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Jukka Loikala, Santtu Hulkkonen, Sudarshan Itkyal, Ashok Kaushik, Seppo Keränen, Riitta Nisula, Ulla Roiha, Helena Saren, Jonas Alam (Ch. 9.5), Pasi Kuusela (Ch. 9.5), Tho Phan (Ch. 9.5), Tuomas Rautanen (Ch. 9.5), Maija Saijonmaa (Ch. 9.5), Sampo Strand (Ch. 9.5)

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Preface

The objective of Sitra's Environmental Programme is to develop environmental technology and know-how into an important growth sector for Finland. The Programme also networks leading-edge and small and medium sized cleantech companies with interesting, growing markets. Sitra's India Programme, for one, is laying the foundation for better India know-how in Finland and assessing India's importance to Finland and Finnish companies. The India Programme also tries to promote mutually beneficial Finland-India economic cooperation – and environmental technology is certainly a sector where this can take place.

The Environmental and India Programmes' joint study analyses the opportunities for Finnish environmental technology companies in India. The report also describes the background of India's environmental issues and gives an overview of international and national funding possibilities from the perspective of India's environment and energy sectors.

Opportunities for Finnish Environmental Technology in India report gives an up-to-date cross-section of the opening opportunities from the perspective of Finnish companies. The report's technology sector reviews are based on the Environmental Programme's fields of interest.

The bulk of the report is produced by Finpro. However, Chapter 9.5 is produced by the Remburssi Association of International Business at Helsinki University of Technology. Both Finpro and Remburssi have collected material from interviews with governmental and municipal authorities, companies, financers and research institutions in India.

Chapter 9.5 is an In Focus section about the Clean Development Mechanism (CDM). The section is written to give an overview of the CDM in India from the point of view of Finnish Certified Emission Reduction (CER) purchasers and technology suppliers. Additionally, it clarifies the basics of

the CDM, which are generally not very well known and are often considered complicated.

We would like to offer our sincere appreciation to all of the contributors to this study.

Helsinki, May 2006

Vesa-Matti Lahti
Research Manager
Head of Sitra's India Programme

Jukka Noponen
Executive Director
Sitra's Environmental Programme

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Executive Summary

Opportunities for Finnish Environmental Technology in India report gives an up-to-date cross-section of the opening opportunities for Finnish Environmental Technology Companies and other bodies involved with environment in India. The study has been made by Finpro and (Chapter 9.5) Remburssi - the Association of International Business at Helsinki University of Technology.

Chapter 1 gives a country background on India. Chapter 2 presents the latest and most important national environmental reports and sector policies made by Indian authorities, presenting five topics and key priority environmental issues: 1) land degradation, 2) biodiversity, 3) air pollution control with special reference to vehicular pollutions, 4) management of fresh water resources, and 5) hazardous waste. Chapter 3 describes the most essential players of the environmental administration and policy framework. Chapter 4 gives an overview of Indian natural resources.

Chapters 5–10 review the six different technology sectors defined by Sitra. The desk study on each technology sector has been completed as field work in India in February and March 2006, by interviewing the most acknowledged and relevant experts of different authorities, municipalities, organizations and companies in India. Each sector has been reviewed from the perspective of the Finnish environmental offering as follows: Environmental Monitoring and Measuring (Chapter 5), Clean Technologies and Industrial Pollution Control (Chapter 6), Water Supply and Sanitation (Chapter 7), Solid Waste Management and Recycling (Chapter 8), Climate Change and Clean Development Mechanism (CDM) (Chapter 9) and Renewable Energy (Chapter 10). Additionally opportunities for Finnish Companies have been summarized at the end of each chapter.

Chapter 11 gives an overview of International Funding, and Chapter 12 of the National Funding, by representing the most potential international

financing institutions and national players funding India's environment and power sectors. A Project List detailing the World Bank and the Asian Development Bank financed projects on environment and power sector (status March 2006) is available from Sitra on request.

Chapter 13 summarizes the five most potential sectors for Finnish companies: 1) environmental monitoring and measuring, 2) clean technologies and industrial pollution control, 3) solid waste management, 4) renewable energy, and 5) climate change and the Clean Development Mechanism (CDM).

1 India

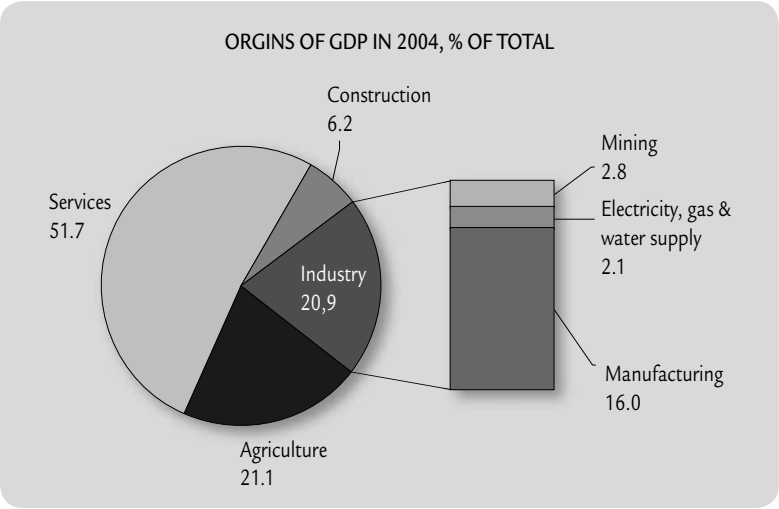
With a population of some 1,027 million people, India is now after China the second country in the world to surpass the one billion mark, making up 16.7% of the world's population. In 2001, India had 35 cities and urban areas with a population of more than one million people. The total surface area of India is 3,287,590 km^2. The country is administratively divided into 28 states, 6 union territories and a National Capital Territory. More information on India is available from data sources[1, 2].

India is mainly an agricultural country. The country also has a large iron and steel industry and India produces every type of manufactured goods. In the last few years information technology has become more and more important.[3] India has built up a diverse industrial sector, which is currently one of the largest in the developing world. The major industries are automobiles and auto ancillaries, iron and steel, food, aluminum, textiles and garments, pharmaceuticals, chemicals and petrochemicals, oil and gas and other hydrocarbons, electricity, telecommunications, information technology (IT) and Business Process Outsourcing (BPO) services, healthcare and biotechnology. The country is fast emerging as a leading sourcing base for global players in auto and auto ancillaries, pharmaceuticals, IT and BPO services, research and development and engineering services.[4]

The development of small scale industries (SSI) has been one of the major planks of India's economic development strategy since independence. The SSI sector occupies a place of strategic importance in Indian economic structure due to its considerable contribution in terms of output, exports and employment. By the end of fiscal year 2001–2002, there were 3.4 million small-scale industry units, accounting for more than 40% of the gross value of output in the manufacturing sector, about 35% of the total exports and provided employment to over 19.2 million persons, which is second only to agriculture.[5]

Figure 1 States of India.

Figure 2 Origins of India's GDP in 2004 (as % of total). [6]



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2 Reports on the State of Environment, Environmental and Water Policies

2.1 General

The purpose of the report reviews on the State of Environment India 2001 and specific environmental policies is to give a cross-section on the current status of the environment in India and highlight the environmental focus areas high-lighted by local authorities.

2.2 Report on the State of Environment, India 2001

2.2.1 Background

The National State of the Environment Report (SoE) of India 2001 aims at providing guidelines for environmental action planning, policy setting and resource allocation for the coming decades, based on a sound analysis of the state of, and trends in, the nation's environment. Through the Ministry of Environment and Forests (MoEF), the Government of India has played a very crucial role in carrying out this participatory assessment process in soliciting input from various government sector agencies. Around 25 agencies and 60 individuals were involved in the process. Essential findings are summarized below.[1]

2.2.2 Priority Key Environmental Issues

The SoE report has identified the five priority key environmental issues for India:

1. Land degradation
2. Biodiversity

3. Air pollution control with special reference to vehicular pollution in cities
4. Management of fresh water resources
5. Hazardous waste management.

Each above environmental priority issue is discussed in the following. The proposed strategies, recommendations, correcting actions and measures by topics can be found in the detailed report.[2]

2.2.3 Land Degradation

Land degradation, which occurs through the natural and man-made processes of wind erosion, water erosion, and water-logging, has been identified as one of the priority concerns in India. The result of such degradation is the loss of invaluable nutrients and lower food grain production. Poor land use practices and management are responsible for the rapid land degradation in India. Various strategies need to be developed by the Government of India (GOI) including policy intervention, promoting research and stakeholder participation, and technological intervention to check land degradation.[3]

2.2.4 Biodiversity

Loss of biodiversity is of great concern to India since many plant and animal species are severely threatened by the destruction of their habitat and over-exploitation of resources. A large number of species are either endangered or on the verge of extinction, both of which can be attributed to a lack of policy and institutional mechanism, including comprehensive policy guidelines for biodiversity conservation, biodiversity legislation, participation of communities, and a clear perspective on intellectual property rights leading to international patents on Indian biodiversity.[4]

2.2.5 Air Pollution with Specific Reference to Vehicular Pollution

Air pollution in India can broadly be attributed to rapid industrialization, energy production, urbanization, commercialisation, and an increase in the number of motorized vehicles. Vehicles are a major source of pollutants in cities and towns. Apart from the sheer numbers, other factors contributing to the increasing vehicular pollution in urban areas include the types of engines used, age of vehicles, density of traffic, road conditions, and the status of automotive technologies and traffic management systems.

2.2.6 Fresh Water Management

The availability of fresh water is going to be the most pressing problem over the coming decades. The stress on water resources is a result of multiple factors including urban growth, increased industrial activities, intensive farming, and the overuse of fertilizers and other chemicals in agricultural production. Untreated water from urban settlements and industrial activities, and carrying chemical run-off from agricultural land, is primarily responsible for the deterioration of water quality and the contamination of lakes, rivers, and groundwater aquifers.

The Government of India formulated the National Water Policy (NWP) in 1987 to provide top priority to drinking water supply and undertook the National River Action Plan to clean up polluted river stretches.

2.2.7 Hazardous Waste Management

There has been a significant increase in the quantities of municipal solid waste and hazardous waste generated in India over the last few decades. The largest quantities of hazardous waste are generated by the following industries: petrochemicals, pharmaceuticals, pesticides, paints and dyes, petroleum, fertilizers, asbestos, caustic soda, inorganic chemicals, and general engineering. The rate of generation of solid waste in urban centres has outpaced population growth in recent years with the wastes normally disposed of in low-lying areas of the cities' outskirts.

The Government of India has promulgated various rules and guidelines on the management and handling of hazardous waste. These rules are implemented through the State Pollution Control Boards (SPCBs) and Pollution Control Committees (PCCs) in states and the union territories.

2.3 Indian National Environmental Policy 2004

2.3.1 Background

The present national policies for environmental management are contained in the National Forest Policy 1988, the National Conservation Strategy and Policy Statement on Environment and Development 1992, the Policy Statement on Abatement of Pollution 1992 and the Wildlife Conservation Strategy 2002. Additionally some sector policies have also contributed towards environmental management such as the National Water Policy 2002.

The National Environmental Policy (NEP, 2004) is a response to India's national commitment to a clean environment.[5] It is intended to mainstream

environmental concerns in all development activities. It briefly describes the key environmental challenges which in future may face the country, the objectives of the environmental policy, normative principles underlying policy action, strategic themes for intervention, and broad indicators for legislative development needed to accomplish the strategic themes and mechanisms for implementation and review.

NEP 2004 is intended to be a guide to action: in regulatory reform, programs and projects for environmental conservation; and review and enactment of legislation, by agencies of the Central, State, and Local Governments. It also seeks to stimulate partnerships of different stakeholders, i.e. public agencies, local communities, the investment community, and international development partners, in harnessing their respective resources and strengths for environmental management.

NEP 2004 reviews the key environmental challenges, their causes and impacts, but also strategies and actions. A large number of such actions are currently under way. In some aspects new themes would need to be pursued to realize the principles and objectives. In the following section the proposed actions, connected to some selected themes, are reviewed shortly because they may be of interest for Finnish environmental companies.

2.3.2 Management of Fresh Water Resources

India's fresh water resources comprise the single most important class of natural endowments enabling its economy and its human settlement patterns. Fresh water resources comprise the river systems, groundwater, and wetlands. Each of these has a unique role, and characteristic linkages to other environmental entities.

River Systems

- Promote integrated approaches to the management of river basins by the concerned river authorities, considering upstream and downstream inflows and withdrawals by season, pollution loads and natural generation capacities; to ensure maintenance of adequate flows and adherence to water quality standards throughout their course and in all seasons.
- Consider and mitigate the impacts on river flora and fauna, and the resulting change in the resource base of livelihoods, of multipurpose river valley projects, power plants and industries.
- Consider mandating the installation of water saving closets and taps in the building byelaws of urban centres.

Groundwater

- Promote efficient water use techniques among farmers, such as sprinkler or drip irrigation. Provide necessary pricing, inputs, and extension support to feasible and remunerative alternative crops from efficient water use.
- Mandate water harvesting in all new constructions in relevant urban areas, as well as design techniques for road surfaces and infrastructure to enhance groundwater recharge.
- Support R&D in cost effective techniques suitable for rural drinking water projects for removal of arsenic and mainstream their adoption in rural drinking water schemes in relevant areas.

2.3.3 Pollution Abatement

Pollution is the inevitable generation of waste streams from production and consumption of anything. Pollution directly impacts the quality of the recipient medium, i.e. air, water, soil, or electromagnetic spectrum, and when this impaired medium acts upon a receptor, say a human being, it also impacts the receptor. In general, the impacts on the receptor are frequently adverse. Typically ecosystems have some natural capacities to assimilate pollution; however, these vary considerably with the nature of the pollutant and ecosystem. In general, it is cheaper to reduce the emissions of pollution, than to mitigate it after generation, or to treat the receiving medium or receptor. The impacts of pollution may differentially impact the poor, women and children, or developing regions, who may also have made relatively little contribution to its generation. Accordingly the costs and benefits of abatement may have important implications for equity.

Air Pollution

- Strengthen the monitoring and enforcement of emission standards for both point and non-point sources, with participation in monitoring by the local communities.
- Prepare and implement action plans for major cities for addressing air pollution for both point and non-point sources, relying on a judicious combination of fiats and incentive based instruments.
- Promote reclamation of wastelands by energy plantations for rural energy through multi-stakeholder partnership involving the land owning agencies, local communities, and investors.

Water Pollution

- Develop and implement, initially on a pilot scale, public-private partnership models for setting up and operating effluent and sewage treatment plants. Once the models are validated, progressively use public resources, including external assistance, to catalyze such partnerships. Enhance the capacities of municipalities to recovery of user charges for water and sewage systems.
- Enhance reuse of treated sewage and industrial wastewater before final discharge to water bodies.
- Promote R&D in development of low cost technologies for sewage treatment at different scales, in particular, replication of East Kolkata wetlands models for sewage treatment to yield multiple benefits.

Soil Pollution

- Develop and implement viable models of public-private partnerships for setting up and operating secure landfills and incinerators for toxic and hazardous waste, both industrial and biomedical; payment by users, taking the concerns of local communities into account.
- Develop and implement strategies for clean up of pre-existing toxic and hazardous waste dumps, in particular, in industrial areas, and reclamation of such lands for future, sustainable use.
- Strengthen the capacities of local bodies for segregation, recycling and reuse of municipal solid wastes, and setting up and operating sanitary landfills, in particular through competitive outsourcing of solid waste management services.
- Give legal recognition to, and strengthen the informal sector systems of collection and recycling of various materials; in particular to enhance their access to institutional finance and relevant technologies.
- Develop and implement strategies for recycling, reuse, and final environmentally benign disposal of plastics wastes, through different means, including the promotion of relevant technologies, and the use of incentive based instruments.

2.3.4 Climate Change

Climate change, resulting from anthropogenic emissions of a suite of gases (called "Green House Gases" or GHGs) due to fossil fuel use, certain agricultural and industrial activities, and deforestation, leading to their increasing conditions in the atmosphere, has the potential, over the next few generations, to significantly alter global climate. This would result in large changes in ecosystems, leading to possibly catastrophic disruptions of livelihoods,

economic activity, living conditions, and human health. On the other hand, abatement of GHGs, would involve significant economic costs.

The following would comprise essential elements of India's approach to multilateral efforts in addressing climate change.

- Adherence to the principle of common but differentiated responsibilities and respective capabilities of different countries in respect of both mitigation of GHGs, and adaptation measures.
- Reliance on multilateral approaches, as opposed to bilateral or plurilateral or unilateral measures.
- Equal per-capita entitlements of global environmental resources to all countries.
- Over-riding priority of the right to development.

2.3.5 Clean Technologies and Innovation

Clean technologies, as distinct from "end-of-the-pipe" abatement technologies minimize the generation of waste streams in the production processes themselves, rather than treating the waste after generation. In general, clean technologies are less intensive in the use of raw materials and energy than conventional technologies, which rely on pollution abatement after generation. For this reason, they may also offer significant cost advantages to the producer.

Following would comprise elements of an action plan:

- Encourage capacity building in the financial sector for appraising clean technology switchover project proposals.
- Set up a mechanism to network technology research in public and private institutions in the country, for cooperation in R&D for clean technologies. Promote the dissemination of the new technologies both in India and abroad.

2.4 National Water Policy 2002 (NWP)

The National Water Policy (NWP) has been prepared by the Government of India (GOI), Ministry of Water Resources (MOWR) in April, 2002. A comprehensive policy on water is necessary in the face of the growing number of social, economic and environmental issues surrounding water resources in India. In 1987, the newly formed National Water Resources Council adopted the National Water Policy (NWP) and submitted the document to Parliament for implementation. The NWP is the primary document stating

the position of GOI on water resource issues ranging from drought and flood management to drinking water provision.[6]

In essence, the policy serves as a guideline to help planners and managers develop the country's water resources to their maximum potential. But the adoption of the policy is also a step-forward for the GOI in terms of promoting the sustainable management of the country's water resources. The policy addresses many issues regarding the planning, development and allocation of water, including groundwater and surface water sources. Among the points addressed in the policy are:

- Development of standardized national information system, containing data on water availability and use, is essential for appraising planning.
- Resource planning should be conducted using a catchment or a watershed as the basic unit.
- Water development projects should be multi-purpose and address various priorities such as drinking water provision and flood-mitigation.
- Environmental impact of new projects should be assessed and minimized where possible.
- Socially disadvantaged groups such as Scheduled Castes and Tribes and other minority groups are to be included in the planning process as much as possible, and farmers must become increasingly involved in irrigation management policies.
- Groundwater development should be based on the basis of potential and the recharge capabilities of the aquifer.
- Water allocation should be based on the following priorities: drinking water, irrigation, hydropower, navigation, industrial and other uses.
- Irrigation planning should attempt to maximize benefits to farmers and integrate soil and water conservation practices.
- Water rates should reflect the true cost of water use and encourage economy of the resource.
- Promotion of conservation through education, regulation and incentives is encouraged.
- Additional research in a number of areas such as hydro-meteorology, groundwater hydrology and recharge, water harvesting, crops and cropping systems, sedimentation and reservoirs, river morphology and hydraulics, recycling and re-use, and sea water resource should be pursued.

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2-4) Ibid.
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3 Environmental Administration, Strengthening and Training of Institutions

3.1 Current Status

India has witnessed significant environmental degradation in the last two decades. Today India is the sixth largest and second fastest growing producer of Green House Gases (GHGs). Increasing urbanization, industrialization, deforestation, transportation, high intensity agriculture and population migration are major factors causing environmental problems being faced by the country. These environmental problems are likely to accentuate further because of the growing population and the rising standard of living. The priority areas for protection and conservation of the environment were presented in the Chapter 2.

The cost of environmental degradation has been estimated by the World Bank (WB) and The Energy Research Institute (TERI). According to WB, the estimated cost of environmental degradation for 1991–92 ads up to 4.8% of GDP and the economic values of environmental degradation and depletion of natural resources in 1997 according to TERI are as follows in Table 1.

Table 1 Costs of environmental degradation (Source: www.envfor.nic.in).

Problem	Annual Economic Value (million Euros)
Poor quality of drinking water and its effect on humans health	2,276
Loss of crop productivity due to soil degradation	1,660–4,300
Loss of wood due to forest degradation	1,060
Air pollution and its impact on human health	16,500–79,300

3.2 Key Players

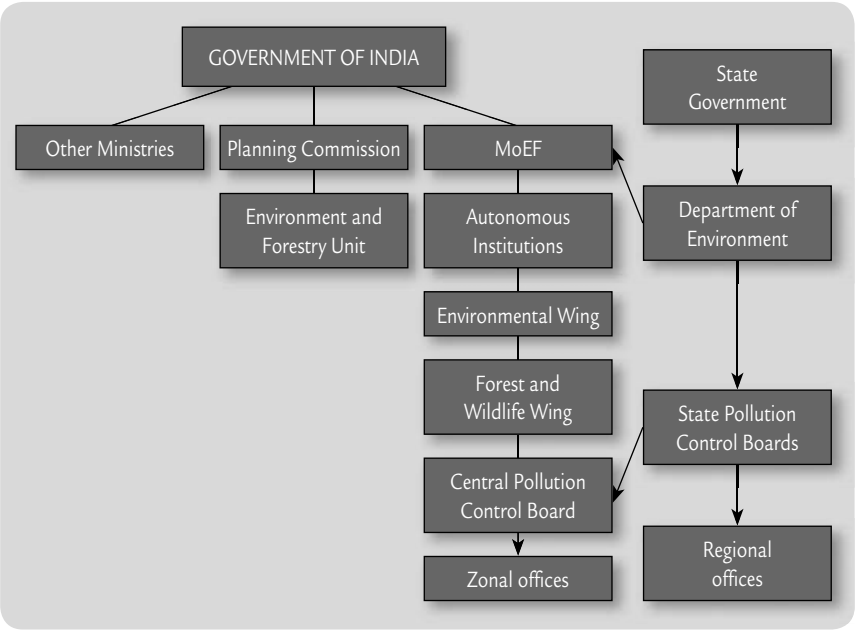
3.2.1 Governmental Organizations

Central Government

Planning Commission is responsible for long-term policy directions and budget allocations including five-year plans. The Ministry of Environment and Forests (MoEF), the nodal agency in the administrative structure of the Central Government, is responsible for the protection and management of the environment. It is in charge of planning, promotion, coordination and overseeing of the implementation of environmental and forestry programmes (Figure 3). The MoEF has also been designated as the nodal agency in the country for the UNEP (United Nations Environment Program), International Centre for Integrated Mountain Development and looks after the follow up of the United Nations Conference on Environment and Development.

The MoEF also functions as the nodal agency for the participation in international agreements relating to the environment such as the Montreal Protocol on Substances that Deplete the Ozone Layer, Vienna Convention

Figure 3 Structure of Environmental Administration in India



for the Protection of the Ozone Layer, the Basal Convention on the Control on Trans-boundary Movement of Hazardous Substances, the United Nations Framework Convention on Climate Change, Male Declaration on prevention of air pollution, the Convention on Biological Diversity, the Convention to Combat Desertification, the Ramsar Convention on Wetlands of International Importance, the Convention of the Conversion of Migratory Species of Wild Animals (Bonn Convention), etc.

Industrial pollution prevention and control, are primarily executed by the Pollution Control Board at the central level, which is a statutory authority attached to the Ministry of Environment and Forests. At the State level, the State Departments of Environment and State Pollution Control Boards are the designated agencies to perform these functions.

The MoEF, the Central Pollution Control Board (CPCB) and state pollution control boards (SPCB) form the regulatory and administrative core. Other ministries are also involved through various functions, policies and schemes to promote environmental management. A brief list of such ministries is as follows:

- Ministry of Non-Conventional Energy Sources (MNES)
- Ministry of Urban Development
- Ministry of Coal & Mines
- Ministry of Petroleum
- Ministry of Human Resources Development
- Ministry of Surface Transport
- Ministry of Water Resources
- Ministry of Power
- Ministry of Agriculture
- Ministry of Rural Development
- Ministry of Finance
- Ministry of Science and Technology.

Additionally, there is a network of government and non-governmental institutions, organizations and laboratories involved in monitoring, reporting and studying environmental pollution and management. Under the MoEF there are around 20 autonomous institutions involved in research activities covering various environmental related issues. A list of these institutes can be found at source: www.envfor.nic.in.

State Governments

Environmental issues are on the concurrent list which means that they are included in jurisdiction of both Central and State Governments. Central

Government gives the policy guidelines, but the implementation of environmental laws and regulations is a state responsibility. Every state and union territory has a Department of Environment. States also have the State Pollution Control Board (SPCB) whose activities are coordinated by CPCB. Various responsibilities of the states along with activities of the state pollution control boards are discussed in more detail in the following sections.

Municipalities and Urban Local Bodies

The approximately 2,850 municipalities of the country are divided into three categories on the basis of their nature and population. The smaller municipalities are known as Nagar Panchayats and Nagar Palika Parishads. Very large ones are called Municipal Corporations or Nagar Nigams. They are governed by a separate set of Acts. The heads of smaller units are known as chairpersons while the heads of Municipal Corporations are Mayors.

The Eleventh Schedule of the 73rd Constitutional Amendment in 1992 empowered local bodies and bestowed them with responsibilities regarding various environmental issues. The passage of the 74th Amendment Act to the Constitution of India in 1992 is an important landmark in the evolution of municipal governance. The Urban Local Bodies (ULBs) are empowered under this act to protect the environment and promote ecological effects. As local governance is a State subject as such, the 74th Amendment directed the States to amend their acts to empower the municipalities to function as institutions of self-government. This envisaged functional and financial devolution of powers to the local bodies and ensured participatory governance at the local level.

Among the environment related functions of ULBs are urban planning including: the regulation of land use; water supply for domestic, industrial and commercial purposes; sanitation and solid waste management. A comprehensive list of the responsibilities of ULBs can be found at the Constitution of India, 74th Amendment Act, 1992 at http://indiacode.nic.in/coiweb/amend/amend74.htm.

However, most of the municipalities are starved of funds to implement environment related programs. A further impedance to their effectiveness is interference from local political systems.[1]

Pollution Control Boards

The Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) were set up under the Water Act of 1974 for the control and monitoring of environmental degradation in the country. CPCB is the apex body coordinating the activities of all SPCBs. At the national level it is

mandated with functions such as advising the Government, providing assistance to SPCBs and coordinating their work, and carrying out research work and awareness creating campaigns.

State Pollution Control Boards, in turn, are responsible for the following activities:

- Pollution control in 17 categories of highly polluting industries
- Pollution control from industries discharging waste water into rivers and lakes
- Inventory of pollution industries in the State and ensuring their compliance to the pollution control norms
- Restoration of environmental quality in critically polluted areas
- Monitoring of water and ambient air quality in the States
- Management of hazardous waste
- Management of municipal solid and bio-medical waste.

3.2.2 Non-Governmental Organizations (NGOs)

India today has over 10,000 Non-Governmental Organizations (NGOs) active in the field of the environment. Also many citizens' groups and other pressure groups play a vital role in this arena. The strength of these NGOs is the local population which has tremendous faith in the NGOs' capability to get the people justice.

The MoEF has constituted a NGO cell in 1992 with a view to strengthening the environmental movement in the country. To be eligible for financial support from the MoEF, an NGO should be a registered voluntary/professional organization having proven credential and experience in environmental fields. It should be registered under the Societies Registration Act for a minimum of three years and with audited accounts for the said period, have a properly constituted Managing Body with its powers, duties and responsibilities clearly defined and laid down in a written constitution/by-laws and having a sound financial position to take up the project.

Major NGOs working in environment sector are as follows:

- Centre for Environment Education (CEE), Ahmedabad (www.ceeindia.org)
- Centre for Science and Environment (CSE), New Delhi (http://cseindia.org)
- Deccan Development Society, Hyderabad (www.ddsindia.com)
- Development Alternatives, New Delhi (www.devalt.org)
- Gandhi Peace Foundation (Environment Cell), New Delhi
- Indian Environmental Society (IES), Delhi,(www.iesglobal.org)

- Society for Promotion of Wastelands Development, New Delhi (www.spwdindia.org)
- Sulabh International, New Delhi, (www.sulabhinternational.org)
- The Energy & Resources Institute (TERI), New Delhi (www.teriin.org).

The MoEF implements various schemes namely, Environmental Education, Awareness and Training, Centres of Excellence, Environmental Research, Grants in aid to voluntary agencies for the National Afforestation and Eco-Development to encourage NGOs to participate in environmental projects. (www.envfor.nic.in)

3.2.3 International Players

There are number of international organizations active in the field of the Indian environment sector. Some of them are engaged in development related activities, bilateral developmental assistance programmes and others in promoting their environmental expertise. The nature of external assistance provided by multilateral, bilateral and other agencies is constantly changing. For example, in recent years, relatively more emphasis has been put on institutional strengthening, governance, and participatory processes. Compared to the 1980s less emphasis has been put on financing large infrastructure projects in industry, large dams, irrigation canals, and urban development projects.

Environment Management Division of the Confederation of Indian Industry (CII) has prepared a compendium for the World Bank, which examines the nature and type of external assistance to India in environment-related areas. It is a snapshot in time (1995–2000) of around 400 different activities totalling nearly 820 billion Euro. This compendium can be accessed from http://www.worldbank.org/sarcompendium

The main multinational organizations operating in the environment sector are the World Bank (WB), the Asian Development Bank (ADB) and UN organizations like United Nations Development Program (UNDP). Besides multilateral organizations there are a number of bilateral organizations providing financial, technical and institutional assistance for the environment sector. The important organizations will be presented in Chapter 11.

3.2.4 The General Public

Public participation and decision-making to safeguard the environment have been highly contentious issues in modern India. Indian environmentalism has always been different from its western counterpart. The concept of protectionist conservationism prevails across the paradigms of environmental

management in the western world. The Indian environmental movement, however, was built on the concept of utilitarian conservationism. This is simply because of the large numbers of people who live from their environment: they survive directly on what they get from nature – firewood, food, water, building materials, medicines and fodder for their animals. The destruction of the forest would threaten their very livelihoods.

The environmental movement receives considerable support both from the media and the judiciary. Its relationship with the political and bureaucratic systems, on the other hand, remains weak and often antagonistic. However, the environmental movement has grown rapidly over the last three to four decades. It has played a key role in creating public awareness in opposing environmentally harmful development projects and in organising model projects showing the way forward towards non-bureaucratic and participatory, community-based natural resource management systems. The emergence of a strong middle class with a greater level of environmental awareness, along with judicial interventions is expected to continue to produce pressure on government and industry for environmental improvements and for demonstration of better results.

The Government has also realized that the success of India's environmental programmes depends greatly on the awareness and consciousness of the people. A National Environmental Awareness Campaign has been launched to sensitise the people to the environmental problems. Paryavaran Vahinis (Carrier of the Environment) have been constituted in 184 districts involving the local people to play an active role in preventing poaching, deforestation and environmental pollution. 4,000 NGOs have been given financial assistance for creating environmental awareness. An Environmental Information System (ENVIS) network has been set up to disseminate information on environmental issues. The website of the Ministry of Environment and Forests (http://envfor.nic.in/) provides the latest information about new policy initiatives, legislations and projects given environmental clearance.

3.2.5 Industries and Industrial Associations

To large extent larger industries have adopted solutions to environmental management to address environmental problems. However, the smaller ones lack both awareness about the environmental effects of their operations and the resources to tackle them. Current technology status is discussed in more detail in section 3.4 and under Chapters 5–10, covering various environmental technology sectors.

At a policy level, the MoEF has focused on several specific measures to combat pollution caused by industries. In its Policy Statement on Abatement of Pollution, the Government has recognized the "polluter pays" principle.

Environmental clearances have been made necessary for new projects and expansion of existing projects in 29 industries. An exercise was initiated to identify the locations of maximum industrial concentration in the country and to characterize the environmental quality at these locations. These locations have been labelled problem areas and they represent potential locations for marketing environmental equipment and services. Government has also launched programs to promote awareness of pollution prevention and waste minimization.

There are numerous, small and big, industrial associations at the national and state level dealing with environmental issues. Following are the major associations - all very active at the national level.

Federation of Indian Chambers of Commerce and Industry

FICCI has developed an Environmental Information Center (EIC) aiming to provide comprehensive information about environmental regulations, technology options, success stories, guidelines and manuals to enable Indian industry to become green, clean and competitive.

Indian Chamber of Commerce

The Environment Management Centre (EMC) was set up by the Indian Chamber of Commerce (ICC) in the year 1998 with the objective of promoting environment management as an important tool for enhancing efficiency and competitiveness of economic activity (www.indianchamber.org/environment).

