HANDBOOK FOR CONDUCTING

Technology Needs Assessment for Climate Change

By the United Nations Development Programme

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Technology Needs Assessment for Climate Change

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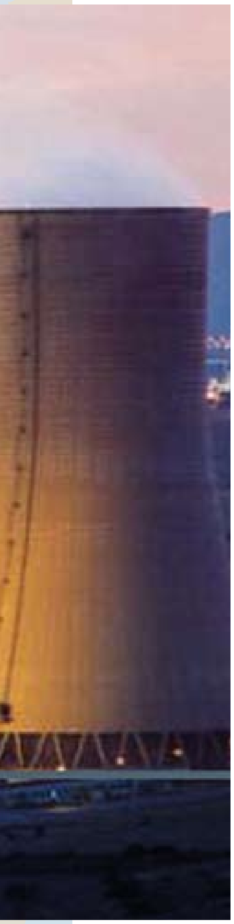
Integrated Gasification Combined Cycle, Spain, Source: Verhelst, C., 2006

Foreword



Climate change is the defining human development challenge of our generation. The way the world deals with climate change today will have a direct bearing on the development prospects of a large section of humanity. We must see the fight against poverty and the fight against the effects of climate change as interrelated efforts. They must reinforce each other and success must be achieved on both fronts jointly.

Technology can be a powerful solution for simultaneously addressing climate change and advancing development. If the process of technology development, diffusion and transfer is designed and implemented effectively, it will generate significant opportunities for both the North and South to address climate change and promote sustainable, innovation-based growth. As such, choices we make on technology selection and investments will have profound and long-term impacts on our societies.

This updated Technology Needs Assessment Handbook is designed to assist countries in making informed decisions in their technology choices. Building on lessons from earlier TNA efforts over the past decade, it offers a systematic approach for conducting technology needs assessments in order to identify, evaluate and prioritize technological means for both mitigation and adaptation. It also provides processes and methodologies for uncovering gaps in enabling frameworks and capacities and for formulating a national action plan to overcome them, as part of overall climate change strategies and plans such as NAMAs and NAPAs.

I hope this handbook will help countries articulate their own priority technology needs and formulate appropriate actions. The handbook is the result of the dedicated efforts of all those involved in its production: the United Nations Development Programme and the Secretariat of the United Nations Framework Convention on Climate Change, under the guidance of the Expert Group on Technology Transfer and in collaboration with numerous practitioners engaged in the development of technology transfer projects in developing countries.

Bruce Wilson
Chair
Expert Group on Technology Transfer

Acknowledgments

This updated technology needs assessment Handbook (TNA Handbook) was jointly prepared by the United Nations Development Programme and the United Nations Framework Convention on Climate Change Secretariat, under the auspices of the Expert Group on Technology Transfer and in cooperation with the Climate Technology Initiative. This updated Handbook was developed as a response to the request from the United Nations Framework Convention on Climate Change Conference of Parties (COP) Decisions as reflected in 3/CP.13 and 2/CP.14.

The Handbook builds on and expands the scope of the first Handbook, entitled "Conducting Technology Needs Assessment for Climate Change" that was published in 2004 and prepared by United Nations Development Programme. The first Handbook was designed to provide practical guidance on how to conduct a technology needs assessment in developing countries.

This updated Handbook is the result of close collaboration with experts from the Joint Implementation Network, the University of Edinburgh-Centre for Environmental Change and Sustainability and the Stockholm Environment Institute (USA-Boston), each of which contributed substantially to the drafting of the Handbook. Members of the Expert Group on Technology Transfer provided valuable comments and guidance throughout the development of this Handbook.

The Handbook also went through a number of iterative processes and received substantive comments and contributions from experts from the Global Environment Facility Secretariat, United Nations Development Programme and the World Bank.

Acknowledgement is also due to experts from the National Renewable Energy Laboratory, University of San Martin – Centro de Ideas, who provided substantive comments throughout the development of this advance copy and also drafted some key sections of the Handbook. In addition, acknowledgement is due to the experts who attended the Workshop "Consultation and Review of Updated TNA Handbook" in Groningen, the Netherlands, in November 2009, and who provided comments on Handbook texts both at the workshop and during a review round in May 2010. Finally, the advise provided by an expert from ETC Energy on the parts in this Handbook covering adaptation is acknowledged.

Special acknowledgement is to due to the Sustainable Energy Programme of Environment and Energy Group of United Nations Development Programme and the Technology team within the United Nations Framework Convention on Climate Change Secretariat. These two teams spear-headed the conceptualization of the updated Handbook and led the production process and coordinated a number of technical drafting meetings to develop this document.

Finally, we would like to thank the United Nations Environment Programme and the United Nations Environment Programme Risoe Centre on Energy, Climate and Sustainable Development for their valuable contributions to this document, including feedback from their on-going work on Technology Needs Assessment. We would also like to thank the Institute for Global Change Research of Tsinghua University for contributing their expertise to the publication of this handbook.

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Glossary

Adaptation
Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007a; glossary).

Adaptive Capacity
The ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007a; glossary).

ClimateTechWiki
An online database with descriptions of technologies for mitigation and adaptation, which have been categorized according to the sector that they belong to, the (energy) service that they provide, their scale of application, and their availability in time. In addition to technology descriptions, ClimateTechWiki contains examples of technology case studies, to which visitors (as registered users) can add further information. The site is targeted at basically all decision makers and policy makers, in developing as well as industrialized countries, who are responsible for or involved in taking decisions on investments in technologies for mitigation and adaptation. It also provides an opportunity to network.

Large scale technologies*
In this Handbook, a large scale technology for mitigation or adaptation is defined as a technology which is applied on a scale larger than household or community level (e.g., connected to a grid).

Long term technologies*
A long term technology for mitigation or adaptation is still in a research and development phase or a prototype.

Medium term technologies*
Technologies which would be pre-commercial in a market context comparable to that of the country concerned in the technology needs assessment (full market availability within 5 years).

Mitigation
An anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks (IPCC, 2007a; glossary).

Multi Criteria Decision Analysis
A technique used to support decision making which enables evaluation of options on criteria, and makes trade-offs explicit. It is used for decisions with multiple stakeholders, multiple and conflicting objectives, and uncertainty.

Non-market-based (“soft”) technologies
Non-market technologies for mitigation and adaptation refer to activities in the field of capacity building, behavioral change, building information networks, training and research to control, reduce or prevent anthropogenic emissions of greenhouse gases in the energy, transportation, forestry, agriculture, industry and waste management sectors, to enhance removals by sinks and to facilitate adaptation (based on Van Berkel and Arkesteijn, 1998; used in IPCC, 2007a).

Short term technologies* Technologies which have proven to be reliable and commercially available in a similar market environment.

Small scale technologies* In this Handbook, a small scale technology for mitigation or adaptation is defined as a technology which is applied at the household and/or community level (e.g., off-grid), which could be scaled up into a program.

(Sub)sector The main sector categories used in this handbook follow the 2006 IPCC Guidelines for National Greenhouse Gas Inventories described in Annex 4. These are sector, division and (sub)sector. The main level of analysis is at the (sub)sector level. (Sub)sector is equivalent to alternatives such as subsector.

Technologies for mitigation and adaptation All technologies that can be applied in the process of minimizing greenhouse gas emissions and adapting to climatic variability and climate change, respectively.

Technology needs and needs assessment A set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties other than developed country Parties, and other developed Parties not included in Annex II, particularly developing country Parties. They involve different stakeholders in a consultative process, and identify the barriers to technology transfer and measures to address these barriers through sectoral analyses. These activities may address soft and hard technologies, such as mitigation and adaptation technologies, identify regulatory options and develop fiscal and financial incentives and capacity building (UNFCCC, 2002, p.24).

Technology transfer The exchange of knowledge, hardware and associated software, money and goods among stakeholders, which leads to the spreading of technology for adaptation or mitigation. The term encompasses both diffusion of technologies and technological cooperation across and within countries (IPCC, 2007b; glossary).

TNAssess An interactive system which guides users of this Handbook through the steps of identifying development priorities, identifying priority (sub)sectors and/or areas, and prioritizing technologies for these (sub)sectors and/or areas. In this process, TNAssess offers support for conducting multi criteria assessments in a stakeholder context.

Vulnerability Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007a; glossary).

* It is noted here that the terms short, medium, and long term are context-specific. A technology that is fully commercial in some markets may not be a commercially viable technology in another country or market. For example, utility-scale wind power is a demonstrated commercial technology, but in smaller, isolated markets (even where there is a good resource) the technology may not be truly "commercial." Therefore, the short, medium, and long term applicability has to be defined specifically for each country (see also Annex 12).

1 Introduction

SUMMARY PAGE FOR THE CHAPTER

This chapter outlines the policy context for this Handbook and introduces principles, goals and key steps for a technology needs assessment for climate change mitigation and adaptation.

Structure

Xinjiang project © UNDP Photo Library

1.1 Overall context: the need for technologies to accelerate a low emission and low vulnerability pathway

Climate change and the accompanying threat of ocean acidification from anthropogenic emissions of greenhouse gases (GHGs) are among the most daunting environmental problems in the world, posing major socioeconomic, technical and environmental challenges.[1] According to the Intergovernmental Panel on Climate Change (IPCC), average global temperatures should not rise by more than 2 °C above pre-industrialized levels as this is widely considered the maximum temperature increase to avoid irreversible damage to global climate and ecosystems.[2] In its *World Energy Outlook 2009* the International Energy Agency (IEA) recommends that in order to reach this goal, energy-related CO_2 emissions need to peak globally by 2020 at 30.9 gigatonnes (Gt) and then decline to 26.4 Gt in 2030.[3]

Urgent efforts to reduce GHG emissions need to take place against the backdrop of a growing international energy demand. In the *World Energy Outlook 2009,* IEA estimates, based on government policies and measures enacted or adopted by mid-2009, that in 2030 world primary energy demand will be 40% higher than in 2007. However, 90% of this increase is expected to take place in non-OECD countries.[4] In addition, 77% of the worldwide energy demand increase will be based on using fossil fuels. At the same time, 1.3 billion people will still lack access to electricity in 2030.

Figure 1-1. Global climate and energy policy challenge and the role of technologies to achieve climate policy goals

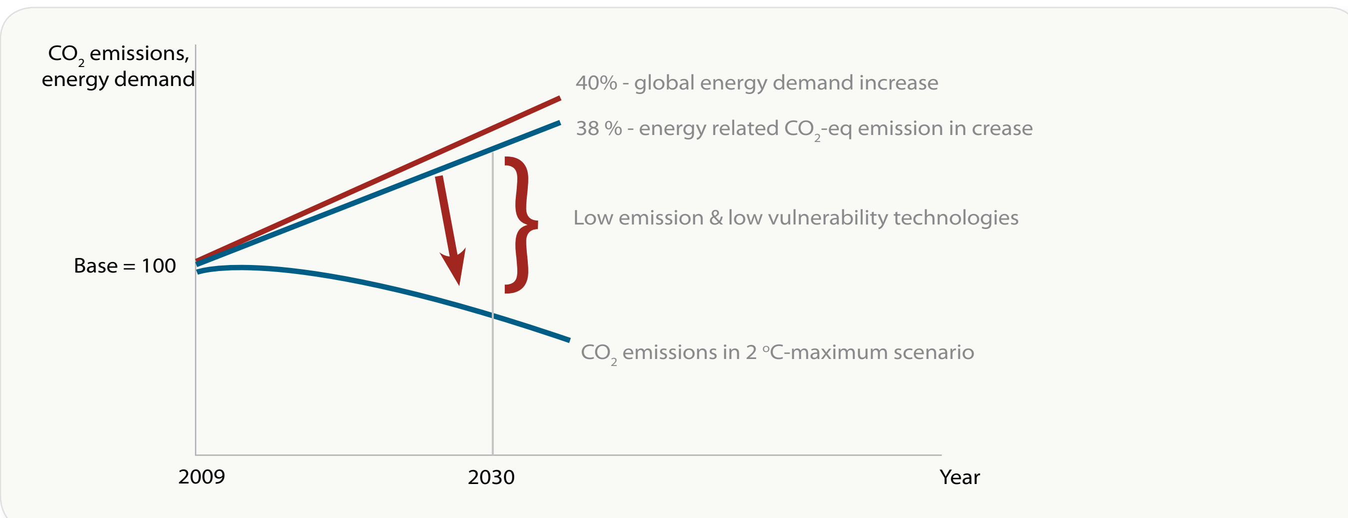


Figure 1-1 illustrates the challenge the world is facing with climate change. If present policies continue without additional measures, world energy demand growth will lead to an increase in energy-related CO_2 emissions (from 29 Gt in 2007 to over 40 Gt in 2030), but in order to reach the 2 °C target, these emissions need to decline (to 26.4 Gt in 2030).[5] Within this context successful and reliable accelerated development and transfer of environmentally sound mitigation technologies are crucial and central.

1. Acidification of the oceans is a simple chemical consequence of increasing GHG concentration levels.
2. IPCC, 2007a.
3. IEA, 2009.
4. ibid.
5. ibid.

The Expert Group on Technology Transfer (EGTT)[6] estimates that the additional financing needs for dealing with the above energy and climate challenge span a range of USD 262–670 billion per year, which is around three to four times greater than the current global investment levels in energy technologies (EGTT, 2009a). Of this amount, USD 100 - 400 billion annually is needed in developing countries.

Mitigating GHG emissions is only one aspect of climate policy. Equally important will be the need to reduce countries' vulnerability to climate change impacts, so that the sustainable livelihoods and ecosystem services on which people depend can be protected. This will require adaptation measures in order to increase countries' resilience in areas like: health and social systems; agriculture; biodiversity and ecosystems; production systems and physical infrastructure, including the energy grid.[7] A number of developing countries have already carried out assessments of adaptation measures needed.[8] These can be used to inform other countries.

Within this overall development and climate policy context, a key step for countries is to select technologies that will enable them to achieve development equity and environmental sustainability, and to follow a low emissions and low vulnerability development path. This Handbook presents a flexible and systematic approach for that. In addition, the Handbook contains steps for identifying activities to accelerate the development and transfer of the priority technologies in the country concerned.

1.2 Policy context: technology as part of climate policy making

This Handbook is the result of a process which started in 2001 with a decision on Development and Transfer of Technologies by COP 7 (Marrakech, November 2001). As part of this decision "*...developing country Parties [were] encouraged to undertake assessments of country-specific technology needs, subject to the provision of resources, as appropriate to country-specific circumstances.*"[9] To assist countries, UNDP, in collaboration with Climate Technology Initiative (CTI), the EGTT and the UNFCCC Secretariat, developed a Handbook for conducting technology needs assessments for climate change.

COP 13 (Bali, December 2007) adopted Decision 3/CP.13 which further encouraged non-Annex I Parties to carry out technology needs assessments and requested the UNFCCC Secretariat, "*…in collaboration with the EGTT, United Nations Development Program (UNDP), United Nations Environment Program (UNEP) and Climate Technology Initiative (CTI), to update the handbook for conducting technology needs assessments before SBSTA 28...*" (UNFCCC, 2007).

6. EGTT was established at COP7 (Marrakech, 2001) and reinstated at COP13 for another period of five years (Decision 3/CP.13) with the objective of enhancing the implementation of UNFCCC Article 4.5, including, i.a., by analysing and identifying ways to facilitate and advance technology transfer activities and making recommendations to the SBSTA (http://unfccc.int/ttclear/jsp/EGTT.jsp).
7. See for example CEC (2009).
8. See for instance the national adaptation programs of action prepared by developing countries at <http://unfccc.int/cooperation_support/least_developed_countries_portal/items/4751.php>
9. UNFCCC, 2001.

This updated Handbook addresses the increasing importance of technology issues on the agenda of negotiations on a future climate policy regime. For example, two of the five pillars in the Bali Plan of Action (Bali, December 2007) focus on enhanced actions on and provision of financial resources to enable technology development and transfer.[10] At COP 14 (Poznań, December 2008) the Poznań Strategic Program on Technology Transfer was adopted as a step towards scaling up the level of investment in technology transfer in order to help developing countries address their needs for environmentally sound technologies.[11] Finally, at COP 15 (Copenhagen, December 2009) the future establishment of a Technology Mechanism was suggested "…*to accelerate technology development and transfer in support of action on adaptation and mitigation that will be guided by a country-driven approach and be based on national circumstances and priorities*."[12]

In addition to facilitating technology needs assessments to produce portfolios of prioritized with priority technologies for mitigation and adaptation, this updated Handbook also establishes links to processes for formulating low emissions and low vulnerability strategies in developing countries (e.g., identification of nationally appropriate mitigation actions (NAMAs)). For instance, the Handbook explores how the development and transfer of prioritized technologies could be accelerated in a country and how this information could provide input in formulating strategies.

With these links, the Handbook addresses recent developments during and after the negotiations at COP 15 in Copenhagen. The EU, for example, has proposed a concept suggesting that developing countries prepare Low Carbon Growth Plans which describe nationally appropriate mitigation actions (NAMAs).[13] Another example is the proposal submitted by Republic of Korea, suggesting that "… *developed country Parties need to provide developing country Parties with a roadmap for low carbon development which includes appropriate policy tools and necessary support to enable them to pursue greenhouse gas emission reduction and economic development at the same time*."[14]

1.3 Key principles and objectives of a technology needs assessment

The objective of a technology needs assessment is to identify, evaluate and prioritize technological means for both mitigation and adaptation, in order to achieve sustainable development ends.[15] This Handbook provides a systematic approach for conducting technology needs assessments.

Besides forming an important input for the formulation of national strategies in developing countries, as explained above, this Handbook can contribute to assessing ways to enhance capacity in developing countries to: acquire environmentally sustainable technologies; increase adaptive capacity and decrease vulnerability to climate change impacts; develop important links among stakeholders within the countries to support future investment and barrier removal (including the formation of networks as explained in Box 1-1); and diffuse high priority technologies and measures throughout key sectors of the national economy. It also assists in acquiring a broader picture of technology needs for a region or group of countries,

10. UNFCCC, 2007.
11. UNFCCC, 2009a.
12. UNFCCC, 2009b.
13. UNFCCC, 2009c, p.83.
14. UNFCCC, 2009d, p.77.
15. This is in accordance with UNFCCC Article 4.5 which calls for identification of environmentally sustainable technologies in the implementation of UNFCCC.

so that international technology support programs or initiatives could be oriented towards a more cross-country or regional approach (e.g., inter-country energy transport and delivery).

When assessing technology needs with a focus on reducing GHG emissions and vulnerability to climate change, it is important that the technologies selected are clearly in line with the countries' development strategies. This addresses the concern that without consideration of development priorities in host countries, transfer of technologies as well as use of limited resources will be unsustainable. *Therefore, this Handbook first assists in describing a country's development needs and priorities before moving to the actual technology assessment.* These priorities will also be formulated in light of long term economic and social trends in the countries, such as increased industrialization and urbanization, as these will have an impact on the eventual technology choices.

Moreover, when generating plans and strategies for the future for mitigation and adaptation and to ensure maximum development benefits, already observed climatic change and possible future changes need to be taken into account. This would help explore, e.g., whether natural resources needed for a technology might be affected by a changing climate and thus make the technology less suitable in the country or whether climate change might require different energy services (e.g., cooling) in the country. A focus exclusively on present climatic circumstances would fail to incorporate such aspects.

Therefore, before prioritizing technologies for mitigation and adaptation the expected range of possible scale and type of climatic change should be considered for the country. From that exercise the expected implications for environmental and social, as well as economic, impacts can be deduced.

In most countries, some information on the impacts of climate change is already available. For example, in their national development strategies and/or National Communications, several countries have described their vulnerability and/or resilience profile with regard to future climate change impacts. During the process outlined in this Handbook, this information could be assessed and discussed. In many cases the final climatic impacts will be highly uncertain and the approach adopted in the technology needs assessment is designed to address these uncertainties by exploring the robustness of the results through sensitivity analysis.

Finally, this Handbook acknowledges that a prioritization of technologies based on national development priorities and in light of a changing climate could result in priority technologies which are not yet available in the short term (as these are still in a research and development (RD&D) stage or in a pre-commercialization stage). Therefore, this Handbook distinguishes between technologies available in the short term (technologies with proven reliability in similar market circumstances), medium term (e.g., available within 5 years to full marketing), and in the long term (technology now in an RD&D phase or existing as a prototype). This distinction is also applied when identifying activities in chapter 6 of this Handbook for acceleration of development and transfer of the prioritized technologies. These activities are specified for the particular phase that a technology is in. This contributes to the formulation of a national strategy with action plan for technology innovation for input to country-level climate change and development plans. This helps to avoid usual stumbling blocks to timely technology commercialization (such as explained by the "Valley of Death" concept as in Annex 12).

Box 1-1

Formation of networks

The process envisaged in this Handbook involves the formation of a network of stakeholders who are involved in energy, climate change planning, and adaptation activities, as well as technology owners and practitioners, entrepreneurs, communities, and sector representatives. It is strongly recommended, that in the networks, stakeholders are involved from both the rural and urban areas in developing countries. Through such integrated networks, the exchange of expert knowledge (among public and private sector stakeholders), indigenous and tacit knowledge and a range of perspectives can lead to the development of a shared vision for moving forward. It is important that people in rural communities are provided with the necessary resources and infrastructure to access and use this Handbook.

The key role of networks for implementing change has been recognized in various studies[16] which indicate that new ways to operate can emerge from exploratory activities combined with deliberative processes. Therefore, such social networks are important for transformation in a system. During the exercise the networks of stakeholders should be encouraged to form as robust a system as possible. Ideally, a "technology transfer" community will be created, capable of addressing the tasks needed for the implementation plan within the country when this initial exercise is complete.

Chapter 2 gives an overview of potential stakeholders involved in the process, which could be a useful indication of the eventual composition of the networks. The formation of networks will be the full responsibility of the countries concerned.

1.4 Key steps for conducting a technology needs assessment

The Handbook contains the following chapters (see Figure 1-2):

- **Chapter 2** concerns the organizational and administrative process required to implement a technology needs assessment. The main output from this chapter is an agreement on the lead coordinating entity, the structure of the national taskforce and their roles, responsibilities and work plan, including the involvement and participation of stakeholder groups.

- **Chapter 3** is related to identifying and deciding on development priorities in view of a changing climate. The main output is a list of clustered development priorities for the country concerned which fully takes into account climate change implications.

- **Chapter 4** is associated with identifying and prioritizing (sub)sectors in terms of their contribution to mitigation and adaptation leading to sustainable development in a climate change challenged world. The main output is a short list of prioritized (sub)sectors for adaptation and mitigation to guide subsequent technology prioritization processes.

- **Chapter 5** concerns identifying and prioritizing relevant low emission technologies to achieve maximum development goals and GHG emission reduction benefits for mitigation and adaptive capacity and reduced

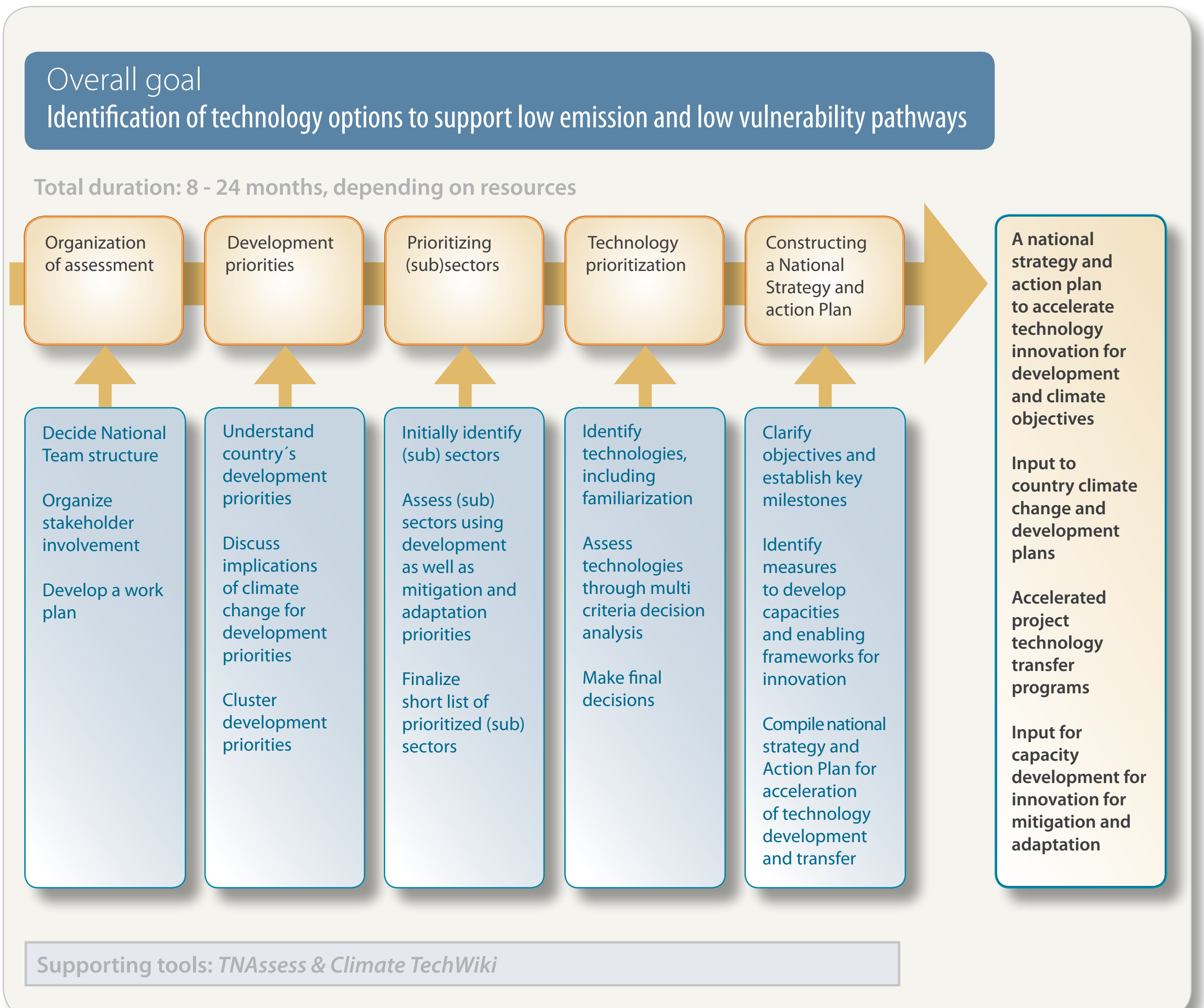
16. e.g., Lundvall et al, 2002, IPCC 2000, ENTTRANS, 2008.

vulnerability for adaptation. The main output is a prioritized portfolio of technologies for a low emission and low vulnerability development for each priority (sub)sector.

