sector flows were 3 to 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, the Middle East and North Africa, South Asia and Sub-Saharan Africa show the highest dependence on public sector flows (World Bank 2003).

The amount of ODA to forestry rose until the 1980s but has since then fallen modestly; 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 the country level, and technology partnerships, which would directly impact on the transfer mechanisms.

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, 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. However, an adequate definition could probably be developed by excluding technologies that have an environmental impact only through increased productivity. Only the ones that are preventive, corrective and mitigating, etc. in addressing 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

### 4.4.2 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 are, 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 the 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.

### 4.4.3 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 the 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 of the benefits of adoption of forest-related ESTs.

### 4.4.4 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 the 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 a 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) under the Kyoto Protocol (Box 3). The CDM is essentially a market mechanism and offers opportunities mainly for the private sector with 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 the public sector could also contribute to this end. There are already several such funds, including the Prototype Carbon Fund, Community Development Carbon Funds, the Biocarbon Fund, CERUPT, and ERU-PT. The first three funds are managed by the World Bank and the last two ones by a Dutch government organization. These funds also act as intermediaries.

**Box 3. 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 include:

- Favoring the diffusion of ESTs in developing countries, which do not wish to subscribe to national targets on GHG emissions;
- Accelerating R&D on ESTs particularly appropriate for developing country conditions; and
- Raising 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 the capacity to be able to mobilize a substantial amount of funds. It is estimated that commitments by institutional purchasers to acquire carbon credits reached 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 and 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 the 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.

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 ESTs.

*Technology partnerships*

Technology partnership programs are another form of cooperation between the private and public sectors. It involves collaboration among 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 developing countries, weakening the basis for mutually beneficial relationships.

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 for enhancing financing to the private sector will contribute to EST transfer in the forest sector; the possibility to establish regional intermediaries targeting specifically 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.

### 4.4.5 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 were 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 the 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. High capital-intensive pulp and paper industries especially benefit from FDI.

There have been concerns that FDI and 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 of 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, ESTs are usually not a separate investment. It is transferred as “part of the package”, which is competitive on a 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 ESTs, a strong regulatory framework has to be in peace. 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. The 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 of 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. ICT 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 actions:

- 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 ESTs.

### 4.4.6 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, between USD 100 and 200 billion annually, 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., 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 ESTs. (OPIC 1999).

Recommended action:

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

# PART III: ENVIRONMENTALLY SOUND TECHNOLOGIES IN PRACTICE

## 5. SELECTED ENVIRONMENTALLY SOUND TECHNOLOGIES

### 5.1 Reduced impact logging in tropical forests

*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; and
- 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, and
- 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.

***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.

***Barriers***

Despite considerable efforts 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.

## 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 the forest sector has been quick to take advantage of the new opportunities. Remote sensing (using aerial photos, satellite imagery, laser, and video) is routinely used in forest resources 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, 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 areas 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; and
- 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.

### *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.

***Barriers***

GIS and remote sensing have been substantially promoted in 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; and
- restricted capacity to support remotely located units (in-house & commercial services) making it difficult to reach the "critical mass" of data users.

## 5.3 Bioenergy

Biomass contributes significantly to the world's energy supply, accounting for about 9 to 13% of the total. It is particularly important in developing countries, where it represents on average one-third to one-fifth of 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 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. (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. (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 for 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 to 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 for the potential of all renewable energy sources indicate that they could contribute 20 to 50% of energy supplies in the second half of the 21st century (Turkenburg *et al*. 2000).

### *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 (Turkenburg *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, eucalyptus) 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.

***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.

## 5.4 Pulp and paper production

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 developed 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), and
- chorine-free bleaching.

Unfortunately, very few of these technologies were adopted in developing countries. In the 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, shifting 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 the use of chlorinated compounds and 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; and
- *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).

### *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 a 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 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).

### *Barriers*

Environmental investments in the 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 an unfavorable economic environment. Typical problems in developing countries include the following.

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

Attracting FDI is constrained further, if the country in question (a) has small market size, (b) lacks 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 a high relative cost; it would be 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 the 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.
- A 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, as well as a 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.

## 5.5 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* (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; and
- *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 value added from pulping by 15 to 20%, and the benefit from reduced lignin content could be of the same order of magnitude. It is estimated that the introduction of a herbicide resistant gene in the seedlings could reduce the initial establishment 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 de-inking.