Confederation of Indian Industry

The Confederation of Indian Industry (CII) is one of the apex industrial associations in the country. Through its Environment Management Division (EMD) it provides several services, like technical advice and training programs to both the service providers and service buyers in the environmental industry (www.ciionline.org). The Green Business Centre developed at CII is a joint initiative of Confederation of Indian Industry and the Government of Andhra Pradesh, with the technical support of USAID. The objective of the GBC is to promote Green concepts leading to sustainable development, efficiency and equitable growth (www.greenbusinesscentre.com).

Indian Merchants Chamber

The Indian Merchants' Chamber (IMC) is an apex body of trade, commerce and industry in the western region of India. IMC has been involved in various

businesses throughout India and abroad through a wide range of activities. IMC has also been providing several value added services to a diverse community of exporters, importers, manufacturers, traders, merchants and professionals (www.IMCnet.org).

3.3 Policy Framework and Environment Related Regulations

3.3.1 National Environment Policy

The MoEF has prepared a draft National Environment Policy (NEP) and made it publicly available for comments in August, 2004. The draft is still awaiting approval of the cabinet and is expected to be released soon. The contents and objectives of the NEP were already discussed in the chapter 2.4. The MoEF has had consultations with various stakeholders including State Governments, Ministries of Central Government, Industry Associations, Voluntary Organizations, Research institutions etc., and would give due consideration to the comments/suggestions received while finalizing the NEP.

3.3.2 Environment Legislation and Major Laws

The Indian Constitution provides necessary directives and powers for framing and enforcing environmental legislation. The Constitution classifies the various legislative subjects into three categories, namely, Union List, State List and Concurrent List including both Central Administration and the States.

As stated in the Constitution of India, it is the duty of the state (Article 48 A) to 'protect and improve the environment and to safeguard the forests and wildlife of the country'. It imposes a duty on every citizen (Article 51 A) 'to protect and improve the natural environment including forests, lakes, rivers and wildlife'. Reference to the environment has also been made in the Directive Principles of State Policy as well as the Fundamental Rights.

The major instrument with the State to check environmental degradation is undoubtedly regulation. The country has adopted almost all environmental protection Acts and rules enforced in developed countries. The government has formulated comprehensive legislation to enable the institutions like pollution control boards to effectively protect the environment. There are around 30 acts and rules related to environment. These can be accessed at www.envfor.nic.in/legis/legis.html. Some of the most important laws covering various natural resources and technologies are discussed in coming chapters. Despite the existence of a legal framework for environmen-

tal protection, environmental degradation continues. The laws are in place, but the enforcement mechanism is very weak. The need to reduce the gap between principle and practice cannot be over-emphasized.

3.3.3 Enforcement Mechanism and Legal Loopholes

In pursuance of the Water (Prevention & Control of Pollution) Act 1974, the Central Government set up a Central Board for the Prevention and Control of Water Pollution. Similar Boards were set up in various States at different points of time when the Act was adopted by the State Legislatures. Subsequently, the responsibility for enforcement of the Air (Prevention & Control of Pollution) Act, 1981 was also entrusted with these organizations which were renamed the Central and State Pollution Control Boards. With the enactment of the Environment (Protection) Act, 1986, which is umbrella legislation, the Central Government assumed the overall responsibility for "environmental protection and improvement". Although the Act empowered the government to designate Authorities for specific tasks, separate machinery for enforcement of the Act was not set up or designated, except for the Central Ground Water Board which was designated the Central Ground Water Authority. It is only in recent times when empowered Authorities have been constituted for specific assignments, including for instance the Coastal Zone Authority and the National Environment Appellate Authority.

The powers of the Environment (Protection) Act have been exercised by the Central Government through the MoEF. However, the monitoring mechanism for implementation of the Act is still undefined, although for the various regulations enforcement institutions have been enlisted. Also in several areas of environmental concern, such as vehicular-pollution control, the MoEF has no decisive role, since it is implemented by a separate Ministry through the Motor Vehicles Act.

It was already stated that the Indian enforcement mechanism is very weak although the laws are very well drawn up. A careful analysis of the laws reveals that there are inherent deficiencies in legislation which are closely linked to lapses in enforcement. Perhaps, the most serious lacunae are the over-dependences on the legal system. The courts are too busy to devote enough time for environment related litigations. As a result, thousands of cases filed by the State against the violators of Environmental Acts are still pending after years on the statutes. In a good number of cases where decisions are taken the polluters have been given the benefit of doubt on technical grounds, as the Boards could not adequately meet the "onus of proof". More often than not, the polluters hire highly paid advocates to plead their cases, whereas the State Boards are unable to do so because of financial constraints.[2]

3.4 Current Technology Status

India represents a wide cross-section of industries in terms of size, manufacturing processes, product range etc. The small scale industries, discussed in the Chapter 1, are a special feature of Indian economy. Though they account for over 40% (in value terms) of the industrial outputs of the organised and unorganised manufacturing sectors in India, it is estimated that the pollution they generate is more than their share of industrial production. Smaller industries have the added burden of using obsolete, inefficient production processes, which are typically more polluting. Such companies are often short of capital and skilled manpower and have limited access to information on pollution control and prevention systems.

In the last few years, Indian industry has become increasingly concerned about discharging its environmental obligations effectively. However there are a number of constraints that limit the industry's ability to adopt sound environmental management practices. Access to know how and technology is one of the major concerns. A large number of technology gaps still persist in the environment sectors.

Most Indian industries have underdeveloped infrastructure required for implementing environmental change, such as the installation of clean technologies. This problem is more serious for smaller firms. Most of the financing schemes apply to the installation of new production facilities and not for the environmental upgrading of the existing ones. Indian industry has poor emphasis on the generation of innovative, cost effective solutions to environmental problems. This is seen in the inadequate research and development focus of Indian industry.

Another problem area is shortage of in-house environmental managers or local consulting firms to help them regarding the precise nature of pollution problems caused by particular processes, and options for prevention, control or remediation of those problems.

However the appropriate technology and know how is becoming increasingly available as Indian environmental industry grows and develops, and as foreign companies introduce new technology and approaches either directly or through alliances with Indian firms.[3]

3.5 Major On-going Projects and Action Plan

During the 10th Plan (2002–2007) new projects adopted and to be taken up relate to the following issues:

- Management of Bio-medical Waste
- Management of Municipal Solid Waste including Plastics Waste

- Vehicular Pollution Control
- Development & Promotion of Clean Technologies
- Strengthening of Pollution Control Boards. (www.envfor.nic.in)

Besides these new issues earlier established schemes relating for example to water and sanitation will continue.

The recent steps taken by the Government of India for maintaining the environment include the following programmes that are interesting from a Finnish perspective. Some of these programmes will be covered in coming chapters covering respective sectors.

- Integrated Forest Protection Scheme for Conservation of Forests (MoEF)
- National Afforestation Programme (MoEF)
- Waste minimization / cleaner production programme (MoEF) provides financial assistance for the establishment and running of waste minimization circles in clusters of small scale industries, with the objective of capacity building in areas such as cleaner production.
- Accelerated Rural Water Supply Project (Department of Drinking Water Supply under Ministry of Rural Development)
- Rural Sanitation Programme (Department of Drinking Water Supply under Ministry of Rural Development)
- Bio-energy and Small Hydro Projects (MNES)
- Accelerated Urban Water Supply Programme (AUWSP) (Ministry of Urban Development).

Resources are targeted at education and the bolstering of institutional capabilities.

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4 Natural Resources Management, Conservation of Soil and Groundwater

4.1 Overview

The mainland of India comprises four regions: the great mountain zone, the plains of the Ganga and the Indus, the desert region and the southern peninsula.[1] Natural resources are under tremendous pressure since India has an area of 2.5% of the world's landmass, but supports over 16% of the world's population and 18% of the livestock. The area suffering soil degradation has increased and out of the total geographical area of 328.7 million hectares more than 175 million hectares are considered to be land-degraded area. In 1997, more seriously degraded area accounted for 28% of the total area – a figure which has been rising since then. Most of the harm was attributed to activities undertaken on farmland. Cropland is becoming less productive because of erosion, water logging, desertification, and other forms of degradation.[2]

Implementation of policies and programs relating to conservation of natural resources including lakes and rivers, its biodiversity and forests are primarily the concern of the Ministry of Environment and Forests (MoEF).

4.2 Biodiversity

4.2.1 Current Status

India has rich and varied vegetation due to the wide range of climatic conditions from the torrid to the arctic. This rich heritage of bio-diversity covers 10 bio-geographical zones. The country is one of the 17 'mega diversity countries' in the world which together possess 60–70% of the world's bio-diversity. In plant diversity India is in tenth position in the world and fourth in Asia. From about 70% of the geographical area surveyed so far, 47,000

plants have been identified by Botanical Survey of India (BOI). More than 35% of the vascular fauna comprising 15,000 species is endemic and not reported anywhere else. The country also has the distinction of having two bio-diversity hotspots in the Western Ghats and Eastern Himalayas.[3]

Destruction of the habitat, the extension of agriculture, the filling up of wetlands, conversion of rich bio-diversity sites for human settlement and industrial development, the destruction of coastal areas and uncontrolled commercial exploitation have all led to the loss of biodiversity. Many Indian plants are facing extinction: approximately 1336 plant species are vulnerable and endangered and approximately 20 are categorized extinct.[4]

4.2.2 Policy Response and Actions

Biodiversity conservation has been made an integral part of conservation of natural resources. The Biological Diversity Act, 2002 aims at protecting the biological resources of the country and it addresses forest ecology in its totality.

In 1994 India ratified and became a party to the International Convention on Biodiversity, an international legal instrument for promoting conservation of biodiversity. Some important steps, like various projects and programmes, have been taken to conserve the biodiversity. These include for example the launching of the National Biodiversity Strategy and Action Plan, which aims at creating National Plan for conservation of biodiversity. The draft is currently under consideration by the Ministry. The National Biodiversity Authority has been set up in Chennai. Government has also initiated number of other schemes to conserve the bio-diversity.[5]

4.3 Forests

4.3.1 Current Status

The official data on forest cover is in a state of utter confusion. Per capita availability of forests in India, which currently is 0.08 ha, is much lower than the world average 0.64 ha. According to the Food and Agriculture Organization's (FAO) statistics for forests, ranging from tropical rain forests of Kerala to dry alpine scrub of Ladakh, and from the deserts of Rajasthan to evergreen forests in the North-East, cover 67.70 million hectares, 20.59%, of the total geographical area. Of this, very dense forest constitutes 5.13, moderately dense forest 33.93 and open forest 28.77 million hectares. The total forest and tree cover is approximately 22.77% (2003) of the land area. www.fao.org

From 2000 to 2005 the forest coverage increased marginally by 147,000 hectares. However, Government satellite surveys in 2005 showed that while the total tree cover has further increased, areas covered by dense forests have shrunk due to mining and industrial development. The states which have shown significant decline in forest cover are Andhra Pradesh and Madhya Pradesh. The states of Gujarat, Maharashtra, Rajasthan and West Bengal, in turn, have shown an increase in forest cover.[6]

Most of India's forest land is state-owned. Around 10 per cent of the total forest land belongs to community and/or private owners, though the exact figures are not available due to the lack of a comprehensive, up-to-date assessment of forest land ownership. The proportion of privately owned forest land is very low, around 4%. However, non-forest private sources account for 50% of the total wood supply in the country. Not only is the private sector not permitted to own natural forest, but its ownership of planted forests is limited by the Private Forests (Acquisition) Act of the 1950s and the Land Ceiling Act of the 1960s. Community-owned forest land primarily belongs to tribal communities in the north east, although small areas of community-owned forest land are also scattered in other parts of the country.[7]

Most of the forests are modified or semi-natural in nature. Forest degradation is a matter of serious concern. About 35 million hectares of forests, some 55% of the forest area, are affected by fires annually. Other factors leading to forest degradation are the transfer of forest lands for other land uses, the on forest lands for agriculture and other purposes, grazing, pests and diseases.[8]

Table 2 Extent of forest and other wooded land (www.fao.org).

EXTENT OF FOREST AND OTHER WOODED LAND			
Categories	**Area (1000 hectares)**		
	1990	2000	2005
Forest	63,939	67,554	67,701
Other wooded land	5,894	4,732	4,110
Forest and other wooded land	**69,833**	**72,286**	**71,811**
Other land	227,486	225,033	225,508
...of which with tree cover	815	815	815
Total land area	**297,319**	**297,319**	**297,319**
Inland water bodies	31,407	31,407	31,407
Total area of country	**328,726**	**328,726**	**328,726**

Table 3 Characteristics of forest and other wooded land (www.fao.org).

CHARACTERISTICS OF FOREST AND OTHER WOODED LAND						
Categories	**Area (1000 hectares)**					
	Forest			**Other wooded land**		
	1990	2000	2005	1990	2000	2005
Primary	-	-	-	-	-	-
Modified natural	30,004	32,561	32,943	2,851	2,355	2,046
Semi-natural	31,981	32,188	31,532	2,850	2,098	1,745
Productive plantation	637	915	1,053	63	91	104
Protective plantation	1,317	1,890	2,173	130	187	215
Total	**63,939**	**67,554**	**67,701**	**5,894**	**4,731**	**4,110**

4.3.2 Implications for the Economy

Forests formally contribute 1.7% to India's GDP. India produces a range of processed forest, both wood and non-wood, products ranging from sawn wood, panel products and wood pulp to bamboo, rattan ware and pine resin.

It is reported that productivity from forest plantations in general is quite low. For example, mean annual increment (MAI) for teak at the average rotation age of 58 years varies between 0.6 to 7 m^3/ha/year with a mean of 2.5 m^3 /ha/year in Kerala, one of the major teak producing states of India.

Total industrial wood consumption by wood-based processing industries in 2002 was about 30 million m^3 accounting for about 10% of total wood consumption. 90% is consumed in the form of small timber and fuel wood. India is the world's largest consumer of fuel wood, and the country's consumption of fuel wood is about five times higher than the amount that can be removed from forests in a sustainable way. An important cause for suboptimal wood use is its relatively low price because of subsidies on wood raw materials, and the free fuel wood supply. Ref www.fao.org

4.3.3 Policy Response and Actions

The MoEF is the body responsible for the enforcement of the Central forest laws. State forest departments along with certain other departments have

a direct or indirect influence on forests. The legal framework of the forestry sector can be classified into three categories: access and use of forest products such as the Indian Forest Act (1927); conservation as in the Wildlife Act (1972) and the Forest Conservation Act (1980); laws that encourage private investment. In addition to the central laws and international conventions, forest resources are governed by a number of state laws.[9]

India has had a forest policy since 1894. The policy was revised in 1952 and again in 1988. The main objectives of the policy are to conserve and raise the forest covered area and increase the productivity of forests. The National Forestry Commission was set up in February 2003 to review the working of forests and wildlife sector. The National Forestry Action Programme (NFAP) has also been formulated as a strategic plan for the next 20 years. Under the Forest Act 1980 prior approval of Central Government is required for the diversion of forest lands for non-forest purposes. In 1990 the Government issued guidelines to involve the rural and tribal communities in the development and protection of partly degraded forests under the concept of Joint Forest Management (JFM). JFM has now been adopted in all 28 States. Also an Integrated Forest Protection Scheme has been formulated.[10]

The aim is to increase the forest/tree cover from 23% to 33% by 2012 and to increase the productivity of existing forests. Forest coverage of 33% was already recommended by the National Forest Policy of 1988. To achieve the target the forest cover needs to be increased by 5 million hectares annually, which is five times more than the current rate of plantation. The private sector must become involved in plantation if the target is to be achieved. Besides, the size of the Integrated Forest Protection Scheme could be increased to give more financial assistance to the state governments. Nevertheless, the states are also required to provide their share from their budgets to facilitate the flow of central assistance.[11]

4.4 Agriculture

4.4.1 Current Status

Arable land covers 161.75 million hectares (2002) and agriculture is the largest sector of economic activity in India. According to FAO's statistics, 273.5 million people, comprising 58% of the total labour force, are employed in this sector. Food grains comprise 65.96% of the gross cropped area. Rice (43.9 million hectares; 23.85% of the gross cropped area) and wheat (26.4 million hectares; 13.79% of the gross cropped area) are the major Indian crops.[12] Agriculture depends mostly on monsoons because only about 38% of the cultivated area is irrigated. However, this irrigated area produces 56% of the agricultural output.

Grain area is very small relative to India's population: just one-and-a-half basketball courts per person, or some 650 m^2. With most available farmland already under cultivation, grain area per person will inevitably shrink as the population increases.[13] Until the 1960s the agricultural production was increased through expanding the area under cultivation. After the ceiling for expanding the land under cultivation had been reached, increases in production have been achieved through increases in yield and cropping intensity.[14]

The spread of the green revolution has been accompanied by over-exploitation of land and water resources. The use of fertilizers and pesticides has increased many times over. Shifting cultivation has also been an important cause for land degradation. Intensive agriculture contributes to soil erosion, land salination, alkalization, loss of nutrients and water logging. Leaching from extensive use of pesticides and fertilizers is an important source of contamination of water bodies.

4.5 Water Resources

4.5.1 Current Status

The total renewable water resources are estimated at 1907.8 km^3/year. The country's water resources are under stress with regard to availability and quality of water. The problems have resulted not only from the growing demand from all the consuming sectors but also from a policy and regulatory framework which does not promote equity, efficiency and sustainability in water management.[15]

The river systems of India are usually classified into four groups: Himalayan rivers formed by melting snow, rained Deccan rivers, short Coastal rivers, and the rivers of the inland drainage basin which are usually considered ephemeral. The two main sources of water are rainfall and the snowmelt of glaciers in the Himalayas. Although reliable data on snow cover in India is not available, it is estimated that some 5,000 glaciers cover about 43,000 km^2 in the Himalayas with a total volume of locked water estimated at 3,870 km^3. Considering that about 10,000 km^2 are located in Indian territory, the total water yield from snowmelt contributing to the river runoff may be of the order of 200 km^3/year. Although snow and glaciers are poor producers of fresh water, they are good distributors as they yield at the time of need, in the hot season.[16]

The rainfall, around 80% of which takes place during monsoon season from June to September, is very unevenly distributed across the country: The levels of precipitation vary from 9,000 mm per year in the north-eastern state Meghalaya to approximately 100 mm in the state of Rajasthan. According

to the Centre for Science and Environment (CSE) in India, some 43% of the country's annual rainfall and snowfall does not reach its rivers and groundwater.[17] The total surface flow, including regenerating flow from groundwater and the flow from neighbouring countries, is estimated at 1,869 km^3/ year, of which only 690 km^3 are considered as utilizable, in view of the constraints of the present technology for water storage and inter-state issues.[18]

The Central Water Commission estimates the groundwater resources to be 418.5 km^3/ year. Part of this, estimated at 380 km^3/year, constitutes the base flow of the rivers.

Water planning in India is fragmented over a large number of ministries and a number of organizations within them. Surface water is treated as state property. All land owners have a de facto right to groundwater lying under their land. Thus, groundwater is viewed essentially as a chattel connected with land. There are no limits how much water a landowner can draw. Chapter 9 gives more information on water authorities.[19]

The introduction of small, inexpensive pumps in the 1990s and indiscriminate pumping of groundwater have led to a fall in the water table in many places. It is estimated that Indian farmers pump out about one sixth of the country's internal renewable water resources each year and only a fraction of this is replaced by rainfall.[20] At an aggregate level overexploitation is not a major concern, but in certain states, for example in Punjab it is a serious problem. In the case of Delhi it is feared that if the pumping of groundwater continues at the current pace the city's supply of fresh water will mix with saline water and Delhi's groundwater resources could turn saline. Water harvesting that starts from the premise that posits rainfall, rather than rivers or groundwater, as the main source of supply is important but has been largely neglected. Harvesting just a small share of this water could make a huge difference, especially for the country's poorest people.[21]

The quality of water in Indian is categorized are as follows:

- Class A: fit for drinking water without conventional treatment but after disinfection
- Class B: fit for bathing, swimming, and recreation
- Class C: fit for drinking after conventional treatment
- Class D: fit for propagation of wildlife, industrial cooling, controlled waste disposal
- Class E: fit only for irrigation, industrial cooling, and controlled waste disposal.

The quality of water is a major issue, since about 70% of the available water is polluted. The major sources of water pollution at are city sewage, industrial waste and input-intensive agriculture. The Central Pollution Control

Table 4 Pollution levels in Indian Rivers (source CPCB).

Level of Pollution	Pollution Criteria	Riverine Length (km)	Riverine Length (%)
Severely Polluted	BOD>6 mg/l	6,086	14
Moderately Polluted	BOD 3–6 mg/l	8,691	19
Relatively Clean	BOD<3 mg/l	30,242	67

Board has established a network of monitoring stations on rivers and lakes across the country.[22] Water in most stretches of Indian rivers is of class C quality, and in some of Class D and E quality.

Water quality standards are not fulfilled (BOD>6 mg/l) in 86 river stretches comprising 14% of the total riverine length (Table 4). Although in their upper reaches most rivers are of good quality, water use for cities, agriculture and industries; and the lack of waste water treatment plants in the middle and lower reaches cause a major degradation of surface water quality. However, as the table shows, about 67% of the total riverine length is still relatively clean.[23]

The worst affected rivers in India are Sabarmati and Khan. The stretches of rivers near cities like Delhi, Kanpur, Varanasi and Ahmedabad are only little better than open drains. The stretch of the Yamuna from Wazirabad to Okhla is one of the most threatened eco-systems of the world. Lakes are in equally bad shape.

Pollution of groundwater is also an alarming concern. It is being depleted fast, and the arsenic and fluoride contents are increasing. According to the CPCB survey the groundwater, especially in industrialized zones, is contaminated with heavy metals and coli form bacteria. Groundwater is also affected by domestic, industrial and agricultural pollutants. The overexploitation of groundwater can also lead to seawater intrusion.[24]

4.5.2 Policy Response and Actions

The water quality management is performed under the provision of the Water (Prevention and Control of Pollution) Act, 1974. The basic objective of this Act is to maintain and restore the wholesomeness of national aquatic resources by prevention and control of pollution. In 1987 India adopted a national water policy for the planning and development of water resources. This policy was discussed in section 2.4.

Under the scheme called National River Conservation Plan (NRCP) polluted stretches of major rivers have been identified for sewage collection and

treatment. All 86 major polluted rivers identified by CPCB are targeted to be cleared by 2007. The focus would be given to cleaning of the river Ganga and its tributaries. About 45% of the cleaning of the Ganga has already been completed. However, while there have been some positive effects from the Ganga Action Plan, the water quality in other rivers has shown very little improvement due among other things to delays in land acquisition and the slow pace of work by municipal corporations. For example Phase-I of Yamuna Action Plan failed to have any significant effect.[25]

The National Lake Conservation Plan was initiated in 1994 for cleaning important urban lakes suffering high levels of silting and pollution. Initially, ten lakes were identified for coverage. However, work has started on only one lake and project reports for just three lakes have been prepared and approved to date. The progress regarding other lakes is extremely slow because of delays in the finalization of detailed projects (DPRs), tender procedures and awarding of contracts.

The program for the conservation of wetlands was initiated in 1987 to fight against the deterioration of water bodies. Until now 66 wetlands in 22 states have been identified. The objectives of this program are to identify wetlands of national importance, promote R&D activities, and both formulate and implement management action plans for identified areas.[26]

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5 Environmental Monitoring and Measuring

5.1 Background

Section 2.2.2 discussed the five priority key environmental issues identified for India: land degradation, biodiversity, air pollution control with special reference to vehicular pollution in cities, management of fresh water resources, and hazardous waste management with special reference to municipal solid waste management.

Some of the recommendations to reduce air pollution and to control industrial pollution include strengthening emission standards and the monitoring and reporting system. It is also recommended that a comprehensive urban air quality strategy should be formulated using information related to ambient air quality, an emission inventory, and air quality dispersion models. Strengthening the current monitoring network is proposed, too. In fresh water management is it essential to collect information on water consumption and impacts of effluents discharged into receiving watercourses. Hazardous and solid waste management need more efforts towards quantifying and characterizing the volume and quality of waste generated by industries and municipalities.

5.2 Policy and Regulatory Framework

The Central Pollution Control Board (CPCB) was constituted as Central Board for Prevention and Control of Water Pollution in September, 1974. The main functions of CPCB, as spelt out in the Water Act (1974), and the Air Act (1981) are [1]

- to promote cleanliness of streams and wells in different areas of the States through prevention, control and abatement of water pollution; and

- to improve the quality of air and to prevent, control or abate air pollution in the country.

In pursuance of its mandate CPCB formulates national programs for prevention and control of pollution. These include a nationwide monitoring network, laying down national standards for ambient water and air quality, source-specific Minimal National Standards (MINAS) for effluents and emissions, and action plans for critically polluted areas and highly polluting categories of industries. In regard to polluting industries, the State Pollution Control Board (SPCBs) and the Pollution Control Committees (PCCs) in UT Administration enforce the standards laid down for various types of industry.[2]

CPCB has been playing a key role in controlling pollution by generating relevant data, providing scientific information, rendering technical inputs for formation of national policies and programs, training and development of manpower, through activities for promoting awareness at different levels of the government and among the public at large.[3]

The functions of CPCB at national level include among others:[4]

- Advise the Central Government on any matter concerning prevention and control of water and air pollution
- Plan and execute nation-wide pollution control programs
- Co-ordinate the activities of State Boards and Pollution Control Committees
- Provide technical assistance and guidance to the State Boards
- Carry out and sponsor investigation and research related to pollution control
- Prepare, codes and guidelines relating to treatment and disposal of sewage and trade effluents as well as for stack gas cleaning devices, stacks and ducts
- Lay down, modify, water and air quality standards.[5]

5.3 Current Status

5.3.1 Water Quality Monitoring

The CPCB in collaboration with State Pollution Control Boards (SPCB) is operating the water quality monitoring network comprising of 784 stations in 26 States and 5 Union Territories spread over the country for monitoring of the aquatic resources. Monitoring is undertaken on monthly/quarterly basis in surface waters and half yearly basis in the case of groundwater. The

monitoring network covers 168 rivers, 53 lakes, 5 tanks, 2 ponds, 3 creeks, 3 canals, 12 drains and 181 groundwater wells.[6] Monitoring of industrial pollution control is discussed in Chapter 6.

According to CPCB overview 2005 India has [7]

- groundwater quality problems in 24 critically polluted areas and urban areas
- water quality standards are exceeded (BOD > 6 mg/l) in 86 river stretches
- common effluent treatment plant (CETP) performance is not up to desired levels in 61 CETPs.

5.3.2 Air Quality Monitoring

The National Ambient Air Quality Monitoring (NAPM) network comprising 295 stations in 92 cities and towns, under the Air Act (1981) collects compiles and disseminates information on air quality. The ambient air quality is monitored by CPCB, SPCBs, Pollution Control Committees, some universities and institutes.[8]

CPCB has identified a list of polluted cities in India based on ambient air quality data obtained under NAMP for the period 1995 to 2001. The list includes 29 Metropolitan cities and 34 other cities.[9]

The CPCB 2005 overview raises some topics on air pollution control:[10]

- air quality values are exceeded / an increasing trend in metro cities (7) and major cities (45) with respect to RSPM (respirable suspended particulate matter)/PM10 (particulate matter) and NOx (nitrogen oxides)
- toxic pollutants (VOC, benzene, PAH) levels in seven cities generally exceed the proposed guideline values.

5.4 Market Potential

Environmental monitoring and measuring offers diversified business possibilities for foreign companies.

5.4.1 Water Quality Monitoring

As stated in section 3.1 India has groundwater quality problems in 24 critically polluted areas and urban areas, water quality standards are exceeded (BOD > 6 mg/l) in 86 river stretches, and common effluent treatment plant (CETP) performance is not up to desired levels in 61 CETPs.

There is the need to increase the monitoring of water quality at source and of impacts of discharged effluents. Many receiving watercourses are heavily polluted, and CPCB has put special emphasis on controlling water pollution by setting more stringent requirements on allowable BOD-loads. This concerns especially BOD-loads from the municipal wastewater treatment plants. The major problems and new requirements set by CPCB are expected to increase the number of on-line monitoring and measuring devices both at water sources and at treatment plants, as well as in recipients.

5.4.2 Air Quality Monitoring

CPCB has stated that the acceptable levels of RSPM (respirable suspended particulate matter)/PM10 (particulate matter) and NOx (nitrogen oxides) are exceeded in over 50 cities. The same situation pertains for toxic pollutants (VOC, benzene and PAHs) in seven cities, where their proposed guideline values are exceeded. Major sources of air pollution are power generation plants, and manufacturing industries (iron and steel, cement, sugar, fertilizers, pulp and paper, copper, aluminum) in addition to vehicular pollution.

Special emphasis is put on SPM (suspended particulate matter), which is the most critical air pollutant in most of the urban areas. SO_2 levels have generally attained air quality standards in the country except in some cities of dense urban and industrial activity. Some of the measures taken, such as cleaner fuel quality and switching to cleaner fuel options, have contributed to lower SO_2 ambient levels. The air quality monitoring data indicate that the annual average nitrogen dioxide has been well within the annual average limits 60 ug per m^3 for residential area and 80 ug per m^3 for industrial areas at most urban cities.[11]

According to the Annual Report 2003–2004 of CPCB there is an immediate need to improve and upgrade the existing air monitoring network.[12] The following measures are proposed:

- old air-quality monitoring equipment needs replacement
- adequate infrastructure be provided and manpower be trained for proper sampling, preservation and analysis, data reporting, etc.
- monitoring of additional parameters such as carbon monoxide, lead, PAHs, benzene, 1,3 butadine, ozone, etc. should be carried out
- existing networks of 295 stations should be expanded and continuous monitoring of air pollutants be carried out, wherever appropriate.

5.5 Opportunities for Finnish Companies

Environmental monitoring and measuring offers possibilities to the following Finnish suppliers:

- on-line water and wastewater monitoring on pH, TSS, BOD, COD, conductivity; the following parameters are studied and analyzed case by case O_2, SS, N, P, As, Hg, Pb, Cd, Cr, Cu, Zn, Se, Ni, F, S, phenolic compounds, Mn, Fe
- on-line air pollution monitoring SOx, NOx, RSPM/SPM/PM_{10}, benzene, VOC, multi-gas analyzers.

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6 Clean Technologies and Industrial Pollution Control

6.1 Background

It is obvious that rapid industrialization and urbanization in booming metropolises are causing serious pollution problems for air, water and soil. The industries most responsible for pollution problems are sugar, textiles and chemicals, mines and minerals, pulp and paper, leather, and process industries.

Key industrial pollution problems are can be summarized as follows:

- air pollution from industrial effluents and vehicle emissions
- discharge of effluents without proper treatment into water courses
- insufficient use of raw materials and waste minimization
- management of hazardous substances.

Industrial pollution problems are addressed by a combination of legislative, punitive, and motivational measures. There are several initiatives and preventive strategies promoting industrial pollution abatement through clean technologies, but no clear incentives or financial support on a large scale for upgrading old technologies.[1]

In this chapter, emphasize is given to industrial environmental problems and India's needs for abating industrial pollution. Industrial pollution problems - weak pollution control in thermal power plants and industrial wastewater and hazardous waste treatment - are examined in more detail.

The term "clean technologies" may be defined in many ways, such as environmentally sound technologies (ETS), cleaner production, low waste technology, etc. In this report "clean" or "cleaner technologies" is used in order to avoid misinterpretations.

6.2 Policy and Regulatory Framework

Environmental legislation is set and regulated by the Ministry of Environment and Forests. Legislation is well developed. Enforcement and control of environmental measures by the State Pollution Control Board is still weak. The shift to adoption of cleaner technologies were boosted back in 1992 with the Government of India's resolution "Policy Statement for Abatement of Pollution". It recognized that mere notification of laws is not enough and instead the focus has to be on integration of environmental concerns in development planning, and on pollution prevention at source by encouraging development and application of best available technical solutions etc.[2]

6.2.1 Main Policy Initiatives

The Government started to demonstrate its commitment to cleaner production through:

- technologies rather than installation of the end-of-pipe systems presently in vogue
- provision of soft loans for switching over-providing incentives, subsidies and other concessions for promotion of cleaner from polluting and outmoded technologies to clean technologies
- abolition of subsidies for raw materials and energy in units dependent upon outmoded technologies.