- **Chapter 6** focuses on identifying activities that a country can undertake to accelerate the development and transfer of the technologies prioritized in chapter 5. These activities are characterized in terms of, e.g., resources required, timeline, risks, and required monitoring, reporting and verification activities. The activities provide input for the development of an overall technology strategy which either will be specific to the sector/technology or will be common across sectors and technologies at the system or national level. The main outputs are a technology strategy and action plans to improve the whole system in the country concerned, including overcoming barriers in all parts of the system, as well as insight into the capacity needs in the country concerned for adoption of technologies for low emission and low vulnerability pathways.

- The Handbook also suggests a structure for reporting on the overall assessment.

Figure 1-2. Key steps in the process envisioned in this Handbook



Children in Sri Lanka show their delight with wind power

2 Getting organized for a technology needs assessment

SUMMARY PAGE FOR THE CHAPTER

This chapter concerns the organizational and administrative processes required to implement a technology needs assessment.

Step 1 Deciding on a national team to coordinate technology needs assessments

1. Select ministry/coordinating entity responsible for overall process
2. Establish national team consisting of:
   - Coordinator
   - Team members
3. Convene national stakeholder groups to discuss process and organization of technology needs assessment

Step 2 Organizing stakeholder involvement

1. Decide on main stakeholder groups to be involved in the decisions in this Handbook, including government, NGOs and community organizations, private and public sectors, financial bodies, and international institutions
2. Determine stakeholder roles and responsibilities in the process and method of engagement

Step 3 Developing a work plan

1. Produce a work plan for a technology needs assessment process with associated tasks, budgets and milestones
2. Agree and endorse work plan with stakeholders

Step 4 Making support tools available for technology needs assessments

Who is involved?

The decision on the entity responsible for the process will be based on an institutional characterization for the country undertaken by the government. The ministry/coordination entity will then appoint a coordinator who will engage the national team and facilitate stakeholder involvement.

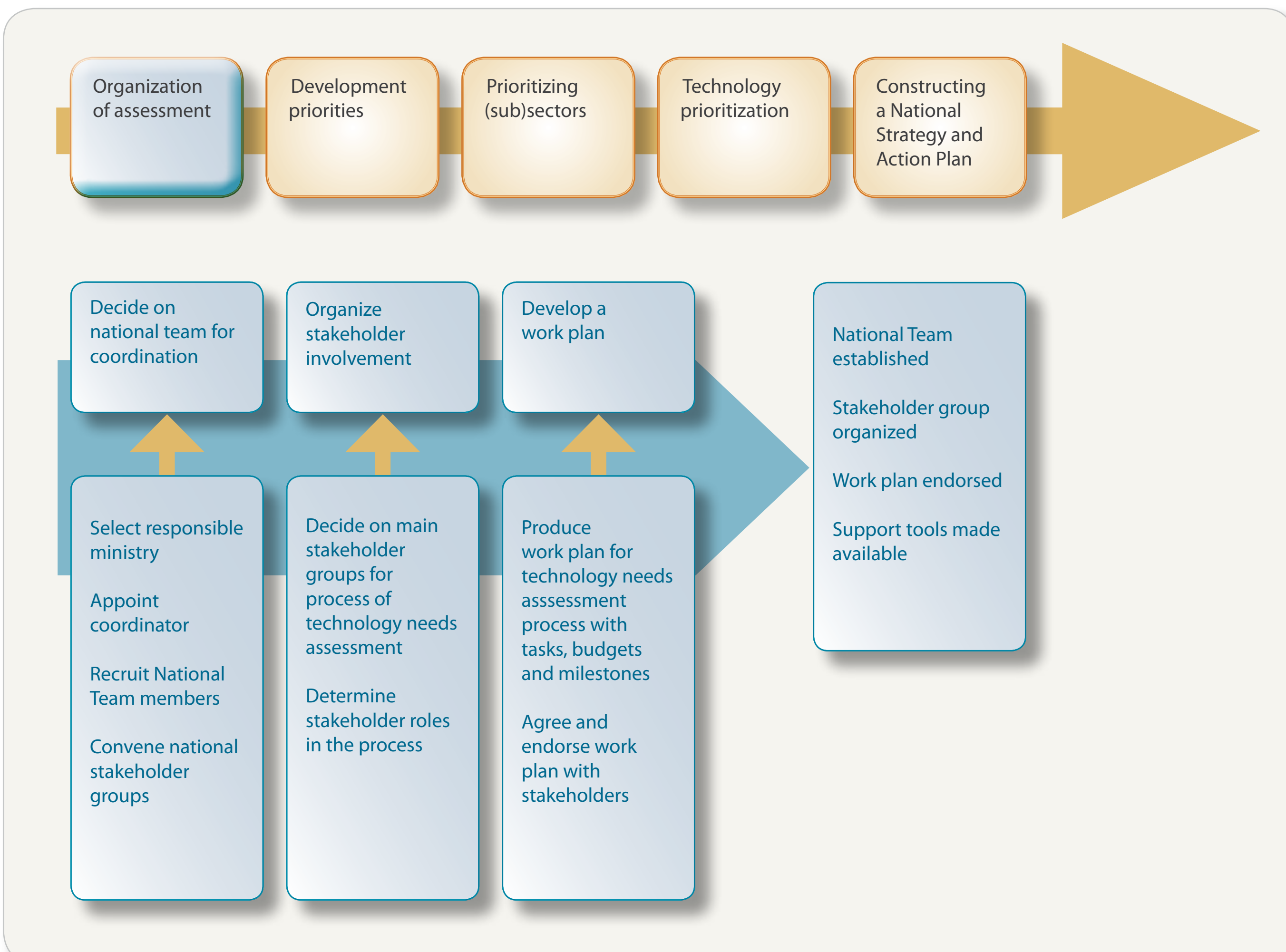
overview

The process of a technology needs assessment is strongly participatory as it requires stakeholder input at each stage. This chapter explains the organization of this process by focusing, first, on the establishment of a national team for coordination of the work, and, second, on the organization of stakeholder involvement. This involves such aspects as the division of tasks between the national team and the stakeholders, as well as a communication strategy between a core group of stakeholders for the assessment and wider stakeholder groups. The latter will be informed about outcomes of the process and can provide feedback to it.

This chapter also provides guidance on how to develop a work plan, which lists the tasks to be carried out, shows a timetable for the work, and defines the expected deliverables. This work plan is country-specific as some tasks in the process may require more time in one country than in another, depending on data availability, resources, or work already done in other studies or projects. Finally, this chapter introduces supporting tools for a technology needs assessment.

The organization of a technology needs assessment, as explained above, is summarized in Figure 2-1.

FIGURE 2-1. OVERVIEW OF THE ORGANIZATION OF A TECHNOLOGY NEEDS ASSESSMENT PROCESS



2.1 Step 1 Deciding on a national team to coordinate the technology needs assessment

2.1.1. Select ministry/ coordination entity responsible for the overall process

The decision of who will hold the responsibility for the technology needs assessment in a country is probably the most important initial decision that needs to be made. A successful assessment depends on strong national ownership. The selection of a lead ministry/coordination entity will be judged based on an institutional characterization undertaken by the government. One possibility is that the process is led by a ministry whose agenda is most closely aligned with the technology needs assessment process or an inter-ministerial committee that includes experts from all relevant ministries and/or agencies (e.g., Ministries of Industry, Local Government, Rural Development, Finance and Economic Planning, Energy, Environment and Natural Resources, etc.). Alternatively, depending on the governance structure of the country, the process could be supervised by the Office of the Prime Minister.

2.1.2. Establish a national team for technology needs assessment

The establishment of a national team for the overall process requires the appointment of:

A coordinator

The responsible ministry or inter-ministerial committee will need to appoint a coordinator who will be the focal point and manager of the overall process. As the leadership of the coordinator is critical for the success of the technology needs assessment in each country, he/she should preferably have skills which may include some facilitation skills, project management experience and scientific or engineering background, so there is some familiarity with technology specifications and performance characteristics.

Team members

The coordinator will lead a small national assessment team which is familiar with national development objectives and sector policies, potential climate change impacts for the country, and adaptation needs. The National Team functions as a task force supervising the assessment process in the country and as a hub through which all activities are coordinated. While the "ownership" of the National Team is national, the team could, in addition to government officials, include non-governmental experts (e.g., local or regional consultants and/or regional centers of excellence). The tasks of the team will be partly administrative, such as workshop organization and facilitation, and partly focused on providing support on content.

It is important that within the National Team there is familiarity with the link between technology transfer and aspects related to mitigation and adaptation objectives. Box 2-1 explains possible composition and skills of the National Team members.

Box 2 -1

Composition of national team and member skills

It is important for the National Team to have a multi-sector and multi-disciplinary scope, with representatives from communities outside the area of development policy making and climate change, as well as from the private sector. While the coordinator should be familiar with the international climate change negotiation process, such knowledge is not a prerequisite for the National Team members. The coordinator can brief team members about relevant developments in the negotiation process.

It is recommended that the composition of the National Team remain flexible as the technology needs assessment process unfolds. However, at some point, additional expertise on a certain technology or sector may be needed. For example, one country's strategic focus may address all geographic areas and a broad range of sectors (e.g., transport, buildings). In such a case, the National Team would need to have a broad familiarity with the distinct technology issues involved. In another country, the focus may be on a key region (e.g., coastlines) to address critical vulnerabilities or on a particular sector (e.g., energy supply). Then, the National Team composition could be adjusted to reflect that focus.

With a view to these tasks, the National Team will require people with a range of skills including:

1. Data acquisition and information synthesis;
2. Experience with participatory processes;
3. Familiarity with current technologies in operation in the country's sectors and the regulatory and policy context for technology transfer;
4. Experience with qualitative assessments (e.g., stakeholder consultations and focus groups), as well as quantitative assessments of technology costs and performance characteristics. Knowledge of Multi Criteria Decision Analysis would be an advantage;
5. Mitigation and adaptation assessment skills (could either be as separate teams for mitigation and adaptation or in one team with specific experts);
6. Local knowledge of specific technologies identified in the technology needs assessment; and
7. Experience of the country's development context.

For some of these skills, the National Team work could, if desired, appoint consultants who could carry out parts of the analysis needed for a technology needs assessment.

The choice of appropriate personnel to recruit for the National Team should take account of the need for both mitigation and adaptation needs. Since adaptation and mitigation represent different entry points to a technology needs assessment, different skill sets and levels of experience will be needed. Data familiarity, stakeholder networks, barriers confronted, and key affected sectors will likely be quite different, and careful attention to team composition will be required.

It is important that candidates for the National Team have experience in working from a cross-cutting perspective within the country's overall development context, and have local expertise as needed on specific technology areas identified in the assessment.

2.1.3. Convene national stakeholder groups

As explained above, a technology needs assessment process is highly participatory and therefore requires inputs from stakeholders within the country. Therefore, next to forming a national team for managing the process, it is recommended that national stakeholder groups be convened as described below. The stakeholder roles and responsibilities in the process are explained in detail in section 2.2.

Convene national stakeholder groups for inputs to the decisions and assessments to be made and to discuss the assessment process and organization

The stakeholder groups should be involved from the start of the process and this is discussed in section 2.2 below.

THE OUTPUT FROM THIS STEP WILL BE A DECISION ON THE "OWNERSHIP"OF THE TECHNOLOGY NEEDS ASSESSMENT PROCESS, APPOINTMENT OF A PROCESS COORDINATOR, THE FORMATION OF A NATIONAL TEAM, AND IDENTIFICATION OF STAKEHOLDER GROUPS.

2.2 Step 2 Organizing stakeholder involvement

Renn et al. (1995) define public participation as: "forums for exchange that are organized for the purpose of facilitating communication between government, citizens, stakeholders and interest groups, and businesses regarding a specific decision or problem." This definition also applies to the process needed to carry out the technology needs assessment.

For a technology needs assessment, it is likely that there will be a core group and subgroups to deal with specific issues in depth, with links to the core group. These groups should represent a network of technology development and transfer in the country, and should be maintained after the initial exercise is completed to take the implementation roadmap through to an implementation phase. A successful engagement of stakeholders can result in a number of important benefits. It can lead to transfer of new knowledge, especially local knowledge, and insights on specific technology challenges and opportunities that might otherwise have been missed. Moreover, it will likely be easier to implement the recommendations from this process, as stakeholders will have already been exposed to proposed actions and provided some level of "buy-in." For example, farmers and their communities would make use of the priority technologies to adapt to climatic patterns. Steps for organizing stakeholder involvement are explained in the next sections.

2.2.1. Decide on main stakeholder groups

At an early stage of the process of assessing technology needs, significant efforts should be made in the recruitment and engagement of an appropriate set of stakeholders. The extent to which all stakeholder types are represented will differ by country, but it is important that as many of these types of stakeholders as is practical are involved from an early stage of the effort. This can be done as follows.

Identify relevant parties for the technology needs assessment process at an early stage, e.g., from the potential stakeholder groups in Box 2-2. Further information sources on stakeholder analysis can be found in Box 2-3.

From a practical point of view, since a large number of people are legitimately classified as stakeholders in some of the categories in Box 2-2, only representative members will probably be able to be involved and form a core stakeholder group. If possible, these representatives should report back to a wider group of stakeholders (e.g., a (sub)sector association) and be informed by them.

Box 2-2

Potential stakeholders to engage in a technology needs assessment

1. Government departments with responsibility for policy formulation and regulation (e.g., power supply) and vulnerable sectors (e.g., agriculture);
2. Private and public sector industries, associations, and distributors that are involved in the provision of GHG-emitting services or are vulnerable to climate change impacts;
3. Electric utilities and regulators;
4. Within the private sector, technology users and/or suppliers who could play a key local role in developing/adapting technologies in the country;
5. Organizations involved in the manufacture, import and sale of technologies for mitigation or adaptation;
6. The finance community, which will likely provide the majority of capital required for technology project development and implementation;
7. Households, communities, small businesses and farmers that are or will be using the technologies and who would experience the effects of climate change;
8. NGOs involved with the promotion of environmental and social objectives;
9. Institutions that provide technical support to both government and industry (e.g., universities, industry RD&D, think tanks, and consultants);
10. Labor unions, consumer groups, and media;
11. Country divisions of international companies responsible for investments important to climate policy (e.g., agriculture and forestry); and
12. International organizations/donors.

2.2.2. Determine stakeholder roles, responsibilities and method of engagement

When structuring the participation process and engaging with stakeholders, the National Team should develop robust networks of stakeholders which can then carry forward an implementation plan after completion of the assessment. This will involve fostering active and competent centers for linkages so that the National Team is not the only linking point and the networks will need to remain connected and empowered after the process finishes.

For an active, inclusive stakeholder dialogue that is sustained over the course of the assessment, the following steps are required (see also Annex 1):

Define goals and objectives of the technology needs assessment for the stakeholders

This involves setting up a transparent process in which the purpose of the technology needs assessment is discussed along with the expectations and privileges of stakeholder involvement. This will lead to a clear sense of the goals and objectives of the overall effort.

Clarify stakeholder roles and responsibilities

The core team of stakeholders could be up to 20-25 people, of which 10-15 would be involved in any particular sector or technology analysis. A wider group of affected and interested parties would also be involved and some might even join the core team temporarily, depending on competencies. It is important to be flexible and identify activities that require direct and detailed input from these two groups, and ensure that relative strengths and expertise are utilized as effectively as possible.

The division of tasks between the National Team, the core stakeholder group, and wider stakeholder groups is explained in each of the steps in chapters 3–6, though this is flexible depending on the circumstances. Wider stakeholder involvement also ensures that the process and outcomes of the technology needs assessment do not remain within a small group of people. In contrast, information from the process is communicated to all stakeholders through workshops, public hearings, and consultation papers, depending on requirements.

Establish ongoing process for stakeholder engagement by addressing the following key points

- **Anticipate competing priorities.** Active engagement of a relatively large number of stakeholders, some with interests and agendas (including those of various government departments) that may be at odds with others, might give rise to conflict and difficulty with decision making.

- **Maintain a focused timeline to maximize stakeholder availability.** It is possible that the relatively long timeframe required for effective technology transfer may work against continued engagement from some stakeholders, notably some private sector participants.

- **Keep control of the process.** It is possible, even likely, that some stakeholders will attempt to drive the engagement process to promote their own set of interests – so-called "capture" of the process by interest groups. To avoid this problem, it is important to ensure decision processes such as technology ranking are transparent, and balanced representation is sought early in the stakeholder selection process.

- **Guard resources** by efficient use of skilled staff time and financial resources to avoid absorbing resources in countries where they are in short supply.

- **Foster development of stakeholder networks.** The formation of networks does not need to be limited to the national borders, as several international networks for environmentally sustainable technology transfer and innovation exist. Through the forum at Climatetechwiki (described in section 2.4), participants in technology needs assessments in different countries can exchange and discuss their experiences and support each other's work.

Box 2-3

Supporting information and techniques for stakeholder engagement

The following resources provide information on stakeholder analysis and other tools for selecting a group appropriate for the problem. For further information on this and stakeholder engagement processes, see Annex 1.

The Overseas Development Institute in the UK provides a range of tools at:
http://www.odi.org.uk/RAPID/Tools/Toolkits/Communication/Stakeholder_analysis.html
It also refers to the following additional resource: http://www.stsc.hill.af.mil/crosstalk/2000/12/smith.html

Finally, some sources on how to do stakeholder analysis based on aid projects and programs are:

- www.euforic.org/gb/stake1.htm
- http://www.scu.edu.au/schools/gcm/ar/arp/stake.html
- http://www.scenarioplus.org.uk/stakeholders/stakeholders_template.doc

THE OUTPUT FROM THIS STEP WILL BE A DECISION ON THE MAIN STAKEHOLDER GROUPS FOR A TECHNOLOGY NEEDS ASSESSMENT AND THEIR ROLES AND RESPONSIBILITIES.

2.3 Step 3 Developing a work plan

2.3.1. Produce a work plan for technology needs assessment with tasks, budgets and milestones

It is recommended that the National Team takes a decision on the envisaged output, identifies what decisions from earlier national projects and sources can be used for the steps in this Handbook, and whether data resources in the country are sufficient for using this Handbook. For example, work already undertaken in the preparation of National Communications to the UNFCCC in terms of GHG emissions per sector and vulnerability of sectors and areas within the country to climatic changes could be useful input for the technology needs assessment process. Once this "diagnostic" step has been completed – chapters 3–6 provide upfront guidance on this – a work plan can be determined. In this work plan (see Annex 2 for an example) the National Team and stakeholders agree on required resources, workshops, meetings, decision conferences, timeline and budget for the process. To this end, the following activities are suggested:

Define tasks

When defining tasks, the National Team could consider that this Handbook can be applied flexibly in terms of envisaged outputs and the overall process. For example, the output from the technology needs assessment can be an important input for a national development strategy in some cases, whereas other countries may only be interested in identification of a portfolio of technologies for mitigation or adaptation ready for implementation.

The National Team may therefore choose to produce an analysis leading to stand alone projects and/or leading to a national technology development and transfer accelerating strategy for input to country climate change and development plans. Alternatively they may aim to produce both main outputs (i.e. projects and strategy) for both mitigation and adaptation.

In addition, some steps in the analysis may not be required, e.g., a country may have up-to-date data on development priorities and/or identified priority sectors.

Annex 2 shows an example of a work plan structure as well as an example of the output from a technology needs assessment.

Budget

Given the tasks defined and the work foreseen in the chapters for these tasks, a budget needs to be established.

Agree on milestones for deliverables

To keep the process on track, it is important to agree on milestones and deliverables for the overall process. However, it should be noted that there may be changes as needs arise, and the process cannot be fully pre-determined.

2.3.2. Agree and endorse work plan with stakeholders

Once the tasks, budget and milestones have been determined by the National Team for technology needs assessments, it is important to discuss these with the stakeholders and agree the plan with them. This would require the following steps:

Convene opening national workshop for the technology needs assessment process with participation of all stakeholders

At the opening national workshop, the technology needs assessment process is formally presented and climate change and technology issues discussed from the country perspective. All relevant interest groups as identified in Box 2-2 are invited to the workshop to stimulate initial discussions and framing of conditions. At the workshop the work plan can be discussed and reviewed with stakeholders with a view to agreeing and endorsing the way forward on the exercise.

Agree on milestones for deliverables

After stakeholder discussion and review of the draft work plan, the National Team prepares a final version of the plan for endorsement by the stakeholder groups.

THE OUTPUT FROM THIS STEP WILL BE A WORK PLAN FOR A TECHNOLOGY NEEDS ASSESSMENT WITH TASKS, BUDGETS AND MILESTONES, ENDORSED BY STAKEHOLDERS.

Figure 2-2. Overall timeline for work plans for technology needs assessment

TNA preparations (Chapter 2)		Identifying development priorities, prioritzing (sub)sectors and prioritizing technologies for mitigation and adaptation (Chapters 3-5)				National Strategy and Action Plan (Chapter 6)		
Month 1-3		4-6	7-9	10-12	13-15	16-18	19-21	22-24
Responsible ministry **National team** **Stakeholders networks**	**Work plan** **Data collection**							
		Chapter 3: **Assessment of long term climate change impacts in the country** **Identification of development priorities** **Chapter 4:** **Identification of high-GHG sectors or high vulnerability sectors** **Assessment of (sub)sectors in terms of sustainable mitigation and adaptation priorities** **Prioritization of (sub)sectors on potential GHG reduction/ reduced vulnerability and sustainable development improvement**						
			Chapter 5: **Technology Identification, familiarization and categorization** **Assessment of technologies through multi criteria analysis** **Making final decisions on priority technologies**					
				Chapter 6: **Identify activities for accelerating prioritized technologies, including priority measures for mitigation and adaptation involving non-market technologies** **Characterize and prioritize these activities and categorize them under common elements** **Prepare a combined national technology implementation and acceleration strategy with action plan** **Develop projects or sector programs for short term prioritized technologies in the country**				
								Reporting

Figure 2-2 shows an overall indicativee timeline for work plans for technology needs assessments with ranges for the different steps in the process depending on the aims and scope of the assessment, the resources available and existing information and capacities. It has been assumed that the longest work plan would take around 24 months, whereas the shortest process could take less than a year. Obviously, these durations are indicative. Moreover, as the diagram shows phases could overlap or begin earlier depending on the progress of the work. For a more detailed version of a work plan and outputs, see Annex 2.

2.4 Step 4 Making support tools available for technology needs assessments

In order to make the process of conducting a technology needs assessment easier and more practical, and to help facilitate informed decision making processes in an intuitively easy-to-follow manner, two main supporting tools have been developed:

- TNAssess, a tool to facilitate and practically guide the sector and technology prioritization processes, using easy-to-follow Multi Criteria Decision Analysis processes, and
- ClimateTechWiki, a web-based digital platform that hosts detailed information on technology options for mitigation and adaptation.

2.4.1. TNAssess

In order to implement an effective technology needs assessment that assesses technologies according to a country's development priorities and climate policy objectives, there is a need for a decision making process with a wide range of stakeholders. In this Handbook, the suggested methodology for the decision making process is to use a Multi Criteria Decision Analysis (MCDA) tool at various steps of the process.

TNAssess has been developed as that tool to allow data entry and processing through an interactive software program to help stakeholders collect and process the information provided and justify the choices made in each of the sector and techology prioritization steps in this Handbook. It will:

- follow each of the steps in the Handbook to produce clear tabular and graphical outputs as specified in the Handbook,
- incorporate a simplified MCDA tool that will assist the facilitator in guiding the stakeholders through the prioritization of the (sub)sectors and technologies with an audit trail, and
- be fully integrated with ClimateTechWiki so that stakeholders can access the data needed to make informed judgments when comparing and assessing technologies.

It is recommended that TNAssess, which is operated as an Excel document, is managed by the National Team and that within the team one person is appointed as operator of the tool (in terms of making sure that the data provided by stakeholders is correctly inserted in each step and output is produced correctly) and facilitator for the decision support process.

It is important to note that TNAssess can be run in both an on-line and off-line mode. Working on-line requires a continuous connection to the Internet, whereas for off-line working TNAssess could be saved to a hard disk or retrieved from a CD-ROM, DVD, or USB storage capacity.

2.4.2. ClimateTechWiki

One of the problems encountered by countries implementing technology needs assessment is the lack of access to information about mitigation and adaptation technologies. There is no single platform where practitioners can find information about different technologies (regarding performance, cost, reliability, development stage, case studies, etc.) so that they can judge whether this would be an appropriate technology for their country, now and in the future.

Therefore, ClimateTechWiki was initiated to bring together information from different places into a coherent online database and platform. The completed ClimateTechwiki will:

- contain information about a broad set of mitigation technologies and technologies for adaptation, including technology feasibility, status, GHG reduction potential, development benefits, costs, etc.
- link to other sources of information, networks and lists of experts, and
- create a "community of practitioners" where people can contribute to the information contained in ClimateTechWiki, have forum discussions and also screen and monitor standards of information.