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).

### *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. Furthermore, the forests' ability to sequester carbon and other GHGs to mitigate the build-up of atmospheric green house gases could be enhanced through biotechnology (Sedjo 2001).

However, it is acknowledged that the 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 a very late stage (Botkin 2001).

In the 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).

***Barriers***

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

- 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 for developing an appropriate policy and regulatory environment
    - Inefficient and inexperienced public institutions to regulate and promote biotechnology
    - Lack of technical knowledge in the 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, resulting in a disincentive for the business sector to make investments in biotechnology that only provides environmental benefits
- Public policies that accord low priority for environmental investments not yielding parallel productive gains
- Public opinion concerned about negative environmental impacts of biotechnology, aggravated by inadequate policy and legal frameworks for biosafety

# 6. CASE STUDY: TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES FOR MANGROVE FORESTS

## 6.1 The state of the world's mangrove forests

Mangroves are tidal forests that have important functions as natural sea defenses, nurseries for fisheries, and habitats for biodiversity. Global climate change and the associated risks of sea level rise and extreme weather events have further underlined the importance of mangroves as a buffer protecting coastlines in the tropics and sub-tropics. Unfortunately, the catastrophic effects of the destruction of these important forest ecosystems have been recently illustrated by the Indian Ocean Tsunami of December 2004 and Hurricane Katrina in 2005. Nonetheless, mangroves worldwide have been subjected to a precipitous destruction resulting from over-harvesting for timber and fuel wood, clearing for shrimp farms, agriculture, coastal development and tourism. It is estimated that 50% of the planet's mangroves have been destroyed, making them one of the most endangered and ignored ecosystems in the world.

Approximately two thirds of the world's population lives within 100 km of the coast. Two thirds of all cities with over 2.5 million inhabitants are located along the coast. All these are dramatically increasing the pressures on coastal habitats and their resources, and the negative effects of ill-planned tourism, urbanization, industry, agriculture, forestry, aquaculture, hydrological changes - and the concomitant commerce and transport-related activities which grow with them - all impact on the sustainability of mangrove forests around the world.

Mangrove forest are restricted mainly to the tropics (between 30° S and 30° N) and extend beyond to the north in Bermuda and Japan, and to the south in Australia and New Zealand. There are two main centers of biodiversity: the eastern group, richer in species, occurs in the Indo-Pacific (Eastern Africa, South Asia and the Pacific), and the western group which is centered on the Caribbean and includes the west coast of the Americas and Africa (Spalding et al. 1997). The Food and Agriculture Organization (FAO) of the United Nations has recently established a mangrove area database with historical and recent references on the extent of mangrove areas in a total of 120 countries. Of these 120 countries, 18 have some 80% of the estimated 180,000 km² of the world's mangrove forests. The four countries with most mangrove areas are Indonesia, Brazil, Australia and Nigeria. Presently, over 15 million ha of mangrove wetland are under protection and sustainable use as part of the Ramsar Convention on Wetlands (Bacon 1997).

## 6.2 The challenges facing sustainable use of mangrove forests

Increasing habitat destruction and ecosystem alterations by physical, chemical or biological means constitutes the most widespread – frequently irreversible – human impact not only to mangrove forests but also to the whole coastal zone and its resources (GESAMP and ACOPS 2001). There are six main types of human activities which negatively impact on mangrove forests: (i) overexploitation by traditional users; (ii) conversion of mangrove land for agriculture and aquaculture; (iii) destruction caused by coastal development; (iv) changes in sediment flows; (v) pollution; and (vi) oil prospecting and exploitation. In addition, mangrove forest located at the periphery of metropolitan areas are being increasingly used for solid waste disposal, a very specific activity which is considered as one of the major causes of permanent destruction of mangrove forests (Lacerda et al. 2000). The negative effects of all these activities have been documented in virtually all countries having major mangrove forests. A few examples are provided below.