So far the incentives to make such an improvement are weak. The main incentive offered by the Government of India is to provide 100% depreciation allowance for the installation of pollution control equipment. Currently, effluents are treated by "volume" not by source, which makes a 'Polluter Pays' principle impossible. The Ministry of Environment and Forests (MoEF) has set up schemes for establishing Common Effluent Treatment Plants (CETPs) and Common Hazardous Waste Treatment and Storage Facilities (CHWTSFs) in clusters of small and medium industry units. The scheme is executed through the Central Pollution Control Board (CPCB) in association with the State Pollution Control Boards (SPCBs). SPCBs are also focusing on modernization and up-grading of old industrial units. The main role of the SPCB is to monitor and control the pollution by industry. Large industrial companies have their own Effluent Treatment Plants (ETPs).[3]

Other Clean Technology Initiatives are focusing on air pollution control by promotion of cleaner energy technologies for generating and supplying power, including sugar cane, biomass, solar, small and mini-hydro, in order to reduce the use of diesel power. The Ministry of Non-Conventional Energy Sources (MNES) has taken up the following programs on various new

technologies: Chemical Sources of Energy, Hydrogen Energy and Alternative Fuel for Surface Transportation.[4]

6.3 Current Situation

For a nationwide drive to control industrial pollution CPCB has listed 17 categories of highly polluting industries and grossly polluting industries,

Table 5 Highly polluting industries in India

Industry sector	Number of units	Key pollution control challenges
Aluminum smelting	7	Pot room secondary emission
Basic drugs and pharmaceutical manufacturing	251	Incinerator performance, VOC
Caustic soda	25	High BOD/COD load
Cement (200 tpd and above)	116	High BOD/COD load
Copper smelting	2	SO_2 emission, sludge disposal
Dyes and dye intermediate	64	High COD waste, incinerator performance, fugitive emission, VOC
Fermentation (distillery)	177	High BOD/COD load, composting, color, lagoon discharge
Fertilizer	110	High COD waste
Integrated iron and steel	8	High BOD/COD load, coke oven plants toxic gas emissions, waste utilization, BOD plant performance
Leather processing (inc. tanneries)	70	High BOD/COD load, heavy metals, salt, TDS, chrome recovery
Oil refinery	12	SO_2 emission, oily sludge, VOC
Pesticide formulation and manufacturing	71	High COD waste, incinerator performance, fugitive emissions, VOC
Pulp and paper (30 tpd and above)	96	High BOD/COD load, AO_x, lime sludge disposal, chemical recovery plant, odor issues
Petrochemical	40	High BOD/COD load, hazardous waste, VOC, valve leakage
Sugar	392	High BOD/COD load, emission from boiler
Thermal power plants	97	High BOD/COD load, heavy metals, coal quality; clean coal technology, high ash Fly as management, emission of SO_2/PM
Zinc smelting	4	High BOD/COD load, SO_2 emission, sludge disposal

comprising 1551 industrial units, all of which discharge their effluents into rivers and lakes. CPCB has listed altogether 64 types of polluting industries. Most of the 17 industries and 1551 industrial units listed below are located in Maharashtra (335 units), Uttar Pradesh (224 units), Gujarat (177 units), Andra Pradesh (173 units) and Tamil Nadu (119 units). Other States have less than 100 units.[5]

6.3.1 Pollution Control at Thermal Power Plants

There are 83 coal based thermal power plants in India. 55 plants comply with emission standards and 63 plants comply with effluent standards. Annual suspended particulate matter emissions from thermal power plants are 60 million tons per year, which is three times higher than from all other industrial applications.

One of the key problems in thermal power plants is the high ash content of the coal (limit 34%). During the year 2003–04, nearly 32% of the total fly ash generation (110 million tons) in the country was utilized, mainly for manufacturing cement, bricks and in the construction of roads and embankments. Other emissions problems from coal fired thermal power plants are heavy metals like Hg, Pb, As, Cr, Cd, Ni, Cu and Zn. Furthermore the average mercury removal efficiency in power plants is 21%, and in the cleaning of coal is 15%.

There is significant interest in using Flue Gas Desulphurization (FGD) or scrubbers to simultaneously remove SO_2 and trace metals, including mercury in coal fired boilers; but so far only one scrubber has been installed. Fuel-switching is from coal or oil to natural gas or renewables like wind or solar, which are also under consideration in Indian thermal plants. The use of cleaner fuels would largely eliminate emissions of articulates, other metals, SO_2, NO_x, and carbon dioxide.[6]

6.3.2 Industrial Wastewater Treatment

Although the industrial sector only accounts for 3% of the annual water withdrawals, its contribution to water pollution, particularly in urban areas, is serious. Wastewater generation from this sector has been estimated at 55 million m^3/day, of which the major part is dumped directly into local rivers and streams without prior treatment (MOWR 2000). The highly polluting industries in the wastewater sector are: cement mills, sugar, thermal power plants, distilleries, chemicals (various), iron and steel, and pulp and paper.[7]

Industrial water pollution is characterised by high Chemical Oxygen Demand (BOD) and Biological Oxygen Demand (BOD) values. Wastewater is often contaminated with highly toxic organic and inorganic substances,

like heavy metals from thermal power plants. Water contamination from industrial areas is compounded due to the usually high concentration of industries in a small area. Increasing industrial development, coupled with inadequate zoning and emission regulations, will only aggravate the problem in coming years.

The main problems are in small-scale industries (SMEs). These have limited resources in terms of finance, space, and technology and cannot afford to treat their wastewater (effluent). The government has established a scheme for Common Effluent Treatment Plants (CETPs) in industrial areas. Implementation has been slow, and most industries are not connected to CETPs, or only partially treat their wastewater before disposal. The concept was evolved to provide necessary assistance to the SME sector, wherein the wastes generated by a number of industries are brought together to a central place and treated.

There are approximately 115 CETPs located in major cities like Delhi, Gujarat and Mumbai. There is an urgent need to increase the amount of CETPs. The goal is to have about 250 CETPs in 5 years time. Currently, the level of the treatment is secondary in up to 95% the plants. In general industries also need pre-treatment before joining CETPs. Larger industries have their own Effluent Treatment Plants (several thousands), but the level of treatment is low. Thus up-grading is also needed in this sector. Currently, tertiary treatment is applied in only 1% of the ETPs.[8]

6.3.3 Hazardous Waste Management

During the last 30 years, the Indian industrial sector has quadrupled in size. Sources of hazardous waste include those from industrial processes, mining extraction, tailings from pesticide based agricultural practices, etc. Presently, a total of around 7.2 million tons of hazardous waste is generated in the country, of which 1.4 million tons is recyclable, 0.1 million tons is incinerable and 5.2 million tons is destined for disposal on land.[9]

The main source of hazardous waste generation and impact on the environment is the chemical industry: petrochemicals, pharmaceuticals, pesticides, paints, dyes, petroleum, fertilizers, asbestos, caustic soda and inorganic chemicals. There has been a significant increase in the number of units manufacturing pesticides, drugs and pharmaceuticals, dyes, fertilizers, paint, chlorine-alkali, etc. which have a major potential for generating hazardous waste such as heavy metals, cyanides, pesticides, complex aromatic compounds (such as PCBs), and other chemicals, which are toxic, flammable, reactive, corrosive or have explosive properties.[10]

Industrial operations generate considerable quantities of hazardous waste and are located in rapidly industrializing regions such as Gujarat,

Maharashtra, Tamil Nadu, and Andhra Pradesh. Since many industrial units are spread all over the country, the impacts are region-wide. There are currently only 22 Common Treatment, Storage and Disposal Facilities (CTSDF) for hazardous waste in India. The concept of TSDF is similar to that of a CETP operated for treatment of liquid effluents. At TSDF, the wastes are collected from the waste generators, treated as per their characteristics and finally disposed of.[11]

6.4 Market Potential for Clean Technologies and Industrial Pollution Control

India offers substantial opportunities for the introduction of clean technologies to its industries. Small and medium size industries are facing the main pollution prevention and control problems. However, large scale industries with better technical and financial resources can be seen as a better immediate target for business openings. There is urgent concern with regard to re-use of raw materials, waste minimization, and heat recovery from processes in various industries.

6.4.1 Pollution Control at Thermal Power Plants

Treatment of power industry wastes from combustion of fossil fuels (mainly coal) includes wastewaters from cooling water systems, ash handling systems, wet-scrubber air pollution control systems, boiler blow-down. Wastewaters are characterized and waste treatment by physical and chemical systems to remove pollutants.

Clean technologies are needed:

- Advanced air pollution control technologies, e.g. wet scrubbers and electrostatic precipitators (ESP) for suspended particles
- Stack air quality monitoring equipment, and monitoring and testing equipment for the thermal power sector
- Clean coal technologies to reduce high ash content of the coal and maximize utilization of fly ash
- Mercury control both front-end changes
- Fuel-switching from coal to natural gas.

6.4.2 Industrial Wastewater Treatment

Most polluting industries, particularly the chemical industry and pulp and paper are lacking advanced treatment technologies in their effluent treat-

ment plants (both at CETPs and ETPs). There is also a need to intensify efficient use of water in industrial processes, recycle and re-use it.

Advanced clean technologies for

- chemical (neutralization, oxidation/reduction, precipitation),
- physical (air stripping, membranes) and
- biological treatment (microbial factors, reactors) of industrial wastewater are needed.

Technologies to reduce BOD and COD load, along with TDS and TSS treatment, are in high demand.[12]

6.4.3 Hazardous Waste Management

The market potential for hazardous waste treatment technologies is enormous. The main problems can be found among SME industry. Many Industrial Development Corporations (IDCs) have planned to set up Common Treatment, Storage and Disposal Facilities (CTSDFs). Common facilities, designed so far mainly by the National Environmental Engineering Research Institute, are considered to be of poor quality.

Clean technologies to solve industrial hazardous waste pollution problems in the following fields are of high interest:

- Cost efficient waste minimization technologies: regeneration, proper maintenance of tanks, pumps, valves etc.
- New waste utilization & recovery technologies e.g. biological waste conversion into biogas, oil recovery and reuse and metals and acids recovery
- Electronic waste (e-waste) treatment in Bangalore, Pune and Napor. IT technology companies looking for solutions to recycle electronic waste
- Hazardous waste landfill sites. Properly lined landfill sites needed for batteries, mercury, and other chemicals
- Hazardous waste incineration e.g. medical waste.

6.5 Overviews of Selected Areas

6.5.1 Maharashtra, Gujarat and Andra Pradesh

Coastal areas of Maharashtra and Gujarat state have highest concentrations of chemical, and pulp and paper industries. In the chemical industry pollution problems focus on air pollution, wastewater and hazardous waste. There are in Gujarat, Maharashra, and Andra Pradesh over 1,500 large

chemical companies and about 10,000 SMEs. Roughly 10% of the large plants are in urgent need of solvent recovery plants and other hazardous waste treatment technologies to deal with mercury pollution and in general improve their processes.

There is also an urgent need in small and medium pulp and paper plants for chemical recovery, linguine recovery plants, odour problem solutions and neutralization of chlorine used in bleaching. In these three States many refurbishment and green field investments will be made in large pulp and paper plants. Other clean technologies needed are sourcing of raw material raw water utilization and advanced waste water treatment (energy efficiency, chemical recovery, color removal).[13]

6.5.2 Delhi

Delhi region consists mainly of SME industry. Delhi has a very strong metal finishing (electroplating) industry with over 300 companies. Pollution prevention solutions are needed in electroplating operations to achieve zero discharge of wastewater and total recycle of recovered precipitates.[14]

6.6 Opportunities for Finnish Companies

The market for clean technologies is booming. The major need for clean technologies is seen within SME industries, but they have limited technical and financial resources. Cost efficient solutions are of the highest interest. The best opportunities for Finnish companies can be found in medium and large scale industries:

- Air pollution control and monitoring equipment in thermal power plants
- Water and waste treatment, and material recovery and utilization of chemical, pulp and paper and steel industry
- Hazardous waste treatment facilities (landfill sites, recycling and incineration) from various industries
- Electronic waste (e-waste) treatment in IT centres: Bangalore, Pune and Napor.

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7 Water Supply and Sanitation

7.1 Background

Access to adequate water is one of the leading factors limiting development in India. Agricultural, industrial and domestic uses are competing more and more for a limited supply. The agricultural sector continues to dominate water use owing to its continued importance in the Indian economy, while industrial demands are increasing as the sector continues to grow. Domestic needs claim only a small portion of the annual water withdrawals as access to adequate water and sanitation supplies remains low throughout most of the country. Greater access and an improvement in the socio-economic situation in rural areas will likely result in higher demand for water from this sector in coming years.[1]

Groundwater occupies an important position not only for agriculture, but also from the point of view of the economy as a whole. At present as much as 70–80% of the value of irrigated production may depend on groundwater irrigation. Since agriculture contributes roughly 29% of India's Gross Domestic Product (GDP), and production from irrigated lands heavily dominates that from rain fed, a large proportion of GDP could actually be seen to depend on groundwater. Groundwater now supplies 80% of the domestic water supply in rural areas and perhaps 50% of urban and industrial uses.[2]

7.2 Policy and Regulatory Framework

7.2.1 Water Authorities

The management of water resources falls under the jurisdiction of a number of governmental agencies. The primary responsibility for the development

of water belongs to the individual States. The Central Government oversees the implementation of national policy on resource development and exploitation, as well as managing inter-state and international rivers and river valleys. It also provides technical advice to individual States on development, flood control, navigation, coastal erosion, dam safety, navigation and hydropower, if and when required.

The Ministry of Water Resources (MOWR) is the principal agency responsible for water in India and as such, oversees the planning and development of the resource from policy formulation to infrastructure support. Other central departments working in water are:[3]

- The Ministry of Agriculture: watershed development and irrigation
- The Ministry of Power: hydropower development
- The Ministry of Environment and Forests: water quality
- The Ministry of Rural Development: watershed development and drinking water provision
- The Ministry of Industry: industrial uses of water
- The Ministry of Urban Development: urban drinking water provision and sanitation
- The Central Pollution Control Board: water quality monitoring
- The Indian Council of Agricultural Research: development of water management techniques.

7.2.2 Legislation

In addition to the National Water Policy 2002, the water sector is governed by the following environmental legislations, pollution control acts, and rules and notifications enforced[4]:

- The Water (Prevention and Control of Pollution) Act (1974, amended in 1988)
- The Water Prevention and Control of Pollution) Rules, 1975
- The Water (Prevention and Control of Pollution) (Procedure for Transaction of Business) Rules, 1975
- The Water (Prevention and Control of Pollution) Second Amendment Rules, 1976
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- The Water (Prevention and Control of Pollution) Amended Rules, 1989.

7.3 Current Situation

According to Indian basic water information, of the total annual water withdrawals the share of agriculture was 92%, domestic use 5% and industry 3%. Of the surface water withdrawals the share of agriculture is 89%, domestic use 9% and industrial use 2%. The corresponding figures for groundwater withdrawals were agriculture 92%, industrial use 5% and domestic use 3%.[5]

7.3.1 Agriculture

Agriculture remains central to the Indian economy. Therefore it receives a greater share of the annual water allocation. As in many other developing countries, it has continued to be the single largest user of water (92%). A significant trend has been the rising share of groundwater. It is often felt that the availability of cheap water to the agricultural sector has tended to encourage its pre-emption as a low value, high volume commodity, and has encouraged its waste and profligate consumption. The necessity of irrigation for agricultural production is great due to the unpredictable nature of monsoons. According to the World Bank (WB) the productivity of irrigated agriculture per unit of land has been estimated at seven times that of rainfed agriculture.

Massive investment in irrigation in the past fifty years has resulted in an expansion of the gross irrigated area from 23 million hectares in 1951 to over 90 million hectares in 1997. Plans exist to continue developing irrigation infrastructure over the coming years. Irrigation expansion has also placed greater demands on surface and groundwater resources. Groundwater alone accounts for 39% of the water used in agriculture and surface water often comes at the expense of other sectors such as the industrial and domestic supply.

7.3.2 Domestic Sector

Groundwater

There are environmental concerns regarding groundwater. The pattern of development of groundwater has created a number of sustainability, equity and efficiency concerns. At an aggregate level, groundwater overexploitation may not be considered to be a major problem. In fact, India exploits only 30% of the annual utilizable potential according to the Ministry of Water Resources (1994). However, groundwater overexploitation is a major concern in certain parts of the country. In Punjab, for instance, the level of exploitation is already around 98%.

Several areas in different states have seen a steep decline in water tables, often implying the water is being "mined", or extracted at unsustainable rates. The implications of this observation for sustainability of growth become clear when we consider the fact that those states are also India's agriculturally most important states with a heavy dependence on groundwater. Efforts have been made, however, to regulate groundwater withdrawals by a series of measures which have included licensing, credit or electricity restrictions for the construction of wells or through spacing norms.[6]

Water Supply

Demand from the domestic sector has remained low and accounts for only 5% of the annual freshwater withdrawals in India according to the World Resource Institute (WRI) (2000).[7] Domestic water use will increase, as the population continues to grow, and access to water is improved. Recent data from the World Bank indicates that the demand over the next twenty years will double from 25 billion m^3 to 52 billion m^3.

Only 85% of the urban and 79% of the rural population has access to safe drinking water. Fewer still have access to adequate sanitation facilities.[8] The recent assessment on Water Supply and Sanitation in India (2002) states that infrastructure for safe drinking water has been provided to about 85% of India's urban and rural population.[9]

The central government made a commitment to improve access to water in rural areas in the National Water Policy adopted in 1987. The original goal of providing water to100% of all citizens by 1991 had to be revised and now stands at 90% access for urban, and 85% access to rural areas. Drinking water and sanitation nevertheless remain high priorities on the government agenda. Environmental analysts say there are at least 100,000 Indian villages facing severe water shortages, while people working at improving the water supply say that only over half the country can count on its water being safe and constantly available.[10]

According the 2002 Assessment on Water Supply and Sanitation 69 to 74% of rural population take their drinking water from protected sources.[11] Between 91 to 93% of urban population take their drinking water from protected sources. Water quality problems include fluoride (66 million people are estimated to be at risk across 17 states), excess arsenic in groundwater (13.8 million people in 75 blocks are reported at risk), varying iron levels, presence of nitrates and heavy metals, bacteriological contamination and salinity.

Although major cities enjoy access to central water supply systems, these schemes often do not adequately cover the entire urban population. They may also be notoriously inefficient and unreliable in rural areas where

access to water is even more precarious. According to a fresh study the overall water supply situation at the city level is reasonably adequate in most cities and towns. The water crisis is often related more to the poor distribution of water than the lack of water at source (e.g. Delhi)[12]. Still, in areas where water is scarce, rural women must travel long distances to wells or streams to fetch water for their daily needs.[13]

Population service coverage of water distribution is 98% in Metropolitan cities (over 1 million inhabitants), 91% in Class I cities (0.1–1.0 million inhabitants) and 89% in Class II towns (less than 0.1 million inhabitants). The specific domestic water consumption is 148 lpcd (liter per capita per day) in Metropolitan cities, 106 lpcd in Class I cities and 69 lpcd in Class II towns. On average only half of the water is metered. The share of unaccounted water is estimated to be over 20%. A very small percentage of urban centres have all connections metered (e.g. Bangalore, Pune). These needs are to be taken up if tariff structures are to be rationalized and made a deterrent to wastage of water. Currently cost recovery is 70% in Metropolitan cities, 55% in Class I cities and 44% in Class II towns.[14]

There are many different types of institutional arrangements for water supply in the urban areas of the country. The most common arrangement is that the capital works are done by a state level agency and the local government does O & M (Operation and Maintenance). However, there are wide variations to this arrangement. These variations range from a state level agency managing the entire water supply system in the whole state (Rajasthan), to the local urban body performing all the tasks related to water supply (Mumbai). Privatization or public-private partnerships are increasing all the time, although they are still not very common in water supply. It is estimated that one-tenth of urban centres are using private participation in this service.[15]

Cost recovery is a major concern in water supply. Almost four-fifths of the urban centres are unable to recover even the O & M cost in this service. This indicates that while theoretically water can be treated as an economic good, there a practical difficulties in implementing decisions on raising water tariffs. Public-private partnerships could reduce the financial burden of public agencies to some extent and bring some financial discipline into this sector. While efforts have to be made to improve efficiency of water supply to reduce operating costs, the maintenance of existing assets could help in reducing new investment requirements in the near future.[16]

Sanitation

Wastewater disposal and treatment is problematic in most Indian cities. Non-collection of wastewater and discharge of untreated wastewater into low-lying areas of various water bodies causes severe water and land pol-

lution problems. This situation reduces the availability of usable water for water supply.[17]

A fresh study indicates that while all Metropolitan cities have a sewerage system, a third of the Class I cities and less than one-fifth of the smaller-sized urban centres have a sewerage system. The service coverage of the sewerage system is 63% in Metropolitan cities, 48% in Class I cities and 51% in Class II towns. Of the generated wastewater 41% is treated in Metropolitan cities, 25% in Class I cities and 11% in Class II towns. This is due to the fact that 4% of Metropolitan cities, 28% of Class I cities and 17% of Class II towns lack Sewage Treatment Plants (STPs).[18]

The Central Pollution Control Board (CPCB) has estimated in 2005 that 22.9 million m^3 of domestic wastewater is generated. The treatment capacity available for domestic wastewater is only for 5.9 million m^3. As can be seen, there is still a big gap between the quantity of wastewater generated and treated. The Government of India is assisting the local bodies to establish sewage treatment plants under the Ganga Action Plan and the National River Action Plan.[19]

Based on the survey by CPCB on the status on wastewater collection and treatment of 212 major cities, only 71 cities (31%) responded on wastewater collection facilities. Out of the 71, three cities Chandrigarh, Bharuch, Bhikai have 100% population covered by sewerage system. Only 18 cities (8.5%) have more than 75% of population covered by sewerage system. None of the twelve Metropolitan cities reported 100% coverage of population with sewerage facilities and only 6 have sewerage facilities covering more than 75% of the population.[20]

Out of the 212 cities only 48 (23%) responded on the existence of wastewater treatment facilities, 15 having partial primary and partial secondary facilities, 13 having secondary treatment facilities. 10 Metropolitan cities have sewage treatment facilities out of which 4 have only primary facilities, 4 have partial primary and secondary and 2 have secondary facilities.[21]

CPCB has carried out a series of studies on performance of sewage treatment plants. Majority of the treatment plants are based on Primary Settling followed by Activated Sludge Process technology (with anaerobic digesters for sludge), Oxidation Pond or Waste Stabilization Pond technology and UASB (Up flow Anaerobic Sludge Blanket) reactor followed by a Polishing Pond.[22] Simultaneously India is actively looking for new wastewater treatment methods and options for adoption. There is special interest in UASB, 2-stage Aerobic Unitank System (TSU-System), Root Zone treatment and land treatment for waste management. Sewage utilization is also discussed, such as use of sewage in pisciculture, sewage utilization in forestry and use of vermiculture for waste management.[23]

All of India's fourteen major river systems are heavily polluted, mostly from untreated sewage discharged into them around the year. In addition, inadequate treatment of human and animal wastes contributes to the high incidence of water-related diseases in the country. Water contaminated by human waste is often discharged directly into watercourses or seeps into the groundwater table from faulty septic tanks or pit latrines. The level of fecal coli form bacteria in most rivers often exceeds WHO standards and is responsible for causing a number of gastrointestinal ailments among the population.

7.4 Market Potential

The Tenth Plan emphasizes provision of these important infrastructure facilities and 100% coverage of urban population with water supply facilities and 75% of urban population with sewage and sanitation by the end of the Tenth Plan period, i.e. March 31, 2007. The funds required for this purpose are estimated at 9.88 billion Euros. Of this sum water supply is estimated to require 527 million Euros, sanitation 432 million Euros and solid waste management 430 million Euros. Simultaneously the likely funding availability from different sources is estimated to total 6.67 billion Euros.[24]

Based on the latest World Bank estimates the total bank lending for Water for India (2004-2008) will increase from 160 million Euros to 750 million Euros a year and will by sectors be made up over the four years as shown below:

- Water resources – developing information systems, rehabilitating and modernizing major infrastructure, watershed management, water rights, capacity building – 350 million Euros
- Watershed management – As part of rural livelihood programs, about 160 million Euros
- Irrigation – de-linking irrigation services and WRM, utility reform, strengthening cost recovery, regulation, beneficiary participation, increased productivity of water, water rights – 1.16 billion Euros
- Rural water and sanitation – Continue demand responsive approach, moving from pilots to scale through centrally funded schemes (SWAPs) – 580 million Euros
- Urban water and sanitation – utility reform, improving services to the poor, PSP – 80 million Euros.

The water and wastewater treatment segment is among the largest in market size. Its potential is expected to triple from about 5.83 billion Euros in 2000 to 18.33 billion Euros in 2010. This market demands technologies among

others for purifying drinking water, processing sewage, and removing pollutants from industrial wastewater.[25]

Trade Team Canada Environment has estimated that the value of water and wastewater market in India is more than 830 million Euros, about which 1/3 is for water provisioning, 1/3 for municipal water treatment and 1/3 for industrial water treatment. The market is estimated to grow 15–20% annually.[26]

7.5 Overviews of Selected Areas

7.5.1 Delhi Wastewater Treatment

Delhi, the capital of India has a population over 13.9 million, and it expected to increase to 23 million by 2021. Presently about 3.364 million m^3 water is daily distributed by Delhi Jal Board (DJB), and about 3.267 million m^3 of wastewater is generated in Delhi, including 0.218 million m^3 from industrial sources.

The total wastewater collected by DJB is 1,979 million m^3, but not all the wastewater collected by the sewer system is conveyed to the treatment plants. The overflows from pumping stations and industrial wastewater from areas without sewerage, finally amounting to about 0,771 million m^3, is discharged into open drains. Nearly 40% of the population does not have sewerage facility.[27]

The annual average discharge in 2003 through drains into the River Yamuna/Agra Canal has been about 3,9 million m^3 including about 0,6 million m^3 of freshwater in Najafgarh drain. The average BOD-load was about 243 tons per day. It is concluded that actual treatment is given only to about 45% of total sewerage generated. Delhi has 30 sewage treatment plants (STPs) located at 17 locations in the city. The total installed wastewater treatment capacity is 2.330 million m^3. 20 plants are running under capacity, 5 over capacity, 2 to their capacity and 3 are not in function. 23 plants are based on activated sludge process, 2 on extended aeration, 3 on high-rate bio-filter and 1 on trickling filter and 1 on oxidation pond principle. Most of the treatment plants based on activated sludge process do not perform satisfactorily due to operational problems. Average reduction in BOD, COD and TSS load are calculated as 87%, 81% and 88% respectively.[28]

The existing capacity of STPs is under-utilized due to deficiency in collection system and chocking of existing sewerage failure of pump connections and trunk sewers, internal sewers and peripheral sewers. The trunk sewers are 136 km and heavily silted. The large network of (6,000 km) peripheral sewers is very old and some of them are under-sized and also in

damaged condition. Since operation and maintenance of interception of sewage from sewer lines and pumping stations is the weakest part of sewage management in Delhi, O & M of STPs is required to be addressed on a priority basis. Additionally primary sludge generated at STPs should have adequate digestion facilities including utilization of biogas.[29]

7.5.2 Mumbai Wastewater Collection Improvement

The Municipal Corporation of Greater Mumbai (MCGM) collects 2.9 million m^3 wastewater in Greater Mumbai area from various places. MCGM has sub-divided its operation into seven geographical zones Worli, Bandra, Versova, Malad, Bhandup and Ghatkopar. Each zone has a wastewater treatment plant, out of which Bhandup, Malad and Versova are lagoons. About 1 million m^3 of the collected wastewater is released into the Arabian Sea and the balance into 3 lagoons at Versova, Bhandup and Ghatkopar.

MCGM's aim is to increase the service coverage of wastewater collection to 80% within the next five years by improving pipelines. The estimated investment cost is about 370 million Euros Currently MCMG use cement pipelines (1,400 km) and the leakage is about 5%. MCGM is looking for new technology for efficient sewerage operation.[30]

7.6 Opportunities for Finnish Companies

The water supply and sanitation sector offers the best opportunities for Finnish companies in the following areas and applications: (See also opportunities described in sections 5.5.)

- Efficient use, re-use and circulation of water in industrial processes, especially in pulp and paper, steel and chemical industry
- Equipment and materials for water and sewage network leakage control
- Waste water treatment equipment, especially bottom aeration (to compensate surface aeration)
- Dewatering, thickening and digestion of primary sludge and utilization of biogas as an energy-source, digestion of sewage sludge.

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8 Solid Waste Management

8.1 Background

There has been a significant increase in municipal solid waste (MSW) generation in the last few decades. Due to rapid urbanization and uncontrolled growth rate of population, municipal solid waste management (MSWM) has become acute in India. MWM as an essential service is given low priority. Lack of financial resources, institutional weaknesses, improper choice of technology and public apathy towards MSW has made this service far from satisfactory. The current practices of the uncontrolled dumping of waste on the outskirts of towns and cities have created a serious environmental and public health problem, endangering water quality.

The per capita MSW quantity generated daily ranges from 100 g in small towns to 500 g in large towns. The increased MSW generation can be ascribed to changing lifestyles, food habits and change in living standards. The amount of waste generated per capita is estimated to increase at a rate of 1–1.33% annually. The total waste quantity generated by the year 2047 is estimated to be about 260 million tons per year. That is more than five times the present level of about 55 million tons. The enormous increase in solid waste generation will have significant impacts in terms of the land required for waste disposal. It is estimated that if the waste is not disposed off in a more systematic manner, more than 1,400 km^2 of land, which is equivalent to the size of city of Delhi, would be required in the country by the year 2047 for its disposal.

Municipal corporations are primarily responsible for solid waste management. Municipal bodies render SWM services. Though it is an essential service, it is not attaining the proper priority which it deserves, and services are poor.

MSW in cities is collected by respective municipalities and transported to designated disposal sites. These are normally low lying areas on the outskirts of the city. But with the growing population and urbanization municipal bod-

ies are facing financial pressures and can no more cope with demands. The limited revenues ear-marked for the municipalities make them ill-equipped to provide for the high costs involved in the collection, storage, treatment and proper disposal of waste. Municipalities are only able to provide secondary collection of waste. It means that they only collect waste from municipal bins or depots. A substantial part of the municipal solid waste generated remains unattended and grows in heaps at poorly maintained collection centres.

Open dumping or garbage facilities breeding of disease vectors such as flies, mosquitoes, cockroaches, rats and other pests. The poorly maintained landfill sites are prone to groundwater contamination because of leachate. The choice of a disposal site also is more a matter of what is available than what is suitable. The average collection efficiency for MSW in Indian cities is about 72.5% and around 70% in cities lacking adequate waste transportation capacities (TERI 1998). The unsanitary methods adopted for disposal of solid wastes are, therefore, a serious health concern.[1]

At present the standard of solid waste management is far from being satisfactory. The municipalities therefore face the challenge of reinforcing their available infrastructure for efficient MSW management and ensuring the scientific disposal of MSW by generating enough revenues either from generators or by identifying activities that generate resources from waste management. The Government has framed Municipal Solid Waste (Management and Handling) Rules 2000, under the Environmental Protection Act, 1986.

8.2 Policy and Regulatory Framework

The Municipal Solid Waste Rules are as follows:[2]

1. Collection of municipal solid wastes – organizing doorstep collection of municipal solid waste from houses, hotels, restaurants, office complexes ad commercial areas
2. Segregation of municipal solid wastes – municipal authority shall organize awareness programs for segregating the waste at source as dry and wet waste and promote recycling or reuse of segregated materials
3. Storage of municipal solid wastes – municipal authority shall establish and maintain storage facilities such that wastes stored are not exposed to the open atmosphere and shall be aesthetically acceptable and user friendly and it should have easy-to-operate design for handling, transfer and transportation of waste
4. Transportation of municipal solid wastes – vehicles used for transportation of wastes shall be covered and waste should not be visible to public, nor exposed to the open environment and shall be designed so that multiple handling of wastes prior to final disposal, is avoided

5. Processing of municipal solid wastes – municipal authorities shall adopt suitable technology or combination of such technologies to make use of wastes so as to minimize burden on landfill
6. Disposal of municipal solid waste – land filling shall be restricted to non-biodegradable, inert waste and other waste that are not suitable for recycling or for biological processing. Land filling of mixed waste shall be avoided unless the same is found unsuitable for waste processing.

8.3 Current Situation

8.3.1 Rural Areas

There are various types of waste in rural areas namely: community wastes, wastes from agricultural and agro-based industries, animal wastes and oil bearing seeds, etc. Table 6 provides estimated annual generation of various types of rural wastes in India.[3]

In 1991 the rural population of 629 million was distributed over nearly half a million villages. This makes for a small population per rural settlement. Additionally, the population densities are also very low compared to highly urbanized areas. Due to these reasons, collection and transportation of rural waste is not a pressing problem. Low overall volumes also do not necessitate institutional structures for its management.

Table 6 Estimated Annual Generation of Various Rural Wastes in India (National Waste Management Council, 1990).