ClimateTechWiki will act as a support to stakeholders carrying out the technology needs assessment process and will feed directly into TNAssess. However this platform will also be a valuable resource and platform for a wide range of stakeholders in developed and developing countries who are involved in technology transfer and the wider context of low emissions and low vulnerability development pathways.

THE OUTPUT FROM THIS STEP WILL BE THAT THE NATIONAL TEAM AND STAKEHOLDER GROUPS ARE ACQUAINTED WITH THE SUPPORTING TOOL TNASSESS AND CLIMATETECHWIKI

Box 2-4

Checklist

It is recommended that the country's coordinator for the technology needs assessment prepare and complete a checklist to ensure that the issues outlined above regarding organizing the assessment are suitably addressed. The checklist below is an example that could be applied.

1. It has been decided who and/or which ministry will have the responsibility for the National Team and process.
2. The purpose of the technology needs assessment in the country has been determined (why is its implementation wanted, and what are the objectives).
3. The National Team members have been recruited and their roles and responsibilities defined.
4. The stakeholders have been identified and invited and their commitment to engage throughout the process secured, both for the core stakeholder groups and wider groups.
5. It is clear, based on past experiences and literature about the relevant processes, how the country's administration operates.
6. It has been decided whether the technology needs assessment process should be divided into several smaller studies (e.g. focussing on particular technologies/(sub)sectors or issues such as capacity development).
7. It has been decided who in the country performs the analysis, who will use the results, contact external parties, and create effective communication corridors among parties involved.
8. The required information, sources and access, as well as potential data gaps, have been identified.
9. The general form of the process has been specified and adapted based on available capacity.
10. The technology needs assessment process has been planned in detail with clearly defined tasks, schedule, and budgets (e.g., select measuring points), and a set criteria for determining its success ex post (profitability, energy efficiency, and how the cooperation worked) has been defined.
11. A network structure of stakeholder groups and communication strategy has been established.
12. Training and support opportunities have been integrated into the work plan.

Annexes to this chapter:

» Annex 1 Stakeholder engagement resources
» Annex 2 Example of a technology needs assessment using this Handbook

3 Identifying development priorities in light of a changing climate

SUMMARY PAGE FOR THE CHAPTER

This chapter is related to identifying development priorities in light of a changing climate.

Main outputs

The main output is a list of clustered development priorities for the country concerned which fully takes into account climate change implications.

How to decide on development priorities?

In order to achieve the above output the following should be carried out:

Step 1 Understanding the country's development priorities, based on existing national development strategies (e.g., poverty reduction strategies, national climate change plans)

Step 2 Discussing the short and long term implications of climate change for the country's development priorities

Step 3 Clustering development priorities, as a basis for guiding subsequent technology prioritization processes

1. Grouped under economic, environmental and social priorities
2. From both short and medium/long run perspective

Who is involved?

The National Team for coordinating the technology needs assessment, in close cooperation with core stakeholders, can take the lead in generating a list of clustered development priorities that take into account climate change implications.

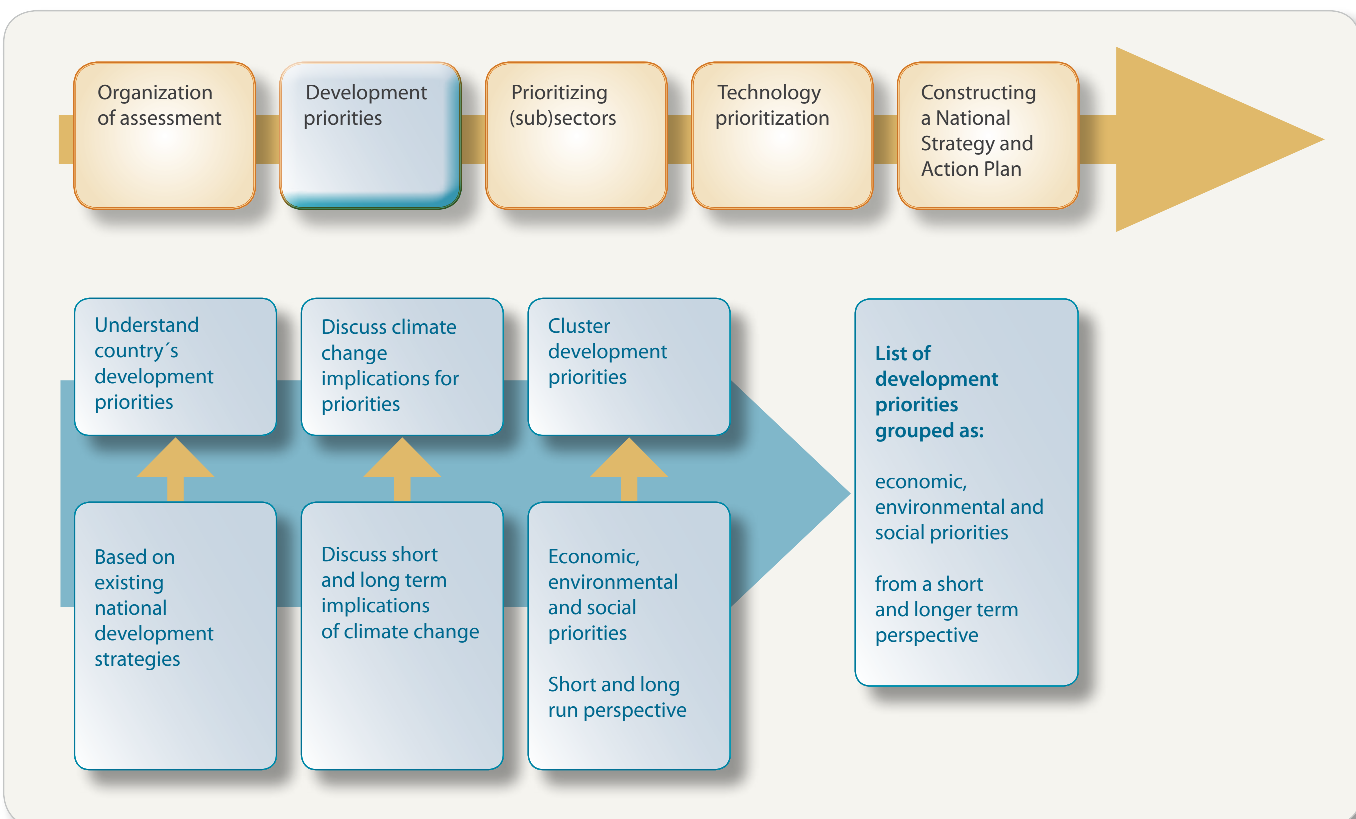
A changing climate may alter a country's development needs over time and this will affect the country's technology needs.

Chapter overview

As explained in chapter 1, the objective of a technology needs assessment is to prioritize technologies for mitigation and adaptation in the light of countries' development objectives and to explore how this could be fed into strategic development plans at a country level, as well as into nationally appropriate mitigation actions (NAMAs) and National Adaptation Program of Action (NAPAs). The process followed in this Handbook is that, first, development priorities are identified for the country concerned (this chapter). Then these priorities can be used as criteria for selecting strategic (sub) sectors for mitigation and adaptation (chapter 4). Next, for these (sub)sectors, technologies are identified and prioritized (chapter 5), followed by an assessment of strategic actions in the country to accelerate the development and transfer of the priority technologies (chapters 6).

This chapter describes the process required for identifying the development priorities of the country and taking decisions on these (see Figure 3-1). Priorities can be based on existing national development strategies, such as poverty reduction strategies, 5-year National Plans and national climate change communications and plans. The National Team and stakeholders are advised to discuss development priorities both from a short ("what is needed now?") and long term perspective ("where do we want to be 30 years from now?").

Figure 3-1. Process diagram for this chapter.



3.1 Step 1 Understanding the country's development priorities

Why? It is important that the eventual technology choices are clearly in line with the long term development priorities in developing countries

How? Identification of development needs already formulated in national development strategies for a country

Who? National Team for coordination of technology needs assessment in cooperation with stakeholders

In this step, an overview of the country's development priorities is prepared. Here, the focus is only on the development priorities of the country concerned. These do not have to include the contribution to global GHG emission reduction as this is explicitly dealt with as a separate criterion in the next chapter on sector prioritization. The process of understanding the country's development priorities includes the following actions:

Identify development priorities already formulated in national documents

The country might already have identified development priorities as part of national development strategies, such as 5-year National Plans, Poverty Reduction Strategies, Sector Policies, National Communications to the UNFCCC.

Based on these official publications, the National Team will generate a list of development priorities which they consider applicable to the country's sustainable development, with a view to both the short and longer term, for the purpose of guiding technology needs assessment.

Discuss priorities with stakeholders

These priorities could be discussed with the stakeholder groups. It is important that the focus is not only on short term needs, but also takes into consideration how development priorities may change in the longer term under the influence of technical, economic, demographic and market developments in light of a changing climate.

Record priorities in TNAssess

The TNAssess tool is available to assist countries in recording this information ready for use in the subsequent sector and technology prioritization processes described in chapters 4 and 5.

The output from this step will be an overview of the country's development priorities.

3.2 Step 2 Discussing the short and long term implications of climate change on the country's development priorities

Why? To ensure that decision making on technology needs takes into account impacts of a changing climate on the country

How? Explore range of possible climate change impacts on different sectors in the economy

Who? National Team for coordination of technology needs assesment in cooperation with stakeholders

A changing climate may alter a country's development needs over time (depending on the type, scale and uncertainties surrounding predictions of the climate change) and this will affect the country's technology needs. Obviously, this will apply to technologies for adaptation. However, since a changing climate will affect resources such as water and alter demand for energy services with implications for the organization of the energy system, it is recommended that climate change information is also taken into account when prioritizing technologies for mitigation in chapter 5. An analysis based on only current climate conditions is liable to fail to prioritize the relevant sectors affected by future changes in climate and the technologies which will be needed.

It must be noted though that an assesssment of climate change impacts is surrounded by large uncertainties. Generally, uncertainties increase with a more disaggregated climate change analysis (e.g., from global to regional and national levels). The proposed work in this section recognizes this uncertainty by recommending that the National Team and stakeholders mainly acquire an idea of the expected uncertainty in key variables for the climatic change. The envisaged output of this section, therefore, is an overview of possible climate change impacts, rather than just one climate change impact scenario. The following actions are recommended.

Analyze range of expected climate change impacts on country

In most countries some information on the impacts of climate change is already available. For example, in their national development strategies, several countries have described their vulnerability and/or resilience profile with regard to future climate change impacts. The National Team can assess this information and discuss it with the stakeholder groups, in order to have some idea of the expected uncertainty in key variables for the scale and type of climatic change in the country context. From that, the expected implications for environmental and social as well as economic impacts can be explored taking account of the uncertainties. This activity therefore does not necessarily imply a need for extensive additional assessments in terms of fully identifying the range of possible future changes.

It is recommended that where a vulnerability assessment has not yet been performed, the National Team carries this out, or commissions an outside expert to perform the task, before progressing to the strategic choices on sectors and technologies in the next chapters. For further guidance on assessing the impacts of climate change on national sustainable development, see Annex 3.

Discuss implications of climate change on the country's development priorities

Examples of possible impacts of a changing climate on a country's development priorities are:

- An expected sea level rise could result in a higher importance given by the country to an improved coastal protection management and/or change of land use in coastal regions, where these measures used to have a lower priority in the country. Such a shift would affect the choice of strategic (sub) sectors in chapter 4 and prioritized technologies in chapter 5.

- An increased demand for cooling services in the future due to climate change would give a higher priority to such technologies as heat pumps. This would also imply that if these technologies are already available, the recommendation would likely follow that the technologies should be implemented in the short run.

The output from this step will be insight in the possible implications of climate change on the country's development priorities.

3.3 Step 3 Clustering of development priorities

Why? To facilitate the prioritization processes for (sub)sectors and technologies (described in chapters 4 and 5)

How? Group the development priorities identified in the categories economic, social and environmental development priorities

Who? National Team for technology needs assessment coordination in cooperation with stakeholders

In order to facilitate the prioritization processes for sectors and technologies (described in the following chapters 4 and 5), the development priorities identified in Step 1 and discussed in light of a changing climate in Step 2 are clustered in categories. Since the objective of this chapter is not to rank development priorities, the order of priorities is random at this stage and does not reflect a weighting or scoring of priorities. It is recommended that the clustering be carried out as follows:

Cluster development priorities in the categories economic, social and environmental priorities

To facilitate the (sub)sectors and technology prioritization processes in the next chapters, the development priorities, where possible, should be grouped under economic, environmental and social priorities from both a short and longer term perspective.

In TNAssess, this clustering is facilitated by enabling users to identify a group to which the priority belongs.

Table 3-1 illustrates how development priorities can be grouped. Descriptions are required to explain what is meant by each of the priorities listed.

TABLE 3-1. EXAMPLE OF CLUSTERING OF DEVELOPMENT PRIORITIES FOR SHORT AND MEDIUM / LONG TERM

Environmental Development Priorities	
Reduced air pollution	Pollution of emissions of particulates, SO_2, etc., in larger cities
Reduced soil degradation	Soil degradation has been a problem with unsustainable harvesting
Reduced water pollution	Inappropriate cleaning techniques have caused water pollution
Economic Development Priorities	
Increased security of energy supply	Energy demand has increased considerably to capacity limits
Improved employment	This holds for both quantity of jobs and human capital transfer
Affordable energy supply	Energy supply must be available for rural and urban areas
Social Development Priorities	
Improved health conditions	Health problems occur in houses where firewood is used
Strengthened empowerment	Improved access for women to labor markets is stongly needed

THE OUTPUT FROM THIS STEP WILL BE AN OVERVIEW OF THE COUNTRY'S DEVELOPMENT PRIORITIES CLUSTERED IN CATEGORIES, WITH DEFINITIONS OF EACH PRIORITY.

Annex to this chapter:

- Annex 3 impacts of climate change on national sustainable development

SUMMARY PAGE FOR THE CHAPTER

4 Priority sectors for climate change mitigation and adaptation

This chapter is associated with identifying and prioritizing (sub)sectors in terms of their contribution to mitigation and adaptation, leading to sustainable development in a climate challenged world.

Main output

The main output is a short list of prioritized (sub)sectors for adaptation and mitigation in guiding subsequent technology prioritization processes.

How to select (sub)sectors?

To achieve the above output the following should be carried out:

Step 1 Initially identifying (sub)sectors

1. For mitigation: (sub)sectors with high GHG relevance based on IPCC sector categorization
2. For adaptation: (sub)sectors that provide the most effective actions for adaptation based on existing vulnerability assessments or National Adaptation Program of Action

Step 2 Describing (sub)sectors in terms of sustainable mitigation and adaptation priorities

1. For mitigation:
   - Review national GHG inventory to identify data gaps, collect information on new technologies, identify key GHG emitting (sub)sectors, and analyze their interrelationships
   - Assess sectoral and development plans to understand future trends
   - List (sub)sectors by their share of GHG emissions until a cumulative share of 75% of the country's overall GHG emission is reached
2. For adaptation:
   - Assess and discuss available information on climate change impacts on the country with stakeholder groups
   - Characterize the (sub)sectors, including existing technologies used and impacts on the country's sustainable development

Step 3 Finalizing a short list of prioritized (sub)sectors according to their maximum mitigation and adaptation benefits

1. Utilize simple performance matrix procedure for prioritizing (sub)sectors
2. Justify the scores given
3. Prioritize (sub)sectors in terms of mitigation and adaptation benefits

Who is involved?

This work will be led by the National Team for coordination of technology needs assessment in close cooperation with stakeholders. Stakeholders' input will be important in vulnerability assessments, national GHG emission assessments and prioritizing relevant (sub)sectors for mitigation and adaptation.

overview

Chapter overview

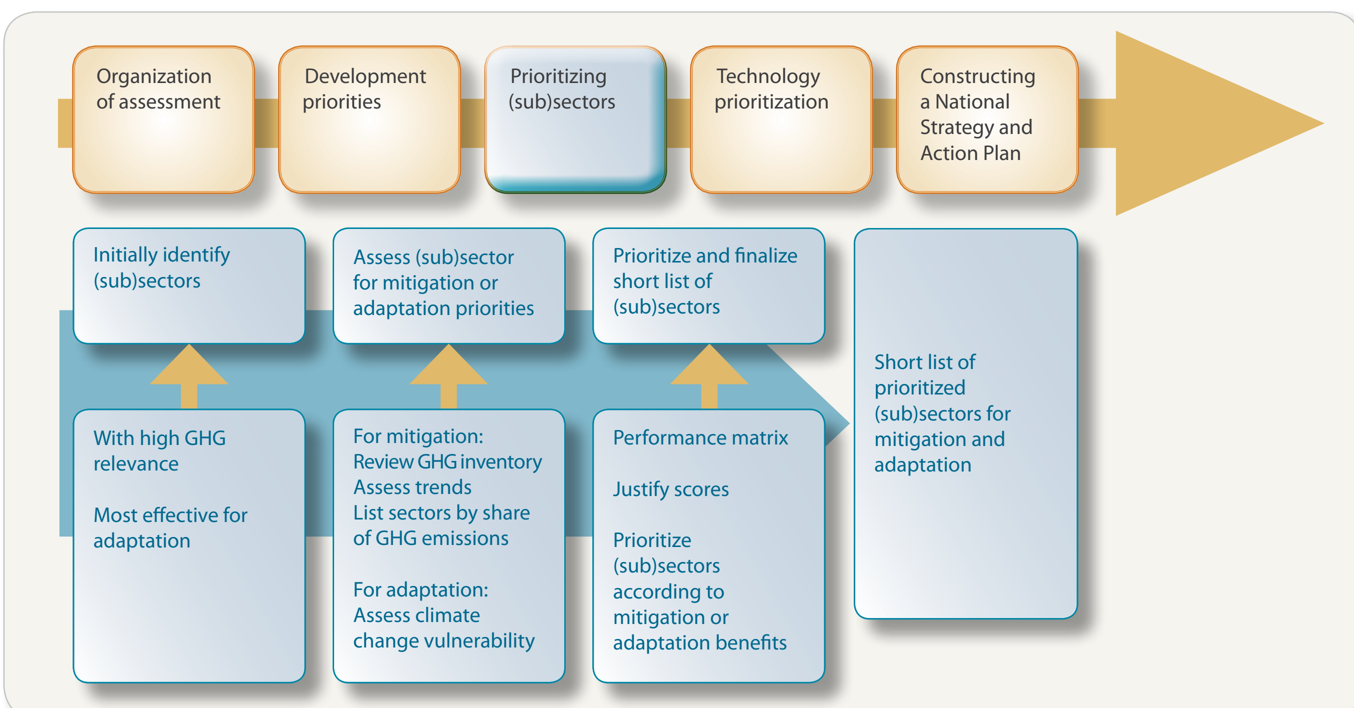
This chapter focuses on selecting sectors and their relevant (sub)sectors which are most strategic for the country in terms of GHG emission reduction or vulnerability reduction and meeting development priorities. The aim of this chapter is also to develop a solid justification for why these (sub) sectors - and not others -have been selected for consideration within the technology needs assessment. For adaptation, within the (sub) sector, the geographical area or other specific subdivision may turn out to be most relevant.

The main output from this chapter is a short list of prioritized (sub)sectors according to their maximum mitigation and adaptation benefits.

The process of prioritization of strategic (sub)sectors takes place in a structured step-wise manner. The National Team and stakeholders are supported through the process by the TNAssess tool which leads the group through the steps and poses the questions for the group to answer. It provides a record of the judgments made and also has access to the climate technology database in ClimateTechWiki. TNAssess can be used both in an online (Internet) and an offline mode (CD-ROM, DVD or memory stick).

The process described in this chapter aims at providing clear win-win opportunities as improvements in the prioritized sectors will contribute to both the country's sustainable development and the mitigation and adaptation of climate change. In chapter 5, these sectors are further analyzed in terms of identification of the relevant technologies for mitigation and adaptation and their prioritization for delivery of maximum benefits.

FIGURE 4-1. PROCESS DIAGRAM FOR THIS CHAPTER.



4.1
Step 1

Initially identifying (sub)sectors for mitigation and adaptation

Why? Identification of (sub)sectors helps focus on those areas in the country with relatively high GHG emissions and high vulnerability

How? 2006 IPCC guidelines categorization of (sub)sectors with high GHG relevance (using National Communications) and identification of (sub)sectors/areas that provide the most effective actions for adaptation based on existing National Communications, vulnerability assessments or NAPAs

Who? National Team for coordination of technology needs assessment

In this step the sector breakdown relevant to the countries is identified and the sectors are screened on the basis of GHG emissions or vulnerability assessment before prioritizing them based on development priorities, as follows:

Identify (sub)**sectors** for mitigation with high GHG relevance based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories identify the following main sectors (IPCC, 2006):

- Energy,
- Industrial process and product use
- Agriculture, forestry and other land use,
- Waste, and
- Other.

These main sector categories are further divided into activities (e.g., "fuel combustion activities" within "Energy", and "product uses as substitutes for ozone depleting substances" within "Industrial processes and product use") and subsectors (e.g., Transport, Energy industries). This sector classification, which is explained in Annex 4, is used within the TNAssess tool and is linked to the ClimateTechWiki database.

As IPCC (2006) focuses on GHG emissions per (sub)sector, TNAssess modifies the (sub)sector list to also allow scope for renewable energy technologies in the next chapter and to be able to combine technologies for reducing energy-related and process-related GHG emissions in industrial sectors (in IPCC, 2006, the latter are separated). It is noted that TNAssess also enables countries to follow their national (sub)sector categorization.

Identify (sub)sectors/areas that provide the most effective actions for adaptation

Possible sectors for adaptation strategies based on analysis of past technology needs assessments include:

- Health and social systems,
- Agriculture and fisheries,
- Coastal zones, and
- Water.

Another possible area:
- Biodiversity and ecosystems.

This is only one possible classification of sectors and in TNAssess other classifications can be used by country groups. As with mitigation sectors, these sectors for adaptation could be divided into subsectors. This is explained in Annex 4.

Additionally, for adaptation the issues of interest tend to impact across these sectors in particular ways. For example, for agriculture projected climate change may mean a water shortage and irrigation problems with implications for the location of agriculture, crop yields and livestock. Annex 4 provides more support and information on sectors for this step.

THE OUTPUT FROM THIS STEP WILL BE AN IDENTIFICATION OF (SUB)SECTORS ACCORDING TO THEIR GHG EMISSIONS OR VULNERABILITY.

4.2
Step 2

Describing (sub)sectors in terms of sustainable mitigation and adaptation priorities

Why? A description of the present situation in (sub)sectors helps to assess how and where improvements can be made through technologies for low emission and low vulnerability development

How? Review of national GHG inventories (for mitigation) and assessment of climate change impacts (for adaptation)

Who? National Team, with stakeholders

To assess possible improvements, first, the present situation in the (sub)sectors listed from section 4.1 needs to be clear. The characterization of these (sub)sectors explained in this section is supported by Annexes 5 and 6.

4.2.1. For mitigation

Review national GHG inventory

This step is meant to compile the GHG emission data per (sub)sector as collected with 2006 IPCC guidelines in, e.g., National Communications (IPCC, 2006).
In case data gaps exist other data sources need to be explored which could provide GHG emission data per (sub)sector for the country.
It is recommended that the interrelationships are analyzed between emitting (sub)sectors, e.g., energy-related and process-related emissions in industrial (sub)sectors.

Characterize present situation in (sub)sectors and assess sectoral and development plans to understand future trends

This step ensures that the analysis considers both the present situation in the (sub)sectors and the medium to long-term developments. Annex 6 provides guidance for characterizing the present situation in (sub)sectors. Long-term trends could include climate change impacts (as discussed in chapter 3), and demographic and economic trends.

The effects of these trends would need to be incorporated in the assessment of how a (sub)sector contributes to the country's GHG emissions now and in the future.

This could lead to an outcome in which a (sub)sector is now seen as a low emitting (sub)sector but could evolve into a high emission (sub)sector and for that reason is taken further into the next step.

These GHG emissions data can be filled in in TNAssess.

List sectors by their GHG emission share

In TNAssess, the (sub)sectors will be ranked automatically according to their contribution to the GHG emissions in the country. It is advised that the (sub)sectors identified in this step and transported to the next step in this chapter should have a cumulative share in the country's GHGs of around 75%. However, this percentage is just an indication, and the National Team may arrive at a different figure based on its professional judgment. Further support on screening sectors for mitigation is given in Annex 5.

4.2.2. For adaptation

Particularly for adaptation it is recommended that the National Team together with stakeholders first reflect on the climate impacts for the country as discussed in chapter 3. If no vulnerability assessment is available (for example, as part of the National Communications), relevant information on ranges of key variables and uncertainties should be gathered before proceeding further. TNAssess will be used for support in this stage. It helps stakeholders provide the outputs in a form that can be used as inputs in the next stage of technology prioritization, and for the audit trail for the process.

The complexity of adaptation measures and the technology transfer process is taken into account in chapter 6, which considers the mapping of the system into which the technology or measure is to operate, including the institutions, organizations, policy regulations and other enabling and supporting systems/activities. It is recognized that not all factors - for example, the world trade regime - can be addressed within this analysis.

For describing (sub)sectors or areas for adaptation the following actions are required (see also Annex 6):

Assess and discuss available information on climate change impacts on the country with stakeholder groups

For this action, the insights from chapter 3 on climate change impacts on the country can be used.

This action ensures that the analysis considers medium to long term developments instead of focusing only on the short term.

Characterize the (sub)sectors/ areas, including existing technology used and impacts on the country's sustainable development

This action results in an assessment of the potential (longer term) climate change impacts on the different (sub)sectors and areas within the country.

It presents an overview of the existing technologies for adaptation in the (sub)sectors and areas so that a clear picture results per (sub)sector, and area (where climate change vulnerability is relatively large and adaptation benefits could be achieved).

The output from this step will be a characterization of (sub)sectors in terms of existing technologies and systems and impact on sustainable development priorities for mitigation and adaptation.