Mangrove forests are directly harvested mainly for fuelwood - especially for charcoal making, in particular along the coasts of Southeast Asia, and Central and South America. Although timber production from mangrove forests continue to be minor in comparison to that from other types of forests, in a local scale it has been and remains to be important to local communities for house and boat building (mainly in South and Southeast Asia). Mangrove forests are heavily exploited for, *inter alia*, firewood (West Africa, Latin America), fishing stakes/poles (Southeast Asia, Central America), wood chips and pulp (Bangladesh, Indonesia, Malaysia), and tannin (South and Southeast Asia, Latin America).

Particularly in Asia, large extensions of mangrove forests have been cleared for agriculture purposes (e.g., rice farming, coconut, oil palm). However, aquaculture expansion has played a major role in the destruction of mangrove forests all over the tropics and the conversion of mangrove areas into shrimp ponds represents one of the major threats to mangroves in many countries. An estimated 3 million hectares of mangrove forests in Southeast Asia (particular in Bangladesh, the Philippines, Vietnam, Thailand, Japan and the Mekong basin) have been destroyed mainly by aquaculture-related activities (UNEP 2000). It has been estimated that, to date, approximately 1-1.5 million hectares of coastal lowlands worldwide (comprising mainly salt flats, mangrove areas, marshes and agricultural lands) have been converted into shrimp ponds (Paez-Osuna 2001).

Poorly planned coastal urban and industrial development has changed and reduced areas previously covered by wetlands and mangroves all over the tropics and represent the single main threat to mangrove forests worldwide. The construction of harbors, tourism facilities, urban and industrial development, airports and power plants without proper planning and environmental impact assessment have destroyed extensive areas of mangrove forests. Also, deforestation, coastal erosion, increasing saline intrusion, nutrient depletion and sediment accretion caused by damming and diversion of rivers have a significant impact on mangrove forests and their resources (Lacerda and Marins 2002, Botero and Salzwedel 1999). Rivers are diverted for various purposes, such as preventing flooding of urban, agricultural and livestock-used lands, and for irrigation purposes. Pollution from untreated or inappropriately treated discharges of domestic and industrial wastewater, and chemicals used in agriculture not only affect mangroves but also threaten the health of coastal human populations. On the other hand, the construction and use of boardwalks (used in mangrove management since they are thought to solve problems of access by people while promoting recreational and educational opportunities) and the people using them may have negative impacts on the mangrove ecosystem (Kelaher et al. 1988).

The negative effects of human activities on the coastal environment primarily stem from two sources (GESAMP and ACOPS 2001): *poverty* (frequently associated with excessive population pressure on natural resources) and the negative effects of *economic and social change* (these changes increase the demand for scarce natural resources, while consumption patterns in industrialized countries add pressure to natural resources in less developed countries). Institutional failure allows these factors to have a much more powerful effect, particularly when governments are unwilling or unable to correct the market failures that occur when markets do not fully reflect the value of the resources. This is particularly true for mangrove forests (see below). Allocating resources through the establishment of property and use rights is thus fundamental to overcoming market failures.

The need that coastal developing countries have for generating urgently economic revenues has led to an increase in activities/practices that negatively impact coastal ecosystems, including mangroves, but which also have serious socio-economic implications for local human populations in particular (GESAMP and ACOPS 2001). Increased internal human migration to the coast, coastal development, urbanization, tourism, aquaculture, among others, have not only increased the demand for more space, jobs, freshwater and food - many times at the expense of natural habitats and by displacing local inhabitants and altering their way of life - but they have also brought greater requirements for municipal and industrial wastewater treatment, augmented pollution and the destruction and modification of critical coastal habitats. All of these are compounded by the economic hardship brought about to many poor countries by natural environmental disasters such as hurricanes and floods.

Thus, it is not surprising that the conservation and sustainable use of mangroves is heavily dependent on how successful we are in ensuring a cross-sectoral and integrated management approach involving all major sectors. Conflicts related to land/resource uses negatively affect the sustainability of the various sectoral plans using the coast and its resources.

Given the cross-sectoral nature of mangroves, coordination of efforts and clear distribution of responsibilities among the various concerned government authorities, both at the national and local level, are also critical to ensure the sustainable management of mangrove forest products and services. In many countries it is still not clear under which government department, ministry or institution mangrove forests are handled and the resulting overlaps in bureaucracy, competition for resources, power and sometime conflicting policies among these authorities have a great impact on how the sustainable use of mangrove goods and services is approached.