Types of Waste	Estimated Generation (million tons)	Percentage of total waste
Community	15	0.81
a) Night soil	5	
b) Refuse	10	
Agricultural residues	322	17.4
Animal dung	1,365	73.74
Agro-industrial by-products	49	2.65
Oil seeds	100	5.4

Table 7 outlines utilization of rural wastes for various end-uses. Agricultural residues are largely used as animal feed; a small portion is also used as fuel and as construction material. It is found that traditional practices of using wastes by way of fuel, animal feed and farm manure accounts for nearby 90% of all waste utilization. Barely 1.6% of wastes are not being utilized for any useful purpose. It is clear that traditional methods have been adequate for handling wastes generated.

Table 7 Percentage Utilization of Rural Wastes for Various End Uses (National Waste Management Council, 1990).

End use	Percent of Utilization (%)
Fuel	14.8
Animal feed	35.0
Farm manure	39.3
Construction material	2.8
Industrial raw material	1.5
Other uses	4.9
Waste	1.6

For use as fuel, animal dung is shaped into cakes and dried and stored to be used for domestic cooking. The excess is also used to make compost for farm applications. Composting is carried out by accumulating dung, domestic and other wastes in a heap or pit. Agricultural residues are largely used as animal feed; a small portion is also used as fuel and as construction material.

The use of certain wastes as industrial raw materials is limited to only 1.5%. A number of possibilities exist to ensure increases in industrial utilization or rural wastes for making value added products. Rice husk based particle boards, bagasse-based paper, charcoal, packaging material; chemicals through bio-conversion and industrial fuel are examples.

Although, solid waste management in rural areas is quite established, some new inputs do exist. Technologies such as improved chulhas (wood/dung stoves), biogas from night soil or agro-residues, biomass densification, gasification and pyrolysis offer ways to enhance energy efficiencies. They also ensure efficient utilization of available resources, in addition to improving quality of life for rural populations.[4]

8.3.2 Urban Areas

Waste quantities and quality

The National Environmental Engineering Research Institute (NEERI) has clarified in 1996 specific quantities of MSW in Indian cities. Studies reveal that the quantity of waste generation varies between 0.2–0.4 kg/capita/day in the urban centres and it goes up to 0.5 kg/capita/day in metropolitan cities (Table 8). In the recent study made by CPCB and NEERI, covering 59 cities in the country, the waste generation rate varied from 0.19 kg per capita per day

Table 8 Per Capita Quantity of MSW in Indian Cities

Population Range (in million)	Average Per Capita Value (kg/capita/day)
< 0.5	0.21
0.5–1.0	0.25
1.0–2.0	0.27
2.0–5.0	0.35
> 5.0	0.50

(Nasik and Imphal) to 0.62 kg per capita per day (Chennai).[5]

The urban population of 285 million is concentrated in a few large cities and 32 Metropolitan cities account for 34.5% of urban population. That is expected to reach 341 million by 2010 (Census of India, 2001). The waste quantities are estimated to increase from 46 million tons in 2001 to 65 million tons in 2010. The yearly increase in waste generation is expected to be around 5% annually.

National Solid Waste Association of India (NSWAI) has estimated that out of the 30 million tons per annum of urban municipal solid waste, 8.5 million tons come from 9 metropolitan cities alone. Only about 60–80% of these wastes are collected on a daily basis and the rest is left to decay on the roads, streets and drains. CPCB has estimated in 2000 that the 299 Class I cities, with a total population of roughly 128 million people, generated 48,134 tpd MSW. Out of this 62.4% solid waste is generated by only 23 Metropolitan cities. The national average for Class I cities was 0.376 kg/capita/day.[6]

Characterization studies carried out by NEERI (1996) indicate that MSW contains large organic fraction (30–40%), ash and fine earth (30–40%), paper 3–6% along with plastics, glass and metal (each less than 1%), calorific value of refuse ranges between 800–1000 kcal/kg and C/N ratio ranges between 20 and 30 (Table 9).

In the recent study of NEERI and CPCB the percentage of the recyclable portion in MSW varies from 10% (Ranchi) to 36% (Shimla). The calorific value of waste generated was in the range of 591 kcal per kg (Dhanbad and Kochi) to 3766 kcal per kg (Imphal and Aizwal).[7] Usually calorific value of

Table 9 Physical-chemical characteristics of MSW in Indian cities (NEERI, 1996).

Population range (in million)	Number of cities surveyed	Paper*	Rubber*, leather and synthetics	Glass*	Metals*	Total* compostable matter	Inert* material
0.1 to 0.5	12	2.91	0.78	0.56	0.33	44.57	43.59
0.5 to 1.0	15	2.95	0.73	0.35	0.32	40.04	48.38
1.0 to 2.0	9	4.71	0.71	0.46	0.49	38.95	44.73
2.0 to 5.0	3	3.18	0.48	0.48	0.59	56.67	49.07
Over 5.0	4	6.43	0.28	0.94	0.80	30.84	53.90

* = All values are in percent, and are calculated on wet weight basis

MSW is low due to the fact that it is mixed waste with high compostable (wet) matter content. Based on NSWAI data the average density of municipal garbage varies between 500–600 kg per m^3.

The waste characteristics are expected to change due to urbanization, increased commercialisation and higher standards of living. The present trend indicates that the paper and plastics content will increase while the organic content will decrease. The ash and earth content is also expected to decrease mainly due to an increase in the paved surface. Although, the organic content is expected to decrease, the material will still be amenable to biodegradation and the calorific value will continue to be unsuitable for incineration.

Waste Collection

Waste collection efficiency ranges between 50% to 70% of the solid waste generated. It is usually much better in larger cities than in smaller urban centres. This could also be due to the motorized transportation vehicles deployed in larger cities. Some of the smaller urban centres still depend on tricycles and animal carts for waste collection.[8]

A community bin collection system is usually practiced in India Collection of waste from house-to-house (for a large percentage of population), dispensing with community bin system, and initiatives for waste segregation has been undertaken in cities like Chennai, Bangalore, Nagpur, Nasik, Chandigarh, Panjim and Gangtok.[9] Suryapet and Namakkal are among the first towns to introduce a bin-less city concept.

The collection bins and associated implements in various cities are not properly designed. It has been observed that community bins have not been installed at proper locations. This has resulted in poor collection efficiency. Lack of public awareness has made the situation worse. Additionally there is a very large informal sector of rag pickers, which collect recyclable waste from streets, bins and disposal sites. They take away paper, plastics, metal, glass, rubber, etc. for their livelihood, but a small quantity of recyclable material is still left behind.

Various types of vehicles are used for collection and transportation of waste to the disposal site. However, these vehicles are not designed as per requirement. In many urban centres, proper garages are not provided for the vehicles for protection from heat and rain. Preventive maintenance system is not adopted and as a result the life of the vehicles is reduced. Many of the vehicles used for transportation of waste have outlived their normal life.

Waste transportation has been privatized in many cities, such as Mumbai, Bangalore, Jaipur, Kochi. Nasik, Jabalpur, Jamshedpur, Asansol, Guwhati, Bhubaneshwar and Kavarati.[10, 11]

Waste Treatment and Disposal

The most critical Indian experts of SWM claim that there is no proper solid waste treatment at all in India. They claim that there is no proper landfill treatment (if it can be regarded as treatment at all), because waste is just relocated to dumpsites. Additionally composting of waste is carried out in an improper way, so that the compost end-product does not fulfil any quality criteria. The lack of will and enforcement more than the lack of money and resources is limiting the progress of solid waste management in the country.

In keeping with the present practices and estimates of waste generation, around 90% of the generated wastes are land filled, requiring around 1,200 hectare of land every year with an average depth of 3 meters. An increase in the solid waste generation impacts the cumulative requirement of land for disposal of solid waste, estimated to cumulate to about 1,400 km^2 by 2047 from about 100 km^2 in 2001. Diversion of land for waste disposal is physically impossible as the area with the largest concentration of solid waste is also the area with a serious scarcity of vacant land. Therefore, if the current methods of SW disposal persist, the waste will have to be carried over long distances, requiring improved transport facilities and infrastructure, involving additional finances.[12]

Waste is disposed of in low-lying areas without taking any precautions and without any operational control. Dumpsites are usually of a low technical level without any crushing, earth coverage, leachate or biogas collection and treatment. In 1997, landfills released about 7 MT of CH4 into the atmosphere, which is projected to increase to 39 MT under the BAU scenario.[13]

Manual composting of mixed MSW is carried out in smaller urban centres. Although in the 1980's mechanical composting plans were set up in 10 cities, currently only one of these plants continues to be in operation. Over the years, a few more plants have been set up. Incineration has not been successful due to the low calorific value and high moisture content of waste. Mumbai was one of the first cities which piloted a waste-to-energy plant and a composting plant in the 1980's.[14]

Based on the study of NEERI and CPCB (2005) of the 59 cities, some cities have set up some waste treatment facilities although most of the cities are operating landfills as uncontrolled dumpsites.[15]

- Ahamdabad composting plant (capacity 500 tpd)
- Bangalore composting plant (capacity 300 tpd)
- Gangtok composting plant (capacity 50 tpd)
- Jamshedpur composting plant (capacity 40 tpd)
- Kolkata composting plant (capacity 700 tpd)
- Raipur composting plant (capacity 100 tpd)
- Simla composting plant (capacity 40 tpd)

- Shillong composting plant (capacity 100 tpd)
- Thirivananthapuram composting plant (capacity 150 tpd)
- Indore vermicomposting (capacity 300 tpd)
- Nagpur vermicomposting (capacity 30 tpd)
- Pune vermicomposting (capacity 50 tpd)
- Hyderabad pelletization and energy recovery plant
- Wiyaywada composting and waste-to-energy.

When reviewing the above treatment technology portfolio, it can be seen, that outdoor vermicomposting or composting of mixed MSW are the dominating technologies. Although composting is regarded as an applicable method for SWM, it also faces some challenges. The biggest challenge to composting is the poor end-quality of the compost end-product. That is due to the "raw material" which is poor-quality MSW. Also lacking are quality criteria for compost end-products, which would enable producing any kind of compost end-product. Actually this means that the end-product is very difficult to market, distribute or utilize reasonably. Ensuring good quality compost product would need segregation of organic waste at source. This is impossible in most cities due to the current waste collection arrangements.

So far about 35 composting projects have either emerged or been finalized in different cities. The installed capacity of the projects ranges from 5 to 700 tpd. Funds required for such project vary from 0.56 million Euros to 1.26 million Euros. Mostly the compost plants have come up with private sector participation in different formats of privatization.[16]

Waste-to-energy (WTE) projects are a relatively new concept for disposal of SW. Although these have been tried and tested in developed countries with positive results, there are yet to get off the ground in the country largely of the fact that financial viability and sustainability is still on test. While a number of cities have adopted WTE plants, such as Hyderabad, Viyaywada, Lucknow, most of these have been unsuccessful experiments till now. This is primarily due to the composition of the waste and the lack of markets for end-products. Although, recent WTE plants have involved the private sector in their installation and O & M, most are heavily dependent on subsidies provided by the Ministry of Non-Conventional Energy Sources (MNES) and financing institutions such as HUDCO. The MNES has prepared a master plan for WTE for India, to ensure optimum outputs from WTE plants.[17]

Urban Local Bodies spend around from 9.32 to 27.98 Euros/ton waste on solid waste management. Of that cost 60–70% is on collection alone, 20–30% on transportation, and hardly any funds are spent on treatment and disposal of waste.

In addition to MSW, also hazardous waste and biomedical waste sectors offer interesting possibilities.

8.4 Market Potential

Solid waste sector offers diversified possibilities to foreign companies with low-cost technologies, products or services. There is an urgent need in most cities to change, restructure or intensify the waste collection systems. This concerns as well as waste bins, containers, and re-loading stations of waste as collection vehicles. There is an apparent need for promoting new ideas and concepts of SWM in waste collection, segregation and waste transportation. This concerns hazardous waste and biomedical waste, too.

Due to the lack of capital, so far low-cost treatment technologies, such as "dumpsite treatment" (if any treatment at all), and composting technologies have been used. The role of waste recovery and recycling has not been essential, because rag pickers have taken care of valuables and recyclables. The lack of land and increasing waste quantities require new technologies, which are applicable for mixed MSW and competitive.

It is quite probable that outdoor composting will increase its role in future, in case, reasonable use can be found for the compost end-product. The prospects for anaerobic digestion (or for anaerobic composting as called in India) are also promising. The economy of the last mentioned technology is highly dependent on the reasonable utilization of heat energy. Some experts regard also gasification and mechanical-biological technologies applicable for mixed MSW. The previously mentioned technologies form the most probable technology portfolio from which the metropolitan cities will choose their own technologies and solutions in future years. Most plans will be implemented using private sector participation and financing. However, as mentioned earlier, the time for recycling technologies is still waiting to come.

8.5 Overviews of Selected Areas

8.5.1 Solid Waste Management in Mumbai

The Solid Waste Management Department of the Municipal Corporation of Greater Mumbai (MCGM) takes care of SWM in Mumbai with a population of rough 15 million people, and a population density of about 46,000 inhabitants per km^2. MCGM is responsible for collection, removal and transportation of solid waste, its disposal in addition to some other obligatory services.

The city area of 438 km^2 consists of 220 sections. The generated MSW quantity is about 7,000 tpd, of which 4,500 tpd is biodegradable waste, 500 tpd dry wastes, 2,000 tpd silt and debris, and 25 tpd biomedical wastes. The waste consists of household waste, commercial waste, hotel and res-

taurant waste, market waste, institutional waste (schools, offices, hospitals, etc.), construction waste (earth, stones, sand, etc.), street sweepings, trade waste, stable waste and silt removed from drain and nallah cleaning. The waste composition include 37.5% compostable matter, 35% sand and fine earth, 15% paper and cardboard, 0.75% plastics, 0.80% metals and 10.55% others.

Waste collection from about 7,000 waste bins is done as community bin collection (83%) and house-to-house collection (17%). The collection vehicles fleet covers open trucks (18), compactors (138), skip vehicles (123), dumpers (82), JCB machines (22), bulk refuse carriers (18) and other vehicles (8). Additionally MCGM has 3 transfer stations, out of which one will be modernized.

Waste treatment is presently based on landfill treatment (95%), localized vermiculture (composting) and recycling of dry wash by rag pickers. MCGM has 3 landfills with the total surface area of 150 hectares: Deonar (111 hectares), Mulund (25 hectares) and Gorai (15 hectares), which receive the respective waste quantities of 4,140, 275 and 1,800 tpd. The quantity of waste converted into manure through processing is 200 to 240 tpd.

MCGM is actively looking for new treatment methods and planning new waste treatment plants to be implemented within the next years, including plants for composting (around 4,500 m^3/d), for biomethanization (around 500 m^3/d), plasma treatment (around 300/500 m^3/d) and RDF (around 300 m^3/d). Based on the discussions there is also interest in biomechanical waste treatment technology.[18, 19]

8.5.2 Decentralized Approach of Solid Waste Management (Delhi, Mumbai)

The main method of waste disposal continues to be open dumping in most urban centres. While many urban centres have landfill sites, not all dispose of their waste in these landfill sites, because sometimes the sites are far away from the city and the transportation costs become prohibitive.[20] Apart from the usual problems of budget constraints and competing use of funds and lack of expertise, mega cities like Mumbai and Delhi face increasing pressure on available land. As a result, the treatment and disposal of MSW faces severe constraints. There is resistance from the population for the locating of dumpsites. Moreover the transportation of MSW from individual wards to the dumpsite itself puts pressure on the already critical road transportation network in this cities.[21] For instance in Mumbai 1/8 of the municipal budget on SWM is spent on maintaining and operating transport vehicles only. The budget provision for SWM services for the year 2003–2004 was 107 million Euros.

Table 10 Decentralized MSW management in Mumbai.

MSW Generation (tpd)	6.000
Average generation of waste per section (tpd)	28
Number of sections in a block Generation of MSW per block (tpd) Organic content of MSW (35%) (tpd)	6 or 7 179 63
Recyclables (20%) (tpd) Construction debris (20%) (tpd) Inert material (25%) (tpd)	36 36 45
Power generation potential (biomethanization) (kW)	400
Number of blocks/projects	34–35

In the above situation, and in the light of heavy expenditure on the transportation of solid waste, it is imperative for administrations of mega cities to adopt a decentralized approach based on the "treatment closer to generation" concept. Under this approach, in each city, five to six contiguous sanitary sections (in Mumbai there are around 220 sanitary sections in its 24 administrative wards) could be clubbed into smaller manageable blocks of required size. In all the wards of the city, door-to-door collection and segregation of waste at source can be organised. The segregated organic waste (not mixed waste as today) would be transported to the treatment plant located in the block itself. These facilities could be based on different technology options.

The viable size for such a project is estimated at 60 tpd of segregated organic waste. A biomethanization project of this size could be in the range of 0.37–0.56 million Euros, whereas composting could be 0.037–0.056 million Euros. A likely Mumbai scenario is shown in Table 10.

8.6 Opportunities for Finnish Companies

Solid waste sector is one of the most promising environmental technology sectors for Finnish companies. The sector offer possibilities in:

- Institutional strengthening and training on SWM; especially for regional Finnish SWM companies
- Engineering and consulting services on waste collection and transportation, landfill treatment, waste treatment plants: outdoor composting, anaerobic digestion of waste and sewage sludge, biological-mechanical waste treatment, waste-to-energy

- Waste collection and source-segregation: e.g. deep waste and hazardous waste containers,
- Waste transportation and re-loading of waste: collection vehicles with loading equipment, removable containers, hook-lift systems, washing of waste bins, re-loading stations
- Landfill treatment: waste compactors, biogas and leachate collection, bottom and top lining/covering of dumpsites and landfills
- Solid waste treatment:
  - in outdoor composting: turning machines, mixing scoop
  - in anaerobic digestion of MSW and sewage sludge
  - in biological-mechanical treatment
  - in waste-to-energy plants
- Hazardous and biomedical waste treatment.

In India, as anywhere in developing countries, there is an urgent need to see different options and solutions on SWM made in developed countries. Many Indian urban local bodies are lacking money for arranging their SWM on a sound basis and making the necessary investments. Therefore Indians are interested in efficient and reasonably priced technologies and solutions. There is also a real and huge need to learn about foreign practices and SWM entities, and how they have financed their operations. Finnish solutions seem to interest local experts, based on the discussions held, and this could offer a possibility to cooperate actively with the Indian cities and SWM experts.

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9 Climate Change and Clean Development Mechanism (CDM)

9.1 Background

Global climate change and its impact on all nations is considered one of the most daunting environmental challenges of the current century. In India climate change represents an additional stress on ecological and socioeconomic systems which are already facing tremendous pressures due to rapid urbanisation, industrialisation and economic development. With its large and growing population and an economy which is closely tied to its natural resource base, India's population is vulnerable to the impacts of climate change such as deterioration of forest and water resources and sea level rise.

Major impacts of climate change to India can be summarised as follows:

- *Increase in sea level:* significant damage to the population and infrastructure in coastal regions are expected.
- *Water resources:* the hydrological cycle is predicted to become more intense due to higher annually average rainfalls as well as increased drought.
- *Agriculture:* productivity will decrease, crop patterns will shift.
- *Forestry:* existing biome types will change, forest diebacks will become more widespread, and biodiversity will decrease.
- *Human health:* temperature increase related illnesses and health effects through extreme weather events and due to food insecurity will occur.
- *Infrastructure:* industry, energy production and transportation will require significant financial investment while facing an ever riskier natural environment.

As the country industrialises, its production of Green House Gases (GHGs) which contribute to climate change will increase. Currently, 73% of In-

dia's power generation relies on coal, making the nation the fifth largest and second fastest growing producer of GHGs. Yet, despite significant economic growth, roughly 30% of the population does not have access to electricity. The country's energy needs will grow considerably in the coming years.[1]

9.2 Policy and Regulatory Framework

India signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and ratified the Kyoto Protocol on 26 August, 2002. India, as other developing countries, does not have CO_2 emissions reduction targets.

The Ministry of Environment and Forests (MoEF) has overall responsibility for climate change issues. The Government of India (GOI) has not formulated clear climate change mitigation policies so far. Measures to mitigate Green House Gases (GHGs) are mainly related to promotion of renewable energy technologies. The actual "policy making" on climate change is driven by the Clean Development Mechanism (CDM). The GOI has a very proactive approach to attract foreign investors to develop CDM projects. In fact, India has been ranked first in the world in terms of approved CDM projects. Chapter 9.5 describes the CDM in more detail.[2]

The GOI efforts to reduce GHG emissions can be summarized as follows:

- Emphasis on energy saving.
- Promotion of renewable energy sources.
- Vehicle efficiency and transport fuel improvements.
- Removal of government subsidies in energy.
- Promotion of joint ventures in capital good investments.
- Fuel substitution policies.

There are a number of areas where India has reduced GHG emissions. The gradual removal of energy subsidies and the move towards world market prices in energy sources has strongly cut back demand for coal, which trades at a five-fold price today compared to 1980. Electricity prices have risen even more over this period. This has lead to a shift towards more energy-efficient imported goods as well as to innovation in producing energy efficient Indian products. Through a long tradition of government promotion of renewable energy sources India reached a yearly renewable energy production of 6,500 MW in 2005.[3]

Other policies have reduced GHG emissions in the transport sector. For example in New Delhi the vehicular pollution measures have dra-

Table 11 Future projects and strategies to mitigate GHG emissions in India.

Activity	Strategy
Retrofit projects: ■ Boiler retrofit ■ Process improvements	Promote technology transition in small and medium industry Link resource discussion programs
Green field investments: ■ New wind farm ■ Gas Power Plant	Promote technical and financial collaborations Jumpstart technology transition and hedging
Infrastructure projects: ■ Gas pipeline ■ Road/Rail infrastructure	Link with development Regional energy cooperation High mitigation potential, but difficult to operate under CDM regime
Mitigation programs: ■ Demand-side efficiency ■ Electricity distribution reforms ■ Consumer awareness	Strong link with economic reforms and sustainable development High transaction costs, but high co-benefits No way to operate under Kyoto regime

matically decreased after the introduction of Euro II and Euro III norms and the requirement to use Compressed Natural Gas (CNG) in taxis and buses.[4]

For coming years the GOI highlights the projects and strategies listed in Table 11.

Despite these efforts it is obvious that GHG emissions in India will continue to rise especially as economic reforms take place. Only strong policies aimed at changing the future composition of energy generation could hinder the increase of GHG emissions.

9.3 Current situation

9.3.1 Green House Gas Emissions

Although India's per capita emission figures are very low, the country is among the top five contributors to the current global Green House Gas (GHG) emissions just after the U.S., China, Russia and Japan. About 60% of GHG emissions come from coal and oil-based industries. Table 12 indicates main sources of GHGs in 2000.[5]

Table 12 Main Contributors to CO_2 equivalent emissions in 2000.

Source categories	Main emissions	Share (%)	Emission (Mt-CO2 eq)
Coal based electricity	CO2	29,9	431.6
Steel industry	CO2	8,8	127.0
Cement industry	CO2	5,1	73.6
Livestock related	CH4, N2O	12,6	181.8
Paddy (rice) cultivation	CH4	6,6	96.1
Biomass consumption	CH4, N2O	5,2	75.0
Synthetic fertilizer use	N2O	4,1	59.2
Transport sector	CO2	9,5	137.1
Waste disposal	CH4	3,8	54.8
Other sources	CO2, CH4, N2O	14,4	207.8
All India (Mt-CO2 eq)	1,443.0		

9.3.2 Power Sector

Coal based electricity generation is the main source of GHG emissions. Current installed generation capacity is about 120,000 MW. India plans to add 50,000 MW of capacity by 2008 and another 216,000 MW by 2012. The future capacity additions in the power sector are expected to be largely in the thermal sector, with coal being the predominant and most cost-effective fossil fuel.[6]

Mitigation measures of GHG emissions for the power sector include:

- Improvement in efficiency of the fossil fuels-based power plants by technology upgrades
- Prevention and reduction in losses in the power supply
- Efficiency improvement in the end use applications
- Switch to non-fossil fuels in power generation.

9.3.3 Renewable Energy

Indian policies promote the use of renewable energy sources. Wind energy is the most commonly used renewable energy source, followed by small hydro power and biomass. Renewable energy technologies are used so that traditional fuels can be exploited in a more efficient manner to meet basic

energy needs for cooking and lighting and for providing energy to the rural industry in order to improve the overall quality of life in India.

Nowadays renewable energy technologies aim more and more at complementing and/or replacing fossil fuels in urban-domestic, commercial, and industrial applications. However, renewables have to compete with other options, e.g. energy efficiency, clean coal technologies, fuel-switching to natural gas, and carbon sequestration, when it comes to climate change mitigation options.[7] An overview of the renewable energy sector is given in Chapter 10 and a closer look at climate change related biomass and wind energy CDM possibilities is taken in Chapter 9.5.

9.3.4 Industry Sector

Major energy-consuming heavy industries are the steel, cement, chemical and pulp & paper industries. Energy intensive small scale industries encompass among others the ceramics, glass, foundry and brick manufactures industries. Energy efficiency projects across all industrial sectors offer cost-effective CO_2 abatement alternatives. Carbon mitigation projects in the industrial sector can be divided as follows:[8]

- Sector specific technological options
- Cross-cutting technologies
- Fuel-switch options
- Recycling and use of secondary materials.

9.3.5 Transport

The transport sector accounts for roughly 10% of the current GHG emissions in the country. The sector is attractive in terms of mitigation of GHG emissions, because its contribution to air quality improvement is immediate. For example, air quality in New Delhi has improved dramatically since the city's entire bus fleet converted to cleaner burning compressed natural gas (CNG) in 2002. Overall, with nearly 10,000 CNG buses in service, Delhi has the largest clean natural gas bus fleet in the world. Other cities using CNG in public transportation are Mumbai and Gujarat.[9]

In general, projects related to vehicle efficiency and transport fuel improvements are favoured. The activities promoted include:

- Road-to-rail modality shift
- Replacement of 2-stroke by 4-stroke two wheelers
- Greener fuels like compressed natural gas (CNG) or bio diesel
- Mass rapid transport system.

9.3.6 Municipal Solid Waste

Emissions from municipal solid waste (MSW) accounted for about 55 million tonnes of CO_2 in 2000. Disposal at landfills (dumpsites) is almost the only treatment method available at the moment. Landfill gas (methane) capture and energy utilisation has so far been significantly exploited in only a few cities. The MSW sector was overviewed in Chapter 8. A closer look at the MSW sector climate change related possibilities is in the section dealing with the CDM below.[10]

9.3.7 Agriculture

The agricultural sector contributes more than 65% of the methane emissions today, although the share is declining. The overall methane emissions continue to rise though. A shift from the former major emitter, the agricultural and livestock sector, to emissions from municipal solid waste and coal bed mining is apparent. The amount of future methane emissions will mainly depend on the macro-economic structure, agricultural sector reforms, irrigation development and on penetration levels of improved technology.[11]

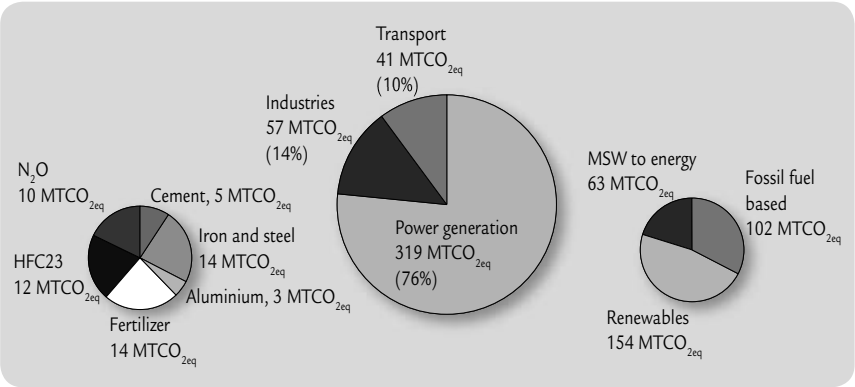
9.4 Market Potential

Economic growth, the use of fossil fuels in power generation and the enormous demand for energy by various industries are the major contributors for the rapid increase of GHG emissions. It is estimated that GHGs will increase 3% annually, coal in electricity-generation being the major contributor. Ignoring unexpected economic developments, the carbon emissions are projected to rise according to the following scenarios in the years 2000-2035:[12]

- 330%, if GDP growth rate is 5.2%
- 450%, if GDP growth rate is 6.1%.

The potential to reduce GHGs in India is immense. The GHGs mitigation potential of key sectors has been estimated until the end of first Kyoto period (2012) as presented in Figure 4. The numbers presented are based on the targets and plans of the GOI regarding capacity additions in the power and the renewable energy sectors, and include also the energy efficiency and technological up-grades which are currently being adopted by different industries.[13]

Figure 4 GHG mitigation potential in key sectors until 2012.



9.4.1 Power Sector

Obviously the power sector, with an estimated 319 million tonnes of CO_2 mitigation potential by 2012, offers most opportunity for emissions reductions. High expectations are set for clean coal technologies and power generated from renewable energy sources like wind, biomass and small hydro power. There is also tremendous scope for emissions- reducing energy generation from municipal and industrial wastes in hot spot metropolitan areas like Ahmedabad, Bangalore, Chennai, Calcutta, Delhi, and Mumbai.[14]

9.4.2 Industry Sector

GHG mitigation potential in the industry sector (57 million tonnes of CO_2) is widely dispersed among different fields. Cement, steel and fertilizer industries are considered the most promising sectors for reductions of GHG emissions. For this purpose energy efficiency and process improvements have the highest priority.[15]

9.4.3 Transport

The transport sector has good potential to reduce CO_2 emissions (41 million tonnes). Transport and community related climate change mitigation initiatives are of high importance for Indian metropolitan areas and projects are usually linked with air pollution control development programs in larger cities.[16]

9.4.4 Agriculture

Agriculture also offers various emissions reduction possibilities by means of the CDM. While contributing over 90% of the nitrous oxide emissions, the agricultural sector is and will continue to be the main emitter in this respect. The major sources of N_2O emissions are the extensive use of synthetic fertilizers, emissions from livestock excretions, field burning of agricultural residues and indirect soil emissions.[17]

The most efficient instrument to boost GHG mitigation and utilise the emissions reduction potential derived from projects in the above fields is the Clean Development Mechanism (CDM).

The next section focuses solely on Indian CDM markets by elaborating procedures to implement and finance CDM projects. Later the study highlights major players in the market and key sectors for CDM project opportunities as follows: biomass, coal power, municipal solid waste, pulp and paper, and wind power. These are also the sectors where the Finnish technology suppliers and consultants have the strongest expertise among the CDM-relevant sectors.

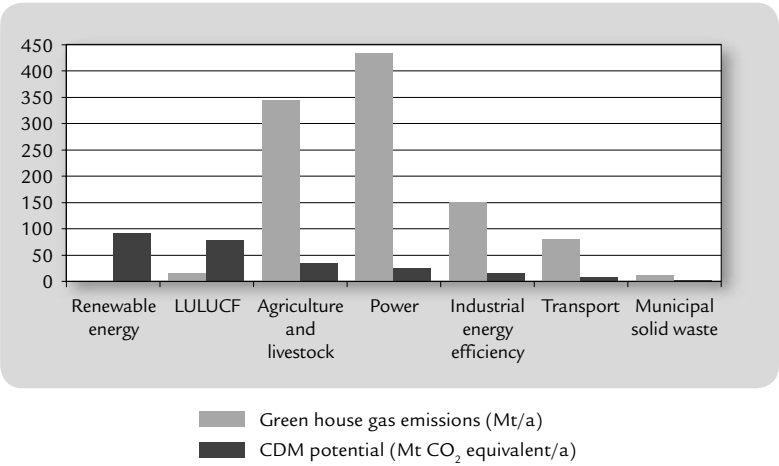
9.5 *IN FOCUS:* The Clean Development Mechanism (CDM)

9.5.1 Background

The Kyoto Protocol was signed in 1997 to reduce global Green House Gas (GHG) emissions. The Protocol came into force in February 2005 giving GHG emission limits for each developed (Annex I) country included in the protocol. In order to facilitate reaching emission limits, three additional mechanisms were agreed upon in the Marrakesh Accords in 2001. These are the Clean Development Mechanism (CDM), Joint Implementation (JI) and Emission Trading (ET).

The CDM was created to give a cost effective option for developed (Annex I) countries to achieve their emission reduction targets. In the CDM, an organization from a developed country (Annex I country) can obtain Certified Emission Reductions (CERs) by reducing emissions in a developing (non-Annex I) country where a comparable reduction requires substantially smaller investments. The country and the organization receiving the CERs from the CDM project are allowed to add the corresponding amount of CO_2 emissions to its emission quota. In the case of an EU country, this is done through the EU Linking Directive converting the acquired CERs to EUAs. The CDM Executive Board (EB) which is under the authority and guidance of the

Figure 5 Green House Gas emissions and CDM potential.[18]



Conference of Parties (COP) and the Meeting of Parties (MOP) supervises the CDM process. The EB is fully accountable to COP and MOP, and it works within the United Nations Framework Convention on Climate Change (UNFCCC). Countries participating in the CDM have their own designated national CDM authorities (DNAs).