4.3 Step 3 Finalizing a short list of prioritized (sub)sectors according to their maximum potential mitigation and adaptation benefits

Why? Shortlisting of (sub)sectors in terms of strong contribution to GHG emission reduction and reduction of vulnerability, as well as high contribution to sustainable development, shows where the largest contributions to mitigation or adaptation and meeting development priorities can be made in the country

How? Prioritize (sub)sectors using a simple assessment procedure supported by TNAssess

Who? National Team for coordination of technology needs assessments together with stakeholders

The above sections have resulted in lists of main GHG emitting and vulnerable (sub)sectors in the country. In this step, those (sub)sectors are identified where improvements (e.g., in terms of low emission technologies or coping strategies) would make a strong contribution to meeting the development priorities identified in chapter 3 and to reducing GHG emissions or vulnerability to climate change.

This judgment is made as follows:

Score the performance of (sub) sectors in terms of how low emission technology implementation or a coping strategy would lead to improvements in these (sub) sectors. An example of a performance matrix is shown in Table 4-1.

Improvements are defined in terms of contribution to the clusters of criteria defined in chapter 3 (economic, social and environmental development contribution) in comparison to the present situation in (sub)sectors and future trends. Annex 6 explains how such a "baseline situation" can be described.

Stakeholders rate improvements through a Multi Criteria analysis[17] process in TNAssess using the following rating scheme:

0 — no benefit
1 — faintly desirable
2 — fairly desirable
3 — moderately desirable
4 — very desirable
5 — extremely desirable.

Table 4-1. Example of performance matrix for prioritizing (sub)sectors

Subsector	Economic priorities	Social priorities	Environmental priorities	GHG reduction potential	Total benefit
Energy supply	5	5	5	5	20
Transport	4	4	3	2	13
Biological treatment of solid waste	4	2	3	4	13
Enteric fermentation	1	1	1	3	6
Other process use of carbonates	2	1	0	1	4

17. The Multi Criteria Decision Analysis approach within TNAssess recognizes and takes account of the fact that an objective decision is difficult to achieve. Some of the inputs to the analysis will, by their nature, be subjective, but these need to be made explicit and justified to the group, and also be consistent and coherent within the analysis.
What is fair or very desirable is fully left to the judgment of the stakeholders and National Team, as these assessments are country-specific. For example, a 5% GHG emission reduction might be considered a very large contribution in one country, whereas in another country it would mean a small contribution.

As explained above, the outcome as presented in Table 4-1 shows how an activity in a particular (sub)sector could lead to an improvement in that sector. Taking the transport sector as an example, an investment in an extention of the underground public transportation system could be considered by stakeholders to have the following positive impacts:

- **Economic development priorities:** less use of private cars reduces the need for imported fuels and the underground leads to a more efficient circulation with less economic losses.
- **Social development priorities:** improved public transport availability will reduce traffic jams.
- **Environmental development priorities:** reduced emission of pollutants from private cars will reduce local air pollution.

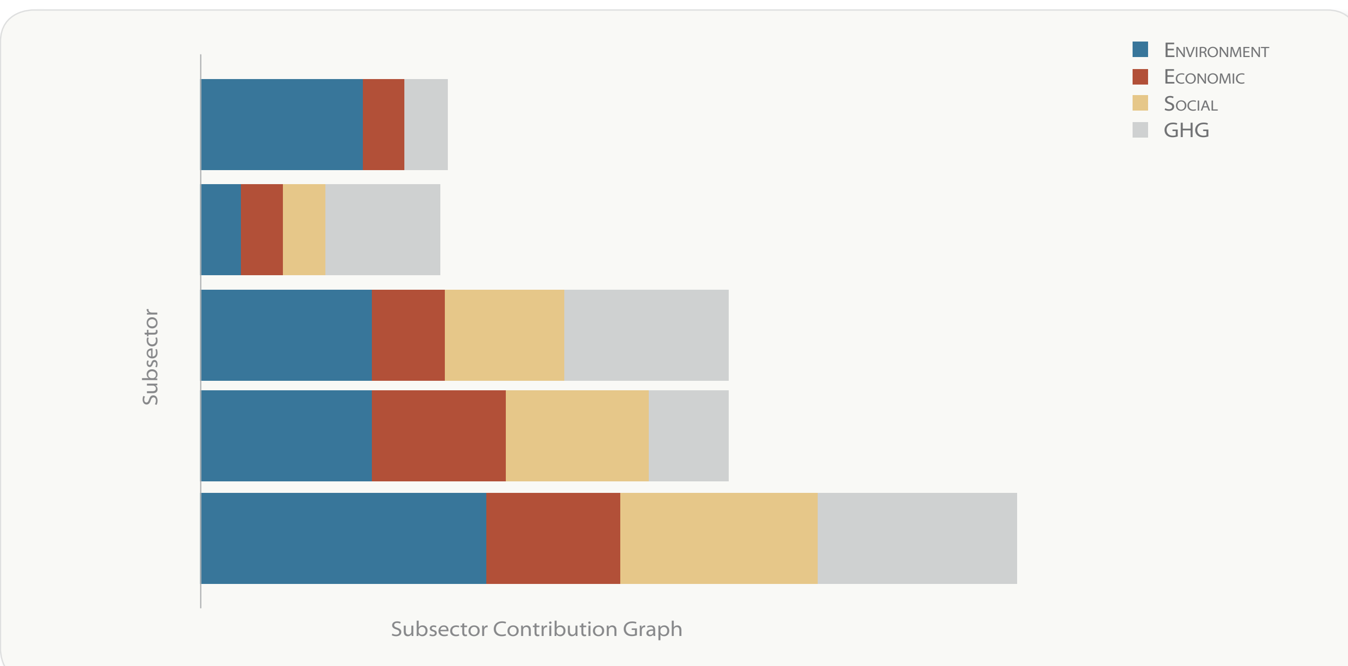
Once the scores have been provided in the performance matrix for (sub)sectors, it is important to:

Justify the scores given for potential improvements and contribution to development priorities in each (sub)sector. The result of this analysis is a criteria contribution bar chart, such as shown in Figure 4-2; this chart will be generated by TNAssess.

The scores given per (sub)sector are a combination of the performance of the (sub)sector on the criterion and how important this performance is considered to be. This needs to be justified and entered into TNAssess, forming the audit trail for the assessments.

Uncertainties or disagreements can be explored using sensitivity analysis on the inputs. The balance in performance across the criteria is also important and this is discussed below. Guidance on the assessment questions to ask the stakeholder group and the process to be followed in assessing the (sub) sectors within each criterion is provided within TNAssess.

Figure 4-2. Criteria Contribution Graph (example for subsectors for mitigation)



From this justification, four main types of (sub)sectors can be expected, as shown below:

Desirability of Intervention in (sub)sector for:		
	GHG emission reduction or Vulnerability reduction	Development priorities
Subsector A	Extremely desirable	Extremely desirable
Subsector B	Extremely desirable	Faintly desirable
Subsector C	Faintly desirable	Extremely desirable
Subsector D	Faintly desirable	Faintly desirable

The final decision in this chapter is to:

Prioritize (sub)sectors in terms of how implementation of a technology for mitigation or technology or measure for adaptation would contribute to improvements in these (sub)sectors

The priority (sub)sectors resulting from this chapter would be those described by (sub)sector A (which have strong contributions to both GHG emission reduction or reduction in vulnerability and meeting development priorities).[18] However, one should be careful not to exclude those (sub)sectors which deliver a high development benefit, even though their GHG mitigation potential or climate vulnerability reduction may be relatively little. (Sub) sectors that perform well on all criteria are particularly preferred, as they are well balanced across the main objectives. However, such a spread might not always be possible, depending on the (sub)sector.

The output from this step will be a short lists of (sub)sectors where a strong combined contribution to the country's sustainable development and GHG emission reduction and adaptation, respectively, can be achieved. For these (sub)sectors, portfolios of priority low emission technologies will be developed in the next chapter.

18. The stakeholder group decides what the thresholds for choice of priority (sub)sectors will be. One possibility is that all (sub)sectors with a score of 4 or higher on potential GHG emission reduction and a total score of 12 or higher on delivery of development benefits will be considered priority areas for which technologies will be identified in the next chapter.

Annexes to this chapter:

- Annex 4 identification of sectors for mitigation and adaptation
- Annex 5 screening of sectors on GHG emissions
- Annex 6 data collection needed for prioritization of sectors for mitigation and adaptation

Mongolian Family Uses Solar Energy to Power Home. Tarialan, Mongolia © UN Photo/Eskinder Debebe

5 Priority technologies for climate change mitigation and adaptation

SUMMARY PAGE FOR THE CHAPTER

This chapter concerns identifying and prioritizing relevant technologies for a low emissions and low vulnerability development to achieve maximum development goals and benefits for mitigation and adaptation.

Main output

The main output from this chapter is a prioritized portfolio of technologies for mitigation and adaptation for each priority (sub)sector.

How to select priority technologies?

For achieving the above outputs the following stages should be carried out through a participatory process:

Step 1 Identifying and categorizing technologies/measures for mitigation and adaptation

1. Identify possible technology options for prioritized (sub)sectors from online databases, networks, and country documents
2. Become familiar with technologies via study tours, expert lectures, and demonstration projects
3. Determine long list of technologies for assessment

Step 2 Assessing technologies through multi criteria analysis

1. Determine assessment framework, including assessment criteria
2. Conduct assessments on technologies based on their:
   - Contribution to development goals
   - Potential for GHG emission reduction or vulnerability reduction
   - Costs and benefits
3. Use TNAssess tool to produce assessment with overall weighted scores for each technology

Step 3 Making final decisions

1. Review assessment results
2. Conduct sensitivity analysis on assessment results, including discussing decisions concerning weighting
3. Decide prioritization of technologies for (sub)sectors

Who is involved?

The work in this chapter is coordinated by the National Team which prepares the steps and organizes the participatory process (e.g., workshops and decision conferencing) leading to portfolios of prioritized technologies. All decisions in the chapter are taken by stakeholders groups in cooperation with the National Team.

Chapter overview

This chapter describes the process required to prioritize technologies for climate change mitigation and adaptation in a technology needs assessment for the prioritized (sub)sectors identified in chapter 4. The result of the chapter will be portfolios of identified low emission technologies and technologies/measures for adaptation.

Within these portfolios, "new" technologies are also considered, i.e., technologies or measures that country stakeholders are not yet familiar with. In order to assist stakeholders becoming knowledgeable about previously unfamiliar technologies, a technology familiarization process is envisaged, consisting of workshops on technologies, expert lectures, and visiting demonstration projects. This process is supported by ClimateTechWiki (see chapter 2).

The technologies/measures identified for the priority (sub)sectors are categorized according to their short or medium to long term availability and whether their implementation takes place on a small or large scale. This categorization allows comparison of technologies and a method for a technology strategy to be formulated over time. Key technologies which are useful across a number of (sub)sectors, but may not be the highest priority in all (sub)sectors, can also be identified. Finally, the (sub)sector technologies in each category are prioritized through a multi criteria decision assessment method.

For mitigation, the process described in this chapter aims at providing clear win-win opportunities as the priority technologies contribute both to the country's sustainable development (e.g., energy efficiency improvement or energy production with low emissions for rural communities) and to the mitigation of climate change.

For adaptation, the complex factors leading to vulnerability to climate change and the uncertainties of climate change impacts at the regional level are well recognized. These issues have to be addressed through a range of measures to improve adaptive capacity. This "bundle" of measures is the main "technology" concept for adaptation, except in specific cases such as for infrastructure (e.g., coastal defenses).

Overall, for both mitigation and adaptation, this process requires close cooperation with stakeholder groups and every step should be participatory. It is important that the decision conferences conducted with the stakeholder group(s) are planned in advance by the coordinator with full commitment from stakeholders and that targets are set for each session.

This chapter provides important input for the analysis described in chapter 6, which is on required activities for successful development and transfer of prioritized technologies in a country. These activities, with their action plans, offer input for the formulation of national development strategies with low emissions and reduced vulnerability to climate change.

The prioritization process

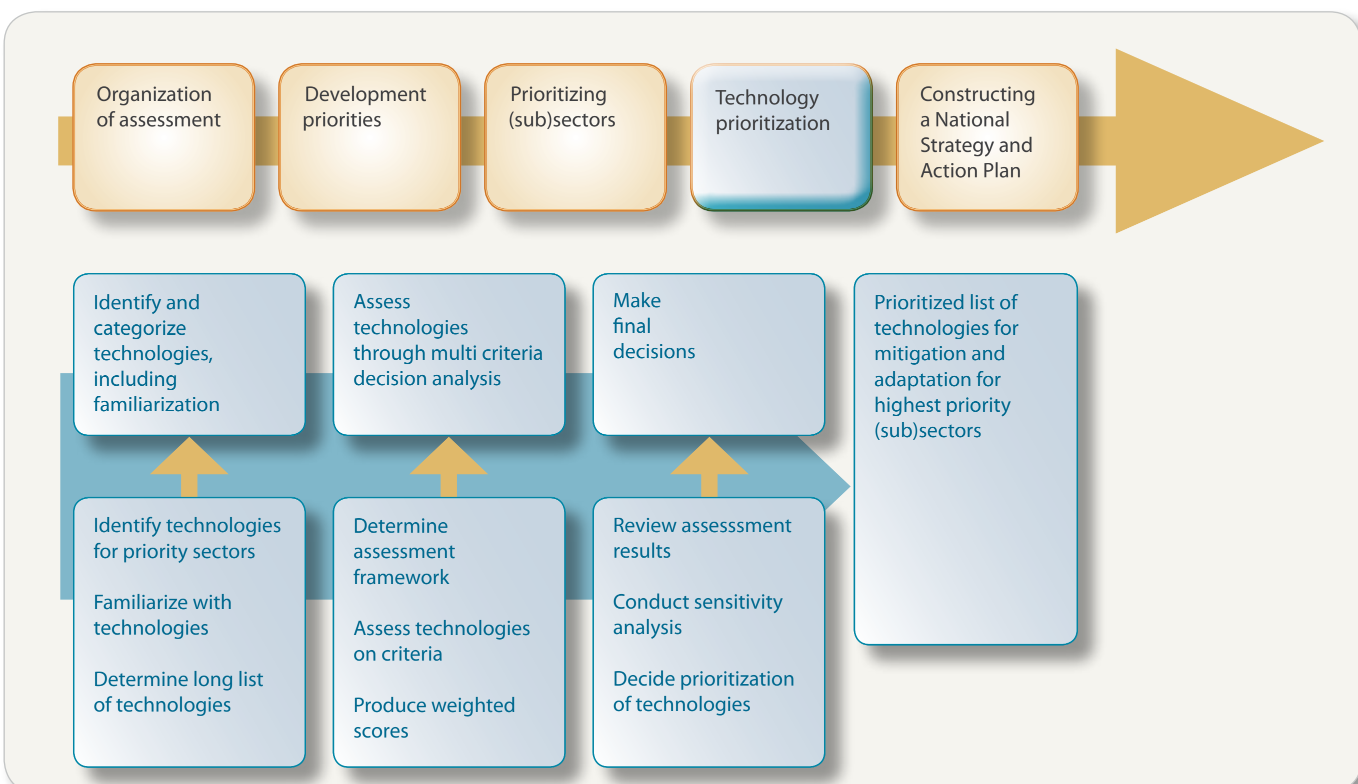
Figure 5-1 presents the overall process of prioritizing technologies. There are three main steps starting with identification of the relevant technologies for mitigation or adaptation for the priority (sub) sectors identified in the previous chapter. This process is supported by TNAssess which guides the stakeholder group through the steps for loading and categorizing the technologies from the ClimateTechWiki database.

Similar to the process in chapter 4, TNAssess can be used offline during the participatory discussions.

The technologies are then characterized in some detail and unfamiliar technologies are investigated through a familiarization process to enable the group to judge their applicability in the country environment. An edited list of technologies within each category for a priority (sub)sector is then assessed using a Multi Criteria Decision Analysis (MCDA) approach again supported through TNAssess. MCDA is grounded in decision theory and allows assessment of the development and mitigation or adaptation benefits within each of the technology categories. It also allows sensitivity analysis of the results to identify robust solutions under uncertainty.

Final decisions can then be taken using cost information and considering the benefit-to-cost ratios of the technology options. The result is a list of prioritized technologies within each category for each priority (sub)sector. The highest priority technologies in each category and any important cross-sectoral technologies can then either be implemented as stand alone projects or rolled out across sectors as part of a national strategy. The latter will be the topic of chapter 6.

Figure 5-1. The process of technology prioritization



5.1 Step 1 Identifying and categorizing technologies and measures for mitigation and adaptation

Why? To acquire an overview of technologies for mitigation and adaptation in the priority (sub)sectors and to enable National Team members, core stakeholder groups and wider stakeholder groups to become familiar with new, unknown technologies

How? Identification: utilize available database, including ClimateTechWiki
Familiarization: technology information, workshops, expert lectures, visits, demonstration projects
Determination of long list of technologies in categories of small/large scale applicability and short/medium/long term availability

Who? National Team: technology identification, familiarization, categorization
Facilitator and possibly chairperson to lead discussions and facilitate use of TNAssess
Core stakeholder groups: technology familiarization
Wider stakeholder groups: information exchange and feedback with core stakeholders

5.1.1. Identification and categorization of technologies

Identification of technologies for mitigation and adaptation takes can take place through TNAssess or country experience. The starting point for the technology prioritization within TNAssess is the list of prioritized (sub)sectors determined in chapter 4, for which a list of technologies or measures can be generated from the technology database in ClimateTechWiki. This can be done on- or offline (see below). If, in chapter 4, the country elected not to use TNAssess for the prioritization process (as the priority (sub)sectors were already known), then these (sub)sectors need to be inserted into TNAssess before proceeding further. To aid optimal comparison and assessment of technologies in this chapter, technologies are categorized in terms of their availability in time and scale of application (based on a case-by-case judgment), as follows:

Small scale technologies available in the short term,

Small scale technologies available in the medium to long term,

Large scale technologies available in the short term, and

Large scale technologies available in the medium to long term

. Small scale technologies are those that are applied at the household and/or community level, which could be scaled up into a program.

. Technologies applied on a scale larger than household or community level are considered large scale technologies.

. Short term technologies have been applied commercially with proven reliability in a comparable market context.

. Medium term would be pre-commercial in that given market context (5 years to full marketing) and a long term technology would still be in an RD&D phase or a prototype.[19]

19. It is noted here that determining whether a technology is available in the short, medium, and long term is context-specific. For example, utility scale wind power is a demonstrated commercial technology, but in smaller, isolated markets (even where there is a good resource) the technology may not be truly "commercial". Therefore, the short, medium, and long term applicability has to be defined specifically for each country.

The identification process includes the following actions:

Load available database, e.g., i) ClimateTechWiki database, (ii) other online databases, networks and country documents

Within TNAssess the (sub)sectors are displayed in their prioritized order and the technologies are grouped in the four categories. Relevant technologies for mitigation or technologies or measures for adaptation are loaded into TNAssess through a link with ClimateTechWiki. This can be done both online and offline. In case of offline application of TNAssess at a stakeholder meeting, the ClimateTechWiki technology lists will be available in an offline mode (e.g., with latest update made shortly before the meeting). Annex 7 contains a list of possible technologies for mitigation and adaptation.

Collate information on possible technologies and insert into technology option page in TNAssess

Within TNAssess each technology will have a technology option page specific to a technology (sub)sector and category. This page accesses the information in ClimateTechWiki and includes specific information on the technology (e.g., lifetime, costs, assumptions on its adoption and statements on impacts of adoption on costs and mitigation/ adaptation).[20] The technology option pages may not be fully populated until completion of the next section on technology familiarization.

Discuss the collated information with stakeholders in a participatory deliberative setting and utilize their input to add ideas and/or refine the information

This part of the exercise can be fairly brief but requires stakeholder input at all stages. The collated information can be augmented with local knowledge of local solutions and strategies. Technologies (e.g., drought-resistant seed varieties for agriculture sector facing more frequent drought episodes), changes in established practices, and indirect use of technologies can be included (e.g., computerized data management systems).

Edit technology list: TNAssess provides opportunities to edit the list at this point

Editing can be done by:

- Adding technologies, e.g., technologies known to country experts with relevant information.
- Bundling technologies: if a group of measures forming a coherent strategy seems more appropriate than individual measures, or where technologies would be implemented together, these should be given an overall title, defined and justified. For these technologies the question is whether these would be carried out individually.

20. These technologies may be "non-market" (know-how) or "hard" (physical assets) and should be relevant to the country conditions now and under the range of potential future climate change impacts.

Display technologies in separate tables per (sub)sector for each category of availability in time and applicability in scale

For each (sub)sector, the categories of technologies are displayed in four separate tables. A particular category from the (sub)sector can be taken forward for the prioritization process after the familiarization phase (see next section). However, technologies cannot be compared across categories.

5.1.2. Technology familiarization

The technology identification stage is supported by a familiarization phase during which stakeholders will be able to acquire information about technologies which are potentially useful but unfamiliar to them. Experience in similar assessments shows that unfamiliar technologies will not be considered, so that many new and existing technologies/measures are not commonly used. As a result, decision makers and other stakeholders are not necessarily able to judge their merit for application in a given country context without further information and familiarization. As Winskel et al. (2006) pointed out, "Organizations operate in embedded socio-technical networks and tend to re-invest in established competences: disruptive technologies (e.g., renewable energy) rarely make sense to incumbents, so their development tends to be left to small outsider organizations." The process of familiarization involves the following actions:

Familiarize with new technologies using the following process and information sources

- Technology champion: For each unfamiliar technology the stakeholder group appoints a "technology champion" to seek out further information for the group and to arrange familiarization activities such as those outlined below (see also Figure 5-2).
- Demonstration projects: Visits to demonstration projects and/or data from actual demonstration projects are helpful. Performance and costs change with economies of scale and technology performance varies under differing conditions.
- Expert lectures: These can be arranged through the links in the ClimateTechwiki and development agencies. In case of offline application of TNAssess, the links will be available on CD-ROM, DVD or memory stick.
- Literature review: For most market and non-market technologies, reports, analyses and articles provide estimates of the required data. ClimateTechWiki offers suggestions for further reading for each technology description.
- Workshops with speakers on technologies can be arranged.

Establish a clear picture of technology options for mitigation and adaptation to meet the identified needs by synthesizing as much as possible from multiple sources[21]

Further information and sources can be used, such as :

. Information on capital and operation and maintenance costs, efficiency (when applicable), technical measurements, capacity factors, lifetime, and degree of technical sophistication required for manufacturing, installation and operation. Also information on reliability, while difficult to predict, should be pursued to assess whether the technologyis sufficiently dependable.

. Other governments: Many governments face similar lack of information regarding new technologies and some may have taken steps to redress their lack of knowledge. Sharing such information can be effective.

. Multilateral institutions: Multilaterals work in multiple countries and can act as a conduit to objective, up-to-date information.

. Manufacturers: Technology manufacturers are often best placed to accurately predict technology performance/cost. Still, since there is an inherent conflict of interest, they should not be the sole source of information.

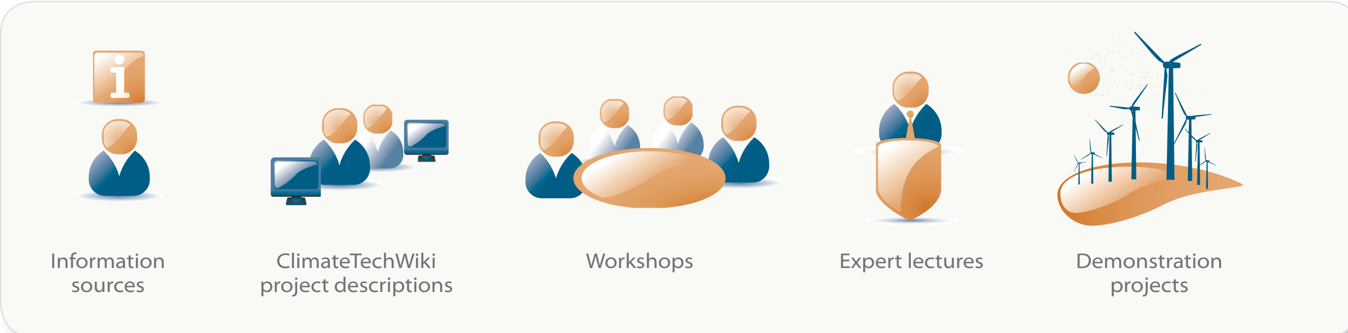
Add information to technology option pages in TNAssess

The technology option pages have mandatory data concerning impacts on development priorities and other key information for the prioritization phase of the analysis in this chapter. Stakeholders explore the role the technologies could play in their (sub)sectors in terms of which technologies in the (sub) sector description in sections 4.1.2 and 4.2.2 would be replaced by the prioritized technologies and at what scale within a period of, e.g., 25 years. Spreadsheets are available for the calculations required for the estimated costs and benefits expected at the (sub)sector level. This provides a basis for the assessments and also an audit trail for the process. The "technology champions" for each unfamiliar technology and the National Team can take responsibility for the information on each page (see also section 5.3.4).

21. Given their forward-looking nature and vested interests of different information sources, new low emission technologies present a considerable challenge in terms of obtaining objective information. Where stakeholders have negative perceptions of certain technologies, because of past experience or incomplete/outdated information, these technologies should still be considered.

22. Confidence to invest is often grounded in seeing the technologies or measures in action, preferably in the country context. In this respect, development of regional centers for adaptation and mitigation expertise and technology demonstrations would be very useful.

Figure 5-2. The process of technology familiarization[22]



To illustrate further, if in a country's (sub)sector of energy supply 30% of electricity is produced annually with hydro technology, 30% with natural gas, and 40% with coal-based technologies, of which 15% are old pulverized coal combustion plants, then the stakeholders could indicate that a technology considered for electricity production should mainly contribute to replacing the 15% old coal plants. Alternatively, the stakeholders can refer back to official government documents indicating medium to long term milestones for the (sub)sector.