Transfer of ESTs among developing countries is becoming increasingly important but, in the particular case of mangrove forests, is still very limited. However, there is a great wealth of knowledge on ESTs in South and Southeast Asia and in many Latin American countries which could be made available within and outside these regions. Consequently, technical cooperation among developing countries needs a much more coordinated effort and stronger national, regional and international support so that its potential can be properly used.

## 6.3 Technologies for the sustainable management of mangrove forests

### 6.3.1 Forest resource assessment and science

Remote sensing is being increasingly used to quantify the decline of mangrove forests. Satellite imagery and GIS can play an important role in the management of mangrove forests and of other natural resources, by assisting in acquiring and processing data which allows the mapping of large areas, preparation of inventories and for addressing key issues. These data, combined with geo-referenced data from other sources (e.g., socio-economic) allow more comprehensive, multi-sectoral analyses in support of management decisions. Satellite imagery is a cost-effective technique. It provides access to synoptic and up-to-date information for the mapping, illustration and modeling of natural and human-induced events (e.g., regular felling, illicit felling, forest fires, reforestation and regeneration). GIS can be used to monitor the impacts of deforestation, and to plan the timing and type of timber management practices based on information on soil types, species requirements, growth and yield.

Compared with information acquired by traditional methods, data obtained from remote sensing offer a number of advantages, including: (i) satellite imagery can cover vast expanses of land (thousands to tens of thousands of $km^2$ on one image) and it can be acquired regularly over the same area and recorded in different wavelengths, thus tracking the state of forest resources; and (ii) satellite data can be acquired without encountering administrative restrictions. GIS provides a means of converting spatial data into digital form that can then be displayed, manipulated, modified and analyzed and reproduced quickly in a new format, available for either visual display or hard copy reproduction. Conventional (paper) maps, in contrast, are time-consuming to prepare manually, and the display and analysis of changed data or the comparison of more than one set of map data (e.g., soil and vegetation) requires additional manual labour. The digital data can also be easily transmitted from one user to another or from one GIS to another merely on disk, tape or by the Internet. As digital maps come into wider use, many users can share the cost of digitizing. In fact, some digitized maps on CD-ROMs cost less than the same maps on paper. As networks and libraries of databases grow, information exchange should reduce the need for redigitizing regional or national maps and other geographic databases than are in common use.

In summary, remote sensing and GIS-based forestry studies can generate results that can be directly used in forest management planning (Dahgouh-Guebas, undated). Applicable findings (when focusing on vegetation layers of different age) can for instance include the prediction of future changes in mangrove forests. In addition, combination of these data with local and global ecosystem data (e.g., biological, hydrological, physicochemical, geographical), socio-economic or socio-geographical data allows to assess future changes under different scenarios (e.g., exploitation, conversion, natural catastrophes, sea level rise) and to adopt conservation strategies by interfering appropriately.

Given that it is widely recognized that the natural regeneration of mangrove forests should be the first choice of any rehabilitation program unless there is irrefutable evidence that it will be unsuccessful (Field 1996), the understanding of mangrove vegetation structure dynamics in a particular area is a prerequisite to the development and successful implementation of conservation and management measures, such as the establishment, protection and management of re-afforestation plots in the framework of regeneration projects. There is a need for a methodology that allows to express reliable predictions about the state of mangroves using a relatively small input from vegetation field work, and to decide whether a mangrove stand at a certain location has the potential to successfully renew and rejuvenate or whether anthropogenic pressure renders human interference such as restoration imperative (Gahgouh-Guebas, undated). Baseline ecological studies, monitoring and assessment of undisturbed mangrove forests and their comparison with more degraded and rehabilitated mangroves remain important to support management and conservation strategies, including the valuation of mangrove ecosystem good and services.

Considering the cost, time constraints and logistics involved in surveying and monitoring mangroves in the field, the most appropriate approach is to take advantage of both field surveys and remote sensing technologies (FAO 1994). There are considerable difficulties to evaluate the potential and sustainability of wetlands and mangrove areas. They are a dynamic environment affected both seasonally and annually by variable climatic conditions and, consequently, their surface area is also in a dynamic state and, therefore, difficult to calculate accurately. A second problem is one of accessibility. The very nature of wetlands provides a problem of marshy ground and dense reed beds. Access via foot, land transport or boats is often restricted by such circumstances. In addition, wetlands are often quite large, covering areas of tens of thousands of square kilometers. This, combined with the above factors, leads to the conclusion that a ground survey can often be difficult, time consuming and economically prohibitive. Thus, the use of satellite data, combined with field surveys, facilitates the monitoring of wetlands (Travaglia and Macintosh 1996).