India is considered as one of the most potential countries in the world for CDM projects. This is due to its large power sector that depends on fossil fuels, and to the proactive policies of the Indian government towards CDM. The power sector alone is estimated to emit 433 million tonnes of CO_2 per annum. The total CO_2 reduction potential through CDM projects in India is estimated to be around 300 million tonnes. The largest potential is in the renewable energy sector with 90 million tonnes CO_2 equivalents (Figure 5).[19]

There are 269 CDM projects submitted to the DNA. Most of them are in the renewable energy sector. The 269 CDM projects are expected to deliver 224 million CERs per annum until the year 2012.[20]

9.5.2 The CDM Process Cycle

In India the DNA is hosted by the Ministry of Environment and Forests (MoEF). In addition to the DNA, India has many state-level nodal agencies promoting and facilitating CDM-projects in their area. These organizations can be of assistance in setting up contacts with public organizations to arrange CDM projects, or in approaching a larger number of small-scale possible project proponents. They can act also as bundling agencies, i.e.

combine a number of small-scale CDM projects and handle financial management for bundled projects.

The CDM also allows an industrial actor in the non-Annex I country to reduce its Green House Gas emissions and to sell the reduction units to a party in the Annex I countries. The GHG reductions and the way to reduce them have to be approved by the CDM EB. The GHG reduction achieved though a CDM project is quantified as a Certified Emission Reduction (CER), one CER corresponding to one tonne of CO_2 equivalent.

The technical way to reduce Green House Gas emissions is called a methodology. A methodology is a description detailing the new way of operating with the result of generating less GHG emissions than in a business-as-usual case. The business-as-usual case is referred to as the baseline in the methodology description. The comparison between emissions of the new and the baseline case yields CERs, provided that the project activity is judged as additional. A project activity is additional if it would not be executed without the CDM. Article 12 of the Kyoto Protocol defines additionality as "Reduction in emissions that are additional to any that would occur in the absence of the certified project activity." Moreover, project activities funded by Overseas Development Aid (ODA) are deemed automatically to be non-additional.

An industrial actor in a non-Annex I country can execute the project activity all by itself, in which case the project activity is called unilateral. If a party from an Annex I country takes part in the project through funding, a project is called bilateral.

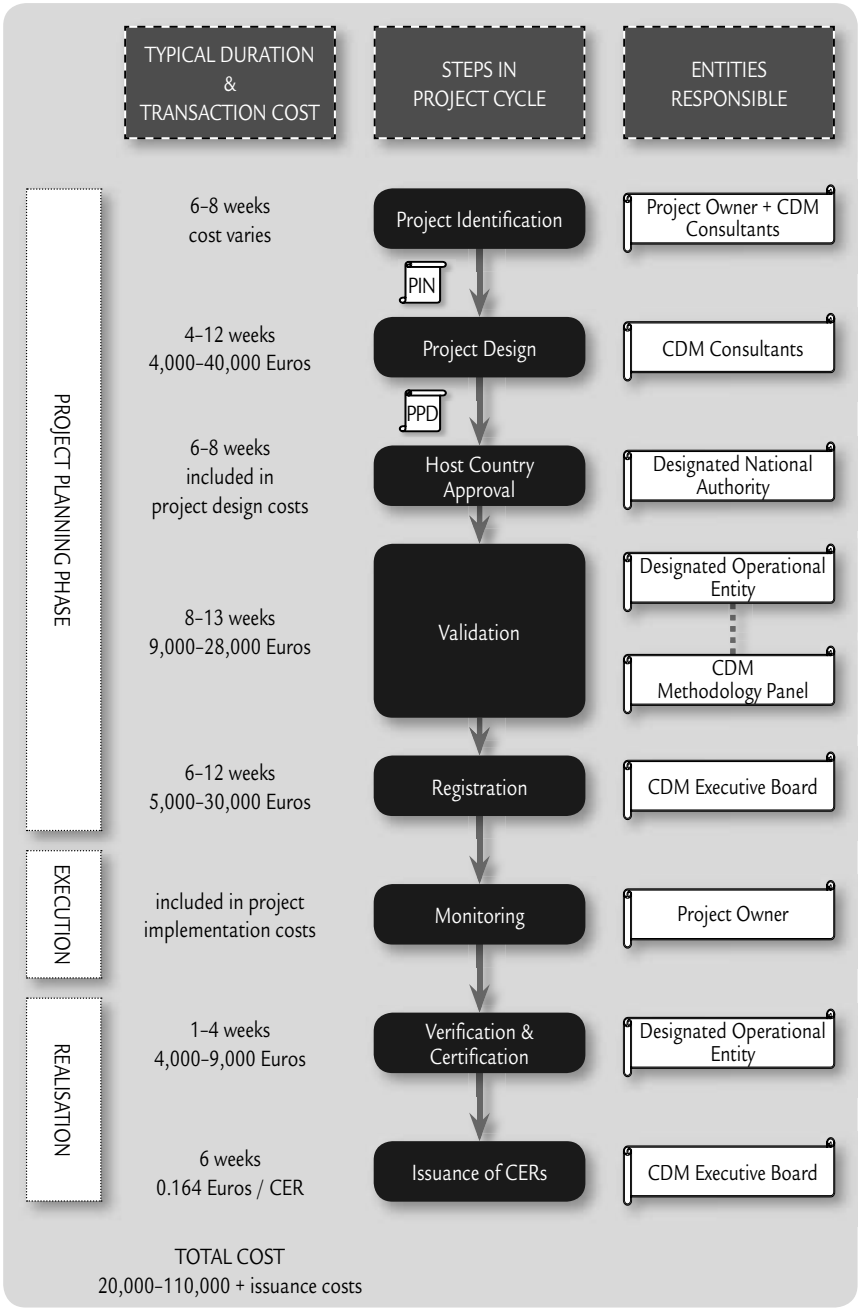
Generally, the CDM process has three main phases. The first one consists of planning the activity, the second one of executing the plan and the final one of realising the emission reductions. Furthermore, the realisation phase can be divided into verification and certification phases and an issuance phase. The planning phase can be broken down to five phases illustrated in Figure 6.

Project Identification

The CDM-project starts with a project identification phase as in any normal project. During the project identification phase, the parties keen to promote the project activity, referred to as the project proponents (PPs), should formulate a Project Idea Note (PIN). In India the PIN is often referred to as a Project Concept Note (PCN). The PCN document should describe all the essential elements of the CDM-project. These essential elements are the same both for the PCN and the Project Design Document (PDD). The PDD is significantly longer than the PCN. They are mentioned later in the project design section.

The UNFCCC does not provide any official PCN-template, but the DNA has its own PCN-template and it requests the PP to use it when the PCN is

Figure 6 Typical CDM project cycle.



submitted along with the PDD to the DNA. The template can be acquired from DNA's website.

The official CDM-cycle laid out by the UNFCCC does not formally require the formulation of any kind of document in the project identification phase, but the DNA requires it later. It is also a useful tool for the project proponents when in dialogue with potential stakeholders such as CER buyers and project financiers.

Hiring a CDM consultant is not compulsory for developing a CDM-project but it is estimated that approximately 90% of all CDM-projects done in India so far have involved one. Many project owners emphasise the importance of making the right choice when selecting the consultant as some of them have been reporting of problems in the cooperation with consultants. In general, some of the most experienced CDM consultants are based in India and the consultants' fees in India are internationally very competitive due to high competition. At least 20 new CDM consultants are trying to enter the market. Further information is easily available, for instance, CDM India posts an up-to-date list of developer consultants in India on its website[21]. There are a number of freely available guidebooks on the matter.

As some of the proposed projects can be too small to be able to carry all transaction costs required, it makes sense to use the bundling provisions of the Protocol. Instances, such as The Indian Renewable Energy Development Agency (IREDA) or certain industry associations have been designated as bundling organizations. Many other public, private or NGO organizations can also act as bundling organizations. More information on bundling CDM projects in India can be obtained from the CDM Pool's website[22].

Project Design

While designing a project activity, the project participants should make sure that the planned project activity will contribute to the host country's sustainable development and that the planned project activity is additional.

While formulating a CDM project, the project proponent needs to address legal, financial, incentives, taxation treatment and business model options issues. Finally, it needs to be defined whether the project is a small scale or a normal scale CDM project. A small-scale project has advantages such as the use of a simplified Project Design Document and additionality test. 37% of projects registered at the CDM EB are small-scale projects.[23]

A project qualifies as a small-scale project if it is:

- a renewable energy project with a maximum output capacity of 15 MW
- an energy efficiency improvement project that reduces 15 GWh annually at most

- a project activity that reduces man-made emissions and does not emit directly more than 15 thousand tonnes of CO_2 equivalent per year.

The concrete product of this phase is the PDD, in which the PP have clearly and concisely described the intended project activity. The PDD has to address such issues as the baseline methodology, the duration of the project activity, the justification for additionality, the monitoring methodology and plan, the calculation of Green House Gas emissions by sources, the environmental impacts and the stakeholder comments.

Host Country Approval

After the PDD is deemed satisfactory, the PP has to submit both the PCN and the PDD to the host country DNA to apply for a Host Country Approval (HCA). The Indian DNA requires both the PCN and the PDD, even though the official UNFCCC's endorsed process requires only the PDD. The DNA requires the project to be additional and the project activity to promote sustainable development. There are three dimensions for sustainable development: financial, environmental and social. Additionally, in the country the project needs to be approved by the local State Pollution Control Board (SPCB), before it can be submitted to the DNA.

The host country approval process includes a hearing of the project proponents and an in-depth analysis of the project by the DNA and other consultants. The DNA holds these hearings on a monthly basis and it can approve over twenty projects per session. Typically, the CDM consultant assists in the hearing.[24]

For unilateral projects, the HCA is enough but for bilateral projects, the PP should acquire an approval letter from the DNA of the CER buyer's country. However, that has to be done only at the stage when the PP requests the CDM EB to transfer the CERs to the buyer.

The Indian DNA has accorded host country approval to 227 CDM project design documents as of March 2006. The DNA's work has been widely praised, and the approval process is said to be smooth and speedy. The Indian DNA has said to have high level political support.

Validation

The project participants should have the project validated by a designated operational entity (DOE) that is accredited by the CDM EB. Typically DOEs are worldwide renowned quality assurance organizations. DOEs have been granted certain sectoral scopes (for instance, energy distribution or chemical industry) in which they are allowed to operate. The DOE checks that the project fulfils the

requirements set forth by the UNFCCC, additionality being the most important issue. In March 2006, 13 companies have received DOE status worldwide, of which 7 are operating in India. The amount is expected to increase.

The typical duration for the project validation phase ranges from 8 to 13 weeks. In case a new methodology has to be developed for the project, it has to be approved by the CDM methodology panel. In this case, the validation phase will take an additional 3–12 months.

Following a successful validation, the project proponents can apply for project registration.

Registration

During the registration phase, the DOE submits all necessary documents to the CDM EB and requests project registration. For projects generating more than 15,000 tonnes of CO_2 equivalent on average per year, an administration fee of 0.164 Euros per CER is collected by the EB. The registration fee is an advance payment for the reductions achieved during the first year. However, if an activity does not get the registration, the amount exceeding 24,600 Euros of the paid registration fee is returned.

The registration decision is made by the CDM Executive Board. By April 2006, the CDM EB has registered 161 projects of which 36 originate from India[25]. At the EB every CDM project is discussed project by project and two persons read every PDD.

Monitoring

The approved PDD has pinpointed all the variables that need to be checked for assessing the real emission reductions of the project activity. The project participants are responsible for monitoring reductions in emissions (according to the approved monitoring plan) and reporting them to the DOE for verification purposes.

The monitoring phase should produce enough quantitative data for the accredited instance, the DOE, to be able to verify the emission reduction units achieved thus far.

Verification and Certification

The DOE is responsible for verifying the monitored results and certifying the exact amount of Green House Gas emission reductions resulting from the project activity. Finally the DOE reports the results to the CDM EB. The same DOE can not take care of both the validation and verification work unless it is a small scale CDM project.

Certification is a written assurance by the DOE stating that during a specified period, a project activity achieved the reductions in anthropogenic emissions which were previously verified.

Issuance of CERs

The CDM EB issues a certified number of CERs within 15 days of receival of a request for issuance. The CDM EB deducts its own fee from the issued CERs, as described in the registration phase.

9.5.3 CDM Project Finance

CDM projects can be considered as any other projects with the exception that CDM projects deliver CERs as additional by-products. Usually a CDM project requires investment in more costly technology and has to cover CDM related transaction costs. The CERs generated by the CDM project are sold to a CER buyer, thus generating an additional source of income for the project making the additional costs possible. When purchasing CERs an emission reduction purchase agreement (ERPA) is made which covers the details of the transaction.

CDM projects can be divided to three groups according to the type of cooperation with financiers: unilateral, bilateral, and multilateral projects. The industrial actor in the non-Annex I country can execute the project activity all by itself, in which case the project activity is called unilateral. If a party from the Annex I country takes part in the project through funding, a project is called bilateral. Multilateral projects can be seen as bilateral projects where a third party takes care of the finance. The share of bilateral projects is estimated to be around 10% and will decrease in the future.

Bilateral Projects

In bilateral projects, the CER buyer is closely involved with the CDM project from early stages of the CDM process cycle. The CER buyer is one of the financiers of the project. The share of CDM financing from the CER buyer can vary from 1.5% (e.g. power generation projects) to 100% (e.g. municipal solid waste projects), but is usually less than 10%.

PPs are free to agree on any type of contract or terms regarding future CERs to be produced. For instance, financing can be arranged using structured equity investment or CER-securitisation. The structured equity is not used very often. In this investment the buyer provides typically 10% of equity, the owner takes care of 20% and rest of the investment is financed by debt.

CER-securitising refers to situations where the PP enters into a forward contract specifying a fixed price for the future CERs. Upfront payment can be

used, which leads to a discounted price of CERs for the buyer. Typical discount is around the current debt interest rate of 9% in India. Usually the upfront share is between 50–100%. There is, however, always uncertainty in the seller's ability to deliver the CERs, especially in a timely fashion. The perceived risk is reflected in the price of the CERs or in penalty clauses in the contract.

In bilateral projects, especially with many of the rural development projects that require either equity funding or lending, the CER purchaser has more pricing power. The lower expected price of these early stage contract CERs is due to the inherently higher risk.

Unilateral Projects

In unilateral projects, the CER buyer gets involved in the CDM project when the project owner decides to make a forward contract, in the late stages of the CDM process. In these cases, the project owner is responsible for getting the project financing without an initial CDM financing from the CER buyer. The additional revenue from CERs comes when the project owner decides to make a forward contract with a buyer for the coming CERs. Another, increasingly popular option is that the CERs are sold at a spot price when they are certified. The spot price of a CER is significantly higher than with forward contracts and comes close to the price of an EUA, as there is almost no risk involved for the buyer.

Despite the higher CER price compared to bilateral projects, many CDM project owners cannot afford a unilateral project due to a lack of funding for their projects without CDM-funded up-front investment. For larger and established companies financing is easily available and thus their projects are often unilateral. However, some Indian banks are considering delivering only loans collateralised by future CER revenues. In such cases, validated projects get better terms.

Financing Sources

The financing patterns of CDM projects in India vary widely. Central and state government financing institutions give financing support to CDM projects. So far there have not been CDM projects totally financed by Indian banks, but they are starting to show an interest. The State Bank of India and ICICI has been mentioned. Banks do not act as outright CER buyers but have began to offer specific financing for CDM projects. In return for a certain share of CERs, they offer lower interest rates on the project financing. Future developments might include loan schemes including carbon (future CER) collaterals. Financial institutions such as IREDA, IDFC and PFC/REC have been active in renewable energy financing and might become increasingly active in CDM project financing.

According to an interviewed CDM consultant, the Indian CDM projects, if developed with an experienced partner can generate interesting payback periods. The payback on equity may be as short as one to two years, and on total project costs three to four years. Indian projects are of high quality and might be interesting investment targets for foreign equity funds as well, but they are often deemed as marginal projects.

CER Pricing

The price of a CER in a project depends on a variety of factors and reflects the risks of failure of the project as well as the market power of buyers and sellers. The pre-validation stage CDM projects relying on unapproved methodology have lower CER prices through the higher risk. Up-front finance is another factor affecting the price in early stage projects. Registered projects having verified vintages bear lower risk than the ones depending on future vintages. The price for verified CDM projects and issued CERs closely reflects the EUA price. Table 13 summarises the factors affecting CER prices and Table 14 summarises the current CER market price ranges.

Table 13 Factors affecting CER prices.

Factor	Direction of price change
Risk factors stated below in section "Risks".	Higher risks, lower price.
Allocation of risks between buyer and seller in the purchase agreement.	More risks to buyer, lower price.
Whether project is unilateral or bilateral (timing of CER sales in project cycle).	Unilateral project, higher price.
Financial position and business operations reliability of seller.	Weak position/ reliability, lower price.
Prices of EUA.	Rise in EUA, higher CER price.
Supply and demand of CERs and other emission rights / negotiation power of buyer or seller.	High CER demand, higher prices. High demand for other emission rights, effect ambiguous.
Future pressures: market entry of Russia and Ukraine with hot air emission rights.	Massive entry of Russia and Ukraine, expected drop in CER prices.

Table 14 CER market price ranges (February 2006).[26]

Pre-validation	Validated project	Registered project	Verification done	EU allowance
4–7 Euros	8–13 Euros	9–14 Euros	15–22 Euros	26 Euros

Risks

Besides the stage at which the project is currently progressing, the CER prices are strongly affected through various risks related to the project, the administrative procedures and project partners. The following lists some of the most commonly recognized risk factors affecting the CER prices in projects in India.

CDM process risks

- Uncertainties and delays in host country approval, validation, registration and verification
- Risks related to additionality, baseline definition and sustainability criteria
- Risk for a proposed new methodology not to be approved by the CDM EB

Performance risks

- Technical ability of the project to produce planned number of CERs in a timely fashion
- Availability of monitoring data

Counterparty risk

- Reliability of counterparty to fulfil obligations to deliver CERs according to contract
- Risks related to the financial status of the project owner
- Lack of CDM consultant's competence to manage the CDM process
- Failure of one participant in bundled project activity affects the whole bundled project

Policy risk

- Validity of the whole mechanism after 2012 (because of this, projects planned to start after 2008 are very rare)
- Compliance of CERs in certain trading regimes (e.g. challenges with approving CERs from LULUCEF projects to EU ETS)

CER Purchasers

CER purchasers can be divided into two groups: public and private CER purchasers. The private CER purchasers can be further divided into traders and end-users, while the public purchasers can be divided into governmental and multinational organizations. The public CER purchasers are the various governmental purchasing organizations, the most active ones being Japanese, Canadian and German organizations. In the private sector, British broker

Table 15 Active CER purchasers in India.

Organisation type	Examples
Governmental purchase organisations	Japan Carbon Fund, UK DEFRA's CCPO, Italy, Spain, Netherlands, Canada, Austria, Portugal, Germany, France, Belgium, Sweden
Multinational organisations	World Bank
Brokers / traders	Ecosecurities, CO2.com, Natsource, Morgan&Stanley, Akzo Nobel, Barclays, HSBC, Pointcarbon, Rabobank
End-users	Endesa, EdF, E.ON, Mitsubishi, Sony, Reco, Kyoto Electric, Kepco, Depco, Shell

companies have been active, and they have organised tours with several potential purchasers visiting different areas to find suitable projects.

Financing transaction costs

The project transaction costs – costs for writing the PDD and having the project validated and certified, as well as legal costs – can be a significant burden on smaller PPs. These costs can form an obstacle for projects where the proponent has insufficient financial resources, as the transaction costs have to be paid before knowing whether the project will produce CERs. To encourage potential proponents to start a CDM project some purchasers are ready to loan the transaction costs – possibly without collateral or interest – and sometimes they are even ready to void a part of the debt if everything goes according to plans. For example, the Canadian purchase programme requires only a payback of 50% of the transaction cost loan, if the CERs are sold to a Canadian CER purchaser. Transaction cost financing can provide a strong competitive advantage when negotiating with potential project proponents who have financial assets.

9.5.4 CDM Status by Sector

The total Green House Gas reduction potential in India is 300 million tonnes per annum. From this, renewable energy and land use, land use change and forestry (LULUCF) are the most potential sectors accounting for more than half of the amount. However, LULUCF credits cannot be converted to EU ETS as of yet. Table 16 summarises sector-wise Green House Gas emissions, CDM potentials and Green House Gas reduction options.[27]

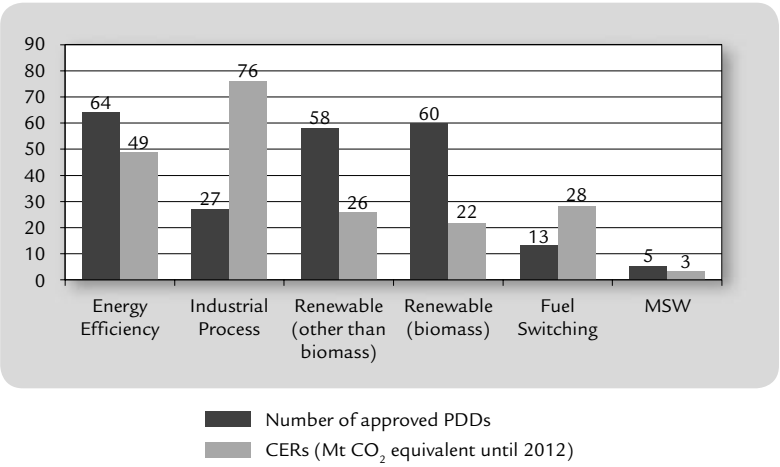
Table 16 Sectoral status in Green House Gas reduction.[28]

Sector	Green house gas emissions (Mt/a)	CDM potential ($MtCO_2eqv/a$)	Green house gas reduction options
Renewable energy	N/A	90	Wind, solar, biofuels, bagasse cogeneration, mini hydro, biomass gasification
Land use, land-use change and forestry (LULUCF)	14	78	Re-vegetation of wasteland areas, promotion of commercial forestry, carbon sink conservation, fossil fuel substitution
Agriculture and livestock	344	35	Energy-efficiency of irrigation pump sets, water management, synthetic and organic fertilisers, animal feeds and digesters
Power	433	24	Coal washing, fuel switch to LNG, critical and super-critical boilers, integrated gasification combined cycle technology (IGCC)
Industrial energy efficiency	151	15	Sector specific technological options, cross-cutting technologies, fuel switch options, recycling, use of secondary materials
Transport	80	6.5	Mass rapid transport system, fuels switch to LNG or bio-diesel, induced energy-efficiency improvement, inter fuel substitution, alternate power packs
Municipal solid waste (MSW)	12	1.2	Reduction of methane emissions, using methane or MSW in power generation, utilising organic fertilisers produced from MSW

The DNA has approved 227 CDM projects (as of February 2006), of which most are renewable energy projects (see figure 7). The 227 projects are estimated to produce in total 204 million CERs by 2012. The average project sizes vary from 0.4 (biomass) to 2.8 (industrial process) million CERs depending on the project type.[29]

The rest of the chapter describes the Indian CDM markets in the following sectors: coal, bioenergy, wind, municipal solid waste, and pulp and paper sector. These are the sectors estimated to be the most interesting ones for the Finnish technology suppliers and service providers in CDM projects. Some other sectors will also be briefly described. These include HFC 23, where a few projecst account for a major share of CERs from India.

Figure 7 Host country approved PDDs by project type.[30]



Pulp and paper

The pulp and paper sector in India is dispersed with 25 larger plants and hundreds of smaller ones – altogether some 470 registered mills[31]. The small- and medium-sized enterprises (SMEs) in many sectors in India have similar challenges with CDM regarding mainly awareness of the mechanism and the financing of capital-intensive investments or the transaction costs. The larger companies in this field are, however, well aware of CDM and typically have a CDM project pipeline with projects or project ideas at different stages.

Technology

Possible methods for reducing Green House Gas emissions in the pulp and paper sector include [32]:

- *Fuel-switching* from e.g. coal to natural gas or biomass in the captive power plants.
- *Energy efficiency* improvements can include installing variable frequency drives; utilising membrane technology for more efficient black liquor concentration and recovery or using vacuum blowers in place of vacuum pumps; installing continuous digesters; falling film evaporators; installing of trinip presses and high-capacity chippers, oxygen dezincification and using disc refiners in place of conical refiners.
- *Waste heat recovery* and increasing the energy efficiency of captive power plants e.g. by turbine replacement.

- *Black liquor recovery* is a potential project type in the smaller mills, which often have no black liquor recovery at all, but the projects may face financial difficulties due to the cost of the equipment

The CDM projects in the pulp and paper industry can typically be realised using technology available on the market. There are no major differences in the way equipment is sourced for CDM projects compared to other investments. In other words, no significant CDM-specific distribution channels or CDM-focused technology suppliers seem to exist. The CDM consultancies do not typically play a role in selecting the technology to be used.

CDM Projects

The potential in the large scale plants ranges from some tens of thousands of CERs per annum in many of the demand side energy efficiency projects, to the range of up to 100,000 CERs per annum in the power generation side.

The projects in the large mills in the pulp and paper sector are typically done as unilateral projects, as the companies are usually in such a financial position as to be able to fund the projects themselves. However, it may be possible to arrange bilateral projects in some of the more capital-intensive project types. The risks of purchasing CERs from the pulp and paper sector are relatively low as the contracts are usually made quite late in the project cycle and the companies often use proven methodologies and experienced consultants. This is also reflected in the price of the available CERs. A large amount of CERs are expected to be sold through auctions, and the CER price will follow the EUA price to some extent. CER purchasers may find the CERs from this sector expensive.

The annual CER generation in the sector during 2008–2012 can be estimated to be from less than one million to some millions of CERs per annum. A large number - as high as some million CERs - is already available or will be available shortly in the sector, as many of the projects have already been implemented. There exists a need for project bundling regarding the smaller energy efficiency projects.

Risks and Challenges

The small and medium sized companies may offer significant potential for CDM projects in the long-term. The major challenges in this sector relate to bundling issues and financing. There are many potential energy efficiency projects, but many of them are too small to merit becoming CDM projects on their own. The bundling of projects is still at a very early stage, but would be beneficial especially in smaller plants. The smaller plants face trouble financing any capital-intensive projects, which forms a very significant obstacle.

The risks in the sector are manageable and mostly emerge in energy efficiency and renovation projects, where proving financial additionality may be a problem. Also the large investments and the long lifecycle of the projects can be a challenge considering the uncertain post-Kyoto period. Most of the risk components are significantly higher when purchasing CERs from small- and medium-sized enterprises in this field.

The project proponents see sustainability or additionality risks in the sector as being relatively low.

Future Trends

There is still potential for further Green House Gas reductions in the sector, and especially the larger companies can be expected to keep initiating new emission reducing projects. The rate of new CDM projects is likely to remain stable. There is a large, mostly untapped potential for CDM projects within the smaller pulp and paper plants, but these smaller projects face financial and transaction problems. Thus this segment will probably not generate major amounts of CERs in the near future until bundling related issues have been solved.

Coal

The biggest single coal power company in the country is the National Thermal Power Corporation (NTPC). NTPC has installed coal power capacity for 19,980 MW, implying a share of the country's total coal power in the range of 17%. NTPC is a government owned company.

Most coal power plants utilise the Rankine steam cycle with overall power generation efficiency of 37% [33]. On the other hand, the report of the Clean Development Mechanism Project Opportunities in India [34] indicated that most of the small plants running on coal operate below 30% efficiency level. The actual efficiency level may vary between 30% and 37%, but overall the technological level of the country's coal-based power generation is lower than the world average.

Technology

The ways to reduce Green House Gas emissions from coal related activities include:

- More efficient power plants with new technologies. Coal using power plant technology has progressed from the simple Rankine steam cycle into such new ones as combined cycle (CC), integrated gasification combined cycle (IGCC) inter-cooled steam injected gas turbine (ICSIGT), pressurised fluidised bed combustion (PFBC), and pulverised coal super-critical boilers (PCSB).

- A combined cycle power plant utilises both the gas and steam turbine technologies to generate electricity with a comparably high efficiency.
- In inter-cooled steam injected gas turbine power plant, the plant is utilising a steam injected gas turbine that is fitted with an intercooler between the compressor stages to increase the electricity efficiency.
- The pressurised fluidised bed combustion technology is an advanced version of the combined cycle technology that utilises a fluidised combustor.
- The integrated gasification combined cycle technology is also an advanced version of the combined cycle technology, but here the novelty is in integrating the coal gasifier with the combined cycle –system.
- The Pulverised coal super-critical boiler is an advanced version of the standard pulverised coal combustor. The new introduction is in the use of the super-critical boiler.
- Renovation and modernisation of old coal power plants to improve electric efficiency - R&M of old coal power plants requires the changing of old power plant components into the newer ones with the end-result being higher efficiency.
- Modification of the plant to operate as combined heat and power (CHP)/ cogeneration plant to produce both electricity and heat. Often a power plant is optimised to generate electricity and the process heat is discarded as an unnecessary by-product. However, if the power plant is to operate adjunct to a factory needing a great amount steam, the heat by-product of a power plant could be tapped to produce the needed steam.
- Switching from coal to less carbon intensive fuels, such as natural gas, biogas, etc.
- Coal bed methane emissions is normally disposed into the atmosphere, but the methane emissions can be captured and used for energy production by coal bed methane recovery technology
- Mine fires release a lot of Green House Gas emissions and reducing fires by better control systems and equipment is a possible emissions abatement option.
- Coal washing is a technology to reduce contaminants from coal and thus produce less Green House Gas emissions when burned in power plants.

The table 17 presents estimates of the investments and emissions abatement costs of the different technology options to reduce Green House Gases in the coal sector.

Table 17 Different technology options and their costs to reduce CO_2 in the coal power sector.[35, 36]

Technology	Investment Cost (Euros/kW)	Emissions reduction (Euros/tonne of CO_2)
Cogeneration	744	8.2
Combined cycle	677	44.3
Inter-cooled steam injected gas turbine	783	63.1
Pressurised fluidised bed combustion	1,567	412.5
Integrated gasification combined cycle	1,305	278.8
Pulverised coal super-critical boilers	994	280.4
Renovation and modernisation	233	N/A
Coal washing	9 (Euros/ton/ annum)	146.8

CDM Projects

CDM projects based on utilising new power technologies typically generate the biggest amount of CERs per project compared to CDM projects in other CDM sectors. Fuel-switching CDM projects are generally smaller generation wise than the projects utilising new power technologies in CER.

Risks and Challenges

The coal related CDM project technologies are established and well proven. Therefore, the performance risks of these CDM projects are quite low. Only fuel-switching projects utilising biomass have a clear performance risk factor, which is related to the availability of crop residual materials.

Mostly the challenges lie in the CDM elements, such as the lack of methodology for R&M projects, and mine fire reduction related CDM activities. Furthermore, it is hard to prove the additionality of R&M projects. For coal washing activities, it is not an easy task to define the baseline and monitoring plan.

Intrinsically to India, the country's electricity market is regulated and that does not give much incentive for the coal power companies to embark on any efficiency-increasing activities such as the R&M CDM projects.

Finally, as many power plant related projects require a long payback time, there is a risk that not all CDM benefits will be realised before 2012. The conclusion is that this is a somewhat risky sector for CDM.

Future trends

Supercritical and ultra-critical power systems are currently becoming the standards in the world, but India remains firmly committed to sub-critical systems. In addition to the supercritical and ultra-critical boiler technology, IGCC is the other area where the country is still lagging behind. The reason might lie in the prohibitively high investment cost of IGCC which ranges between 1.4 and 1.5 million Euros per MW [37]. Comparable figures for the super-critical steam cycle and the ultra-critical steam cycle are 816,200 Euros per MW and 890,400 Euros per MW respectively [38].

Renovation and modernisation (R&M) can increase the power generation efficiency by 5–8 percentage points through relatively inexpensive actions, e.g. only 190,000 Euros – 280,000 Euros per MW [39]. One globally operating CDM consultant indicated that R&M projects are easily done as unilateral projects, but that IGCC requires big investment and the use of multilateral projects.[40] R&M could be easily done unilaterally, but this is not the case for every company in India.

It seems that R&M activity and coal bed methane capture are the most realistic of all the options available. R&M is inexpensive and there is a large number of old coal power plants to be renovated and modernised. However, the additionality issue might be a challenge here. Coal bed methane capture does not face a similar additionality challenge, but the technology is more expensive than the coal-using technologies. Thus, it is uncertain how the sector will develop in terms of CER-price or of the sector's absolute and proportionate growth rate. Thus CDM-activity encompasses high risks in this sector.