5.1.3. Determine long list of technologies for assessment

At this stage the group can review the list of technologies and determine which technologies will be taken further through the prioritization process. This can be accomplished through discussions as shown below:

Review and reject technologies and provide a rationale for the decisions

Most countries already have explored the type and extent of resources available to them (e.g., insolation levels for concentrating solar power, and water for crop management) through past country studies. Where a technology is relatively new, or a resource assessment has not been carried out, this should be performed before proceeding further.

A decision to reject a technology must be fully justified. At this stage, this should not be done on the basis of cost; cost will be a criterion for prioritizing technologies in the next section.

Compile final categorized lists for each prioritized (sub)sector in the format of Tables 5-1 and 5-2

These lists are generated in TNAssess and edited through discussion by adding, bundling or rejecting technologies. The latter may happen if stakeholders consider the technology or measure unsuitable within their country context. The final categorized lists will form the key input into the next phase of assessing technologies through multi criteria analysis.

Ensure all mandatory data in technology option pages are available

Within TNAssess, the technology option pages will have been initially populated from the information sources such as ClimateTechWiki and the other sources suggested above. All mandatory data must be filled in before the next phase of prioritization as this is the basis for the assessments.

Table 5-1. Example of long list of technologies for mitigation, identified and categorized for a prioritized (sub)sector

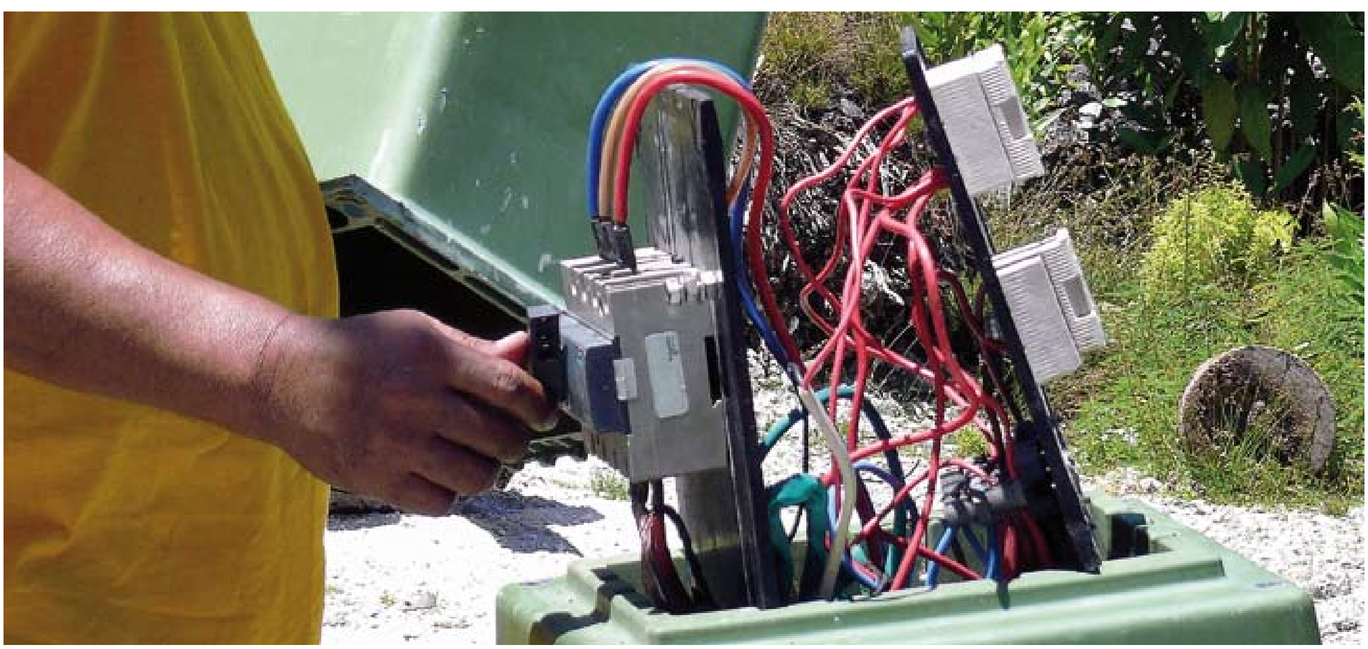
Priority (sub)sector		Technology identification		
Sector	**(Sub)sector**	**Technology**	**Scale of application**	**Short-, medium/ long term availability**
INDUSTRY	CEMENT	SMALL SCALE /SHORT TERM		
		Improved process control	Small scale	Short term
		Optimizing heat recovery in clinker coolers	Small scale	Short term
		Lowering fossil fuel consumption	Small scale	Short term
		LARGE SCALE/ SHORT TERM		
		Co-production of power and cement	Large scale	Short term
		Wet-to-dry clinker production	Large scale	Short term
		High efficiency classifiers/ separators	Large scale	Short term
		LARGE SCALE/ MEDIUM TO LONG TERM		
		Advanced kiln concepts	Large scale	Medium to long term
		Advanced milling technologies	Large scale	Medium to long term
		SMALL SCALE/ MEDIUM TO LONG TERM		

Experience shows that unfamiliar technologies will not be considered, so that many new and existing technologies/measures are not commonly used. Familiarization therefore is an important step in technology prioritization

Table 5-2. Example of long list of technologies for adaptation, identified and categorized for a prioritized (sub)sector

Priority (sub)sector		Technology identification		
Sector	**(Sub)sector**	**Technology**	**Scale of application**	**Short-, medium/ long term availability**
AGRICULTURE	FOOD PRODUCTION	SMALL SCALE /SHORT TERM		
		Water saving measures	Small scale	Short term
		Irrigation strategies	Small scale	Short term
		Animal feed changes	Small scale	Short term
		LARGE SCALE/ SHORT TERM		
		Improved drought resistance of crop strains	Large scale	Short term
		Improved animal husbandry practices	Large scale	Short term
		Irrigation and water collection	Large scale	Short term
		LARGE SCALE/ MEDIUM TO LONG TERM		
		Advanced seed varieties	Large scale	Long term
		Land use practices	Large scale	Long term
		Changes in consumer behavior concerning food	Large scale	Long term
		SMALL SCALE/ MEDIUM TO LONG TERM		
		Changes in location or animal type	Small scale	Long Term

The output from this section are lists of categorized technologies for mitigation and adaptation for the priority (sub)sectors identified in chapter 4. These technologies will form input to the next phase of technology prioritization (see following section).



UNDP, France and New Zealand..Samoa © UN/Ariane Rummery

5.2 Step 2 Assessing technologies with Multi Criteria Decision Analysis (MCDA) to facilitate robust decisions

Why? To find the best technologies for maximizing sustainable development, GHG emission reduction and/or adaptation benefits

How? Multi Criteria Decision Analysis (MCDA)
Discussion and exploration of prioritizing options

Who? National Team for coordination of technology needs assessment: formulation of criteria for technology prioritization, facilitation of MCDA
Facilitator and possibly chairperson to guide stakeholders through MCDA process
Core stakeholder groups: elicit criteria for MCDA, score and weight technologies against criteria, explore decisions from MCDA, and agree on a way forward
Wider stakeholder groups: explore decisions from MCDA, and agree on a way forward

5.2.1. Determination of assessment framework

In this step, technologies are compared within the categories assembled in Step 1, based on criteria to be elicited from groups using the MCDA participatory approach (see Box 5-1 and Annex 8 for further details). These criteria can vary with the category of technologies being assessed and the group can incorporate additional criteria. The decision to be taken by stakeholders is: **What are the best technologies for maximizing benefits in terms of sustainable development priorities and GHG emission reduction potential and/or adaptation to climate change consequences, while minimizing costs?**

The MCDA provides decision makers and other stakeholders with a framework around which they can structure their thinking. Above all, it allows focused communication on a problem so that different perspectives and experiences can be applied to its solution. Additionally, uncertainties arising from lack of data, differing perspectives or uncertainties in future changes can be explored in the MCDA assessment phase to develop robust solutions. This process includes the following actions:

For each category within a prioritized (sub)sector, choose the technologies or measures with their technology option pages in TNAssess to be prioritized first

→ The final lists of technologies for each of the (sub)sector categories in TNAssess have to be prioritized separately. No cross-category comparisons are valid.

TNAssess manual prioritization or TNAssess MCDA priorization

→ Where the number of suitable technologies is small (i.e., less than four), then these can be manually prioritized within TNAssess with justifications for the assessments made.

For more technologies (up to a maximum of 10 per category), TNAssess leads the users through the process of assessment. For categories with more than 10 technologies, a pre-screening is recommended (see Annex 9).

Multi Criteria Decision Analysis (MCDA)

MCDA is used for prioritizing (sub)sectors and technologies and measures for mitigation and adaptation because it is the most appropriate approach for evaluation of problems involving multiple stakeholders and trade-offs between multiple and conflicting objectives, where assessments can be difficult to quantify and there is uncertainty. The technique is therefore appropriate to determine to what extent a (sub)sector or technology maximizes sustainable development, GHG emission reduction and/or adaptation benefits. MCDA has been applied to many problems. It is a mature technique grounded in Decision Analysis theory.

An MCDA exercise is usually performed with a group of stakeholders helped by a decision facilitator. The process is interactive using a computer-based decision model to aid the process and feed back to participants the effects of changes as they explore decisions. It therefore provides a framework for structured thinking, allows a shared understanding to develop, allows negotiation within the group and develops a common purpose, so that the group can agree on a way forward.

MCDA uses criteria, scores and weightings, which are necessarily subjective concepts, requiring human judgment for their determination. It therefore acknowledges the fact that there is no such thing as an objective decision and subjective judgments are explicitly elicited, encoded and tested for coherence against uncertainties.

These judgments are documented and made explicit and open, and can be subject to public scrutiny. In a cost-benefit analysis (CBA), judgments are not made explicit, though many are involved. For example, in CBA the selection of system boundaries, discount rates, lifetimes and other assumptions are less obvious, less public and more technical. In MCDA, the route from a performance measure to a score and further to a weighted score and a final result is clear and an audit trail is generated for all judgments made. The route in a CBA from a performance measure (e.g., GHG abatement of a project) to a monetary unit can be opaque (e.g., assigning a monetary value to human life or biodiversity protection) and may attribute arbitrary value, or even ignore altogether criteria that are difficult to quantify.

The TNAssess tool simplifies some of the steps in an MCDA for the stakeholders and fully supports them through the process. In general, the process can be described as follows:

1. Establish the decision context.
2. Identify the options to be appraised (i.e., sectors or technologies).
3. Identify objectives and criteria.
4. "Scoring": assess the expected performance of each option against the criteria.
5. "Weighting": assign weights for each of the criteria to reflect their relative importance to the decision.
6. Combine the weights and scores in a linear additive manner for each option to derive an overall expected value (TNAssess performs this automatically).
7. Examine the results.
8. Do sensitivity analysis on uncertainties in scores and weights, perspectives and "what if" scenarios.
9. Iterate the above steps until the group is satisfied that a robust decision has been reached.

More details are provided in Annex 8 and the full MCDA process is described in DETR (2000).

Box 5 -1

5.2.2. Choose criteria for assessment of technologies

As explained above, the assessment of technologies is based on their contribution to sustainable development goals and to mitigation or adaptation in the light of climate change impact scenarios for the country. The criteria on which the assessments are to be based need to be decided, which involves the following actions and which may need a communication strategy with a wider group of stakeholders:

Discuss as a group the appropriate criteria for prioritization of technologies or measures for mitigation or adaptation

The main objectives against which a measure or technology can be judged would be expected to include the following:

- Maximize the resilience of the (sub)sector to climate change impacts and of other (sub)sectors liable to be impacted indirectly.
- Minimize any GHG emissions.
- Maximize development priority benefits in terms of environmental, social and economic benefits and minimize adverse impacts due to the measure.

Decide on and define the criteria for the assessment

The following sets of criteria can be defined, reflecting the objectives outlined above:

- Contribution to the country's development priorities, clustered in chapter 3 as:
    - Environmental development priorities,
    - Social development priorities,
    - Economic development priorities.
- GHG emission reduction potential of the technology (for mitigation).
- The technology's potential contribution to reduction of vulnerability to climate change (for adaptation).
- Performance of technology in terms of cost over the lifetime of a technology investment. This implies that both the upfront capital costs and the operational and maintenance costs are considered in the assessment (see Box 5-2 for more details).
- In addition, stakeholders could consider looking at the profitability or pay-back potential of a technology investment (e.g., internal rate of return and net present value). Box 5-2 and Annex 10 provide guidance for such calculations.

The group must also decide whether additional criteria are appropriate (e.g., market potential) and, if so, what these are and fully define them within TNAssess. TNAssess provides this option for as many as five new criteria.

5.2.3. Conduct assessments on technologies: scoring and weighting

Technology assessments take place by, first, scoring technology options within a category of technologies (e.g., small scale/ short term) in terms of their performance on the criteria selected and defined in section 5.2.2, followed by assessing weights for these criteria. This process of scoring and weighting, followed by making final decisions (section 5.3) should be fully carried out for one category of technologies or measures in, for example, the highest prioritized (sub)sector in TNAssess. The process of scoring and weighting is then repeated in each of the other categories in that (sub)sector, and subsequently in other (sub)sectors (see Annex 8). Stakeholder involvement in all stages is essential. Below, the steps in this process are explained, starting with the scoring of technologies or measures against criteria.

Scoring: conduct assessments of the expected performance of the technologies or measures with the stakeholder group based on their contribution to the criteria within TNAssess

The performance of the technology or measure on the criteria should be assessed considering the information already collated in the technology option page, country knowledge and any expert input.

Users are asked within TNAssess to score the technologies on a scale of 0-100 (0 means that the option is least preferred, not that it has a zero performance).[23] The best and worst performing options are identified first and assigned scores of 100 and 0, respectively. Then, other options are scored relative to these.

A rationale must be given for each score. This provides an opportunity to specify details about how the technology was scored relative to other options, and also forms part of the audit trail for the decision.

Additionally, the environmental, social and economic improvements do not need a monetary valuation under MCDA. However, if a valuation is available, it can be taken into account.

Input scores to TNAssess

There may be disagreement on scores for the criteria, but following discussions, the variations in scorings should be noted and explored through sensitivity analysis at the end of the input phase.

Assumptions and uncertainties should also be noted. For example, current cost of technologies for mitigation and adaptation, fuel, feedstock, spare parts, as well as financial criteria (e.g., interest rates) are liable to change over time as deployment of a technology increases. This uncertainty can be explored under MCDA through analysis of the sensitivity of the decision to changes as explained in later sections.

23. In chapter 4, for scoring (sub)sectors a simplified scoring scheme was used with a qualitative scale common to all criteria, which was appropriate for informing (sub)sector prioritization and selection. In this chapter, however, a more complete scoring and weighting MCDA process is used for technology prioritization, including a scoring scale of 0 to 100. This provides the required rigor and detail for these more complex assessments.

Once all the options have been scored within the technology category the criteria are weighted. This is needed as scores applied to one criterion are independent of the others. For example, a score of 100 against the environmental criterion is not the same as a score of 100 against the social criterion. Weights are used to convert the scales to a common measure of value.

This weight reflects the importance of the criterion in the decision. It takes into consideration the difference between the top and bottom of the scales and how much the group cares about it (so-called swing weighting). The group is led through this process within TNAssess as follows:

Weighting: conduct assessment of weights with stakeholder group

The weighting question focuses on valuing the improvement gained against the different criteria when going from the least preferred to most preferred option. For example, if improvement against social development delivers more value than the improvements against other criteria, then this criterion is given a weight of 100. The other value swings are weighted relative to this 100, e.g., the value gained from the improvement in a criterion weighted at 50 delivers half the value gained from the improvement in the social criterion.

Differences in weighting by the group members should be noted and used in sensitivity analysis.

Input weights to TNAssess

Input relative weights into the TNAssess model and justify the weights assigned. This forms part of the audit trail for the decision.

5.2.4. Results

TNAssess combines the scores and weights assigned to the technology options to provide an overall result, comparing technologies within the category. The final process involves the following:

Finalize inputs and generate final results in TNAssess

At this stage, only the benefit contributions are displayed. Preferred options are those which are well balanced on the key criteria and which perform well. These options tend to be robust. Sensitivity analysis on uncertainties in the results is essential and will be performed in the next step.

The output from this section will be an assessment with overall weighted scoring for each prioritized technology. An audit trail justifying the judgments made will also be available. This is a transparent record of the justifications made for the scores given and the weights assigned as well as the variations in perspective and the result. It will also include the sensitivity analyses conducted. To this the insights gained in the next step will be added.

Applying cost criteria in prioritization of technologies for mitigation and adaptation

Box 5 -2

Cost assessment

From the outset, it must be made clear that the cost information to be assessed in this Handbook will be mainly used as part of the analysis of whether a technology would be appropriate for the country concerned. It may prove to be a relevant criterion when resources are limited.

Cost-effectiveness is defined in terms of its use when a target must be reached at the lowest cost, or when there is a budget with which as many activities as possible must be carried out. Cost-effectiveness may help identify relevant technologies according to how well they reach an environmental objective against a certain cost level. Both capital cost and operation and maintenance costs should be considered. In terms of the technology needs assessment, the aim is not to look for the cheapest options, but to identify the most appropriate technologies within a country in terms of benefit-to-cost ratio.

For example, for a technology for *mitigation,* a high cost figure (e.g., in terms of USD per tonne of GHG emission reduction) would show that it might not be appropriate to invest in the technology, especially if the technology does not score well on other criteria. When a technology is expensive (USD/GHG) but makes a substantial contribution to sustainable development then there could be a stronger argument to consider it. Therefore, when calculating technology costs, it should be done for the purpose of exploring the appropriateness of the technology.

Cost-effectiveness may also apply to the evaluation of technologies for *adaptation*, e.g., adapting infrastructure design from a preventative perspective (e.g., dam size) or adapting to flooding from insufficient dam capacity, e.g., through disaster relief, health care, etc. The measure could also be expressed in terms of risks (e.g., how to avoid a number of people being affected at the lowest cost). However, quantifying and valuing in monetary terms all the vulnerability benefits from the adaptation action across all the (sub)sectors is problematic.

In the MCDA all the benefits are already valued and included in the analysis, including any quantitative values available. Costs or cost-effectiveness information are complementary and can be added in as shown in section 5.3. The difference is that the values in the MCDA are preference values.

Capital costs and IRR

Capital costs can be expressed in terms of net present value, using a discount rate over the lifetime of the project to express the value of money now and in the future (i.e., valuation of the expenses and revenues from an investment over a period of time, discounted to the present-day value). However, when allocating resources, the actual upfront investment capital required may be the key challenge and it is then this figure which should be included in the analysis.

Another financial criterion which could be added to the MCDA analysis is Internal Rate of Return (IRR). IRR shows the profit from an investment (expressed as a percentage) for a given period of time, e.g.,10 years. It is derived from calculating the interest rate for which the net present value of an investment project for the given period of time is equal to zero (see also Annex 10)

In combination with an overall cost figure (e.g., in terms of USD/GHG emission reduction), IRR could provide a more complete financial assessment for a technology or measure. For instance, a project with a high USD/GHG cost figure could still have a high IRR (e.g., small scale combined heat and power projects), whereas a project with a low USD/GHG figure could also have a low IRR (e.g., landfill gas capture). The IRR can be an indicator of a technology's rollout potential, as, e.g., a high IRR shows that application of the technology is profitable.

In Annex 10, a spreadsheet example is shown for the cement sector, which calculates IRRs for different technologies. Through sensitivity analysis, account can be taken of the impact of the lifetime of the project or measure on an IRR.

However, it must be pointed out that for many adaptation measures "classical" IRR calculation may be difficult to make and avoided costs may be a more appropriate measure. IRR is relevant only when there is more than one option.

Marginal abatement cost (MAC) curves and project-level assessment

As an example of a Marginal Abatement Cost (MAC) curve, consider the case of energy supply technologies. A cost-effectiveness analysis will essentially develop a GHG abatement cost curve which will rank each technology in the order of its cost-effectiveness for reducing a tonne of CO_2-equivalent emissions. This ranking is typically represented in the form of a curve, as shown in Figure 5-3.

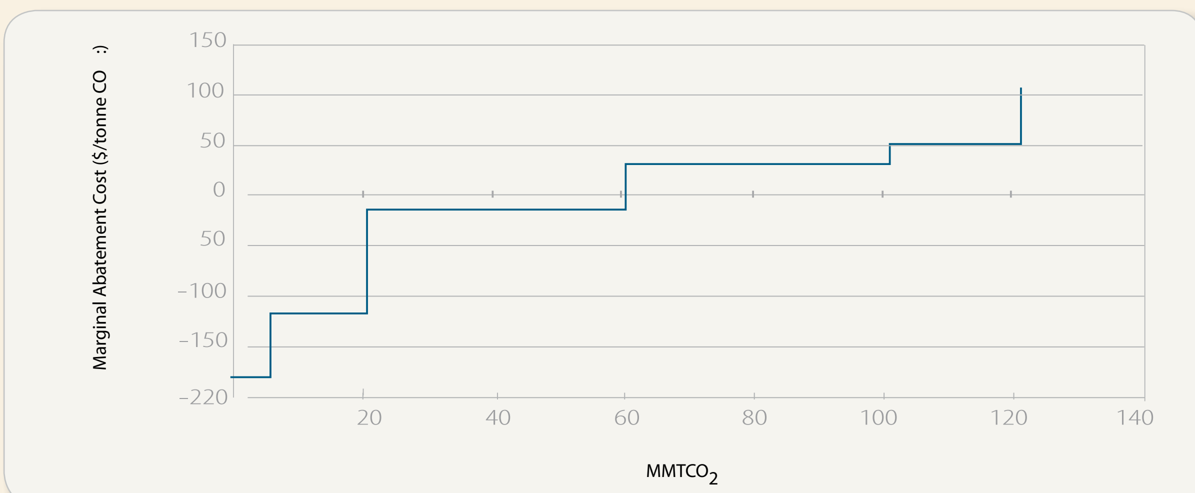
The identification of priority (sub)sectors and technologies could use as a criterion USD/tonne GHG abatement or MAC curves. A MAC curve would calculate for a country or a group of countries the cost of an additional tonne of GHG reduction. These costs depend on the technology with which that marginal emission reduction is achieved. A cost-effectiveness analysis based on costs/tonne GHG abatement could be carried out at the project or plant level, and it would involve total capital costs and operating and management costs divided by the project's total GHG emission reduction. This could be expressed as an annual cost/benefit.

Each point on this curve represents the cost-effectiveness of a given technology relative to the cumulative GHG emission reduction potential achieved when compared to the technology currently used in the country. The points on the curve appear sequentially, from most cost-effective in the lower left area of the curve, to the least cost-effective options located higher in the cost curve in the upper right area.

There are several sources of MACs and it is important to be aware of the following caveats on their use:

1. MAC curves do not represent the full picture in terms of all abatement technology options to meet development needs. This can be because of a lack of data or resources or because of methodological choices. It may not be valid to use them out of the context in which they were derived.
2. Many MAC curves cover mainly CO_2 reduction. The US EPA (2006) study covers options for reducing GHGs other than CO_2, including methane. The MAC curve developed by Bakker et al. (2007) combines a large set of bottom-up country abatement studies and covers a large share of abatement options in all sectors and (sub)sectors including electricity, industry, transport, buildings, waste, agriculture, forestry and land use for most non-Annex I countries. Inevitably, however, these cost curves do not include the full set of mitigation options. The McKinsey & Company (2009) cost curves also have a broad sectoral coverage.
3. In many other studies, mainly the electricity supply (sub)sector is analyzed though some industry efficiency, transport, and forestry may also be included (e.g., Bakker et al., 2007). The focus tends to be mainly on large scale technologies used in centralized grid systems. The decision on which technology is selected is made by the authors who have constructed the MAC curve graph.

Figure 5-3. Example of marginal abat ement cost curve for all sectors in Brazil in 2020.



Source: Center for Clean Air Policy, 2006.

4. In some studies decisions are based on model simulations (Ellerman and Decaux, 1998) and expert judgment to derive abatement potential and average costs. Technologies tend to be categorized so that individual technologies are not explicitly analyzed.
5. Some data on which the MAC curves are based can be quite old. New technologies for low emission and low vulnerability development may not be included and studies can become out of date quite quickly.
6. The original data for calculations may cover a range of methods and assumptions that are not necessarily all robust or compatible.
7. In some cases, no-regret options are not identified so that these activities, which would save money and reduce emissions but face other implementation barriers, do not appear on the cost curve. However, not appearing on the MAC curve does not mean these options do not exist. In the case of demand side technologies to reduce GHG emissions from fossil fuel combustion, there are many technologies whose cost-effectiveness results are located below the horizontal axis in Figure 5-3, indicating a negative cost technology (i.e., there are net societal benefits from introducing the technology as opposed to net societal costs).
8. Traditionally, the cost calculations used in constructing MAC curves do not take into account co-benefits of mitigation options, e.g., for air quality. In a proper societal abatement cost assessment, these should be included, resulting in significantly lower abatement costs for many options (see Johnson et al., 2009). These are included in the MCDA.

It is important to note that a decision to include cost-effectiveness as a criterion in the MCDA process commits a country to some fairly involved analysis, the expertise for which may not be available in country.

Cost-benefit analysis

The main alternative to MCDA is a cost-benefit analysis, which would need to be carried out for each technology. However, cost-benefit analysis is relatively complex, as it requires that all benefits are expressed in monetary values, which is not necessarily possible in a coherent way for some benefits, such as valuing a human life when assessing a coastline protection plan. Where this is feasible it can be used anyway under an MCDA exercise, such as, for example, for the costs in terms of GHG abatement or employment gains, income gains, energy savings, etc. In this chapter benefits are not monetized, but benefit-to-cost ratios are considered as explained in section 5.3.