### 6.3.2 Management systems

Table 1 illustrates the advantages and disadvantages of various mangrove management systems. Given their cross-sectoral nature, any envisioned management strategy of mangrove forests should take into account the present and potential uses and users. Those alternatives include: preservation (extraction of forest products is not allowed), subsistence forestry (which recognizes the dependence of coastal communities on mangrove products such as fuel wood, charcoal and timber for fences and posts, and the management of the forest will be the responsibility of the communities themselves), and commercial forestry. Ecological characteristics of mangroves are in general fairly well known, but detailed information is needed on local and regional variations. This is important in discussing socio-economic aspects of human settlements because mangroves have hinterlands with a great diversity of natural and socio-economic environments which exert a strong influence on ecological processes and human activities within the mangroves.

Table 1. Characteristics of mangrove management systems (Kunstadter et al. 1996)

| | | | |
|---|---|---|---|
| Yield | Relatively low | Temporarily high, then declining | Moderate to high |
| | **Traditional systems** | **Transitional systems** | **Ideal developed systems** |
| Net productivity | Self-sustaining | Extractive | Self-sustaining, with inputs for restoration |
| Population | Small, slow growth, little net migration | Rapid growth, net in-migration | Large, slow growth, little net migration |
| Purposes | Multi-purpose | Often single-purpose | Multi-purpose |
| Knowledge | Local, detailed, traditional | Technical, general | Scientific, local, detailed, general |
| Technology used for management | Simple, low use of machinery and chemicals | Increasing use of machinery and chemicals | High use of machinery and chemicals |
| Management objectives<br>Method of control of exploitation | Subsistence in perpetuity<br>Customary behaviour and values supported by local moral community | Profit, poorly enforced laws and international regulations, loss of moral community | Profit and sustainability, national and international regulation, and international moral community (e.g. control |
| Use of resources | Largely local | Increasingly national and international | Local, national, international |
| Employment | Self-employed, local | Corporate, remote | Self-employed and corporate |
| Economic-system boundaries | Largely self-contained, involving trade and barter | National and international, commercial | National and international, commercial |

| | | | |
|---|---|---|---|
| | | | of trade in endangered species) |
| Pollution | Local, biodegradable, chemically non-toxic, minor, micro-biological pollution may be effectively controlled by dilution | Local and regional, bio-degradable and non-biodegradable, non-toxic and toxic, major (oil, agricultural and industrial chemicals), poorly controlled, with danger of secondary spread by marketing | Full range of potential sources and types, actively controlled |

Given the rapid and increasing rate of destruction of mangrove forests throughout the world, the development and implementation of mangrove-related ESTs, including effective replanting techniques and procedures, are becoming increasingly important (Stubbs and Saenger 2002). Mangrove forests can be considered as a particular case of an estuarine environment and the continuity and interdependence of riverine, estuarine and marine environments is a biological reality for coastal fish resources; thus, the management of their resources has to be integrated and go beyond the frequent division of responsibilities between inland and marine/coastal fisheries management bodies (Baran and Hambrey 1998).

Restoration and impact mitigation projects, which incorporate appropriate ESTs, have become one of the main ways to cope with destruction or degradation of wetlands, in particular, of mangrove forests, and the number of these initiatives has increased in recent years (Botero and Salzwedel 1999). Between 1970 and 1998, only 20 of the 121 countries with mangrove forests have attempted the rehabilitation of mangroves, and only nine countries have planted more than 10 $km^2$, and they have done so with various degrees of success (Field 1998). However, few of these projects have been sufficiently well monitored, limiting the availability and thus the use and transfer of lessons learnt. There is already a great deal of knowledge and experience in technologies for rehabilitating mangroves by artificial means around the world; however, many of these efforts are being carried out without taking into consideration the experience and lessons learnt from similar projects which have lead to duplication of efforts and waste of resources.