CDM projects are categorised by their types e.g. energy efficiency or fuel-switching. As coal power is not a CDM project category, the number of approved or submitted coal power related PDDs in India can not be comprehensively identified.

Bioenergy

The development and utilisation of renewable energy, including bioenergy, has a high priority of the government and it is seen as a very promising CDM sector. In 2004 total biomass-based power generation/cogeneration capacity was 727 MW accounting for around 20% of the total installed capacity in the renewable energy sector.[41]

Being an agricultural country and the world's largest producer of sugar cane, India has abundant quantities of agricultural residues; rice husks, coconut shells, wheat husks and mustard residues and sugar cane bagasse, all of which can be used as bioenergy raw material. India produces about 350 million tonnes of biomass every year, which is equivalent to 220 million tonnes of

coal in terms of heat value. The available biomass could generate 19,500 MW of power annually, but the current biomass utilisation is far from ideal.[42]

The government has been promoting the biomass projects through its Ministry of Non-Conventional Energy Sources and many states now have power purchase policies under which they will buy biomass-generated power.[43]

CDM projects

Out of the total 227 host-country approved CDM projects (as of December 2005), 60 are in the biomass energy sector. The expected CER generation from these biomass projects until 2012 is estimated to be around 21.8 million CERs. This corresponds roughly to 11% of the total expected CER generation of all approved projects.[44] Therefore biomass projects are on average smaller in scale than other sectors' CDM projects. In February 2006, CDM EB had approved a total of 15 biomass projects from India [45].

Risks and Challenges

In general, renewable energy CDM projects, especially the case of bioenergy, have strong sustainable development benefits but in some cases the additionality is difficult to demonstrate due to the regulatory framework. According to the Electricity Act of 2003, state electricity commissions have a mandate to promote cogeneration and renewables, hence leading to a closer scrutiny to show the additionality of CDM projects.[46]

Other challenges in the biomass-energy projects are the high transaction costs that are due to their small and dispersed nature. Another aspect to consider is the limited servicing and repair infrastructure, which is the case mostly in rural areas where the majority of the small scale biomass projects could take place. The lack of market infrastructure for biomass-energy projects in terms of financial mechanisms and distribution companies is still a bottleneck.[47]

In the biomass sector, the methodology risk is considered low, as suitable methodologies for the projects are widely available. For biofuel projects, the methodology issue is a challenge as no methodologies yet exist, although some are currently under development (as of February 2006).

Technology

In the bioenergy sector CDM possibilities can be divided into two main subcategories; use of biofuels and solid biomass combustion and gasification.

Use of Biofuels

The biofuels' CDM potential lies mainly in the transport sector fuel substitution and in the rural sector electrification. Biofuels are seen as an important

option to energise rural areas in a sustainable way. The main sources of raw material for biofuels are oil-bearing seeds of the Jatropha and Pongamia tree species. The CDM potential in the fuel substitution is estimated to be around 40 Mt CO_2 equivalents in the years 2011–2012 assuming a 20% biofuel blend. The CDM project potential in biofuel usage for rural electrification is estimated to be high[48]. Biogas manufactured for example through biomethanation (anaerobic digestion) of agricultural residues is another potential biofuel. This can be used as a cooking gas in rural areas.

Solid Biomass Combustion and Gasification

Power generation from biomass can be based on either direct combustion of biomass or solid biomass gasification. In biomass gasification the solid biomass is gasified to generate combustible gas, which can be used to replace diesel in a diesel generator set either partially or fully. The CDM related risks in the biogas sector are considered reasonable and the sector CDM potential is considered very high.

Domestic technology in smaller unit sizes seems to be readily available but the need for 1–3 MW biomass boilers in rural areas is growing. The market for bigger units is limited by the biomass availability, but in 25–50 MW unit sizes there seems to be lack of technology providers (e.g. larger capacities in co-generation in sugar mills). In biomass gasification the Indian technology is competitive, but large-scale (up from 10 MW) biogas plants offer project opportunities for foreign technology providers.

Future trends

For large industries biomass is rarely suitable and in small industries awareness is low. In the rural areas, small scale biomass projects have potential but so far interest in project development has been low. It could be reasonable to consider the utilisation of bundling possibilities in the small-scale bioenergy projects.

The limiting factor in the bioenergy sector is the availability of the fuel and the high cost of fuel collection. In rural areas bioenergy utilisation is increasing but not through the CDM. Projects are small and mainly related to household energy utilisation and cooking. So far larger scale biomass projects have mainly been limited to bagasse-based co-generation projects in the sugar mills.

Wind

India is the fifth largest wind power producer in the world after Germany, the U.S., Denmark and Spain. The Ministry of Non-Conventional Energy Sources (MNES) reported that 4,800 MW has been installed by 2006, but the MNES pointed out that the off-grid applications have largely been neglected

in this figure. Total wind power potential has been estimated at 45,000 MW of which the current technically realizable potential is 13,000 MW.[49, 50] There are some millions of CERs coming from the wind power projects that are accepted by the DNA.

According to the National Action Plan for Operationalising CDM in India report, TERI states that the cost effectiveness is 309 Euros per ton of carbon dioxide, making it still quite an expensive mitigation option.[51]

Technology

State-of-the-art wind power technologies are now widely available in India. Currently sub-MW wind mills are in use, but gradually multi-MW wind mills are being introduced and generators of up to 1,650 kW unit capacity are manufactured. Subsidiaries and joint ventures of major international wind power suppliers, such as Suzlon, Enercon, NEG Micon and GE Wind all operate in India.[52]

CDM projects

CDM projects in this sector are typically small sized. Based on the data of approved PDDs from 2005, wind projects generate on average 40,000 CERs per year. The grid-connected wind projects are mostly driven by big corporations that are in good financial condition. These companies would normally undertake the CDM projects unilaterally and then sell the CERs at a higher price later on.

Risks and Challenges

According to one globally operating consultancy company present in India, many proposed grid-connected wind power projects have failed on additionality issues. Quite a number grid-connected wind power projects are proven to be business-as-usual and therefore not eligible to be CDM-projects. Thus, wind power is not considered as such a promising CDM-target nowadays anymore.

For grid-connected wind activities there are many approved methodologies, but the situation is not that good with the off-grid wind activities. However, it seems to be easier to prove the additionality of off-grid wind projects. Off-grid activities tend to take place in remote areas and be driven by poor inhabitants, therefore the counter-party risk is higher than with the grid-connected wind activities. Furthermore, as the off-grid projects tend to be quite small they have a high bundling potential. Bundling is a risky activity as if one project fails the whole bundled project faces trouble.

Finally, as with any other power activities the payback time is long, bringing the risk of not having realised all CDM benefits before 2012. The conclusion is that this sector's risk is high.

Future trends

Of the various additionality aspects, technological additionality has been the most easily identified. In the IGES report, the following technological additionality points related to wind power projects were presented:

- Multi-MW-size wind power systems.
- Wind machines for low wind regimes.
- Better designed rotor blades, gear boxes and control systems.

These additionality points are being addressed by coming activities that utilise multi-MW size windmills. More efficient windmills that are designed for low wind regimes are being introduced to India and they will see more action in future CDM activities.

India still supports ardently its wind power sector and the MNES is responsible for this activity. The existence of the support structure is a disincentive for the CDM activities.

To conclude, despite the potential for growth in the off-grid sector, the general growth estimate for the wind CDM sector is low due to the reasons outlined.

Municipal Solid Waste

The total waste production in India is estimated to be between 0.10 and 0.15 million tonnes per day. In Indian cities, only 50–90% of the municipal waste is collected and out of the collected waste, an average of 94% goes to open dump yards. 5% is composted. Waste stacked in open dump yards develops large quantities of biogas, including methane, which is a strong green house gas. This is a problem especially in the metropolitan districts such as Ahmedabad, Bangalore, Chennai, Calcutta, Delhi and Mumbai [53].

More detailed non-CDM specific description of the MSW sector is found in Chapter 8.

The estimates of the annual MSW methane emissions have a lot of variation. The most conservative estimate is 0.6 million tonnes while the highest estimate is seven million tonnes. A conservative estimate for the Green House Gas reduction potential from the MSW sector is 1.2 million tonnes CO_2 equivalents per annum [54] (see Table 16). For comparison, TERI estimates that the reduction potential is 8.1 million tonnes of CO_2 equivalents per annum [55].

Technology

The technological options for reducing GHGs in MSW are manifold:

- In methane recovery, methane is collected from deep covered sanitary landfills where pipes are installed to collect methane. The challenge

with methane recovery is that it requires big and managed landfills, which is not the case in India currently.

- In incineration, the waste is burned in an oven and the heat is used to produce steam that is used to generate electricity. The challenge with incineration is the low energy content of the waste, which is not expected to be changing in the coming years. In addition to incineration, there are other related technologies such as plasma-arc and pyrolysis.
- Composting is a biological process in which the organic waste is composted to produce fertilisers. These can be used to reduce the amount of GHGs emitted from producing the corresponding amount of chemical fertilisers. However, due to the low quality of composted waste, the produced fertilisers are of low quality and their usage is limited. Currently, composting is the mostly used technology in MSW in India.
- In gasification, organic waste is gasified in limited air and in high temperature to create low molecular weight gases. The gases can be used for power generation in combustion engines or for steam generation in boilers. Compared to other technologies, gasification works at a high efficiency.
- In biomethanation, waste is digested anaerobically in specially designed digesters through bacterial activity. This process produces combustible gas methane and sludge. There is a growing trend of starting small, 20–40 tonnes MSW per day, biomethanation projects in India. Biomethanation is a high efficiency technology that is considered highly potential in MSW projects in the future.
- In pelletisation, the solid waste is sorted and the suitable materials are turned into small pellets that can be burned for power generation.

The Indian players in MSW are interested in affordable low cost solutions for solid waste management. There is potential for consulting in waste collection, transportation and landfill treatment, as well as a need for equipment used in biomethanation.

CDM projects

From the CDM point of view, the MSW sector is immature with only five host country approved MSW CDM projects so far (see Figure 7). In addition to these, around 20–45 project prospects are estimated to be in project design phase.[56]

With an estimated CER output of 60,000 to 100,000 per project per annum, projects in the MSW sector are large on average when compared to projects in other sectors. Many MSW CDM projects are capital intensive and the share of CDM-funding is higher than in other sectors. Thus, there is a clear demand for bilateral cooperation with CER purchasers. For this

reason, and because of the immatureness of the MSW sector, the CER-prices are generally lower than in other CDM sectors. TERI estimates that, for instance, a MSW-to-pellet project's cost per CER would be around four Euros and the transaction costs would account for 4% of the CER price.[57, 58]

Risks and Challenges

In addition to the relatively low CER-price expectations, MSW CDM projects are subject to counterparty risks. Municipal corporations, which mainly run solid waste management in the cities, are government owned bodies that may react to changes slowly, and do not always manage public-private partnerships effectively in their handling of MSW operations. The contracts with the current private operators are not yet mature, resulting in problems in the contractual arrangements of the CDM projects. Some of the municipalities also lack financial resources and do not have strong credit ratings.

According to the Municipal Solid Waste Management & Handling Rules 2000 of the Government of India, municipal corporations are required to collect the gases from landfills. The municipalities have not implemented the law due to financial reasons and to prioritisation of other projects. According to the DNA, these rules do not prevent CDM additionality as long as 50% or more of the municipalities do not obey them [59]. However, if a major share of the municipalities starts to implement the rules, there is a policy risk that MSW CDM projects are not considered additional anymore.

The low quality of waste content and landfills creates a challenge for implementing Green House Gas mitigation technologies. The organic content of waste is very low and the waste is scattered in open areas, which are usually only two to three meters deep. An Indian law prohibits dumping organic waste, but as the law is not properly followed, and the result is merely a reduced organic content of the waste. Additionally, the quality of waste is low because there is no tipping fee for mixed waste, which would give an incentive for people to sort their waste. The solid waste management technology used in industrialized countries cannot always be directly transferred to India as they are mostly designed to work in different climates and in deeper and more condensed landfills.

Approved methodologies are available for MSW CDM projects and there is no special risk involved with methodologies. In addition, the sustainability criteria and monitoring does not pose special risks for MSW CDM projects.

Future trends

Unmanaged MSW disposal sites are expected to continue as the dominant means of waste management and only slow improvement is expected in the

foreseeable future. This is due to poor regulatory enforcement and the lack of financial resources of municipalities.

In the future, Green House Gas emissions from MSW will grow as the amount of waste grows hand in hand with the population and GDP growth. With the growing market size and the maturation of the sector, MSW CDM projects have potential for growth. Due to the slow development of organizational practices and the limited market size, the growth expectations are estimated to be within a few millions tons of CERs per annum. Biomethanation is seen as the most promising growing technology option in the sector. According to the DNA, new methodologies for MSW sector are going to be approved for flaring of methane and methane power generation projects. This will speed up the growth of the number of MSW CDM projects.

Other sectors

In addition to the focus sectors of the study, there exists significant potential in other sectors as well. An overview can be obtained from several sources. Some of the more interesting sectors from the point of view of purchasing CERs are the iron and steel and cement industries. The production of hydrochlorofluorocarbons produces hydrofluorocarbons as a by-product. These both, together with perfluorocarbons and nitrous oxide (N_2O), are very potent Green House Gases. Emission reductions from these projects can be very significant.[60, 61]

Iron and steel

The iron and steel sector accounts for 42% of the total CO_2 emissions from the industrial sector, and that was estimated to be responsible for 34% of the total CO_2 emissions. These emissions mostly come from the production processes. There is a savings potential estimated to be roughly 15% of the energy consumption in the sector, according to the World Energy Assessment Report (data from 1999). The total annual CO_2 emissions in India from the sector were approximately 75 million tons in 1999.[62, 63]

Cement

The cement industry, like the iron and steel industry, is undergoing strong growth in India, and many of the larger plants are relatively new and modern. For instance, according to a consultant familiar with the field, six of the ten most efficient cement plants currently operating worldwide are in India. Potential for CDM projects still exists, especially in the mid-size plants. One of the most popular project types in the cement sector has been fuel-switching and fly ash utilisation in cement manufacturing.

HFC, PFC and N20

The incineration of HFC 23 (CHF3) waste streams is one of the major CER sources at the moment, and the sector has been an early adopter of the CDM process. The waste streams are a by-product of HCFC22 manufacturing. The HFC projects are very large, but the potential in the sector is very limited, as the projects have largely already been carried out.

9.5.5 Summary and conclusions

There is a substantial CDM potential in India. CERs from large-scale, low risk CDM projects offering reliable delivery are usually sold early. In addition to tenders, direct contacts and proactive searches are essential ways to be involved in the market as a CER purchaser. Finding good quality bilateral projects is challenging but they offer more affordable CERs than most

Table 18 Sectoral characteristics of CDM.

Sector	CER price level	Risks	Emission reduction potential (Mt CO_2 eqv)	Relative growth expectations	Absolute growth expectations	Unmet technology and service needs
Biofuel	N/A	Medium	Medium (10–50)	Medium	Medium	Biomethanation technology (anaerobic digesters)
Bioenergy	Low	Medium	High (>50)	Medium	High	Biomass boilers (1–2 and 25–50 MW) , large scale gasification and co-generation plants
Coal power	N/A	Medium	Medium (10–50)	Uncertain	Uncertain	Renovation and modernisation equipment and services
Municipal solid waste	Low	Medium	Low (<10)	High	Low	Biomethanation technology (anaerobic digesters)
Pulp and paper (large)	High	Low	Low (<10)	Medium	Low	–
Pulp and paper (SME)	Low	High	Low (<10)	Low	Very Low	Low cost small-scale black liquor recovery
Wind power (grid-connected)	High	High	Low (<10)	Low	Low	Over 1,5 MW wind power plants
Wind power (off-grid)	High	Medium	Low (<10)	Low	Low	Off-grid wind power plants

unilateral projects. However, the former are associated with an inherently higher level of risk.

From the sectors discussed in this chapter, bioenergy and municipal solid waste have the most potential with a medium general risk level and possibility for low CER prices (see Table 18). The bioenergy sector also has high emission reduction potential and growth expectations. On the other hand, the MSW sector is growing but has a small absolute growth potential in sectoral comparison.

In general, CDM-projects in the pulp and paper sector offer relatively low risk CERs but price levels are often high as the larger paper companies can afford to establish projects unilaterally. Projects in the wind power sector are very often business-as-usual and thus proving additionality can be very challenging. Even though the sector is in general quite profitable, it does not seem to offer significant potential for CDM projects. The coal sector has high potential but no R&M related CDM market has emerged yet. Thus, for CER acquirers risks are high, but due to high future potential, keeping an eye on this sector is advisable.

Technology is seldom a problem for carrying out CDM projects in India. Competitive Indian technology is easily available in most sectors, and there are many international companies and their subsidiaries present in the market. The CDM opens possibilities for Finnish companies having expertise in biomethanation, biomass boilers and gasification plants. Despite the uncertainties, there might also be a potential in the renovation and modernisation equipment and services sector.

9.6 Opportunities for Finnish Companies

India offers substantial opportunities for Finnish companies to mitigate GHG emissions. Characteristics of CDM projects are summarized in table 18. From the point of view of technology providers the most promising CDM project opportunities are listed below:

- Renewable energy sources: bioenergy
- Municipal solid waste: biomethanation
- Process improvements (energy efficiency) and fuel switch to natural gas or biomass/bagasse in large scale cement, steel and pulp and paper industries
- Transportation: vehicle efficiency and transport fuel improvements in major cities.

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10 Renewable Energy

10.1 Background

Energy is a basic requirement for Indian economic development. Every sector of economy – agriculture, industry, transport, commercial, and domestic – needs inputs of energy. Energy consumption is heavily rising and dependency on fossil fuels such as coal, oil and gas is seen as a threat for economic development and environment. New sustainable energy sources are needed.

Fortunately India is blessed with a variety of renewable energy sources. The main ones are biomass, biogas, the sun, wind, and small hydro power. Municipal and industrial wastes are also seen as useful sources of energy.

The Ministry of Non-Conventional Energy Sources (MNES) has been implementing comprehensive programmes for the development and utilization of various renewable energy sources in the country. A number of commercially viable technologies and devices have been developed such as biogas plants, solar water heaters, street lights, pumps, wind electric generators, biomass gasifiers and small hydro-electric generators. Also energy technologies of the future such as hydrogen, fuel cells, and bio-fuels are being actively developed.[1]

Currently the total power generation capacity is about 120,000 MW and the share of renewable energy sources is about 6,754 MW (October 2005). Thus renewable sources already contribute to about 5.5% of the total power generating capacity.[2]

Key factors responsible for growth of the renewable energy sector in India include:

- Large demand-supply gap in electricity
- India is generously endowed with renewable energy resources like solar, wind, bio-mass materials, urban and industrial wastes and small hydro resources
- Low gestation periods for setting up renewable energy projects with quick return

- Conducive government policies and a large number of financing options available for capital equipment
- Increasing awareness among industry that being environmentally responsible is economically sound
- Solution needed for rural electrification.[3]

10.2 Policy and Regulatory Framework

The Electricity Act 2003 contains several provisions to promote the accelerated development of power generation from non-conventional sources. The Electricity Act 2003 provides that co-generation and generation of electricity from renewable sources would be promoted by the State Electricity Regulatory Commissions (SERCs) by providing suitable measures for connectivity with grid and the sale of electricity to any person, and also by specifying for the purchase of electricity from such sources the percentage of the total consumption of electricity in the area of a distribution license.[4]

10.2.1 Renewable Energy Policy

A comprehensive Renewable Energy Policy for development of the sector, encompassing all the key aspects, has been formulated by MNES. The broad objectives envisaged in the policy are:

- Meeting the minimum energy needs through renewable energy:
- Providing decentralised energy supply in agriculture, industry, commercial and household sectors in rural and urban areas
- The policy envisages 10% of additional grid power generation capacity to be from renewable energy by 2012. The policy is awaiting approval by the Government.

10.2.2 Incentives for Renewable Energy

Fiscal Incentives

The government provides various types of fiscal incentives such as direct taxes – 100% depreciation in the first year of the installation of the project, exemption or reduction in excise duty, exemption from central sales tax, and customs duty concessions on the import of material, components and equipment used in renewable energy projects. MNES has issued guidelines to all state governments for the creation of an attractive environment for evacuation and purchase, wheeling and banking of electrical power from

renewable energy sources. So far 14 states have announced policies for purchase, wheeling and banking of power from all sources.[5]

Financial Incentives

MNES provides financial incentives for various renewable energy programmes. These include interest and capital subsidies. In addition, soft loans are provided through the Indian Renewable Energy Development Agency (IREDA), some nationalised banks and other financing institutions.[6]

10.3 Current Situation

India is implementing one of the world's largest programmes in renewable energy. The country ranks second in the world in biogas utilization and fifth in wind power and photovoltaic production. The total installed capacity of power generation from various non-conventional energy sources has reached about 6,754 MW in 2005. Currently wind energy is the leading renewable energy source in India followed by small hydro power and biomass. There are a plenty of development plans for waste-to-energy as well as also for modern renewable energy sources.[7]

It has been estimated that about 5.5 billion Euros has so far been invested in the renewable power sector in the country. About 90% of the investment has come from the private sector.[8]

10.3.1 Wind Power

India is the fifth largest wind power producer in the world after Germany, the USA, Denmark and Spain, with a wind power generation capacity of 3,595 MW (March 2005). The Wind Resource Assessment Programme (WRAP) is one of the largest programmes of this kind in the world. It covers around 1,000 wind monitoring and mapping stations in 25 States and Union Territories. So far 208 potential sites have been identified in 13 states by state nodal agencies (SNAs).[9]

Wind power generation is mainly concentrated on states in South and Western coastal parts of India such as Tamil Nadu, Maharashtra, Gujarat and Karnataka.[10]

State-of-the-art wind power technologies are now widely available in India. Wind electric generators up to 1,650 kW unit capacities are manufactured. Major manufacturers of wind turbines are Enercon (India) Ltd, Vestas RRB India Ltd and Suzlon Energy Ltd. Also advanced R&D activities are undertaken through several research institutions, laboratories, and technical centres.[11]

Table 19 Renewable energy in India at a glance. (Source: Ministry of Non-Conventional Energy Sources (MNES), Booklet Series, 2005.)

Source/System	Estimated potential	Cumulative installed capacity/number *
Wind power	45,000 MW	3,595 MW
Biomass power	16,000 MW	302.53 MW
Bagasse cogeneration	3,500 MW	447.00 MW
Small Hydro (up to 25MW)	15,000 MW	1,705.63 MW
Waste to energy • Municipal solid waste	1,700 MW	17 MW
• Industrial waste	1,000 MW	29.50 MW
Family-size biogas plants	12 million	3.71 million
Improved chulhas	120 million	35.20 million
Solar street lighting systems	--	54,795
Home lighting systems	--	342,607
Solar lanterns	--	560,295
Solar photovoltaic power plants	--	1,566kWp
Solar water heating systems	140 million m^2 of collector area	1 million m^2 of collector area
Box-type solar cookers	--	575,000
Solar photovoltaic pumps	--	6,818
Wind pumps	--	1,087
Biogas gasifiers	--	66.35 MW

* as on 31 March 2005

IREDA has been the most active promoter and financing body in India for wind energy projects. IREDA has financed 10% of all wind energy installed in India.[12]

10.3.2 Small Hydro Power

The total installed hydro power capacity is 29,500 MW. Hydro power sources are located in north eastern parts of the country. India has so far set up 523 Small Hydro Power (SHP) of up to 25 MW capacities totalling 1,705 MW. Besides these, 205 SHP projects with an aggregate capacity of 479 MW are under implementation. These projects are spread throughout the country in hilly regions as well as on canal drops.[13]

In India there are about 10 manufacturers, who fabricate almost the entire range and type of SHP equipment, some of whom have foreign collaborators. There is an immediate need to bring down costs and develop equipment for small-size micro hydro projects.[14]

The World Bank (WB) has been focusing on SHP projects in India since 1992. At the moment WB has 90 million Euros credit line open for SHP until the end of 2007.[15]

10.3.3 Biomass

Biomass has always been an important energy source. Although the energy scenario in India today indicates a growing dependence on conventional forms of energy, about 32% of the total primary energy use of the country is still derived from biomass and more than 70% of the country's population depends upon it for its energy needs.[16]

The GOI has been aware of the potential and role of biomass energy in the Indian context and has initiated a number of programmes for promotion of modern biomass technologies. Biomass power generation is an industry that attracts investments of over 112 million Euros every year, generating more than 5,000 million units of electricity and yearly employment of more than 10 million man-days in rural areas. The three main technologies being promoted by the MNES for productive utilization of biomass are bagasse-based cogeneration in sugar mills, biomass power generation, and biomass gasification for thermal and electrical applications.[17]

The technology for the use of biomass for power generation and bagasse-based co-generation is fairly well established in India. The equipment required, mainly boilers, turbines, and grid inter-phasing systems, exists or is imported in the country.

Biomass for Power Generation

A power generation capacity of about 302 MW has been commissioned through 54 projects. A further capacity addition of about 270 MW through 39 projects is reported to be under implementation. A state-wise list of commissioned and "under implementation" biomass power capacity follows in the table below (March 2005).[18]

Bagasse-based Co-generation

Indian current total capacity of bagasse-based co-generation is 447 MW. State-wise distribution of commissioned and "under implementation" co-generation capacity (March 2005) is shown in Table 21.[19]

Table 20 Biomass for power generation capacity.

State	Commissioned capacity		"Under implementation" capacity	
	Number of projects	(MW)	Number of projects	(MW)
Andhra Pradesh	37	194.2	11	70.25
Chhattisgarh	2	11.0	5	51.00
Gujarat	1	0.5	--	--
Haryana	1	4.0	--	--
Karnataka	5	36.0	11	61.00
Madhya Pradesh	1	1.0	--	--
Maharashtra	1	3.5	1	6.00
Punjab	1	10.0	1	6.00
Rajasthan	1	7.8	4	29.10
Tamil Nadu	4	34.5	6	48.50
Uttar Pradesh	--	--	--	--
Total	54	302.5	39	271.85

Table 21 Bagasse-based co-generation capacity.

State	Commissioned capacity		"Under implementation" capacity	
	Number of projects	(MW)	Number of projects	(MW)
Andhra Pradesh	12	73.05	7	55.71
Gujarat	--	--	--	--
Haryana	1	2.00	--	--
Karnataka	10	115.98	9	94.60
Maharashtra	8	32.50	7	69.80
Punjab	2	12.00	--	--
Tamil Nadu	15	138.50	3	28.50
Uttar Pradesh	10	73.00	8	64.30
Total	58	447.03	34	312.97

Biomass Gasification

The biomass gasifier-based thermal and electricity generation applications are at a "take off" stage. Many systems have been installed and only MNES has provided partial financial support for installation of about 1900 gasification systems in the country.[20]

10.3.4 Energy Recovery from Waste

The quantity of wastes generated in Class I cities (229) per annum is estimated to be about 27 million tonnes of municipal wastes and about 4,400 million m^3 of sewage. In addition, large quantities of wastes are produced by industries, such as sugar mills, distilleries, pulp and paper mills, dairies, slaughter houses, tanneries, pharmaceutical industries, etc. So far the capacity of energy recovered from municipal and industrial waste is about 47 MW. Technological options available are: biomethanisation or anaerobic digestion, combustion, gasification and landfill gas recovery.[21]

10.3.5 Solar Energy

Currently, about 66 MW aggregate capacity (about 10,800,000 individual Photovoltaic /PVsystems and power plants) have been installed for various applications. In addition, PV products of 55 MW aggregate capacities have been exported. India has about 15 companies that manufacture PV modules, and over 45 companies that manufacture SPV systems. India is also a major exporter of PV modules and SPV systems.[22]

10.3.6 Biogas

The use of biogas is derived from animal waste, primarily cow dung. Up to December 2004, under the National Biogas Programme, over 3.7 million biogas plants in the capacity of 1–6 m^3 had been installed. Larger units are located in villages, farms, and cattle houses.[23]

Besides solar, wind, hydro, biomass and bio fuels, there are other eco-friendly and renewable sources from which energy can be tapped for varied applications. These are: chemical sources of energy - fuel cells, hydrogen energy, alternative fuel for surface transportation, geothermal energy, and ocean and tidal energy.[24]

Table 22 Wind Power Potential (gross and technical).

State	Gross Potential (MW)	Technical Potential (MW)
Andhra Pradesh	8,257	2,110
Gujarat	9,675	1,900
Karnataka	6,620	1,310
Kerala	875	610
Madhya Pradesh	5,500	1,050
Maharashtra	3,650	3,060
Orissa	1,700	1,085
Rajasthan	5,400	1,050
Tamil Nadu	3,050	2,150
West Bengal	450	450
Total	45,195	14,775

Table 23 Identified small hydro sites up to 25 MW.

State/ Union Territory	Number of identified sites	Total capacity (MW)
Andhra Pradesh	286	254.63
Arunachal Pradesh	492	1,059.03
Himachal Pradesh	323	1,624.78
Jammu and Kashmir	201	1,207.27
Karnataka	230	652.61
Kerala	198	466.85
Madhya Pradesh	85	336.33
Maharashtra	234	599.47
Tamil Nadu	147	338.92
Uttaranchal	354	1,478.24
Uttar Pradesh	211	267.06
Other States	1,466	2,039.18
Total	4,233	10,324.37

10.4 Market Potential

The potential for generating power from wind, small hydro, and biomass is estimated to be around 80,000 MW. Only about 6,700 MW has been exploited to-date. The market for renewable energy business is estimated at 400 million Euros (2005). It is growing at an annual rate of 15%. The major areas of investment are: wind energy, small hydro projects, waste-to-energy, biomass, solar energy, and alternative fuel.[25]

10.4.1 Wind Energy

India's wind power potential has been assessed at 45,000 MW. The current technical potential is estimated at about 13,000 MW, assuming 20% grid penetration, which would increase with the augmentation of grid capacity in potential states. The state-wise gross and technical potentials are given in Table 22.[26]

States with high wind power potential are Tamil Nadu, Gujarat, Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh and Maharashtra. About 11.3 billion units of electricity have been fed to various state grids from wind power projects. Almost 80% of the power thus generated has been used for captive consumption, and the rest sold to the grid or to a third party.[27]

10.4.2 Small Hydro Power (SHP)

India has enormous economically exploitable and viable hydro potential amounting about 84,000 MW. The estimated potential for SHP is about 15,000 MW. MNES has a database of 4,233 potential

sites with an aggregate capacity of 10,324 MW for projects up to 25 MW. A remaining 5,000 MW is under examination.[28]

The states mentioned in table above have announced policies for private sector participation in the SHP.[29]

10.4.3 Biomass

500 million tons of crop and plantation residues are produced every year, a large portion of which is either wasted, or used inefficiently. Conservative estimates indicate that even with the present utilization pattern of these residues and by using only the surplus biomass materials, amounting to roughly 150 million tonnes, about 19,500 MW of distributed power – biomass power generation 16,000 MW and 3,500 bagasse-based co-generation – could be generated.[30]

Table 24 Energy potential of biomass by major States.[31]

State	Potential (in MW)
Maharashtra	1,000
Uttar Pradesh	1,000
Tamil Nadu	350
Karnataka	300
Andhra Pradesh	200
Bihar	200
Gujarat	200
Punjab	150
Others	100
Total	3,500

10.4.4 Energy Recovery from Waste

There exists a potential for generating an estimated 1700 MW of power from the urban and municipal wastes, and about 1000 MW from industrial wastes. The potential is likely to increase further with economic development. The state-wise and sector-wise potential is given in table below.[32]

Table 25 Potential for recovery of energy from urban wastes by major states.[33]

State/Union Territory	Liquid wastes (MW)	Solid wastes (MW)	Total (MW)
Andhra Pradesh	16	107	123
Delhi	20	111	131
Gujarat	14	98	112
Karnataka	26	125	151
Maharashtra	37	250	287
Tamil Nadu	14	137	151
Uttar Pradesh	22	154	176
West Bengal	22	126	148
Other States	55	349	404
Total	226	1,457	1,683

10.4.5 Solar Energy

The scope for generating power and thermal applications using solar energy is promising. Only a fraction of the aggregate potential in renewable resources and in particularly solar energy is being used so far. There are about 300 clear sunny days in a year in most parts of India. This is equal to over 5,000 trillion kWh/year, which is far more than the total energy consumption of the country in a year. The daily average solar energy incident over India varies from 4–7 kWh/m^2, depending upon location.[34]

The Government of India is aiming, on a short term basis, at an additional 1 million SPV (Solar Photovoltaic) systems for lighting, 8,000 SPV pumps for irrigation, 10,000 SPV generators, stand-alone SPV power plants, solar water/air heating systems, solar cooking systems etc. Although India is quite self sufficient with solar electricity products, there is a good market for new modern and advanced solar technologies and devices.[35]

10.4.6 Biogas

The estimated potential of household biogas plants based on animal waste is 12 million units. The estimated biogas production from these plants is over 3.5 million m^3 per day, which is equivalent to a daily supply of about 2.2 million m^3 natural gas.[36]

10.5 Overviews of Selected Areas

10.5.1 Maharasthra - Bagasse Cogeneration from Sugar mills

Bagasse is a by-product of sugar cane, used as a fuel in boilers to produce process steam. Potential of power through bagasse co-generation is about 1,000 MW in Maharashtra.