References to literature used in this box can be found in the overall reference list in this Handbook.

The output from step 2 will be an assessment spreadsheet with overall weighted scoring for each prioritized technology. An audit trail justifying the judgments made should be available as well. This is a transparent record of the justifications made for the scores given and the weights assigned as well as the variations in perspectives, the results, sensitivity analyses conducted and the insights gained.

5.3 Step 3 Making final decisions

Why? To reach final decisions on technologies in terms of achieving maximum development goals, GHG emission and vulnerability reduction benefits for mitigation and adaptation while minimizing costs

How? Assessment review: review assessment results in participatory workshops
Sensitivity analysis: include discussions behind weighting during sensitivity analysis
Decision on prioritization: prioritized portfolio of technologies and measures in each category of small and large scale technologies for the short and medium to long term for each sector of interest

Who? National Team for coordination of technology needs assessment: assessment review, technology option pages in TNAssess, decision on prioritization, sensitivity analysis
Facilitator and possibly chairperson to guide stakeholders through decision making process
Core stakeholder groups: assessment review, decision on prioritization, sensitivity analysis
Wider stakeholder groups: communications strategy

5.3.1. Review assessment results

At the end of the prioritization process, country teams should have a prioritized portfolio of technologies and measures in each category of small and large scale technologies for the short and medium to long term for each (sub)sector of interest. In this step, assessment results are reviewed based on the following action:

Review assessment results in participatory workshops

Stakeholders discuss outcomes found in the previous step in terms of the uncertainties in the inputs (in the scoring and weighting as well as in the uncertainties surrounding the decision and the range of perspectives applying to the decision).

During the review the assumptions and uncertainties to be explored are identified and used in the sensitivity analysis in the next step.

5.3.2. Conduct sensitivity analysis on assessment results

Conducting sensitivity analysis on assessment results to assess the robustness of the results relative to the weights and scores applied and other uncertainties can be done based on the following actions:

Perform sensitivity analysis on variations in scores and weights noted during discussions

To explore scores and weights a cloned (i.e., copied) version of the basic model should be used to explore changes in inputs in TNAssess so that the basic model is always available. This allows different perspectives to be considered. For example, there might be a disagreement about the scores or weights in the workshop, or the country might want to run different workshops with different stakeholders.

Up to three prioritizations (scores and weights) are supported in each category. The analysis will test the robustness of the results. Sensitivity analysis is provided in TNAssess to give an indication of robustness using a "traffic light system."

Analyze effect of uncertainties on inputs

This also allows an exploration of variations in scores and weights under different futures and the robustness of the technology under different conditions. The sensitivity analysis tool in TNAssess will be used here.

Explore balance in achieving key objectives

A final bar chart allows the total expected value of the technologies to be displayed and the balance between the different objectives/criteria contributing to the overall score to be seen.

Compare individual technologies against each other within their categories

Individual technologies can be compared to see their strengths and weaknesses and hence how they may be improved.

During the review, assumptions can be challenged, key criteria identified, improvements to options created, and consequences analyzed interactively, so that the group achieves a shared understanding of the problem and can move forward to making final decisions.

5.3.3. Decide final prioritized[24] technologies for (sub)sectors

At the end of this process, country teams will decide on a prioritized portfolio of technologies and measures in each category of small and large scale technologies for the short and medium to long term for each priority (sub)sector. This decision process will include the following actions:

Combine cost information with benefit assessments for benefit-cost ratios in TNAssess	The estimated cost information from the technology option pages now has to be finalized and scaled up to the (sub)sector level in terms of the assumptions made for the penetration of the technology in the sector and timescale (see Box 5-2 and Annex 8). This is discussed further in the next section 5.3.4. Spreadsheets for the calculations are available. TNAssess assists with this process and allows the computation of the benefit-to-cost ratios.
Compare results	Use the results from the different prioritizations to decide which technology options should be taken forward. Within TNAssess the user can see the options side-by-side, with benefit value and benefit-to-cost ratio shown (see Annex 8 for an example of benefit-to-cost ratios), to help facilitate this selection process. The user will select a number of technologies to be shown in the final summary tables, report, etc.

5.3.4. Potential investment costs and climate and development benefits from prioritized technology for priority (sub)sectors

Having selected the final list of prioritized technologies on the basis of their costs and benefits, the next stage is to bring the information together for each prioritized technology on a (sub)sector wide basis in the summary table in terms of total potential investment costs required, the development benefits from MCDA and the potential GHG or vulnerability reductions. The potential costs and benefits at the (sub)sector level depend on assumptions regarding how the technology will be introduced and rolled out. These potentials will be maximum figures which will be mitigated by the complexity of the technology transfer process which is considered in chapter 6.

Therefore, for the completion of the summary tables 5-3 to 5-6, stakeholders can refer both to the description of technologies presently operational in the (sub)sectors (as discussed in chapter 4), as well as to assumptions for (sub)sector roll out of the technologies (in the TNAssess technology option pages, section 5.1.2). As a next step, in chapter 6, for prioritized (sub)sectors and technologies milestones are generated to support the country in reaching its long term development priorities.

For the tables 5-3 to 5-6, there is spreadsheet support available for the potential (sub)sector GHG reduction calculations and vulnerability assessments based on the assumptions of what changes could occur at the level of the (sub)sector with the introduction of the technology or measure as explained earlier. Similarly, estimates of the required investments in the

24. Prioritizing technology portfolios in each category (as opposed to selecting individual technologies) provides the opportunity to start to formulate a strategy for implementation over time within the (sub)sector and across sectors. Clear winners which can be implemented right away can be identified, though in some (sub)sectors, groups of technologies may be more appropriate (e.g., wetlands). Depending on climate impact scenarios, activities can be put in place for transfers over time for medium to longer-term adaptation options.

prioritized technologies under these assumptions for roll out in the (sub)sectors and technologies, are also available from the spreadsheets. The early estimates from the technology option pages can therefore be updated with any new information at this stage. For that, it is suggested that the National Team and stakeholders consult again sources such as the ClimateTechWiki for any new information about costs of the technologies, or project examples in the region (e.g., with information about manufacturers of the technologies) for input to the spreadsheets. The development benefits assessed in the MCDA are input directly to the Tables 5-3 to 5-6 as these are already assessed on a (sub)sector scale.

The information on (sub)sector wide costs and benefits from these tables will be combined in chapter 6 with costs for accelerating innovation in the (sub)sector for the national action plan.

Produce summary tables (see Tables 5-3 - 5-6 below) for technologies for mitigation, cross-sector mitigation, adaptation and cross-sector adaptation

The summary tables can integrate across the (sub)sector to provide an indication of overall costs or benefit-to-cost ratios and expected adaptation or mitigationn as well as development benefits using the outputs from TNAssess and calculation.

Specific to adaptation, since measures are country- and (sub)sector-specific, and often determined by national and (sub)sector circumstances, different applications of technology in different cases may be expected; what works in one set of circumstances might be unsuitable in another.

Comparison across (sub)sectors may identify technologies not necessarily the highest ranked but highly ranked in a range of (sub)sectors, indicating that they may be a useful choice for technology transfer in the short and medium to long term.

Prepare factsheets for each of the priority technologies based on the technology option pages from TNAssess

The purpose of the factsheet is to create a succinct document that synthesizes essential information for each priority technology within the context of the country that would be most pertinent to an audience of non-specialists.

Produce the final audit trail for the prioritizations

The audit trail for the decisions can be produced from TNAssess using the reporting function for input to the final report.

Table 5-3. Summarizing table for prioritizing mitigation technologies for each (sub)sector*

(Sub)sector A (repeated for (sub)sector B, C, etc.)	Technology	**Potential for mitigation in (sub) sector in timescale** (e.g., 20-years; cumulative GHG emission reductions) (For this calculation a spreadsheet will be available)	**Benefits output from MCDA assessment**	**Estimated total lifetime costs per technology times the technical potential in (sub) sector**** (for this calculation a spreadsheet will be available)
Short term/ Small scale	Highest priority technology			
	Next highest			
Short term/ Large scale	Highest priority technology			
	Next highest			
Medium to Long term/ Small scale	Highest priority technology			
	Next highest			
Medium to Long term/ Large scale	Highest priority technology			
	Next highest			

Table 5-4. Summarizing table for cross-sector mitigation technologies***

	Technology	**Potential for mitigation in (sub)sectors in timescale** (e.g., 20-years; cumulative GHG emission reductions) (For this calculation a spreadsheet will be available)	**Benefits output from MCDA assessment**	**Estimated total lifetime costs per technology times the technical potential in (sub) sectors**** (For this calculation a spreadsheet will be available)
Short term	Cross-sectoral technology			
Medium to Long term	Cross-sectoral technology			

Table 5-5. Summarizing table for prioritizing technologies for adaptation for each (sub)sector or area*

(Sub)sector A (repeated for (sub)sector B, C, etc.)	Technology	**Potential for adaptation in (sub)sector** (e.g., 20-years) (Uncertainties will be made explicit in a spreadsheet provided where possible)	**Benefits output from MCDA assessment**	**Estimated total lifetime costs per technology times the potential scale of investment in the (sub)sector**** (For this calculation a spreadsheet will be available)
Short term/ Small scale	Highest priority technology			
	Next highest			
Short term/ Large scale	Highest priority technology			
	Next highest			
Long term/ Small scale	Highest priority technology			
	Next highest			
Long term/ Large scale	Highest priority technology			
	Next highest			

Table 5-6. Summarizing table for cross-sector technologies for adaptation***

	Technology	**Potential for adaptation in (sub)sectors in timescale** (e.g., 20-years) (Uncertainties will be made explicit in a spreadsheet provided where possible)	**Benefits output from MCDA assessment**	**Estimated total lifetime costs per technology times the technical potential in (sub) sectors**** (For this calculation a spreadsheet will be available)
Short term	Cross-sectoral technology			
Long term	Cross- sectoral technology			

* Not all of these categories will be filled by the priority technologies depending on the sector characteristics. Therefore if there is time working further down each prioritized technology portfolio list would be beneficial. The calculation of the potential in the sector can only be an estimate dependent on many uncertainties which must be made explicit and gives a maximum value for the sector which in the light of other possible innovations may not be reached.

** Estimated lifetime cost calculations for a technology contain both the upfront capital costs and the operational and maintenance costs (see Box 5-2 and Annex 10 for more details).

*** Since the analysis in chapter 6 will mainly focus on identification of activities to accelerate development, deployment and diffusion of technologies prioritized in this chapter, irrespective of whether a technology is applied on small or large scale, Tables 5-4 and 5-6 with cross-sectoral priority technologies will only distinguish between short and long term technologies.

In this chapter, low emission and low vulnerability technologies categorized by size and availability have been assessed based on development and climate benefits and costs. This led to the identification of a portfolio of priority technologies to be implemented in the priority (sub)sectors to meet country development objectives and enhance national action on mitigation and adaptation. Useful technologies at cross-sector level have also been identified. Tables 5-3 to 5-6 summarize the information at a (sub)sector level and this is used in the next chapter where enabling frameworks and capacity development measures for technology transfer within the country are considered and a national strategy is developed for accelerating innovation and implementation.

Annexes to chapter 5:

- Annex 7 Technology options for mitigation and adaptation
- Annex 8 Multi-Criteria Decision Analysis using TNAssess
- Annex 9 First prioritization of mitigation and adaptation technologies before MCDA, only if numbers are large
- Annex 10 Spreadsheet example cost assessments

Solar voltaic panels in Thies, Senegal © UN Photo/Sean Sprague

6 Preparing strategy and action plan for prioritized technologies

SUMMARY PAGE FOR THE CHAPTER

This chapter focuses on the measures needed for successful development and transfer of the technologies beyond a needs assessment, and how they can be formulated into a national strategy and action plan.

Main outputs

The main outputs are a national strategy with implementation action plan to accelerate the adoption of prioritized technologies for adaptation and mitigation at each main technology stage (RD&D, deployment and diffusion). The strategy and the action plan should be presented as an integral part of a country's national climate change strategy (e.g., NAMAs, NAPAs and low emission development strategies). The analysis also provides suggestions on developing projects or sector programs for rapid implementation of prioritized technologies available in the short term.

How to construct strategies and action plans for accelerating technology innovation?

For the technologies for mitigation and adaptation prioritized in chapter 5, the following analysis process is suggested:

Step 1 Clarifying priorities and establishing key milestones

1. Refresh development and climate priorities
2. Generate milestones for (sub)sectors and technologies

Step 2 Identifying measures to develop capacities and enabling frameworks

1. Characterize existing systems, such as policies, incentive structures, market conditions, institutional frameworks and stakeholder networks
2. Conduct an analysis to identify bottlenecks in the systems as well as measures to address these for acceleration of technology development and transfer

Step 3 Compiling an overall national strategy and action plan

1. Aggregate and rationalize the measures identified to develop national capacities for acceleration of technology development and transfer
2. Prioritize and characterize measures for technology acceleration for a national action plan
3. Incorporate technology investment costs and benefits.
4. Finalize the national strategy/action plan on technologies to address climate change, as an integral part of national climate change strategies (such as NAMAs, NAPAs and low emissions strategies).

Who is involved?

With stakeholder groups' support, the National Team leads the process on how the technologies prioritized earlier can be implemented in the country and how implementation circumstances can be improved to overcome barriers from RD&D to deployment and diffusion.

Chapter overview

This Handbook at the outset identified a country's development priorities that were derived from long-term visions as well as strategies for mitigation and adaptation already in place with accompanying goals for the future (chapter 3). Subsequently, these development priorities were used along with climate mitigation and adaptation criteria for identifying highest priority (sub)sectors (chapter 4), and for prioritizing technologies for mitigation and adaptation within these (sub) sectors (chapter 5). The potential GHG mitigation/ vulnerability reduction, development benefits and costs for the technologies at the (sub)sector level were then summarized in Tables 5-3 – 5-6.

At this stage of the work, the Handbook has therefore not only mapped out a country's long term development priorities but also identified which technologies are needed to fulfil these priorities with estimates of their potential climate and development benefits and costs.

However, the process of technology development and transfer is complex.[25] Each country has specific national institutional structures and social networks of actors (e.g., technology providers and private project developers) who operate under their respective policies and regulations. These actors are supported by a range of market services; including quality & assurance practices, research, development and demonstration (RD&D), and financial services that underpin operation of the system.

This chapter therefore focuses on what is needed for successful development and transfer of the technologies beyond a needs assessment, and how this can be formulated into a national strategy and action plan. More specifically, this chapter helps address the following question:
"How can the development and transfer of the priority technologies be accelerated in the country to deliver their full potential in terms of climate benefits and contributions to the country's development priorities?"

The country's development priorities identified in chapter 3 are used as the starting point and these are revisited and refreshed to ensure that the priorities of the analysis are clear. Aspirational intermediate milestones to reach those priorities are then generated at the (sub)sector and technology levels. Next, a national strategy is compiled through a process of analyzing how the development and transfer of prioritized technologies can be accelerated to meet these milestones

To illustrate further, the approach used is to explore the gap between the existing situation for technology development and transfer in the country and the desired situation. This is done by identifying barriers and system inefficiencies. This is followed by identification of measures to close the gap. It is emphasized that the chapter distinguishes between technologies in different stages of development, so that identified measures address, e.g., how to accelerate technology RD&D in the country; how to manage technology deployment; and how to accelerate technology diffusion? The measures to overcome the barriers and inefficiencies identified are structured under core elements of capacity development and enabling frameworks, which function as key building blocks for the strategy.

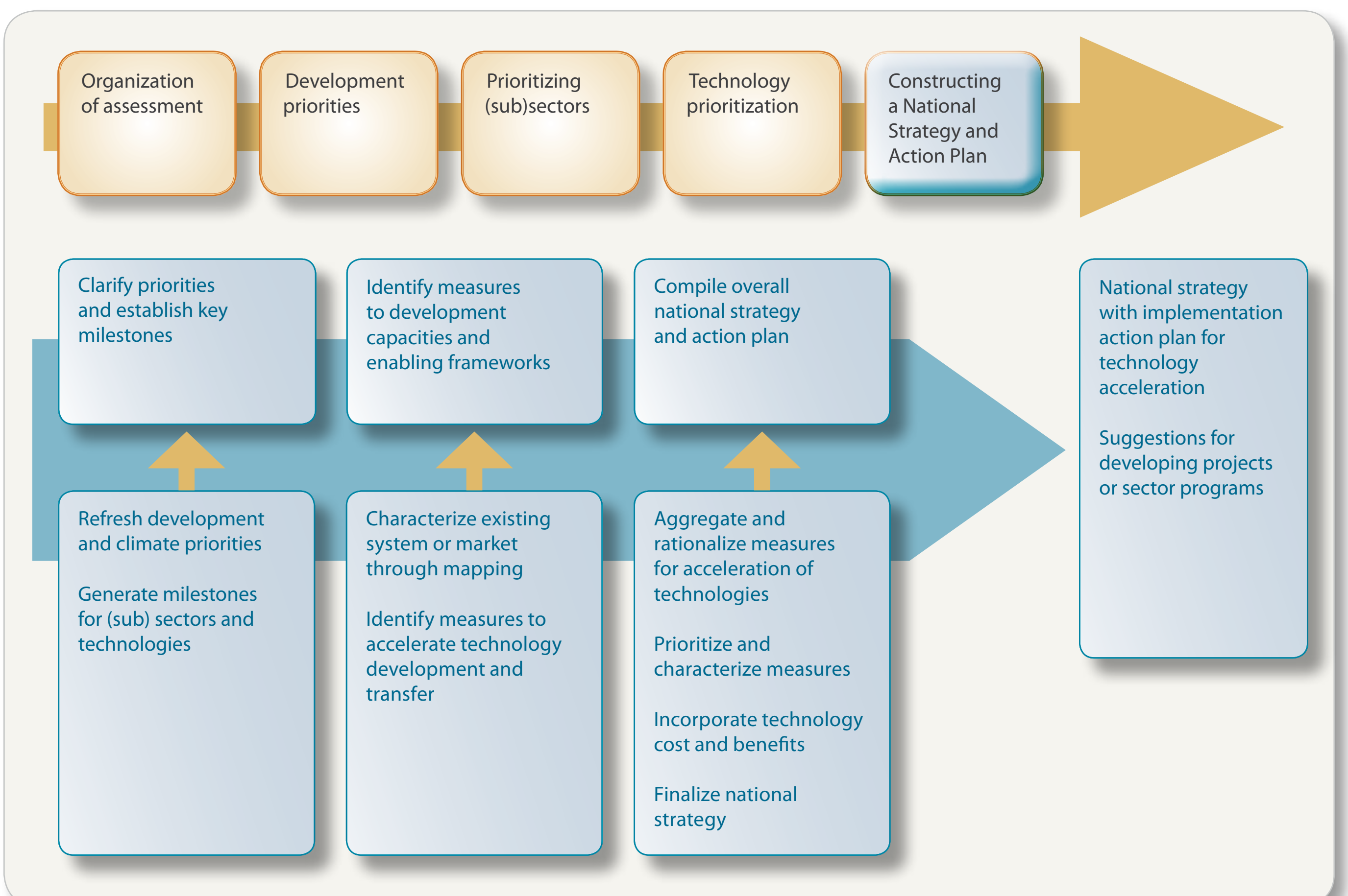
Bringing these measures together across technologies, (sub)sectors and sectors helps the country formulate a national strategy for the short, medium and long term. The implementation of the strategy is supported by an action plan which specifies such factors as: estimated resources needed for the measures, allocation of responsibilities, requirements for monitoring and verification of the measures, and envisaged timeline for each activity. This process of identification of measures for acceleration of technology adoption and their formulation into national strategy and action plans will also contribute to capacity development for successful technology development and transfer in the country. Additionally, the national strategy and action plan may best be conceived as part of the country's overall development and climate change strategy (e.g., Nationally Appropriate Mitigation Actions (NAMA) and National Adaptation Plans of Action (NAPA)).

The process of this chapter could also lead to a pathway for implementing technologies as demonstration projects. For such projects, stakeholders can follow the same process of characterizing the existing system for the technology and exploring what is needed for a successful demonstration. Although the strategy formulation with action plan has a national focus, it should be kept in mind that a technology may be developed within a country or involve country-to-country transfers.[26] As a consequence, the national strategy and action plan for technology innovation could contain measures that will require international partnerships and cooperation along the innovation chain. Background information on this can be found in Annex 11 ("A Multi-polar World of Innovation").

Finally, the aspirational milestones for the technologies set at the beginning of this chapter should be carefully reviewed, and as needed, adjusted, before finalising the national strategy/action plan. This can be done in the light of the analysis and action plan information on costs, benefits and timelines for acceleration of innovation through the country system.

25. Throughout this chapter the term "technology development and transfer" is used to reflect a set of actions to accelerate deployment, diffusion and transfer of affordable environmentally sound technologies in developing countries. The term covers a broad range of forms of cooperation, such as between Annex I and non-Annex I Parties, among non-Annex I Parties, as well as within non-Annex I Parties.
26. A technology may also need to be modified to suit the long term implications of climate change within the country, or to suit the country's supply chain constraints

Figure 6-1. Process diagram for formulating national strategy and action plan



Overall, developing a national strategy[27] on technology transfer will involve three main considerations: a clear vision or set of priorities to be attained by the strategy with milestones specifying the pathway to the priorities; measures for accelerating technology innovation grouped under core elements of the strategy with a clear view on proper implementation of these measures, including monitoring, reporting and verification to ensure success of strategy. The analysis in step 1 below considers the vision, priorities and milestones while the measures for the core elements of a strategy and its implementation are dealt with in steps 2 and 3.

The entire process in this chapter is highly participatory and requires stakeholder involvement in each step.

6.1
Step 1

Clarifying priorities and establishing key milestones

Why? To clarify the priorities and establish milestones

How? By revisiting the vision and development priorities in chapter 3 and the goals to be achieved by the country and discussing interim aspirational milestones for their achievement

Who? National team facilitates the process with the stakeholder group and decision makers

6.1.1. Refresh development and climate priorities

The development and climate priorities for the country as discussed in chapter 3 were derived from a vision of what the country would like to achieve for a sustainable and equitable future. In chapters 4 and 5 these priorities were used as criteria for identifying priority technologies to deliver the required benefits. In the first step of this chapter, the vision and priorities need to be refreshed in order to specify intermediate milestones for achieving progress on the priorities overtime. These milestones should be generated through discussions for the priority (sub)sector level and for the priority technology or mix of technologies required.

The following action is recommended:

Refresh development and climate priorities identified in chapter 3 with the relevant stakeholder group[28]

Based on the analyses from chapters 3, 4 and 5, the stakeholder group refreshes the overall vision on development for which the national strategy is being devised and clarifies the key priorities.

27. As discussed later, the process starts with the highest priority (sub)sector and its portfolio of prioritized technologies or adaptation measures identified in chapter 5, which are expected to deliver the required development and climate benefits in the country. Although, in principle, the portfolios of priority technologies should be implemented over time, for the manageability of the work in this chapter, it is recommended that the processes in this chapter are applied initially to a limited number of technologies. The technologies to be analyzed should include the highest priority technologies in each of the categories 'available in the short term' and 'available in medium to long term' covering, if possible, small and large scale technologies in each of the priority (sub)sectors in turn (potentially four per (sub)sector) starting with the highest priority (sub)sector. This should provide four technologies for each priority (sub)sector for analysis. It is also suggested that two "cross-sectoral" technologies from chapter 5 will be included in the analysis, which, though not occupying the most preferred position, are nevertheless highly rated and are common across more than one sector.

28 . Stakeholders already available from the technology needs assessment process and extending the group to relevant experts (players involved in the import of the technology, adaptation of technology to local conditions, indigenous manufacture of the technology and its use) could be a good way forward. Stakeholder groups can form the basis for the transfer networks for implementation of the strategy.

6.1.2. Generate milestones for (sub)sectors and technologies

The following actions are suggested:

Establish aspirational milestones at (sub)sector/ national level in line with development and climate priorities, as refreshed above. For example, a milestone at (sub)sector level may be: x% electricity generated from renewables by 20XX.	The stakeholder group can discuss the vision and key priorities with the timescales involved and brainstorm to set interim milestones for reaching the priorities. This will involve gathering information from existing plans on the priority (sub)sectors identified in chapter 4.
Establish aspirational milestones for priority technologies to meet these (sub)sector/national milestones.[29] For example, the x% renewable electricity target by 20XX will be met by wind energy by x%.	At this stage, these can only be aspirational milestones as the technology development, supply chains, market system and infrastructure requirements must all be developed in parallel to allow the technology to fulfil its potential to deliver benefits as described in this chapter.[30] The stakeholder group[31] should be encouraged to brainstorm options how the prioritized technologies can contribute to reaching the (sub)sector and national milestones in 20XX. At this stage stakeholders can build further on the work already done in chapter 5 when completing the summary Tables 5-3 – 5-6. For these Tables stakeholders already made a first analysis of the potential role of the prioritized technologies within the (sub)sector.

THE OUTPUT FROM THIS STEP IS A REFRESHED VISION AND PRIORITIES AND ESTABLISHED MILESTONES TO BE ACHIEVED BY A NATIONAL STRATEGY AND ACTION PLAN.

29. These milestones can be revised at the end of step 3
30. Examples of unrealistic target setting show the need for care in this approach. For example, California zero emission vehicle mandate set in 1990 had a target of 10% by 2003 which was not met due to setting at an unrealistic level. This did not account for technology development time, market state and infrastructure and supply chain requirements (Review of ZEV mandate).
31. The group will need to consider how the priority technology will be brought into the (sub)sector and developed within the country. This is an important step as it will affect delivery of the development or climate priority, e.g., reduced unemployment. If the transfer can involve country supply chain system and skills base, and not just the import and installation of a fully functioning turnkey technology, then the technology transfer is more likely to generate jobs and thus contribute to the milestones for that development priority. It also affects the boundaries for the analysis in terms of the extent to which cooperation with other countries will be required.
Discussions on a scenario for this aspect presented in chapter 5 can be used as a starting point. The form of technology transfer in the country context will also depend on funding arrangements for the technology transfer and various constraints and whether private sector transactions may need to be incentivized.