### 6.3.3 Marketing and trade

Well-managed charcoal industries using mangrove wood (e.g., based on sustainable supplies) can contribute to the well being of coastal rural populations. If charcoal is produced efficiently and marketed competitively it can serve the needs of local consumers (e.g., by contributing to reduce their over-dependence of rural populations on non-renewable fossil fuels) and even be exported. Access to credit and finance (through, for instance, the establishment of partnerships with the private sector) to improve carbonization methods and capacity building of personal are needed (FAO 1994).

Certification can contribute greatly to the sustainable management of mangrove forests, but cannot work effectively without government support and input. Certification was developed as a mechanism to substitute for national and international processes, which had failed, and these were the responsibility of national Governments (Certification Information System, undated). Governments can play a significant role in improving the system of certification and in making it more efficient, by *inter alia*: (i) facilitating multi-stakeholder involvement in defining standards and procedures; (ii) ensuring consistency within government (e.g., between different departments or Ministries); (iii) ensuring compatibility with law and international obligations, and contributing to the framework for international compatibility of certification; (iv) supporting research and trials in certification of mangrove forest products; (v) monitoring the impacts of certification on mangrove forests, stakeholders and trade – especially as there is very little evidence of this impact; (vi) submitting government forest enterprises to certification; and (vii) using government monitoring and audit systems in certification.

**6.4 Enabling investing environment**

Mangrove forest stakeholders can be, in principle, divided into three categories (Franks and Falconer 1999): primary stakeholders (those whose livelihoods are directly dependent on mangrove resources, e.g., fishermen, paddy farmers, charcoal makers), key stakeholders (those whose actions directly affect decision-making in the mangrove forests, e.g., developers, government officials) and secondary stakeholders (those who have an interest in the mangrove forests, but no direct involvement, such as tourists and traders). Cooperation and trust among all these three categories of stakeholders is essential for any sustainable exploitation scheme to succeed on a long-term basis.

The participation of the private sector in the transfer of ESTs relevant to mangrove forests is still meager. Given the long gestation and risks associated with forest-resources investment, attractive incentives are needed to stimulate the active participation and involvement of the private sector. Improving the enabling environment to encourage private sector investments in all aspects related to sustainable forest management, including transfer of ESTs, would require efforts by the public sector to, *inter alia* (Chipeta and Joshi 2001):

- avoid excessive and inappropriate regulations and bureaucracy which increase costs;
- ensure stable and clear policies, institutional and operational environments;
- have adequate government commitments to, and support for, the forestry sector, and provide public incentives and investment in public infrastructure;
- seek ways for a augmenting the competitiveness of forestry as an investing option;
- develop instruments to hedge excessive market fluctuations and seek mechanisms for achieving better prices in international markets;
- seek ways to deter major markets from buying low-priced products supplied from unsustainable sources that unfairly

undermine responsible suppliers committed to achieving sustainable forest management;

- ensure training and skills development and research in the forestry sector;

- seek the political stability necessary to assure investors.

# PART IV: THE WAY FORWARD

## 7. SETTING PRIORITIES FOR ACTION

### 7.1 Technology Assessment at the National Level

The 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 have often prejudiced the choices 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.

The 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 the 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 ESTs. The actual impact under prevailing constraints may be substantially less than the potential one achievable only under ideal conditions (Fig. 1). Constraints are found both outside and inside the forest sector, and it is realistic to assume that only some 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 and 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 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).

## 7.2 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, 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 for the analysis.

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 the 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 it should be considered a 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 oftentimes is not direct conversion of forest into agricultural land; instead, conversion frequently 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 social, economic and environmental benefits. Tree breeding and biotechnology play a key role in this endeavor. The participation of the private sector in relevant R&D is unlikely, owing to the limited purchasing power in the potential market among small holders.

*Reducing the cost of forest monitoring.* Lack of relevant and up-to-date information on forest resources is a major constraint for the formulation of appropriate policies. The 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, for example,, 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 individuals such as improved stoves, and support from the public sector would be justified. However, 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 to the LDCs, which currently have trouble benefiting from market-based EST transfer. In a 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.