Table 26 Bagasse cogeneration projects in Maharasthra.

	Number of Sugar Factories / Projects	Biggest Project	Installed / Proposed Capacity (MW)
Projects Implemented	9	Hupari - Yelgud, Dist. Kolhapur. (24 MW)	73.5
Projects Under Implementation	4	Pravaranagar, Ahmednagar (35 MW)	84.5
Projects In Pipeline	25	Yeotmal (30 MW)	334.50
			Total 492.5

Bagasse-based co-generation power projects are one of the important schemes of the Maharashtra Energy Development Agency (MEDA). There are nearly 160 sugar factories in Maharashtra, of which nearly 50 have shown their interest in co-generation. Table 26 summarizes the bagasse-based co-generation projects in Maharasthra. There are several projects in pipeline.[37]

10.5.2 Tamil Nadu - Wind Energy

Tamil Nadu has the largest installed wind energy capacity 2,036.9 MW (March 2005) in India, which accounts 56.7% of total wind energy capacity in the country. Technical potential for additional capacity is 2,150 MW.

The Tamil Nadu Government provides a favourable set up for wind energy projects through various incentives and promotional efforts such as resource assessment studies, demonstration projects, conductive and consistent policies, including attractive wheeling and banking facilities. Furthermore, Government provides infrastructure for easy accessibility and power evacuation, and is motivating the private sector to invest in wind electricity generators through the Textile Upgradation Fund (TUF) of the Ministry of Textiles. The TUF helps power-intensive textile mills to invest in wind mills.[38]

10.6 Opportunities for Finnish Companies

The Indian renewable energy industry is vast and diversified and offers strong business prospects for Finnish companies. The Clean Development Mechanism is recommended to take into consideration whenever possible. Key project opportunities are listed below:

- Biomass - small biomass 1–3 MW in rural areas. Larger capacities in co-generation in sugar mills (bagasse) and pulp and paper factories: advanced biomass gasification technologies, biomass combustion systems and high pressure cogeneration systems
- Small Hydro Power (5–25 MW) - Himalayan region: low head power generation systems, high efficiency systems and portable hydro sets
- Waste to Energy - municipal and industrial solid waste in major cities such as Mumbai: high rate biomethananization systems, incineration and sanitary landfills Financing plays a very important role in Waste to Energy projects and BOT or BOOT concepts should be considered
- Wind Energy - latest technologies and higher capacities needed: over 1–2 MW size wind power systems, wind machines for low wind regimes and better designed rotor blades, gear boxes, and control systems
- Biogas - large scale biogas plants: 250 kW–1,000 kW.

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11 International Funding via International Financing Institutions

The most prominent International Financing Institutions (IFIs) in the case of India and the environment sector are the World Bank (WB) and the Asian Development Bank (ADB). Also, the Global Environment Facility (GEF) and United Nations (UN) should be considered as potential financers in some niche sectors.

India is the largest recipient of the World Bank's funding world-wide. The Bank has provided low-cost, long-tenor financing to infrastructure projects through loans under its International Development Association (IDA) and the International Bank for Reconstruction and Development (IBRD). WB has also provided technical assistance for feasibility studies. WB's strategy is to expand its Indian portfolio. Energy and other infrastructure have constituted the maximum share, over 50%, of WB lending. The focus has especially been on the water sector. Uttar-Pradesh state has been the main focus with a share of about 20% of the total.

The Asian Development Bank (ADB) is the second most active player. It has supported India in the form of policy dialogue, loans, technical assistance, grants, guarantees and equity investments. The focus has mainly been on energy (24%) and urban social infrastructure (13%). Many water and energy projects include large environmental components. In the new Water Financing Program (WFP) for the years 2006–2010, the target is to make water a core investment area for ADB. This programme is expected to lead project generation also in India. In the energy sector the focus is on increasing private sector involvement, long-term renewable energy projects, and usage of clean energy in general. Regional co-operation will be supported by enhancing export-oriented hydropower and natural gas-based generation and transmission projects.

In the following sections, the text focuses on the most relevant topics and environmental issues. The general descriptions of the financers can be found in the web pages presented in the text.

11.1 Potential Financers – The World Bank Group

The world Bank Group comprises five organizations:

- The International Bank for Reconstruction and Development (IBRD)
- The International Development Association (IDA)
- The International Finance Corporation (IFC)
- The Multilateral Investment Guarantee Agency (MIGA)
- The International Center for the Settlement of Investment Disputes (ICSID).

Here, the term World Bank (WB) is used for IBRD and IDA. The World Bank's Trust Fund Global Environmental Facility (GEF) is presented shortly, too. More information can be found on the web-pages.

Global Environmental Facility – Trust Fund

Trust funds are provided by an external donor and are used e.g. for technical assistance, advisory services, debt relief, post-conflict transition and co-financing. Of interest to Finnish companies is the Global Environmental Facility (GEF). The World Bank manages GEF in cooperation with United Nations Environment Programme (UNEP) and United Nations Development Programme (UNDP). GEF provides grants and concessional funds to recipient countries for projects and activities that aim to protect the global environment. Project proposals in countries eligible for funding can be presented directly to the GEF Implementing Agencies. Project ideas that meet the initial criteria are then handled by the proposing party and the UNDP, UNEP or the World Bank.[1]

11.1.1 World Bank Strategy for India 2005–2008

The Country Strategy guides the Bank's programs in India until 2008. Together with Asian Development Bank (ADB), the Bank is focusing on the 12 largest and poorest states of India in the development of fiscal management, governance, service delivery, and power sector (Andhra Pradesh, Assam, Bihar, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Tamil Nadu, Uttar Pradesh, and West Bengal). The Bank has increased its financing with other development partners under common arrangements for national programs in the areas most critical to meeting the Millennium Development Goals (MDGs).[2]

The strategy focuses in helping to improve government effectiveness, in supporting investments in people and empowering communities, and in

promoting private sector-led growth. In this respect, the following sectors will receive increased lending:

- Infrastructure: roads, transport, power, water supply and sanitation, irrigation and urban development
- Human Development: education, health, social protection
- Rural Livelihoods: with an emphasis on community-driven approaches.

Earlier, the main focus in the Country Strategy was on Andhra Pradesh, Karnataka, and Uttar Pradesh states. As the gulf between India's faster and slower growing states is widening, the following shifts have been made:

- Largest and poorest states of India are engaged in a dialogue.
- Target is to build a productive development relationship with four states with increasing poverty: Bihar, Jharkhand, Orissa, and Uttar Pradesh.
- Remaining state-level adjustment lending operations aimed at supporting the achievement of the MDGs.
- Instead of concentrating on 'focus states', investment lending will be channelled more broadly to states on the basis of guidelines for each sector.

WB's environmental activities are mainly focused on water sector projects. Water Resources Management Strategy includes sub-sectors such as hydropower, water supply and sanitation, irrigation and drainage, and environment. Also, the existing infrastructure should be more effectively used, and environmental and financial sustainability should be better taken into account.

Assistance for water supply and sanitation is focusing on extending water supply and sanitation services to the urban poor, improving service provider performance, increasing rural access to water supply and sanitation and on improved management of the water resources base. The priorities are the following: strengthening governance, ensuring the financial sustainability of water supply and sanitation schemes, strengthening service delivery mechanisms, targeting interventions to the poor and improving health outcomes.

11.2 Potential Financers – The Asian Development Bank

The main goal of ADB is to reduce poverty by supporting pro-poor economic growth, inclusive social development and good governance. Under its Long-Term Strategic Framework (2001–2015), the ADB takes into account in its

activities three cross-cutting themes: private sector development, regional cooperation and environmental sustainability. ADB's principal instruments are loans, guarantees and technical assistance, which it mainly provides for governments for specific projects and programs. ADB has programmed a total loan assistance of 5.39 billion Euros for India for the years 2005–07 or an average annual lending of over 1.75 billion Euros, excluding the sub-regional projects. Of this, 37.8% has been allocated for the transport sector, 15.5% for both energy and urban infrastructure, 12.4% for the financial sector, 11.5% for agriculture and water management and 7.3% for governance and public resource management.[3, 4]

ADB's procurement is generally done on the basis of international competition, which is open to firms and individuals from any ADB member country, regional or non-regional.

11.2.1 Environment Policy

Poverty reduction together with environmental sustainability forms the basis of ADB's Environment Policy. Environmental sustainability should promote economic growth; provide essential services, including clean water and sanitation; increase agricultural productivity; and improve the overall quality of life for the poor. The environment and natural resources in the region are under intense pressure. Through sectoral policies water and energy sectors are the most important in the field of the environment.

The water policy, approved in 2001, concentrates on water management and development. Water is seen as a vital economic good that needs careful management to sustain equitable economic growth and reduce poverty. Also, water conservation and protection in the region are seen as important.

ADB formulated a new Water Financing Program (WFP) for 2006–2010 in March 2006. The target is to make water a core investment area for ADB. Until present, the investments in water have been modest, ranging from 270 million Euros in 2004 to 1.16 billion Euros in 2005. Under the WFP, ADB proposes to increase its water investments to well over 1.66 billion Euros annually. Its focus will be on combining increased investments in water infrastructure with capacity building and private sector participation.

There are three sub-sectors in the program, namely rural water, urban water and basin water. In rural water sector the focus is to improve health and livelihoods in rural communities, including investments in water supply and sanitation, and irrigation and drainage. In urban water, the target is to support sustained economic growth in cities, including investments in water supply, sanitation and wastewater management, and environmental improvement. In basin water, the goal is to promote integrated water resources

management and healthy rivers, including investments in the infrastructure. WFP will also mobilize co-financing and investments from government clients, the private sector, and multilateral and bilateral partners.

The Water Financing Program should result in improved access to safe drinking water and sanitation, more productive and efficient irrigation and drainage services, reduced risk of flooding, integrated water resources management including reduced wastewater pollution and improved river ecosystems, and also in improved water governance through national water sector reforms and capacity development.

11.2.2 Energy Policy

The target of policy is to support creation of an energy infrastructure for sustainable economic growth, and thus reduce poverty. Also, private sector involvement needs to be increased. The policy also supports the financing of long-term renewable energy projects and usage of clean energy in general. Regional co-operation will be supported by enhancing export-oriented hydropower and natural gas-based generation and transmission projects.

11.2.3. Technical Assistance

Technical assistance (TA) is a vital element of ADB's development strategy. With technical assistance operations, ADB assists its developing member countries in identifying, formulating, and implementing project. The target is to improve the institutional capabilities of governments and executing agencies for promoting the transfer of technology fostering regional cooperation.

There are three types of TA activities:

- project preparatory technical assistance (PPTA) to prepare a project loan, a program loan, or a sector loan for financing by the ADB and other external sources
- advisory technical assistance (ADTA) to finance, for example, institution building or sector-, policy-, and issues-oriented studies
- regional technical assistance (RETA) for any of the activities covering more than one member country
- ADB deems any technical assistance projected funded for under 125,121 Euros a small-scale technical assistance (SSTA).

TA financing is a good indicator showing the future priorities of ADB project financing. For example in March 2006, there were the following projects in the pipeline; Project Implementation and Urban Management Improvement in the North Eastern Region, Energy Efficiency Improvement, Environmental Invest-

ment Opportunities in the Energy Sector, and ORISSA Integrated Irrigated Agriculture and Water Management Project. In addition, TA projects approved or implemented in 2004–2005 were focusing on solid waste and CDM mechanism. As far as regional technical assistance is concerned, air pollution and urban water supply and sanitation have recently been the main focus.

11.3 Other International Development Financers

The Government of India has restricted official aid to multilaterals and to a limited number of bilateral donors. The main European players are UK (DFID) and Germany (GTZ). Globally speaking, USAID and Japan Bank for International Cooperation (JBIC) have an active role. In addition to development financers presented above, the United Nations (UN) is an important player. The UN implements its projects in India's environment sector through its sub-organization United Nations Development Programme (UNDP).[5]

11.4 European Union's Assistance for India

The EU has implemented its co-operation with India through Development Co-operation and Economic Co-operation. For example environmental initiatives and collaboration has been implemented through Asia Pro-Eco Programme.[6]

In the near future no major projects in the field of the environment are planned for India. In the beginning of 2007, the EU will have a new co-operation instrument for Asian countries instead of the present ALA (EU's External Aid Programme for Asia and Latin America) programme. The exact contents and financing of the new instrument is still unknown.

11.5 Finnish Cooperation Funds Focusing on the Environment

The Government of Finland has agreed to make additional contributions to ADB's Finnish Technical Assistance Grant Fund over the next three years totaling 3.72 million Euros equivalent (July 2004).[7]

Activities to be financed by the fund will be in the areas of environmental protection and development of renewable energy forms in developing countries. It will promote environmental sustainability, one of the five thematic priorities of ADB's Poverty Reduction Strategy.

11.6 How the International Financing Institutions work

11.6.1 Project Cycle of the World Bank

The development financiers' project cycles resemble one another. Therefore, the project cycle of the World Bank (WB) is here used as an example. In practice, the development financiers and the borrowing country work closely together throughout the project cycle although they have different roles and responsibilities. Generally, the duration of the project cycle is long by commercial standards. From identification to completion it can last over 4–5 years.

The project cycle includes six stages: (1) Identification, (2) Preparation, (3) Appraisal, (4) Negotiation/ Approval, (5) Implementation and

Figure 8 Phases of the project cycle.

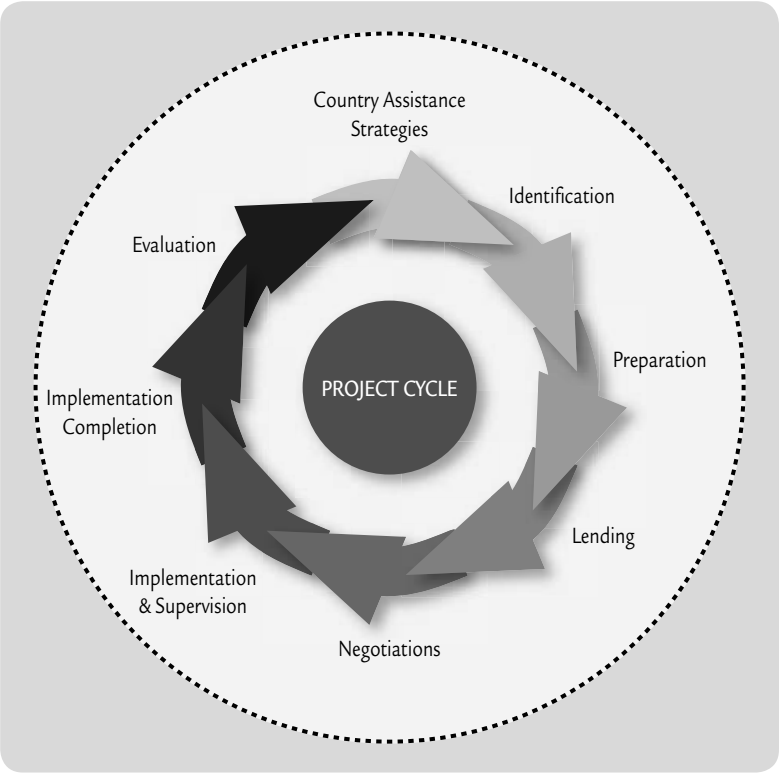

Table 27 Business Opportunities during the Project Cycle.

Stage	Type of Opportunity	Buyer
Pre-Pipeline	Short-Term Consulting (< 83,414 Euros)	World Bank
Identification	Short-Term Consulting	World Bank
Preparation	Short-Term Consulting Medium-Term Consulting Services (> 166,828 Euros)	Borrowing Country Borrowing Country
Appraisal	Short-Term Consulting	World Bank
Negotiation & Approval	N/A	N/A
Implementation	Consulting Services, Equipment, Goods & Civil Works	Borrowing Country
Supervision	Short-Term Consulting	World Bank
Post-Evaluation	Short-Term Consulting	World Bank

(6) Evaluation. A project in one of the first three stages is referred to be "in the pipeline". The Implementation stage may also be referred to as "supervision" since this is when WB staff will monitor the implementation of a project. Understanding the project cycle is central to identifying business opportunities. Table 27 presents some business opportunities on each phase of the project cycle.

11.6.2 The Asian Development Bank's Procurement Procedures

Like in the case of the World Bank, also ADB's rules for procurement of goods and civil works and for procurement of consultants need to be closely followed. The executing agencies in the borrowing country are responsible for all aspects of the procurement process. For technical assistance (consulting) projects funded directly by the WB, the procurement process is the responsibility of the ADB. In private sector operations, procurement is the responsibility of the borrowing firm and will be undertaken on a commercial basis.

In the case of procurement under co-financed contracts, ADB procurement procedures must be followed even if the ADB loan finances only part of the contract. For other parts of the contract that do not involve the use of ADB loan proceeds, the ADB still requires that the procedures are in line with efficient project implementation.

11.7 How Finnish Companies can benefit from International Development Financing

Both the World Bank and the Asian Development Bank generate numerous contracts annually ranging in size from a few thousand Euros to multi-million Euro expenditures for the delivery of a vast range of goods and services. Each project may involve many separate contracts and business opportunities for suppliers, contractors, and consultants worldwide. All contracts are between the borrower (usually the government department being the implementing agency) and the supplier, contractor or consultant.

Business opportunities exist at each stage of the project cycle. There are opportunities for short-term consulting in the pipeline phases. In the project implementation phase there are opportunities for large and small contracts for goods and equipment suppliers, for civil works and consulting firms. The overall objective of the procurement guidelines is to allow borrowing countries to buy high quality goods and services as economically as possible. Companies respond to open tenders and are selected by the borrowing country according to formal procedures and evaluation criteria.

Interested companies should, depending on their experience in the procurement methods, decide on which efforts it should do in order to become a successful actor in this business. It is essential to follow procurement opportunities and pipeline information. Also, meetings with relevant contacts at the financiers to receive strategy analyses for given projects or sector-specific interests should be considered. In addition, for pursuing goods and/or works contracts for development financiers' projects, it could be valuable to visit the implementing agency in the borrowing country and to have contact with the relevant project specialists.

Planning a visit to the borrowing country is essential for consulting and engineering firms, as well as for exporters of goods. On the local level, it is advisable to find a reliable local partner or agent to ease the process of providing services to a foreign country. Partnering with a local firm can help reduce costs while bringing in local expertise. In partner search, reliable potential partners can be found among the successful actors. Subcontracting with firms that have been awarded prime contracts also provides an opportunity to participate in projects funded by the development financiers. Subcontracts need not be governed by financiers' procurement regulations. In this case, interested companies and organizations should contact prime contractors directly. In section 11.11 some of the most successful recent consultants in the India's environment sector have been listed.

In ADB, the pre-qualification of bidders is the preferred method for most works contracts, turnkey contracts and contracts for the supply of expensive and technically complex equipment. This will ensure that only ca-

pable firms can submit eligible bids. Invitations to pre-qualify are published on the ADB website and in national newspapers.

In ADB, rules for the procurement of consultants are different from the rules for procurement of goods and works. The ADB Consultant Selection Committee is responsible for hiring consultants for TA contracts. For this purpose, companies must be registered in the ADB Database on Consulting firms (DACON http://adb.org/ Consulting/dacon.asp). Individual Finnish consultants can be registered in the ADB Database on Individual Consultants (DICON http://www.adb.org/Consulting/ dicon.asp). Even though registering in DICON is not mandatory, DICON is used when there are specific needs for an assignment. The three most prominent short-listed candidates are contacted in order of rank to determine their availability and interest in the project. Whenever possible, ADB encourages consulting firms from developed countries to use qualified domestic consultants and/or consultants from other developing member countries.

11.8 Financing for Own Projects

We have described above the business opportunities in India for Finnish companies in International Financing Institutions projects. Below, we in-

Table 28 Financing possibilities for own projects.

Organisation	Main focus	More information
Finnfund	Long-term risk capital for private projects in emerging markets and transition economies outside the EU	www.finnfund.fi
Finnpartnership	Expense covering for identifying business partners, preparing feasibility studies, drawing up business plans, training employees in the developing country and the utilization of external experts.	www.finnpartnership.fi
Finnvera	Export and project financing	www.finnvera.fi
Nordic Investment Bank	Long-term loans and guarantees	www.nib.int
International Finance Corporation	Loan and equity financing for private sector projects	www.ifc.org
Multilateral Investment Guarantee Agency	Insuring eligible projects against losses relating to currency transfer restrictions, expropriation, war and civil disturbance and breach of contract.	www.miga.org

troduce shortly some possibilities for financing companies' own projects in India. It is clear that nowadays it is more and more important for Finnish companies to be able to explain the financing possibilities to the potential clients in the target country. Financing can be grants and loans and be used e.g. for feasibility studies or investment itself. Table 28 does not include any commercial banks.

11.9 Project Pipeline – Asian Development Bank

More specific information on ADB's project pipeline and lately approved loan and technical assistance projects as of March 2006 can be obtained from Sitra.[8, 9]

11.9.1 Environment

Environmental projects are being addressed through urban social infrastructure projects such as supply of potable water, sanitation, sewerage, and solid waste management.

11.9.2 Urban sector

Several of ADB's infrastructure projects have project components to promote social development. Urban sector projects combine water supply and sanitation, sewerage, and drainage interventions with targeted components for slum improvement, low-cost sanitation, livelihood development through vocational and entrepreneurial training, and microfinance activities.

ADB's ongoing urban sector operations in Gujarat, Karnataka, Madhya Pradesh, Rajasthan, and West Bengal combine infrastructure development (primarily water, sanitation, and waste management) with targeted poverty reduction components. There is also a strong focus on municipal reforms and capacity building.

The North Karnataka Urban Infrastructure Sector Development Program (2005) will pilot an innovative, performance-based model for enhancing private sector investment in urban infrastructure and its involvement in operation and maintenance of basic municipal services. This model has potential for replication in other states. Assistance is proposed for Karnataka and Kerala (2005), Jammu and Kashmir (2006), Rajasthan and Uttaranchal (2007), and the North-Eastern states including Assam (2006 and 2008). These projects will focus on improving and upgrading infrastructure facilities such as water supply, sewerage and sanitation systems, drainage, and solid waste management; building capacity of municipalities; strengthening

urban management and revenue generation; and improving operation and maintenance of infrastructure.

The Uttaranchal Tourism Development Project, programmed for 2008, will help improve the infrastructure of some of the tourist centres in the state. Support for the National Urban Renewal Mission of the Government will provide assistance with assessing infrastructure needs of selected cities, preparing a development plan, and support for PPP in urban development.

11.9.3 Water Resource Management

In connection with the new Water Financing Program (WFP) for 2006–2010, ADB has developed a strong pipeline of water projects for 2006–2008. Out of these selected projects, North Karnataka Urban Sector Investment Program is a loan project and the other urban water sector projects are in the technical assistance phase; Jammu and Kashmir Urban Development, North Eastern Region Urban Development (Phase I), North East Region Urban Development (Phase II) and Uttaranchal Urban Development.

11.9.4 Power

ADB's assistance at the national level will continue to focus on strategically important areas such as strengthening the national transmission grid and other critical investment needs. ADB has supported power sector reforms and investments in Assam, Gujarat, and Madhya Pradesh. State power sector loans will continue to focus on up-grading transmission, distribution, rural electrification, and capacity building of power sector institutions, particularly reducing system losses and improving collection of bills as required by the Electricity Act 2003.

The second phases of the Madhya Pradesh and Assam power sector loans are programmed for 2008 to support necessary investments to sustain the on-going sector reforms in these states. The North Eastern Region Power Development Project, programmed for 2007, will promote the use of locally available resources including hydropower, natural gas, and renewable energy sources for power generation; upgrade critical transmission and distribution facilities; and strengthen power sector institutions.

11.10 Project Pipeline – World Bank

More specific information on WB's project pipeline and lately approved loan and technical assistance projects as of March 2006, can be obtained from Sitra.[10, 11]

11.10.1 Environment

The World Bank's active and pipeline projects including an environmental component are focused on the water sector in the near future. Water supply and sanitation, municipal services, solid waste both in the cities and rural area projects will be e.g. in Punjab, Delhi, Uttaranchal, Tamil Nadu, Madhya Pradesh and Andhra Pradesh and Karnataka. National Urban Infrastructure Fund's activities will also focus on water supply and sanitation.

GEF financed, approved or pipeline projects are focused on biodiversity, removal of barriers to energy efficiency improvement, and biomass power generation.

11.10.2 Urban Sector

The lending pipeline consists of national operations supporting multi-state programs and encouraging broad-based sector reforms e.g. National Urban Infrastructure Fund. State-specific projects to build institutional capacities and pilot in-depth reforms in Andhra Pradesh, Karnataka, and Tamil Nadu are in the pipeline or approved.

11.10.3 Water Resource Management

Water Resources Management is the integrating concept for water sub-sectors like hydropower, water supply and sanitation, irrigation and drainage, and environment. An integrated water resources perspective ensures that social, economic, environmental and technical dimensions are taken into account in the management and development of water resources.

The Indian Government is now remodelling its rural water supply scheme, which is one of the largest in the world. This reform framework has been developed and implemented with World Bank support. Under this scheme, there are three states under preparation.

In the water resource management sector, the on-going projects include e.g. Madhya Pradesh Water Sector Restructuring (approved 2004), Hydrology II (approved 2004), and Maharashtra Water Sector Improvement (approved 2005).

Rural Water Supply and Sanitation projects in Punjab, Uttaranchal and Tamil Nadu are in the pipeline as well as Delhi's Water Supply and Sewerage Project. Maharashtra's Rural Water Supply and Sanitation has been approved in 2003 and is continuing. Also Karnataka's urban sector projects Municipal Reform and Water sector Improvement approved in 2006 and 2004 and Andhra Pradesh urban sector project include water components. GEF has a biodiversity project in the pipeline.

11.10.4 Power Sector

In the power sector, there is an on-going state power sector restructuring loan to Rajasthan and assistance for Power Grid Corporation and for developing renewable energy sources. In order to keep with agreed country priorities, World Bank is developing activities in: (i) developing the national power grid, focusing on efficient generation and allocation of electricity; (ii) developing environmentally and socially sustainable large-scale hydropower; (iii) supporting expansion of electricity access in rural areas, focusing on piloting and scaling up sustainable "last-mile" delivery models, and (iv) supporting on-going reforms and improving service delivery of state level utilities.

The World Bank is developing a carbon finance portfolio aligned with these activities and exploring options for additional support for low-carbon growth of the power sector, notably through coal station rehabilitation. Third Power System Development –project, totalling 0.82 Billion Euros, is an example of power projects including environmental assessments.

11.11 Successful Players in the Indian Environment Sector

For entering the environment sector projects that are financed by international development financiers, the Finnish companies could partner-up with successful players. Table 29 gives a short exemplary listing of the most

Table 29 Examples of successful foreign consultancy companies in environmental projects in India.

Contractor	Type	Country of the contracted company
BCEOM Societe Francaise d'Ingenierie	Consulting	France
Chemonics International	Consulting	US
Carl Bro - Intelligent Solutions	Consulting	Denmark
Environmental Resources Management Ltd	Consulting	UK
DHV Consultancy and Engineering	Consulting	NL
Agrotec	Consulting	Italy
Lahmeyer International	Consulting	Germany
Arcadis	Consulting	NL
Sinclair Knight Merz	Consulting	Australia
Groome Poyry	Consulting	NZ
Finnagro Ab Oy in association with Orgut Consulting	Consulting	Finland

successful consulting companies in the environment sector in India during the last couple of years. More detailed listing can be obtained on separate agreement.[12, 13]

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12 National Funding

12.1 Background

For years the funding for environmental projects came from the government and multilateral agencies. Domestic financial institutions, banks and private investors avoided investments because of the lack of commercial viability, long gestation periods, uncertain revenue streams and overall low creditability. However, over the past few years the situation has been changing and more financers have entered the stage.

Still much of the development of environment spending in the short to medium term will likely be in the public sector. However, there are opportunities for private initiatives in areas like solid waste management, water supply and waste water treatment. It is also expected that the mechanism announced by the Government to promote Public-Private Partnerships (PPPs), viability gap funding, will increase private sector investments in this area.

As described in Chapter 11, multilateral agencies like the World Bank, ADB, International Finance Corporation (IFC) and UNDP together with bilateral organizations like Japan Bank for International Cooperation (JBIC) and USAID have traditionally been active in India. In addition there are number of other institutions both at central, state and municipal level providing funds in form of both debt and equity for mostly large-scale environmental projects. Most of these agencies specialize in infrastructure projects, and there are no organizations focusing solely on the environment. The funding is mostly targeted at sectors like power, telecom and roads. Many of these agencies are also actively involved in urban infrastructure development and allocate funding, for instance to water supply, sanitation and solid waste management projects. However, from the total portfolio these segments form only a small part. Commercial banks are also increasingly involved in the sector, but venture capital for environment sector has been limited. Micro-finance institutions providing small loans are viable alterna-

tives for financing small enterprises. The funding opportunities provided by these institutions are discussed in more detail in the following sections.[1]

Both fiscal incentives and financial measures play an important role in ensuring conformity to norms of environmental protection. The Government of India has also initiated a number of schemes to provide financial assistance and incentives to industries. However, the use of fiscal instruments towards environmental objectives has been rather limited, consisting mainly of tax concessions, investment incentives for adoption of pollution control equipment and promotion of renewable energy technologies.[2]

12.2 Governmental Funding

12.2.1 Central Level

Since the sixth five year plan (1980–1985) environmental concerns are included in the planning process of the Government. The Finance Ministry with the help of planning commissions is responsible for planning the budget and allocating the funds to the various ministries. The Government is responsible for policy and regulatory frameworks related to financing. It provides equity for project agencies; offers guarantee mechanisms and funds/programs for capacity building; promotes fiscal incentives and fuels bond markets with governmental borrowings.

In terms of expenditure, various ministries, like the Ministry of Environment and Forests (MoEF), the Ministry of Water Resources, the Ministry of Agriculture, the Ministry of Rural Development, the Ministry of Non-Conventional Energy Sources (MNES) and the Ministry of Urban Development are supporting environmental and resource management projects and schemes. 1.1 billion Euro has been allocated to the MoEF for the Tenth Five Year Plan (2002–2007). An outlay of 231 million Euros was allocated for the Annual Plan 2005–2006 and 250

Table 30 Outlays of relevant ministries.

Expenditure Budget 2006–2007	Amount required (million Euros)
Ministry of Agriculture	1,300
Ministry of Environment and Forests	250
Ministry of Rural Development	5,888
Department of Rural Development	4,499
Department of Land Resources	265
Department of Drinking Water Supply	112
Ministry of Non-Conventional Energy Sources	101
Ministry of Urban Development	515
Ministry of Water Resources	131

million Euros for the annual plan of 2006–2007.[3] Table 30 below shows the outlays of ministries and their departments dealing with environmental issues.

The budgets of these ministries have been growing during the past years. For example the budget of MNES almost doubled from 52.4 million Euros in 2005–2006 to 100 million Euros in 2006–2007. Various ministries are providing financial assistance for states and districts and organizations within them directly and via various programmes. Table 31 illustrates the budget allocations from the centre for various important programmes.

Most of the centrally sponsored programmes require states' contribution. Many of them also receive funding from international sources.[4]

The Centre's budgetary support for water and sanitation schemes has been growing over years. 56,270 habitations and 140,000 schools are to be covered in the current fiscal year, and non-recurring assistance of 39.9 million Euros is to be provided in 2006–2007 for setting up district-level water testing laboratories and field-level water testing kits. Like the above table shows, provision for the Rajiv Gandhi National Drinking Water Mission will be increased from 682 million Euros to 876 million Euros, and for the Rural Sanitation Campaign from 118 million Euros to 135 million Euros. 20,000 water bodies with a command area of 1.47 million hectares will be identified and repaired, renovated and restored.[5]

Table 31 Allocations from the Centre for Major Environmental Programmes in 2006–2007.