6.2
Step 2

Identifying measures to develop capacities and enabling frameworks

Why? Characterizing existing systems for prioritized technologies forms the basis for identifying measures for improving the system to accelerate technology transfers by developing capacities and enabling frameworks

How? By mapping out the existing environment for each priority technology at participatory workshops and analyzing/discussing with stakeholders how to overcome problems and take advantage of opportunities

Who? The National Team facilitates the workshops and stakeholders characterize the systems or markets

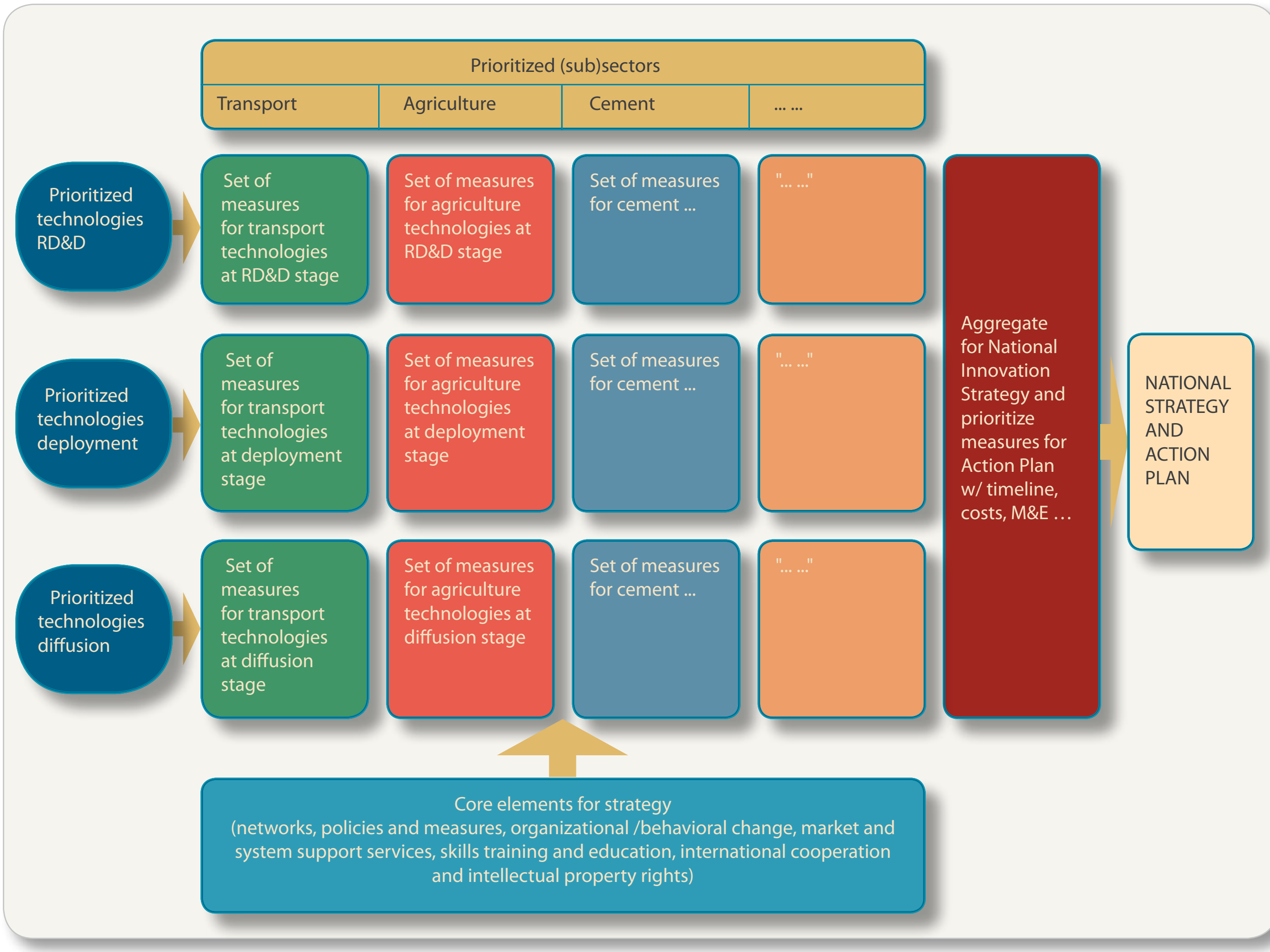
This step focuses on the enabling framework for the prioritized technologies and required capacity development measures. This will be based on an identification of barriers and inefficiencies within the systems/markets for the technologies, and is followed by recommendations on measures to overcome these obstacles.[32]

Before starting the process in this step, it must be noted that technologies analyzed will be at different stages of development. As chapter 5 has shown, some technologies are close to market commercialization whereas others are still in the process of research and development. When mapping the enabling environment for a technology and identifying measures to improve markets for technology development and transfer, it is important that stakeholders perform the analysis according to the technology's development status. See Box 6-1 for clarification.

The focus in this step is first on identifying measures to accelerate the highest priority technologies in the highest priority (sub)sector in the country, specified for the innovation stages RD&D, deployment and diffusion. Subsequently, the highest priority technologies in the second-highest priority (sub)sector will be analyzed, etc. The flow of analysis is shown in Figure 6-2, which also shows how the outputs from this steps will be used in the next steps in this chapter.

32. The process suggested for this step is that stakeholders first 'take a picture' of the relevant market or system for the technology. This is done by mapping such aspects as relevant regulations, legislation, culture, market actors, and availability of supporting services. Based on this map, stakeholders can identify where problems exist in the system and subsequently decide on what measures are needed to solve these problems. The idea is that repeating this process for a range of prioritized technologies will result in a set of measures for technology acceleration grouped under 'core elements for a strategy', which will offer concrete building blocks for a national strategy for technology innovation in step 3. The end product in step 3 is clear insight in what enabling framework and capacity requirements are needed for a successful national strategy to achieve the technology milestones formulated in step 1.

Figure 6-2. Analysis flow for generating a national strategy to accelerate technology innovation



At the end of the prioritization process, country teams should have a prioritized portfolio of technologies and measures in each category of small and large scale technologies for the short and medium to long term for each (sub)sector of interest.

Technology innovation stages

In chapter 5, it has been recognized that technologies are at different stages of innovation, which are reflected in the technology categories in terms of availability in the short or medium to long term. Measures in a country to accelerate technology transfer therefore will depend not only on the country context but also on the technology and its innovation stage: research, development and demonstration (RD&D), deployment or diffusion. These innovation stages are usually described as a learning curve for technology innovation, which is illustrated in Figure 6-3.

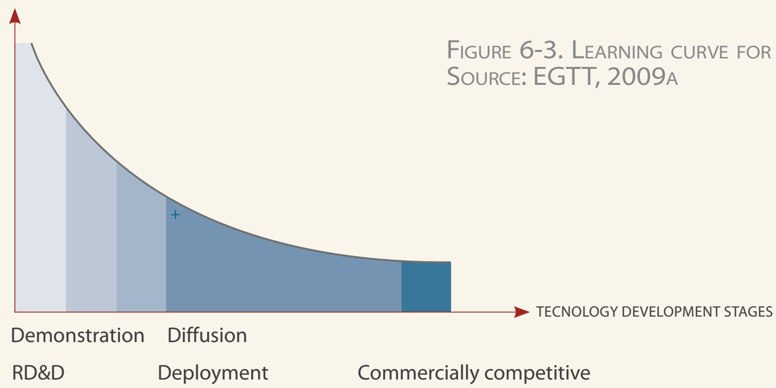


FIGURE 6-3. LEARNING CURVE FOR TECHNOLOGY INNOVATION, SOURCE: EGTT, 2009A

The innovation stages are as follows:

1. **Research, development and demonstration (RD&D):** RD&D measures are required for fundamental research on experimental new, long term technologies or for developing medium term promising technologies at the RD&D phase. International cooperation with developing countries on enhancing in-country RD&D capacity and measures is recommended. Demonstration takes place when prototypes are proven and scaled up to the applicable demonstration scale for final proof before deployment.
2. **Deployment:** The deployment of a technology into a market is a difficult process where a technology may be unknown to users. A period of awareness building of the technology, its capabilities and applicability as well as trial-ability with development of back-up services for maintenance and support is useful. The market 'pull' for these technologies is also important in terms of their affordability, demand, availability of finance, and commercial presence of entities able to deploy the technologies. The practicalities of deployment must recognize that transfers will be enacted through private sector agents and include consideration of facilitation of the process for investors and users.
3. **Diffusion:** The diffusion of a technology or measure within the market refers to the process of widespread adoption of a technology or measure to the point where sufficient numbers are deployed to make the manufacture and sale of a technology commercially competitive or the use of a measure widespread. Acceleration of technology diffusion in a country requires consideration of the whole system, including enabling (business) environment of institutions, policies and regulations surrounding the transfer, market chain involved in the sector concerned, and supporting measures, which allow the market to function. This whole-system approach is similar to the UNCTAD (1998) definition of enabling environment, which refers to the underlying macroeconomic environment bringing together technology suppliers and consumers in a cooperative manner.

In practice, the above stages form a continuum where phase boundaries are blurred depending on the technology and circumstances.

Box 6 – 1

6.2.1. Characterize existing system or market through mapping

This step allows the national team and stakeholders to identify gaps between the existing systems and where they want to be according to the priorities and milestones discussed in step 1. For this, the group first develops a picture of the existing environment (e.g., market) to enable the transfer of the technology, including where improvements are needed. Such a picture of the technology environment is developed through a wide-ranging discussion structured to elicit the issues surrounding the transfers (e.g., policies and regulations, market chain of actors and the services required to make it work including financial advise, quality control, consultancy and information). A range of techniques are available for this, such as market mapping (Albu and Griffith, 2005 and 2006), use of workshops and focussed meetings such as World Café, cognitive mapping, H-form and action planning, and Delphi techniques (see Annex 1 for explanations of these techniques).[33]

The resulting picture or map helps stakeholders gain insights on the barriers and blockages in the system which need to be removed for development to take place. This "mapping" also helps identify opportunities for successful technology development and transfer. The final picture may therefore include:

- **key players** with market power,
- **barriers,** bottlenecks and inefficiencies (e.g., in current regulations and policies),
- **missing elements** (e.g., regulation and enforcement),
- **major issues affecting the system,**
- **market support** structures (e.g., good quality assurance standards and enforcement), and
- **opportunities** (e.g., balancing the grid).

However, it should be noted that the method used for describing the enabling environment for a technology depends, to a certain extent, on whether the technology, e.g., is small-scale for use by households, or only relevant for restricted markets, or comprises large infrastructure projects such as hydro dams or coastal protection, or is non-market or 'soft'. In case the technology will be clearly rolled out in a market, then market mapping would be a suitable tool.[34] Examples of "typical" technologies for market mapping are: small-scale agro-products and small to medium-scale bioenergy projects. However, for large infrastructure projects, which will not be spontaneously diffused by market force alone, but rather require policy interventions , the discussion would need to examine what this political process looks like and where and how this can be improved. In the steps below, further guidance is provided on this, including examples of questions to be asked during the development of a picture of the present enabling environment for the technology.

It is suggested that the process is applied to at least one technology from each of the categories (small/large scale applicability and short/long term availability) in each priority (sub)sector. This would result in at least four technologies to be analyzed, but this number could become larger depending on the resources and time available. On the other hand, it may well be that in chapter 5 for some categories in the (sub)sectors no technologies have been prioritized. For example, in some countries, stakeholders may not have prioritized long term technologies in a (sub)sector due to, in their view, insufficient domestic RD&D capacity for these technologies. In those cases, the analysis will naturally focus on those categories for which technologies have been prioritized.

33. During market or system mapping discussions, a range of market-chain actors can meet 'to share their perspectives, problems, and expectations; build common understandings and trust; and identify blockages, challenges and opportunities in the market system' (Albu and Griffith, 2006).
34. The technique of market or system mapping is described in Annex 13 along with examples of market maps and the depth of detail possible.

In any case, it is recommended that the range of technologies analyzed are balanced as much as possible across the four categories in each sector. In addition, it is recommended to apply the process to a number of cross-sectoral technologies, as identified in chapter 5. Also, in this case, it is recommended that technologies analyzed represent the different categories well. How many cross-sectoral technologies will be analyzed depends on the number of technologies which are, according to the stakeholder groups, not among the highest rated in each (sub)sector but nevertheless seem to be able to play an important role across sectors. Through step 2, all technologies are analyzed one at a time.

During the analysis it will become clear that many barriers and system blockages are common across all technologies, and only some will be technology and sector specific. This means that after having analyzed a number of technologies, time can be saved in subsequent technology analyses. The same holds for the process explained below (section 6.2.2) to identify measures to improve systems after describing the existing technology environment. *It would also be expected that feedbacks will be required within the process and across the (sub)sectors to minimize duplication and ensure efficiency.*

The following process for characterizing existing systems or environment for the technology and innovation stage is suggested:

Organize interactive discussions (e.g., workshops) to map the systems/markets for acceleration of technologies

This will involve the stakeholder network group with key players in the market

Determine exact stage of innovation of the technology as described in Box 6-1[35]

This is self-explanatory and determines the scope of the measures required to bring the technology to market or instigate behavioral changes.

For a **short-term** technology, market mapping is done with a view to the **deployment** of the technology and **diffusion** into the market to the point of commercial application.[36]

It is also noted here that for some short-term technologies RD&D activities might be needed to modify the technologies so that they can be implemented successfully under country circumstances. These activities are explained in Box 6-2.

For a **medium to long-term** technology, the analysis focuses on the system for the **RD&D stage** of innovation.

For **non-market** technologies, a similar system characterization is suggested.

Characterize the existing environment or system for development and transfer of the prioritized technology keeping in mind the development stage of the technology

As a first activity, it is recommended that stakeholders select the most appropriate method for developing a picture of the overall enabling environment for the technology, system or market, depending on the technology characteristics (see above explanation). Tools that could be used are described in Annex 1.

Irrespective of the method used, the resulting picture of the technology's enabling environment can be built up over time through discussion of a number of questions.[37]

This approach allows the structure of the existing system to be revealed and explored. This enables stakeholders to create new links and additional structures to help the system operate more efficiently. This can be done by:

. considering the advantages and disadvantages of the system and

. posing questions such as 'What measures can improve efficiency in the system?'

The H diagram approach in Annex 1 is useful for this part of the exercise.

Identify barriers to acceleration of technology implementation

Once the environment relevant for the technology has been revealed, barriers can be identified that hamper the development and transfer of the technology.

These barriers can be diverse as they can refer to insufficient legislation to support the technology, or counter-productive legislation (e.g., feed in tariff effects could be neutralized by an import tariff on the hard ware), insufficient human capacity to support the operation and maintenance of the technology, insufficient legal and financial supporting service, poor communication system, lack of media interest in promoting technology, etc. Table A13-2 in Annex 13 shows an illustrative example of a possible overview of barriers that could result from this step.

35. The special case of a technology which needs to be modified to operate under country conditions is treated in Box 6-2.
36. When the National Team and stakeholders are interested in demonstration of a short term technology, the analysis can focus on how to deploy a technology project. In case a short term technology needs to be modified to country conditions, the stakeholders are referred to measures suggested for this in Box 6-7.
37. These questions include:
    - Who are the main stakeholders?
    - What are the networks involved?
    - What are the links between the enabling and supporting environments and the development chain?
    - Who has the power in the development chain?
    - What are the policies and regulations surrounding this stage and how can they be improved?
    - How can the required RD&D be supported?
    - What other supporting measures are required?
    - What are the barriers, blockages and inefficiencies?
    - What are the opportunities?

    A system map can be easily visualized as shown in Annex 13 for which stakeholders can use flip charts initially but later can illustrate in MS Word or MS Power point. A more specialized software tool for system mapping is MindJet.

Box 6 - 2

Deriving measures to accelerate modification and adaptation of short term technologies

For a prioritized technology to work well in a country, it is important to ensure that it is robust under present country conditions and also in the future climate impact scenarios. Some technologies may not need further modification to be applied in the country concerned but some technologies may require some RD&D to ensure that they operate reliably now and remain robust to future climate conditions. The following activities are recommended:

Visit demonstration projects operating under similar country conditions	Country experts can undertake the visits to see the technology in action and to discuss with operators and installers any issues relevant to the host country conditions now and in the future.
Define need for technology modifications and agree on who should do this and indicate appropriate funding for this	Modifications to the technology can be made and tested in the country in collaboration with manufacturers without invalidating warranties and compromising operator safety.
Demonstrate supplier capability, support, and service record for the technology	When a new technology is introduced, there needs to be sufficient manufacturer back up support over a period of time to ensure all the problems are overcome as operators and managers start to gain experience. After the initial intensive training, this process should involve back-up visits every 1/2 months for the next 6 to 12 months after installation. Otherwise, the technology may fail even after all the investments.
Develop capacity, for identifying the skills required to successfully operate and maintain the technology	Current national training programs can be reviewed to ensure the skills required are available within the timescales.
Develop list of measures for a strategy and prioritize and characterize to proceed on modifications needed, ensuring manufacturer back-up support, and building capacity	This characterization of the prioritized list of measures would contain a definition of who does what, how, and when, and how these measures can be monitored, reported and verified, with an estimation of costs as described for input in Table 6-2 and Box 6-6. As a result, the technology can then be available to investors for deployment and diffusion.

6.2.2. Identify measures to accelerate technology development and transfer

During the discussions to describe the existing system for an individual technology people will have developed an understanding of where the bottlenecks are. It will also have become clear that an understanding has developed of which improvements can be made. New insights can also be gained from viewing the map and examining its flows and bottlenecks. From this, measures to improve the system can be identified and catalogued.

To structure the discussions and categorize technology acceleration measures as building blocks for a national strategy for step 3, it is suggested that the measures are categorized under '**core elements for a national technology innovation strategy'.** An indicative list of core elements, which may be amended by the stakeholder group to suit the circumstances of the country analysis, is provided in Box 6-3.

Box 6 - 3

Core structuring elements of a strategy

Creation of stakeholder networks is an important means of enabling the exchange of ideas and information to ensure dissemination of innovation; and successful implementation of accelerating measures including information dissemination strategies and awareness raising campaigns.

Policies and measures to promote technology transfers may exist in the country but many existing blockages can be solved through implementation and enforcement of new targeted policies and measures, rationalization of existing policies and measures or incentives for new directions.

Organizational/behavioral change is usually outside of a market system but nevertheless important in improving market and non-market functioning. Blockages caused by the way institutions or organizations currently operate may require change management approaches.

Market, system support, and financial services to ensure their proper functioning, and provision of these services is key to efficiency so that there are appropriate systems in place. This can involve financial services, quality assurance systems, consultancy or information services etc.

Skills training and education is a key foundation for development. Planning and investment in this area will be needed in parallel to other measures to provide the skills needed and to ensure training and education needs are met.

International cooperation and IPR issues. In-country networks may not be sufficient for some technology acceleration and international links may be required along with international action. International trade and IPR systems may need to be revised and commitments under other international agreements put into effect.

For each core element the stakeholders will discuss, based on the picture of the technology enabling environment, which measures are needed to accelerate the development and transfer of an individual priority technology. In step 3, these technology specific measures will be aggregated under core elements for the (sub)sector and subsequently for enhanced national action.

For the collection and categorization of measures identified, a spreadsheet will be made available. For each prioritized technology analyzed there will be a worksheet where measures for accelerating the transfer of the prioritized technology can be collated for that technology under the core elements.

Identification of measures required for the enabling framework for an individual prioritized technology can be achieved through the following actions:

Identify measures to support creation of **stakeholder networks** for technology development and transfer

For all stages of innovation, these measures could include:

- identifying and supporting existing social networks for implementation of the technology in the country context,
- creating new networks if required, and
- encouraging development of robust networks over time with more than one hub or coordinating institution.

The stakeholder group can act as a central point or hub for a network, which means that it is the centre of communications between members of the network and can initiate network development and circulate information to all the stakeholders in the network.[38]

Identify actions to **improve policies and measures** for technology development and transfer

For all stages of innovation, accelerating policies and measures can be discussed[39] and checked for completeness.

Monitoring, reporting and verification procedures should be in place in the (sub)sector as part of the process.

Identify measures to **strengthen functioning** of organizations and institutions

For all stages of innovation, the following measures to strengthen functioning of organizations and institutions will be important:

- Identify and support technology champions/key players at all levels (see chapter 5),
- Identify processes and measures to be changed,
- Create new technology champions,
- Identify information and training requirements, and
- Create change through managing the process, allocating resources, developing training programs/guidelines. This applies especially to non-market measures.[40]

Identify measures for strengthening **market, system support and financial services** through quality assurance, availability of consultancy services, market information, financial services, etc.

In particular, for short term technologies at deployment stage in the market, it is important to:

- Discuss financing requirements for the technology and raise awareness on the utilization of capital markets (see Box 6-3).
- Devise a program of measures to familiarize decision makers in the market/system with new technology, build confidence in the technology (similar to the process described in chapter 5).
- Consider measures related to a program for demonstration of technologies.

- Commission and disseminate information to stakeholders.
- Have information and other services within the system for technology adoption for creating a market pull.
- Determine actions in the country for provision of information and financial or other incentives for minimizing investor risks and assisting in assembling sufficient investment capital.[41]
- Raise awareness of alternative schemes for leasing for affordability of the technologies.
- Identify[42] required level of support for technology development thereby possibly distinguishing between international, national and/or regional level measures (for this, use experience from developers in similar situations).
- Consider best practices and experiences with other technologies and sectors.

Medium and long term technology financing requirements are discussed below in Box 6-4.

38. Such a hub can be a starting point for relevant sector and technology network development and is especially important for rural enterprises at the micro and small to medium scale. However, robustness comes with more than one hub. Support for the development of networks and hubs will be necessary
39. It should be ensured that the proposed measures do not act as perverse incentives.
40. Such approaches also usually involve public engagement processes, and it is important to work out a framework for the engagement in advance for eventual funding (as a diverse set of approaches will need to be coordinated for different receptor groups with a range of experiences and cultural backgrounds).
41. Measures to minimize risks for developers through demand driven policies could also include creation of situations for roll out under low-risk conditions for developers through dedicated demonstration pilot scale applications, such as in refugee camps or new estates. Other market pull activities for consideration could include raising the ability to pay for technology services for consumers, and the commercial presence of entities able to deploy the technologies. The financing model to be used for implementation of the technology, whether joint venture, manufacture and operation under license, leasing, micro-finance, grant funding, or incremental funding, will require support to minimize risks for the developer and to ensure affordability. New financing approaches may also be required.
42. This allows for an identification of what measures, at what stage, would work best under which circumstances.

Identify measures for supporting **skills training and education** for technology development and transfer

For technologies at all stages of innovation:

- Anticipate skills required for new technology construction, operation, maintenance and decommissioning; for supply chains, policy and regulatory enforcement, quality control and market and finance, etc.
- Formulate specific recommendations on training and capacity building requirements.
- Compile training program requirements for national or international funding.
- Accelerate research and development measures for non-market technologies/measures, which tend to be diffused and difficult to measure. However, there are successful initiatives.[43] Research can be funded for non-market measures to explore specific current approaches and their effect on other social and economic issues such as gender equality, equity and poverty alleviation.
- Compile information on best practices.[44]

Identify measures for **facilitating international cooperation** and dealing with **intellectual property rights (IPR),** particularly for a more cooperative model **for RD&D**

For technologies at all stages of innovation, address IPR issues, the implications of which could vary across different technologies (Tomlinson, *et al.*, 2008) and affect the particular business model used and measures to facilitate this aspect.

Input to spreadsheets

Input the accelerating measures in the worksheet for the technology concerned in the spreadsheet tool made available for this chapter. In the worksheet, the measures identified above can be collated.

Return to next priority technology under the priority (sub) sector once step 2 has been completed for one technology; repeat the process

Complete Step 2 fully for one highest priority technology in the highest priority (sub)sector in one technology category before returning to the highest priority technology in the next technology category within the (sub)sector.

43. As seen by the adaptation techniques identified by EGTT (2009a).
44. Pilot studies especially on non-market measures can be initiated in countries with an action research agenda built in to obtain maximum benefit from the process.

Box 6 - 4

Financing requirements for technologies and assistance for capital market utilization

Financing for medium term technologies in development stage

Where a technology is important and promising, incentives and support structures may need to be put in place to allow developers access to additional funding to support the pre-commercialization phase. This support can be offered for identifying low-cost routes for supply chains, manufacturing or even subsidizing the technology until economies of scale come into play.

Financing for long term technologies still in RD&D stage

For early stage technologies, continued guaranteed support for development will be needed involving national and international cooperative programs especially on RD&D. Additionally, maintaining diversity in design to cope with future uncertainties and developing robust technology alternatives will be important.

For deployment of short term technologies both at the system and project implementation & demonstration levels, some of the available sources of assistance are listed below.

Selected sources are provided here for general information, and can be passed on through the stakeholder networks and through the specific dissemination and awareness raising measures for deployment acceleration:

1. CTI's Private Financing Advisory Network, which can review the priority actions at a relatively early stage in their identification. Most individuals familiar with the technical aspects of a project are not experts in project financing. This facility helps structure the projects being identified and assists in preparing supporting business plans. [45]
2. A Guidebook for investors on preparing technology transfer projects for financing is available from EGTT (2008).
3. An analysis of financing models and funding sources including the Clean Development Mechanism can be found in EGTT (2009a).