## 8. RECOMMENDATIONS FOR PROMOTING THE INTERNATIONAL TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES

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 ESTs (hardware, software, services)
(v) Contributing to the development of appropriate regulations for IPRs
(vi) Enhancing SMEs' access to investment financing with priority on ESTs
(vii) Exploring the opportunities to introduce fiscal and financial incentives for private enterprises to adopt ESTs
(viii) Establishing micro-credit schemes linked with ESTs available to communities
(ix) Removing monopolies, oligopolies and other market imperfections restricting the domestic supply of ESTs

***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:

(i) *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 ESTs with social and environmental benefits that cannot be captured through market mechanisms.

(ii) *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.

(iii) *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.

(iv) *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 ESTs. Incorporation of environmental criteria in agreements made between the public and private sectors provides substantial incentives to increase EST transfer.

(v) *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.

(vi) *Providing technical and financial support to the transfer of specific ESTs*. The main vehicle for supporting EST transfer in the forest sector will be projects integrating ESTs 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.

(vii) *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 judgments. To reduce the possible bias due to the subjective views of business and political interests, it is advisable that such processes are carried out in a participatory and transparent manner involving all relevant stakeholders.

(viii) *Integration of ESTs into national policies*. Policies for EST transfer should be formulated as part of comprehensive sector strategies such as national forest programs (NFPs), 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.

## 9. CONCLUSIONS

Technology is a central ingredient of economic growth. Environmentally sound technologies help mitigate the environmental impacts of growth. Developing countries that are most dependent on imported technologies have difficulties in benefiting from global technology flows that are predominantly within the private sector in the industrialized world. Environmentally sound technologies have great potential to contribute to sustainable forestry and forest industries. Despite the political emphasis given to technology transfer, the obstacles are persistent.

This study identified barriers and potential technologies as well as recommendations on how to create enabling conditions for the successful and sustainable transfer of ESTs. It suggested approaches for improving EST transfer for SFM. It provided also an overview of international processes and agreements relevant to environmentally sound technologies (ESTs) for sustainable forest management (SFM), including a special chapter on mangrove forests

The majority of international processes for sustainable development and multilateral environmental agreements contain clauses addressing technology transfer. The most important multi-lateral environmental agreement with references to technology transfer in forestry is the United Nations Framework Convention on Climate Change, which has direct implications for the forest sector. The Convention on Biological Diversity, the Convention to Combat Desertification and various agreements of the World Trade Organization also address technology transfer. IPF and IFF have prepared proposals for action related to the transfer of ESTs in the forestry sector, which are now being followed up by the UN Forum on Forests.

The framework developed by Puustjärvi et al. emphasized the need to view barriers to the successful transfer of ESTs using a demand-supply based systems approach. They stated also that analysis of barriers, including action aimed at improving EST transfer, should make use of the division of barriers to those specific to ESTs in general, general barriers within the forest sector, and general barriers outside forest sector. Regarding an enabling environment for EST transfer, most existing barriers are not specific to ESTs or the forest sector. Instead, they result from international agreements (e.g., WTO agreements) or national policy or macroeconomic frameworks (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 ESTs, 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 administrations 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 the private sector in EST transfer to make best use of the opportunities provided by privatization, the 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 of eroding cost-efficiency and using 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 the transfer of specific ESTs
(vii) EST assessments
(viii) Integration of ESTs into national policies and national forest programs.

The analysis of mangrove forests illustrated that the general framework for EST transfer captures the barriers inhibiting transfer of technologies important for this very specific ecosystem. The specific nature of mangrove forests stresses the importance of technology assessment and demonstrates the important role of South-South transfer and indigenous technologies. It is likely that the framework outlined in this study for improving technology transfer will benefit especially the management of ecosystems like mangrove forests and help sustain the various economic, social and ecological benefits that they provide.

As Puustjärvi et al stressed, technology transfer is not capable of halting deforestation by itself. Environmentally sound technologies may not be sufficient, but they are absolutely a necessary precondition for sustainable development. Many of the impediments for ESTs need to be looked at in a broader framework. Sectoral policy coordination is of course a starting point and EST policy formulation separate from, for example, the context of financing for SFM is hardly meaningful. However, forests have numerous linkages to other sectors of society, and policies beyond the control of the forest sector have often implications for the preconditions of SFM. Sustainable forest management contributes to poverty eradication, food security, safe drinking water and numerous other development priorities. Therefore, it is important to recognize technology transfer in the development policy framework. Technology transfer continues to be a challenge for policy development.

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