	2005–2006 (million Euros)	2006–2007 (million Euros)
Ministry of Environment and Forests		
National Afforestation Programme	38.1	51.9
Integrated Forest Protection Scheme	3.9	8.7
National River Conservation Plan	55.6	68
National Lake Conservation Plan	10.5	11.2
Ministry of Rural Development		
Accelerated Rural Water Supply Project	228	350
Rural Sanitation Programme	118	135
Command Area Development and Water Management Programme	29.6	37.3
Rajiv Gandhi National Drinking Water Mission	682	876

In terms of smaller programmes, under the Pollution Control scheme "Waste minimization and cleaner production" financial assistance is provided for establishment and running of waste minimization circles in clusters of small scale industries with objectives of capacity building in areas like cleaner production. The Pollution Control scheme, "Common Effluent Treatment Plants", subsidizes clusters of industries to set up common effluent treatment plants. Both central and state subsidies provide 25% of the total project costs whereas entrepreneur's contribution is 20%. The remaining 30% can be raised as loans from Indian financial institutions. Central assistance is provided only for the capital costs – not the recurring ones.[6]

A centrally sponsored scheme under the Ministry of Urban Development for infrastructural development in mega cities provides assistance for infrastructure development projects in cities of regional significance covering also components like water supply and sewerage and solid waste management. The 10th Plan (2002–2007) has a provision of 197 million Euros under the scheme. The Accelerated Urban Water Supply Programme (AUWSP) assists states to address the problems of drinking water in towns having a population of less than 20,000. Central government has released assistance of 117 million Euro for this purpose. A total amount of 163 million Euros has reportedly been spent with 365 schemes fully or partially commissioned.[7]

The Ministry of Non-Conventional Energy Sources is promoting renewable energy in various ways. There has been a shift from direct financial incentives like subsidies to indirect incentives like low interest loans and tax concessions. MNES promotes private investments in the renewable energy sector through fiscal incentives. It is also supporting R&D programs and demonstration projects. More information on incentives provided by MNES can be found in Chapter 10.[8]

12.2.2 State Level

Central Government together with multilateral agencies is funding a large number of environmental projects in states, some of them mentioned in earlier chapters. The states are also expected to match central monies through state funding.

12.2.3 Municipal Level

The traditional sources of finances for municipalities include grants and devolutions from Central Government via State Governments; State Government grants and their own taxes generated However, Urban Local Bod-

ies (ULBs) receive only a portion, around 40%, of their share of transfer from the states. This is due to deductions for things like overdue power charges and loan payments. Cost recovery from individual services is very low. In addition, ULBs lack a system to track and identify income and expenditure.

Steps have been taken to improve finances at ULB level. Municipal Development Funds have been established with objectives of enhancing the viability of local development projects through facilitating financial arrangements with private capital flows, and increasing the sustained access of the poor to local services and infrastructure through user participation. Funds are often created through collaboration with an international counterpart and a local counterpart, along with the local government as equity participant.

These steps taken by the Government include establishment of the City Challenge Fund (CCF), the Urban Reform Incentive Fund (URIF) and the Pooled Finance Development Fund (PFDF). Presently URIF targets selected reforms but does not finance specific infrastructure investments. The states are not obliged to invest the incentives received for urban infrastructure investments or to provide the same to municipalities to use directly for such capex schemes. CCF was thought to be designed to provide investment funding coupled with specific city level reforms. These funds have not been taken up very well, since the corpus was too small and the wish-list of reform interventions sought too long. Thus there is discussion underway concerning integration of URIF and CCF into an Urban Infrastructure Development Fund (UIDF), a much bigger fund which could provide funding to states to take up large infrastructure projects. Flow of funds to the states would be linked with reforms. It should be possible to merge other governmental funds in the proposed fund as well.[9]

The process of developing urban projects in a commercial format and raising commercial loans is a relatively new trend. Even tough municipal bodies still find it difficult to access funds and FIs remain unreliable financial flow for ULBs, accessing capital markets has become an option for ULBs to finance their projects. Resources have been mobilized through taxable bonds and tax-free bonds. However, only financially strong, large municipalities are in position to directly access capital markets. For smaller ones pooled financing is an option. The Tamil Nadu Urban Development Fund (TNUDF) in an example of pooled financing, whose objective is to fund urban infrastructure projects including water supply, sewerage and solid waste management. TNUDF has brought to the fore a network of lenders and borrowers including various stakeholders. Municipalities, statutory boards, and state level enterprises as well as local entities are eligible borrowers from the Fund. (www.tn.nic.in/tnudp/about_us.htm)

12.3 Private Sector Participation

The need for private sector participation in the environment sector has been recognized by the union government. The private sector is slowly being involved in implementation of projects on BOOT (Build Own Operate and Transfer) and BOO (Build Own and Operate) bases. However, the sector has not yet found great investor interest in the absence of clear directions on various aspects, such as social and political risks, regulatory, cost recovery mechanisms, etc. Various attempts are being made to convert some projects (e.g. urban services like water, waste-water, solid waste) into bankable projects, which is likely to open a new area for investments and a new breed of operating companies to provide these services.[10]

The Government is now promoting Public Private Partnerships (PPP) in infrastructure development including water supply, sewerage and solid waste management through a special facility envisaging support to PPP projects with at least 51% private equity through 'viability gap funding'. Primarily, this facility is meant to reduce the capital cost of the projects by credit enhancement, and to make them viable and attractive for private investments through supplementary grant funding. The Government has also set up a Special Purpose Vehicle (SPV), the India Infrastructure Finance Company Limited (IIFCL) to meet the long term financing requirements of potential investors involved in PPPs. (indiabudget.nic.in)

Viability gap funding can take various forms, including but not limited to a capital grant, subordinated loans, O & M support grants or an interest subsidy. A mix of capital and revenue support may also be considered. The total Government support required by the project must not exceed 20% of the project cost. The projects may be proposed by any public agency at the central, state or urban local body which owns the underlying assets or private agency, with sponsorship from the relevant central or state government agency.[11]

Several development agencies and Indian financial institutions have already joined hands with state governments to promote environmental infrastructure development and facilitate private participation. Examples from the urban infrastructure sector include the Tamil Nadu Urban Development Fund (TNUDF), the Project Development Corporation (PDCOR) in Rajasthan and iDeck in Karnataka. TNUDF has been involved e.g. in drainage scheme, PDCOR in water supply projects and iDeck in sanitary landfill development.[12]

Despite difficulties the future looks good in this sector due to the financial inputs and more active participation of various multinational and bilateral agencies to promote PPPs. However, the Government still needs to improve its investment capabilities and further encourage private sector

players. Most compost plants in the country have come up with private sector participation in different forms of privatization. In solid waste management around 55 ULBs have invited some form of private participation. On the other hand, at present most waste-to-energy projects are heavily dependent on subsidies provided by MNES and financing institutions like HUDCO. Some new plants have involved the private sector in installation, operation and maintenance.[13] This does not include the existing sewage treatment plants, most of which have been established under schemes financed by the Government of India.

The companies involved in PPPs across sectors like water, waste water and solid waste management have been to a large extent domestic. A few foreign companies - Joint Ventures (JVs) between domestic and foreign companies - have been involved in water supply and solid waste handling in municipalities. In Chennai an Asian arm of the French Veolia, Onyx, has joined hands with the municipality to collect, transport and treat garbage. However, successful cases are almost non-existent.

12.4 Key Funding Organizations

Apart from multilateral financers funding is provided by domestic agencies. These include Development Financial Institutions (DFIs) at central, state and municipal level, provident funds, commercial banks and export credit agencies. Agencies provide debt themselves, arrange loans from other sources, provide guarantees and in some cases play an advisory role. DFIs playing a developmental role usually provide the largest share of financing for large scale projects. Apart from debt, some of the DFIs also invest in equity. Until recently DFIs and especially banks were not eager to fund capital intensive infrastructure projects with long gestation periods, but during recent years the situation has been changing.

Of the types of financing, project financing dominates in the sector because of the capital intensive nature with long gestation periods. Corporate financing is resorted to in low-risk projects with prominent corporate groups. Hybrid finance through equity/quasi equity is relied on occasionally. Bond financing is being resorted to mostly by established infrastructure companies or authorities with the backing of Central and State Governments.

The major domestic DFIs operating also in the environment sector across the country are as follows:

- Industrial Finance Corporation of India (IFCI) (www.ifciltd.com)
- Industrial Development Bank of India (IDBI) (www.idbi.com)

- Life Insurance Corporation (LIC) (www.licindia.com)
- Industrial Investment Bank of India (IIBI) (www.iibiltd.com)
- Small Industries Development Bank (SIDBI) (www.sidbi.com)
- Infrastructure Development Finance Company (IDFC) (www.idfc.com)
- Housing and Urban Development Corporation (Hudco) (www.hudco.org)
- India Infrastructure Finance Company Ltd (IIFCL)
- L&T Finance (www.ltfinance.com)
- Infrastructure Leasing & Financial Services Limited (IL&FS) (www.ilfsindia.com)
- Indian Renewable Energy Development Agency Ltd (IREDA) (www.iredaltd.com)
- National Bank for Agriculture & Rural Development (NABARD).

Sector-wise power has been the preferred investment for infrastructure financers, followed by roads and ports. Environmental projects in urban areas receive in many cases only a fraction of the total investment and lending portfolio. IIBI and IDFC have been active in this sector, although of IIBI's cumulative assistance of 660 million Euros disbursed to infrastructure sector up to March 31, 2004, urban infrastructure's share was 286 million Euros. The respective figures for IDFC were 1.3 billion and 186 million Euros and for LIC 3.8 billion and 715 million Euros. Water supply projects have attracted most attention and their number is expected to grow. In the water and waste management sector active domestic players include HUDCO, L&T and IL&FS. HUDCO's loan assistance to environmental projects has been increasing. From its total assistance of 7.3 billion Euros to urban infrastructure sector more than 30% (2.4 billion Euros) was directed to water supply schemes. Sewerage attracted 335 billion and solid waste 53 million Euros.[14]

The involvement of DFIs in projects has traditionally been quite intense and they often take a blend of debt and equity positions. Most DFIs are moving towards becoming universal banks which allows them to access low-cost savings and offers more flexibility in terms of loan types and tenors. The financial institution IDBI merged with IDBI bank in 2004, and the new entity, the Industrial Development Bank of India, was incorporated.[15]

The most recently established financer is the 100% government owned infrastructure financing Special Purpose Vehicle (SPV) IIFCL which was established in late 2005. There were many infrastructure projects which were financially viable but, in the current situation, faced difficulties in raising resources. The SPV will fund projects in both the public and private sectors along with PPP-format. A project awarded to a private sector company for development, financing, construction through PPP shall have overriding priority under the scheme. Private sector companies will not be eligible for

direct lending and only the refinancing option will be available in such cases. The SPV would lend funds, especially debt of longer term maturity, directly to the eligible projects to supplement other loans from banks and financial institutions. The total loan assistance from SPV will not exceed 20% of the total project cost. Apart from raising resources from long-term funds from both domestic and foreign sources, SPV will borrow from multilateral agencies like the World Bank and ADB.

The Indian Renewable Energy Development Agency Ltd (IREDA), already presented briefly in Chapter 10, is a specialized DFI providing soft loans for Renewable Energy and Energy Efficiency projects. Sectors eligible for IREDA funding are hydro energy, wind energy, bio energy, solar energy, developmental activities and new initiatives like infrastructural projects and market development assistance, new and emerging technologies and energy efficiency and conservation. The agency was established by MNES in 1987 since there were no other agencies interested in financing renewable energy projects. At the outset IREDA was funding mostly wind power projects. But due to depreciation allowances and other incentives wind power projects have become viable investments with commercial banks starting to finance them, and IREDA's focus has shifted mostly to financing small hydro-power projects – the sector that is financed by just two commercial banks.[16] IREDA provides financing for projects, equipment and manufacture of equipment. Though loans are available through IREDA, their utilization has been limited.[17]

Commercial banks are also increasing their exposure in environmental infrastructure. Prominent ones include the State Bank of India (SBI) and its associates, ICICI Bank Corporation, Punjab National Bank (PNB), Canara Bank, Union Bank of India, Allahabad Bank and Corporation Bank. Due to the increased involvement of banks the need for DFIs is likely to diminish. The contribution of mutual funds and pension funds in lending has yet to become substantial. When it comes to loans for manufacturing purposes commercial banks are a viable source.[18]

Venture Capital is available with for instance following agencies involved:

- Risk Capital & Technology Finance Corporation
- Technology Development & Information Corporation
- IFCI Venture Capital Fund.

Whereas renewable energy projects, urban infrastructure and environmental projects in urban areas have received finances, rural infrastructure has been largely overlooked even though allocations under the Rural Infrastructure Development Fund have been increasing. Micro-finance institutions are another funding source for rural and other areas with limiter resources. Presently there

are around one million self-help groups covering 17.5 million poor families. The market size of micro-finance is approximately 3.3 billion Euros. Focused micro finance institutions include Basix (with IFC), SEWA Sahakari Bank, Spandana, Myrada, Share Microfin and Cashpor Financial.

Additionally, in the states there are state owned industrial and infrastructure development finance corporations. These facilitate industrial investments, but some of them also formulate, implement, monitor and mobilize finances and finance environmental projects in areas like drainage, solid waste management and water supply. There are also state level municipal finance agencies but their role has been largely marginal except in Tamil Nadu and Karnataka.[19]

12.5 Future Policy Direction

The need to attract private players into the environment sector has been recognized by the Government. It is estimated that projects will become commercially more viable and the number of available funding alternatives for environmental projects is likely to grow. For example commercial banks will increasingly be funding environmental projects and manufacture of equipment. However, the rural areas are not considered very attractive and it is mostly government and multilateral agencies who continue financing projects in the rural areas e.g. water supply and sanitation.

Nowadays there are many different financing alternatives available. There is money coming into the government system at the central, state and municipal levels. However, those institutions through which funds could be channelled into both rural and urban infrastructure sectors, with an assurance that funds will be around for long enough, have to be established. The environment sector needs both commercial financing and support from other sources. A combined effort is required from private players, governments, local communities and domestic and international finance institutions.

Project financing is likely to be the dominant financing method in the future as well, but other methods, such as corporate and hybrid financing, will gain some more importance as well.

12.6 Opportunities for Finnish Companies

Until now Finnish companies have not utilized the resources of Indian finance institutions. However, it is possible for Finnish companies to acquire funding from Indian DFIs. The loans from commercial banks are viable alternatives as well.

Indian SMEs have not been eager to invest in environmental equipment since the benefits are not seen; the costs are considered very high. In these situations carbon credits offer an opening. The advantage of carbon credits has also been taken up in Wärtsilä's new power plant for Nokia's manufacturing unit in Chennai, which is running with bio-oil.

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13 Recommendations on the most promising Business Areas for Finnish Companies

Based on the study Finpro regards the following five sectors to be most promising for Finnish companies and organizations for future co-operation in India

- Environmental Monitoring and Measuring, especially air pollution control including vehicular pollution control
- Clean Technologies
- Solid Waste Management, especially plant technologies on composting, anaerobic digestion, biological-mechanical treatment, and waste-to-energy
- Renewable energy
- Clean Development Mechanisms (CDM).

The following sections give argumentation to the given recommendations and highlight the products, services and technologies of future potential in India.

13.1 Environmental Monitoring and Measuring

Environmental monitoring and measuring has a vital role in India, due to diversified environmental problems. Air pollution attributed to rapid industrialization, energy production and urbanization, and the rapid increase in the number of motorized vehicles needs continuous work. Vehicular air pollution control is the special interest of Indian authorities. Collecting basic data on the current air pollution situation, building distribution models and on-line monitoring of polluting industries - and facilitating later measures for improving the current situation - offers diversified opportunities not only to Finnish technology companies, but also to organizations and institutes with relevant capability in building up larger air pollution management systems, reporting of monitoring,

in capacity building and in diversified training. By being present in building air pollution monitoring and follow-up systems, Finns could maybe later sell consulting and engineering services, technology, products and services for vehicular pollution control to energy power plants and metropolitan cities.

In addition to air pollution control, municipal and industrial wastewater sectors offer limited possibilities for Finnish companies with measuring and monitoring equipment.

Key areas:

- on-line water and wastewater monitoring on pH, TSS, BOD, COD, conductivity; following parameters are studied and analysed case by case O_2, SS, N, P, As, Hg, Pb, Cd, Cr, Cu, Zn, Se, Ni, F, S, phenolic compounds, Mn, Fe
- on-line air pollution monitoring SOx, NOx, RSPM/SPM/PM10, benzene, VOC, multi-gas analysers.

13.2 Clean Technologies

Legislation drives the up-grading of technologies and the introduction of new preventive ways to cope with industrial pollution. Current treatment level is poor; for example advance waste water treatment is applied to only 1% for the discharged industrial waste waters. Highly polluting medium and large scale industries like pulp and paper, steel, cement and the chemical industry, which are facing serious problems in treating wastes and waste waters, can be seen as potential targets for Finnish environmental companies, because there are also many good references in Finland to prove the performance of Finnish solutions and technology.

Key areas:

- Efficient use, re-use and recycling of water in industrial processes along with advanced purification technologies
- Hazardous waste treatment from chemical industries like petrochemicals, pharmaceuticals and fertilizers, waste minimization, utilization & recovery.

13.3 Solid Waste Management

The solid waste sector is just developing in India. Development of SWM is regarded more as a “will” than a “money” topic. However, we have to accept that money is limiting the real development of this sector in India. In

tandem with the more stringent legislation and enforcement, this sector is awakening. The country is lacking varied and good concepts, examples and references for managing mixed MSW, and for developing SWM at city and municipal levels in future. Dumpsites can not be a sustainable solution on a long-term basis.

Indians are interested in co-operation with foreign parties to find new technologies, or develop new, low-cost technologies, applicable to Indian circumstances. There is also a need to learn about the practices, how to cover the costs of SWM, and maintain its operational costs at a reasonable level. This might open up possibilities for Finnish regional SWM companies and other bodies for knowledge sharing in regard to moving from dumpsites in the direction of actual waste treatment.

Key areas:

- Institutional strengthening and training on SWM; especially for regional Finnish SWM companies
- Engineering and consulting services on waste collection and transportation, landfill treatment, waste treatment plants: outdoor composting, anaerobic digestion of waste and sewage sludge, biological-mechanical waste treatment, waste-to-energy
- Waste collection and source-segregation: e.g. deep waste and hazardous waste containers
- Waste transportation and re-loading of waste: collection vehicles with loading equipment, removable containers, hook-lift systems, washing of waste bins, re-loading stations
- Landfill treatment: waste compactors, biogas and leachate collection, bottom and top lining/covering of dumpsites and landfills
- Solid waste treatment:
  - in outdoor composting: turning machines, mixing scoop
  - in anaerobic digestion of MSW and sewage sludge
  - in biological-mechanical treatment
  - in waste-to-energy plants
- Hazardous and biomedical waste treatment.

13.4 Renewable Energy

India is gradually increasing its renewable energy capacity and exploiting the huge potential (80,000 MW) successfully. The Government of India has set convenient financial and fiscal incentives, e.g. 100% tax depreciation in the first year, in order to attract private investments. Although the country is self-sufficient with many renewable energy technologies and many foreign

players are already in country, there is plenty of space also for Finnish companies. Especially the latest technologies regarding wind turbines and biomass power (co-)generation etc. are needed. At least the following areas of renewable energy offer substantial opportunities for Finnish companies:

- Bagasse co-generation (high pressure) from hundreds of sugar mills. Biomass power generation and biomass gasification for thermal and electrical applications
- 1–3 MW size wind power systems, wind machines for low wind regimes and better designed rotor blades, gear boxes, and control systems.

13.5 Climate change and Clean Development Mechanism (CDM)

India is utilizing the unfolding opportunities from climate change mitigation efficiently. The country has become a number one target for CDM projects. The Government has proactive policy towards CDM and the potential to reduce GHGs is enormous, mainly due to vast coal based electricity generation. Key project opportunities can be found from areas such as:

- Renewable energy (biomass, wind)
- Clean coal technologies in thermal power plants
- Energy efficiency, improvement of industrial processes and fuel-switch e.g. in pulp & paper, steel and cement industries
- Solid waste management – especially landfill gas capture in major metropolitan areas like Ahmedabad, Bangalore, Chennai, Calcutta, Delhi, and Mumbai.

ABBREVIATIONS

ADB	Asian Development Bank
ADTA	Advisory Technical Assistance
AO_x	Adsorbable Organic Halogen
AUWSP	Accelerated Urban Water Supply Programme
BOD	Biological Oxygen Demand
BOI	Botanical Survey of India
BOO	Build Own and Operate
BOOT	Build Own Operate Transfer
BOT	Build Operate Transfer
BPO	Business Process Outsourcing
CCF	City Challenge Fund
CDM EB	CDM Executive Board
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CETP	Common Effluent Treatment Plant
CH_4	Methane
CHWTSF	Common Hazardous Waste Treatment and Storage Facility
CII	Confederation of Indian Industry
GNG	Compressed Natural Gas
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organization
DJB	Delhi Jal Board
CO2	Carbon Dioxide
DFI	Development Financial Institution
DNA	Designated National Authority
DOE	Designated Operational Entity
ENVIS	Environmental Information System
ERPA	Emission Reduction Purchase Agreement
ETP	Effluent Treatment Plant
ETS	Environmentally Sound Technologies
EUA	European Union Emissions Trading Scheme allowance
FAO	Food and Agriculture Organization (UN)
FGD	Flue Gas Desulphurization
FI	Financial Institution
FICCI	Federation of Indian Chambers of Commerce and Industry
GDP	Gross Domestic Product

GEF	Global Environment Facility
GHG	Green House Gas
GOI	Government of India
HFC	Hydrofluorocarbon
HFC-23	Trifluoromethane
HUDCO	Housing and Urban Development Corporation
IBRD	International Bank for Reconstruction and Development
ICC	Indian Chamber of Commerce
IDBI	Industrial Development Bank of India
IDFC	Infrastructure Development Finance Company
IFC	International Finance Corporation
IFCI	Industrial Finance Corporation of India
IFIs	International Financing Institutions
IDA	International Development Associations
IGCC	Integrated gasification combined cycle
IDC	Industrial Development Corporation
IIBI	Industrial Investment Bank of India
IIFCL	India Infrastructure Finance Company Limited
IL&FS	Infrastructure Leasing & Financial Services Limited
IMC	Indian Merchants Chamber
IREDA	Indian Renewable Energy Development Agency
IT	Information Technology
ITL	International Transaction Log
JBIC	Japan Bank for International Cooperation
JFM	Joint Forest Management
lpcd	litre per capita per day
LoE	Letter of Endorsement
LULUCF	Land Use, Land Use Change, and Forestry
MAI	Mean Annual Increment
MCGM	Municipal Corporation of Greater Mumbai
MEDA	Maharashtra Energy Development Agency
MDGs	Millenium Development Goals
MNES	Ministry of Non-Conventional Energy Sources
MoEF	Ministry of Environment and Forests
MOWR	Ministry of Water Resources
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
MtCO2e	million tonnes of carbon dioxide equivalent
MW	Megawatt
N	Nitrogen
NABARD	National Bank for Agriculture & Rural Development
NAPM	National Air Quality Monitoring Network

NCA	National Clean Development Mechanism Authority
NEERI	National Environmental Engineering Research Institute
NEP	National Environmental Policy
NFAP	National Forest Action Programme
NGO	Non-Governmental Organization
non-Annex I	Parties to the UNFCCC with no quantitative targets to reduce greenhouse gas emissions
NO_x	Nitrogen Dioxide
NRCP	National River Conservation Plan
NSWAI	National Solid Waste Association of India
NWP	National Water Policy
O & M	Operation and Maintenance
P	Phosphorus
PAHs	Polycyclic Aromatic Hydrocarbons
PCC	Pollution Control Committee
PCF	Project Concept Note
PCP	Polychlorinated Biphenyls
PDD	Project Design Document
PFDF	Pooled Finance Development Fund
PIN	Project Idea Note
PM	Particulate Matter
PPP	Public Private Partnership
PPTA	Project Preparatory Technical Assistance
PV	Photovoltaic
R & D	Research and Development
RETA	Regional Technical Assistance
RSPM	Resprirable Suspended Particulate Matter
SERC	State Electricity Regulatory Commission
SHP	Small Hydro Power
SIDBI	Small Industries Development Bank
SME	Small and Medium Enterprise
SNA	State Nodal Agency
SO_2	Sulphur Dioxide
SoE	National State of Environment India
SPCB	State Pollution Control Board
SPM	Suspended Particulate Matter
SPV	Special Purpose Vehicle
SPV	Solar Photovoltaic
SS	Suspended Solids
SSTA	Small-Scale Technical Assistance
STP	Sewage Treatment Plant
SSI	Small Scale Industries

TA	Technical Assistance
TDS	Total Dissolved Solids
TERI	The Energy and Resources Institute
TNUDF	Tamil Nadu Urban Development Fund
tpd	tons per day
TSS	Total Suspended Solids
TUF	Textile Up-gradation Fund
UIDF	Urban Infrastructure Development Fund
ULB	Urban Local Body
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
URIF	Urban Reform Incentive Fund
UASB	Up-flow Anaerobic Sludge Blanket
VER	Verified Emission Reduction
VOC	Volatile Organic Compound
WB	World Bank
WFP	Water Financing Programme
WHO	World Health Organization
WRAP	Wind Resource Assessment Programme
WTE	Waste-to-Energy

INTERVIEWED ORGANIZATIONS

1. Governmental Authorities and Organizations

Ministry of Environment & Forests
www.envfor.nic.in
- Mr. R. K. Sethi, Director (Climate Change)
- Ms. M. Subba Rao, Additional Director
- Mr. R. K. Vaish, Joint Secretary

Ministry of Non-Conventional Energy Sources (MNES)
http://mnes.nic.in/
- Mr. Rajiv Arora, Director

Central Pollution Control Board (CPCB)
www.cpcb.nic.in
- Mr. B. Sengupta, Member Secretary
- Mr. R. C. Trivedi, Additional Director
- Mr. P.K. Mahendru, Administrative Officer

Department of Environment, Government of Maharashtra
- Ms. Sharwaree Ghokhale, Principal Secretary

Department of Environment, Government of N.C.T of Delhi
- Mr. B. C. Sabata, Senior Scientific Officer

Department of Environment, Government of Delhi
- Mr. Anil Kumar, Senior Scientific Officer

Maharashtra Pollution Control Board
www.mpcb.mah.nic.in
- Mr. D. B. Boralkar, Member Secretary

National Cleaner Production Centre (NCPC)
www.npcindia.org/cleaner.htm
- Mr. S. Kalathiyappan, Deputy Director

National Productivity Council
- Mr. O. P. Joshi, Head (RPMG)

2. Municipal Authorities and Organizations

Municipal Corporation of Brihanmumbai
- Mr. Dilip M. Shotriya, Executive Engineer

Municipal Corporation of Delhi
- Mr. Anil Prakash, Director-in-Chief
- Mr. Devendar Kumar, Superintending Engineer
- Mr. V. S. Seth, Director (CSE)

Municipal Corporation of Greater Mumbai
www.mcgm.gov.in
- Mr. S. G. Bedage, Assistant Engineer
- Mr. T. G. Dange, Chief Engineer (Sewerage Operations)
- Mr. S. I. Golwalkar, Assistant Engineer
- Mr. A.B. Khanolkar, Executive Engineer
- Mr. V. R. Pande, Assistant Engineer
- Mr. S. S. Sheth, Executive Engineer (S) E/S
- Mr. Dilip M. Shrotriya, Executive Engineer
- Dr. J. R. Toravi, Assistant Engineer
- Mr. V. R. Vani, Assistant Engineer

The Thane Municipal Corporation
www.thanemahapalika.com
- Mr. R. T. Kendre, Executive Health Officer

3. Industry and Other Associations

Confederation of Indian Industry (CII)
www.ciionline.org
- Ms. Shruti Bhatia, Deputy Director – Energy
- Mr. Yogendra Chaudhry, Counsellor – Environment
- Mr. Sajal Ghosh, Deputy Director – Energy

Federation of Indian Chambers of Commerce and Industry (FICCI)
www.ficci.com
- Ms. Rita Roy Choudhury, Team Leader – Environment Division

National Solid Waste Association of India (NSWAI)
www.nswai.com
- Mr. Amiya Kumar Sahu, President

4. International Financers

British High Commision, New Delhi
www.ukinindia.com
- Ms. Preeti Malhotra, Environment & Energy Adviser
- Ms. Meghna Misra, Assistant Trade and Investment Adviser

EU Delegation to India
www.delind.cec.eu.int
- Ms. Giulia Buscosi, Adviser
- Mr. Andrew Sors, Counsellor, Science & Technology
- Mr. Dirk Swillens, Deputy Head of Section, Development Co-operation

United Nations Development Programme (UNDP)
www.undp.org.in
- Ms. Preeti Soni, Team Leader, Sustainable Environment & Energy Division

World Bank
www.worldbank.org
- Mr. Rachid Benmessaoud, Operations Adviser, India

5. Domestic Financers

Indian Renewable Energy Development Agency Limited (IREDA)
www.iredaltd.com
- Ms. Debjhani Bhatia, Manager (Technical)
- Mr K S Sridharan, Executive Director

6. Companies

City & Industrial Development Corporation of Maharashtra Ltd. (CIDCO)
www.cidcoindia.com
- Mr. Satish C. Deshpande, Superintending Engineer (Environmental Engineering)
- Mr. A. R. Jambekar, Chief Engineer and General (Tech)

ERM India Private Limited
www.erm.com/india
- Mr. R. Chenemougam, Principal Consultant
- Ms. Raakhee Kulkarni, Consultant

IT Power India
www.itpi.co.in
- Mr. Nishant Bhardwaj, General Manager
- Ms. Teresa Marston, Manager, Publications & Awareness
- Mr. Jean-Philippe Puyravaud, Chief Executive Officer

Maharashtra Industrial Development Corporation
www.midcindia.org
- Mr. R.V. Sonje, Executive Engineer (Environment)

7. Research Institutions

Centre for Science and Environment (CSE)
- Mr. T. V. Jayan, Science Editor
- Mr. Kushal Pal Singh Yadav, Correspondent

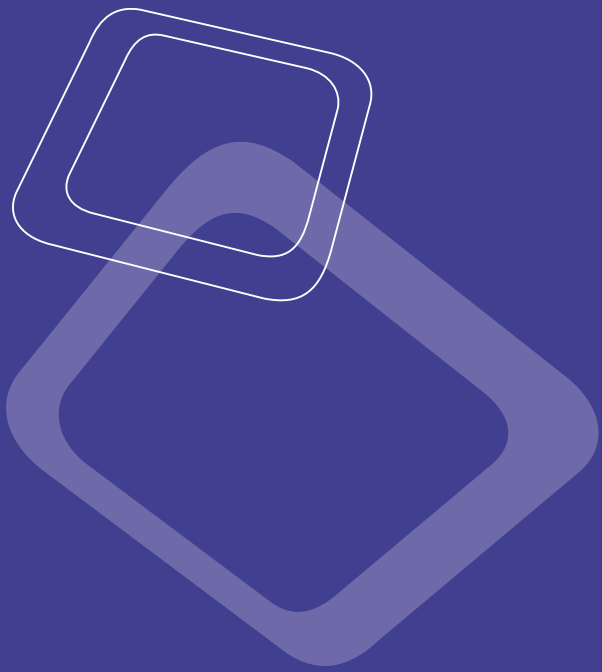
The Energy Research Institute (TERI)
www.teriin.org
- Ms. Malini Balakhrisnan, Fellow
- Ms. Preety Bhandari, Director (Policy Analysis Division)
- Mr. Rakesh Johri, Fellow
- Mr. Sameer Maithel, Director (Energy-Environment Technology Division)
- Mr. N. B. Mazumdar, Consultant
- Mr. Suneel Pandey, Fellow & Area Convenor
- Mr. T.S. Panwar, Senior Fellow

Indian Institute of Technology, Delhi
www.iitd.ac.in
- Mr. Subhash Chandra Kaushik, Professor (Centre for Energy Studies)
- Mr. Ashok Srivastava, Professor & Head (Department of Biochemical Engineering & Biotechnology)

Indian Institute of Technology Mumbai
www.iitb.ac.in
- Mr. S. K. Gupta, Head (Centre for Environmental Science & Engineering)

National Institute of Urban Affairs
www.niua.org
- Ms. Usha P. Raghupathi, Professor

India's economy is expanding rapidly, creating big markets and demands for environmental technology and know-how. Environmental technology is certainly a sector where mutually beneficial Finland-India economic cooperation can take place. A lot of opportunities are opening up in India for Finnish cleantech companies. This study analyses these opportunities and highlights some of the most promising ones.



SITRA

Finnish National Fund for Research and Development

Itämerentori 2, P.O. Box 160, FI-00181 Helsinki, Finland, www.sitra.fi
Telephone +358 9 618 991, fax +358 9 645 072, sitra@sitra.fi

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