THE OUTPUT IS A LIST OF MEASURES CATEGORIZED UNDER CORE ELEMENTS FOR A STRATEGY TO ACCELERATE THE DEVELOPMENT AND TRANSFER OF PRIORITISED TECHNOLOGIES FOR MITIGATION AND ADAPTATION [46]

45. However, some projects may not conform to current investment criteria but are important for development and low emission/adaptation and these types of technology projects need to be considered under alternative financing arrangements.
46. For cross sectoral technologies, the accelerating measures can either be fed in directly to a national strategy or the measures can be added into the list under the specific (sub)sectors in which the technology is to be applied. As other technologies are analyzed, they are used as input to the spreadsheets for the list of measures ready to be compiled in step 3.

6.3
Step 3

Compile a national strategy and action plan

Why? The measures identified in step 2 as needed for the acceleration of development and transfer of the prioritized technologies can be compiled to form a national strategy for technology transfer and its action plan.

How? By compiling and rationalizing across technologies and (sub)sectors measures for acceleration of innovation of the priority technologies structured under the core elements, a national strategy with its action plan are developed. This allows enabling costs and benefits to be made explicit and allocation decisions to be taken.

Who? National team facilitates the process with the stakeholder group and decision makers.

As explained at the beginning of this chapter, the technologies identified in chapter 5 are prioritised because of their contribution to mitigation and adaptation and realising a country's long term vision on sustainable development. The strategy to be developed in this chapter helps shaping the pathway towards that long term vision. The first two steps in this chapter have provided insight in what measures are needed to accelerate the development and transfer of the prioritised technologies. This section aims at formulating a national strategy for technology development and transfer by suggesting a structured approach to be applied in a participatory setting and which is intended to support the overall political process in the country to eventually decide on and implement the strategy.

6.3.1. Aggregate and rationalize measures identified for technology acceleration

Step 2 has resulted in an overview of measures needed for the acceleration of technology innovation, for technologies in different stages of development. These measures have been grouped under core elements for a strategy and in this step, they will be aggregated from a technology level to a (sub)sector, sector and national level to form a national strategy for technology innovation. The aggregation can be done as follows:

Compile measures

Using the spreadsheet made available for this process in this chapter (see section 6.2), compile measures for technology acceleration identified in step 2 across technologies and (sub)sectors for a national strategy under the core elements and for the innovation stages as indicated in Figure 6-2.

This compilation can be done in a number of ways, for example for specific innovation stages (e.g., diffusion) or mitigation only as discussed below and in Box 6-5.

Check for duplication and rationalize measures at the aggregated (sub)sector, sector or national levels

There will be common measures, which can be rationalized or combined to ensure the lists of accelerating measures are concise and complete.

This rationalization should take place at the (sub)sector aggregation stage and also at the national aggregation stage across the (sub)sectors.

AN EXAMPLE OF OUTPUTS IS GIVEN IN TABLE 6-1 WITH AN EXPLANATION IN BOX 6-5.

TABLE 6-1. AGGREGATION FOR STRATEGY FORMULATION*

Strategic measure	Accelerating innovation RD&D	Accelerating deployment	Accelerating diffusion
Creation of Network			
Measure 1			
Measure 2, etc.			
Policies and measures			
Measure 1			
Measure 2, etc.			
Organizational/behavioral change			
Measure 1, etc.			
Market support actions			
Measure 1			
Measure 2, etc.			
Skills training and education			
Measure 2, etc.			
International cooperation and IPR			
Measure 1			

* This table illustrates a strategy of acceleration measures according to a color code, using the timescale for completion of an action. This enables groupings of actions over the timescale. Here, green refers to measures which need to be started in the short term and carried out within the next 5 years; yellow refers to: measures which can be completed in up to 10 years; blue refers to: longer term measures which can be planned for completion within 15 years from the current date.

Box 6 – 5

Measures for a national strategy to accelerate climate technology development and transfer

The outputs from this analysis provide lists of measures to accelerate technology development and transfer aggregated to compile a national strategy that are brought together in the overview Table 6-1 as shown below for the market and non-market short and medium to long term prioritized technologies for mitigation and adaptation for the priority (sub)sectors. This table[47] illustrates the compilation of all the analyses undertaken for all the prioritized technologies to form a national strategy and action plan.

The entire list of measures are included in the spreadsheet tool which is supplied to support the process of this chapter (see section 6.2). The spreadsheets would allow participants to explore a national strategy with the following components:

- for accelerating diffusion through overcoming barriers and system inefficiencies for short term market and non-market technologies for mitigation and adaptation at the (sub)sector or national level.
- for accelerating deployment of market and non-market short term technologies either at the project, (sub)sector or national level for mitigation and adaptation including modification of technologies to country conditions;
- for accelerating RD&D for medium to long term market and non-market technologies for mitigation and adaptation at the technology, (sub)sector or national level.

Alternatively, the measures can also be grouped in terms of the technology-specific actions.

Exact strategies for implementation will depend on development priorities and resources of the country as well as availability of international support and milestones to be delivered.

What has been generated so far is a list of measures for a national strategy[48] for accelerating the climate technologies.

6.3.2. Prioritize and characterize measures for technology acceleration for a national action plan

The output from the analysis above provides a list of measures for technology acceleration for the technology and innovation stage structured under core elements for a national strategy. Though all the measures are relevant to success, they have to be prioritised based on practical considerations, e.g., existing capacity and resource availability. This step takes such issues into consideration by prioritizing the measures and then characterizing them for an action plan.[49] Suggested actions in this step are:

47. The table as it stands cannot accommodate the complexity of the individual activities under the headings nor the resources required and other details needed for the complete strategy.
48. With these measures the national team can continue with formulating a national strategy with a range of focus, such as:
    - for market and non market technologies for mitigation and/or adaptation,
    - for specific innovation stages of development/deployment/diffusion,
    - for core elements or aggregations of core elements, e.g., capacity building and financing measures,
    - according to urgency of actions, and
    - across all technologies, (sub)sectors and innovation stages and for mitigation and adaptation.

    To give an example, a national strategy and action plan could be developed and specified for technology innovation for: mitigation at the technology diffusion stage with the possibility of picking out measures for individual core elements such as skills and training
49. Depending on resources the remaining measures can be implemented at a later time, but should not be neglected.

Prioritize measures under each core element to be included in action plan for technology acceleration

- Use a simple process of asking the group to allocate (in the spreadsheet) one, two or three stars to the measures they regard as most important for implementation.[50]
- Select prioritized measures for further analysis, which will lead stakeholders to a new worksheet for action plan development for these priority improvement measures. This worksheet will have the structure of Table 6-2 in Box 6-6.

Assess prioritized measures for technology acceleration according to the inputs required for Table 6-2 for an action plan; including estimates of resources.

In the worksheet for action plan development (as part of the spreadsheet support for this chapter), the selected prioritized technology acceleration measures are listed. Stakeholders can indicate for each prioritized technology acceleration measure what needs to be done, who should do it, when, how much it would cost and what are the monitoring, reporting and verification requirements (this is explained in Box 6-6). The stakeholder groups may consider consulting experts from their wider groups (see chapter 2) or other experts to support the assessment of information in this step.

Some measures, e.g., training, will require characterization at the technology level as illustrated in Box 6-6 and Table 6-2 before aggregation to the national level can take place while other measures may be common across technologies and (sub)sectors.

Windmills © SR stock

50. Not all measures will be given priority (e.g., the higher the number of stars the higher the priority) under all key elements.

Characterization of prioritized technology acceleration measures

Table 6-2 shows how the characterization of the measures for accelerating prioritized technologies takes place. The table groups the prioritized measures, for one technology in one (sub)sector and innovation stage, vertically under the core elements of a strategy. Then, horizontally, the priority of the activity and the characterization of these measures under the headings for an implementation action plan are placed. These can be aggregated up as required using the spreadsheets to form a national action plan.

TABLE 6-2. PRIORITIZATION AND CHARACTERIZATION OF TECHNOLOGY ACCELERATION MEASURES

Sector: Agriculture							
Specific Technology and category: Crop rotation system – small and large scale – short term							
Innovation Stage: Deployment – Diffusion							
Measure (grouped under core elements)	Priority	Why is it important?	Who should do it?	How should they do it?	Time scale	Monitoring, reporting and verification for measure	Estimated costs
Formation of networks							
Identification of existing networks	1						
Creation of hubs	2						
Policies and measures							
Demand driven innovation policies	1						
Other core elements as listed, e.g., skills training, etc.							
Measure 1 etc	3						

A rough estimate of resources is required, along with a determination on how to measure progress on the activity in terms of what can be appropriately monitored, verified and reported on, to ensure measures can be modified if they are not progressing, and lessons can be learned and shared. Spreadsheets will be provided to track the process.

Box 6 - 6

The next section considers implementation of the national strategy where the national action plan for innovation is expanded to include the investment costs and benefits of the technologies as estimated in chapter 5. This allows linking back to delivering the priorities for the country and the milestones along the way.

6.3.3. Incorporate technology investment costs and benefits

In this section, information on the potential investment costs of implementing the technology across the (sub)sector, the potential benefits in terms of GHG emission or vulnerability reduction and the development benefits from chapter 5 (Tables 5-3 – 5-6) are combined with the national action plan for acceleration. This provides an overall implementation action plan for a national strategy. The following actions are suggested:

Import and revise technology potentials in (sub)sectors from Tables 5-3 to 5-6

From chapter 5, investment costs and climate benefits for the technologies in the (sub)sectors were calculated on assumptions of how the technology would be brought into the (sub)sector (in Tables 5-3 to 5-6). In addition, Tables 5-3 to 5-6 show the technical potential of a technology within the sector with no consideration of the transfer processes required in the country. These values represent a maximum which could be reached.[51]

Import and revise the overall mitigation or adaptation potential and development benefits for the prioritized technologies from chapter 5

From chapter 5 and Tables 5-3 and 5-4 for the prioritized technologies and cross sectoral technologies, the potential GHG mitigation and development benefits for the technology in the (sub)sector are provided. Similarly, in chapter 5 the equivalent data is available for adaptation potential and development benefits in Tables 5-5 and 5-6.

In both cases, the figures can be refreshed at this stage on the basis of the revised estimate of the technology potential in the (sub)sector. The figures can then be added to the action plan for the particular (sub)sector or national level strategies being explored.

Import and revise technology costs in (sub)sectors in Tables 5-3 to 5-6

From chapter 5, **Tables 5-3 to 5-6,** the total investment costs required for the prioritized technologies for the (sub)sectors can be revised on the basis of the revised estimate of the technology potential in the (sub)sector (i.e. costs per unit of technology times the number of units expected (sub)sector).

The figures can then be added to the action plan for the national level strategy being developed.

51. In step 1 of this chapter, consideration was given to how the technology would be brought into the (sub)sector when setting up milestones and this can be used along with the information from the action plans on the timescales and measures required for acceleration to revise these initial estimates. This can be done in terms of a more realistic assessment of the technical potential of the technologies in the (sub)sectors given the barriers and measures to overcome them in discussion with the group.

Produce a national strategy with combined technology acceleration and implementation action plan, characterized and summarized to provide information on a national level (across short and medium to long term prioritized technologies; and cross-sectoral and non-market technologies for mitigation and adaptation)[52]

Develop the national strategy and action plan by combining:

. The technology implementation cost and benefit data as estimated in chapter 5 at the level of (sub)sectors and as revised based on the analysis in this chapter, with

. The information compiled for the (sub)sectors on how to accelerate development and transfer of technologies for mitigation and adaptation, in terms of (following the headings of Table 6-2 - Box 6-6):

  . why the measures are needed,

  . who should do them,

  . when,

  . how,

  . how much the acceleration measures at the (sub)sector level would cost, and

  . how they could be monitored, reported and verified.

This then allows strategic decisions at the national level to be taken as well as demonstration projects or sector programs developed (see Box 6-7).

Box 6 – 7

Developing projects or sector programs for rapid implementation of prioritized technologies available in the short term

Specific implementation of prioritized technology programs or projects can also be developed from the analyses undertaken. These may initially apply to prioritized technologies for mitigation and adaptation that are available in the short term and would require the following actions:

Identify priority technologies for mitigation and adaptation available in the short term

This information can be taken from the output Tables 5-3 to 5-6 in chapter 5 for the prioritized and cross sectoral technologies

Generate measures needed for accelerating their implementation

Apply step 2 to the deployment stage of innovation and for the diffusion stage to generate enabling frameworks and capacity development measures needed for overcoming barriers to implementing demonstration projects.

The following specific sections could be applied:

a) Section 6.2, Box 6-2, Modification to country conditions,

b) Section 6.2, step 2 with specific attention to the deployment and diffusion stages. In the analysis, consider how the technology could be introduced in the country so that implementation issues addressed are useful for future expansion from the demonstration phase from (sub)sector analysis in chapter 4 and from the Technology Option Page in chapter 5. It is important to ensure alignment with country milestones and objectives.

Box 6 - 7

Generate action plans for the technology/ie	The list of measures for technology acceleration derived from step 2 can be prioritized as in section 6.3.2 above for an action plan for demonstration projects and/or programmes with their resource requirements and other information required for making decisions and implementing the projects (Table 6-2).

6.3.4. Finalize national strategy

From the aggregation of all the information from the analyses in chapters 5 and 6, the stakeholder group can:

Decide on resource allocations for the action plan for an overall national strategy	This decision is guided, among others, by the estimated financial resources required for the key measures in the national strategy and action plan. The outputs from this chapter and chapter 5 will allow countries to explore possible ways forward at the national level.
Appraise capacity needs for technology adoption	Within the measures in the strategy, there are also components related to capacity building at all the technology stages, and these can be combined to provide national requirements for each stage, with costs.
Prepare timeline for technology implementation and acceleration	Using the activity information within the overall strategy structure, or at the (sub)sector/technology strategy level, measures can be grouped in terms of a timeline for action within the next 5, 10 and 15 years. Table 6-3 indicates a possible way of doing this, but other database techniques can also be applied.
Compile monitoring, reporting and verification plan for the implementation and acceleration measures	When launching a strategy at any level, appropriate monitoring, reporting and verification indicators/actions should be put in place so that if the strategy is failing in some way (e.g., implementation or financing reasons), adjustments can be made and lessons learned. Indicators/actions suitable for measures were identified in Table 6-2, and can be combined as appropriate for any level of strategic action. A management plan for this may be required.

52. Separate categories such as mitigation versus adaptation can also be maintained.

Assess risks and uncertainty

The major assumptions on which the strategy has been characterized should be questioned and explored in sensitivity analysis, key defining risks identified, and measures to manage these risks considered.[53]

Revise technology milestones for (sub)sectors from step 1

From the considerations in sections 6.3.3 on the revised technology potentials in the (sub)sectors, and in section 6.3.2 and 6.3.4 for the (sub)sector level,[54] milestones for the technologies generated for the priority (sub)sectors in step 1 can now be revised to be more in line with a realistic assessment of timescales and measures which should be in place to achieve the development and climate benefits through transfer and roll out of priority technologies.

This also applies to the national milestones as this will allow the milestones to be aligned with the action plans for a national technology innovation and implementation strategy.

TABLE 6-3. NATIONAL STRATEGY FOR TECHNOLOGY DEVELOPMENT AND TRANSFER FOR MITIGATION AND ADAPTATION

	0-5 years	5-10 years	10-15 years
Commercially available technologies			
Measure 1			
Measure 2, etc.			
Pre-commercial to market			
Measure 1			
Measure 2, etc.			
Long term technologies			
Measure 1			
Measure 2, etc.			

THE OUTPUT FROM THIS CHAPTER WILL BE A NATIONAL STRATEGY AND ACTION PLAN TO MEET DEVELOPMENT AND CLIMATE OBJECTIVES AND MILESTONES. ADDITIONALLY, AS ILLUSTRATED IN BOX 6-7, PROJECT ACCELERATED TECHNOLOGY TRANSFER PROGRAMS CAN BE GENERATED.

53. Costs and the mitigation or vulnerability reduction potentials can only be estimated at this stage. Therefore, some indication of the uncertainty surrounding the figures should be given. Feedback from initial experiences in implementing technologies will be important in refining these estimates.
54. The measures to accelerate specific technologies within a (sub)sector have been aggregated across the (sub)sector as part of the national strategy. Within the spreadsheets the specific technology acceleration measures for the (sub)sector will be available from the analysis and an action plan can be generated for these measures as in section 6.3.2 above for the technologies in the (sub)sector so that the timescales etc from the action plan and measures required can be directly related to the milestones assigned in step 1 for the (sub)sector to revise the milestones and ensure that the milestones can be achieved.

7

Synthesize technology needs assessment process in a report

SUMMARY PAGE FOR THE CHAPTER

The aim of reporting the results of a technology needs assessment is to summarize the outputs of the process in a coherent, policy-relevant document.

Main outputs

The main output of this chapter is a report on the results of a technology needs assessment combining all the outputs from each of the chapters.

Structure of the Report

Executive summary

Main Report

1. Technology needs assessment process overview
2. Identification of development priorities for the country (based on chapter 3)
3. Identification of key (sub)sectors for low emission and low vulnerability development (based on chapter 4)
4. Prioritization of technologies for low emission and low vulnerability development (based on chapter 5)
5. Preparation of strategy and action plan for prioritized technologies (based on chapter 6)
6. Final conclusions and recommendations

Annex: audit trails from using multi criteria decision analysis in TNAssess in chapters 4 and 5

Who is involved?

The report is prepared by, or under the auspices of, the National Team with feedback from stakeholder groups.

7.1 Aim of a national synthesis report on technology needs assessment

The aim of reporting the results of the technology needs assessment process is to summarize the outputs of the process in a coherent, policy-relevant document that provides a basis for follow-up implementation activities. This national synthesis report should be a well-edited and comprehensive report suitable for presentation to policy makers and members of the international donor community considering technology transfer possibilities.

In order to facilitate country comparisons, the national synthesis report should follow a specific format for which a structure is suggested. An annotated outline of the report structure is provided below, together with suggested page lengths which can be considered minimums.

7.2 Structure of the report

7.2.1. Executive Summary

This would be a standard executive summary following conventional protocols on depth of coverage and length. Its aim is to present the key findings of the assessment without copying and pasting from the main report, and is meant to be digested within no more than 30 minutes. The Executive Summary should provide a sense of "national actions" to move forward. Specifically, the following items should be addressed:

- Overview of development priorities and description of range of possible climate change impacts for the country;
- Justification of the priority (sub)sectors selected;
- Description of the present situation in the prioritized (sub)sectors in terms of GHG emissions (for mitigation) or vulnerability to climate change (for adaptation), as well as technologies in use in the (sub)sectors.
- Discussion of the evaluation criteria used to prioritize technologies for prioritized (sub)sectors;
- A summary of the prioritized technologies, together with a tabular summary of key characteristics on mitigation or adaptation potential, investment costs and benefits as in Tables 5-3 to 5-6;
- A summary of how a national strategy with action plan has been formed on the basis of measures identified for acceleration of the prioritized technologies.

The Executive Summary allows for cross-country comparisons, aggregation, and/or disaggregation based on the information contained in the summary from each of the country synthesis reports. A page length of 2-3 pages is recommended.

7.2.2. Main Report

The main report should be based mainly on the outputs specified within each chapter of the Handbook.

1. Technology needs assessment process overview (3-5 pages)

This section should discuss the process followed by the National Team in undertaking the assessment. It should address the fundamental objectives of the effort and how it is linked with national policy actions in the field of sustainable development and climate change policy making. It should address the process by which stakeholders were identified, recruited, and engaged throughout the process, including a list by stakeholder type (it will be important to be able to show that the process was inclusive), and distinctions between mitigation and adaptation processes (from chapter 2).

Finally, this section should describe the major steps followed in conducting the technology needs assessment process. This need not be in great detail but should make clear that the process was embedded in a multi-stage process, the origins of which were based on guidance provided by identified sources.

2. Identification of development priorities for the country (3-5 pages)

A starting point in the technology needs assessment process is to focus on the country's development context and priorities. This provides a background regarding the sector-specific plans and priorities currently in place in the country and which new technologies for mitigation and adaptation would be introduced. This section, which is based on chapter 3 of this Handbook, describes the long term vision for the country from which a list of development priorities are derived, which are grouped as economic, environmental and social priorities.

This section should also describe the discussion on the short and long term implications of climate change for the country.

3. Identification of key (sub)sectors for low emission and low vulnerability development (3-5 pages)

This section should discuss the prioritization process adopted for prioritizing (sub)sectors, including the criteria used and the output of the assessment made for the identification of priority (sub)sectors. The section should also include a detailed review of the key (sub)sectors themselves, with the discussion focusing on technology-related aspects (e.g., types/vintages of technologies in use, and plans, if any, for bringing specific technologies online) based on the outputs from chapter 4, particularly Table 4-1 and Figure 4-2.

4. Prioritization of technologies for low emission and low vulnerability development (10-15 pages)

This section should be based on the audit trail for the MCDA exercise in chapter 5, defining the criteria used, the value tree, the scores and justification for the scores on the criteria, the weightings derived and their justification, followed by the initial results and subsequent sensitivity analysis, to explore the uncertainties and differences in perspectives and identify robust priority technologies.

The audit trail itself can be annexed to the report.

The section should also include a tabular summary of the priority technologies for each of the categories, with the total GHG reduction/adaptation potential for prioritized technologies in the sector, and total investment costs and benefits from the MCDA exercise, as in the Tables 5-3 to 5-6 for mitigation and adaptation.

5. Preparation of strategy and action plan for prioritized technologies (8-10 pages)

In this section the process in chapter 6 is described by explaining how, as a starting point, stakeholder groups refresh the development priorities for the country identified in chapter 3 in order to formulate intermediate (sub)sector and technology targets ("milestones"). Subsequently, the process of describing the existing enabling environments in the country for acceleration of the prioritized technologies is summarized as well as how measures are identified for improving these environments. The final part of the section describes how these measures have been grouped under core elements, subsequently prioritized and characterized so that they form the basis for a national strategy with action plan for the prioritized technologies.

The section should also contain, where applicable, a description of the technology projects and/or (sub)sector programs formulated in chapter 6.

6. Final conclusions & recommendations (1-2 pages)

This section should be brief and highlight the main conclusions and recommendations of the assessment. A page length of 1-2 pages is recommended.

Annex – Audit trails

When the National Team and stakeholder groups use TNAssess for discussing development priorities, identifying key sectors for realizing a long term vision, and prioritizing technologies within these sectors, an audit trail is automatically generated. This document not only contains all inputs and outputs, but also collects considerations during the discussions and gives an overview of the work flow during the sensitivity analyses.

New Delhi, India, a conical concentrator © UN Photo/John Isaac

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Abbreviations

CBA	Cost-Benefit Analysis
COP	Conference of the Parties
CTI	Climate Technology Initiative
EERE	Energy Efficiency and Renewable Energy
EGTT	Expert Group on Technology Transfer
FAR	Fourth Assessment Report of the IPCC
GEF	Global Environment Facility
GHG	Greenhouse gas
IARU	International Association of Research Universities
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property Rights
LULUCF	Land Use, land use change and forestry
MAC	Marginal abatement cost
MCDA	Multi Criteria decision analysis
MRV	Monitoring, reporting and verification
NAMA	Nationally Appropriate Mitigation Actions
NAPA	National Adaptation Program of Action
NREL	US National Renewable Energy Laboratory
PMCA	Participatory Market Chain Analysis Approach
ppm	parts per million
RD&D	Research, development and demonstration
SBSTA	UNFCCC Subsidiary Body for Scientific and Technological Advice
SBI	UNFCCC Subsidiary Body for Implementation
SD	Sustainable Development
SME	Small and medium scale enterprises
TNA	Technology needs assessments
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change

Annexes

Annexes

Handbook for Conducting Technology Needs Assessment for Climate Change

Table of Contents:

Annex 1

Stakeholder engagement resources

Public participation is defined as: "forums for exchange that are organized for the purpose of facilitating communication between government, citizens, stakeholders and interest groups, and businesses regarding a specific decision or problem" (Renn et al., 1995). This applies to the process needed to carry out the technology needs assessment. For this process, it is likely that there will be a core group and subgroups to deal with specific issues in depth. The latter groups have links to the core group. These groups should represent a network of technology transfer in the country, and should be maintained after the initial exercise is completed to carry the implementation road map through to an implementation phase.

The following sections only give an indication of some of the resources and techniques that can be used to address problems in a participatory decision making process. However, it should provide a basic resource for following up on key aspects of these processes.

A. Identification of relevant stakeholders for technology needs assessment

Stakeholder analysis is the usual first step to identify the people who will take the project forward, and it involves defining the groups/sectors from which stakeholders will be selected as a representative group of people for the decision process. It is important to be clear that robust processes and outcomes are to be produced; representation of the perspectives of those involved in and affected by a decision is required.

The following links provide information on stakeholder analysis and other tools for selecting a group appropriate for the problem:

- The Overseas Development Institute in the UK provides a range of tools at **http://www.odi.org.uk/RAPID/Tools/Toolkits/Communication/Stakeholder_analysis.html,** and also refers to the following additional resources: **http://www.stsc.hill.af.mil/crosstalk/2000/12/smith.html**

- A guidance note by the UK Department for International Development (DFID) on how to do stakeholder analysis of aid projects and programs can be found at:

  http://www.euforic.org/gb/stake1.htm
  http://www.scu.edu.au/schools/gcm/ar/arp/stake.html
  http://www.scenarioplus.org.uk/stakeholders/stakeholders_template.doc

B. Participatory processes for eliciting knowledge

It is important to plan stakeholder meetings to maximize their usefulness and maintain engagement of participants. The objective(s) of the meeting must be clear and a plan for eliciting and structuring views is essential to ensure efficient use of time. The coordinators can either facilitate the meetings themselves or bring in an independent facilitator to help in the process. An audit trail of what was discussed and reasons for the basis of any decisions should always be written up after each event and circulated for feedback.

The list below indicates a few of the approaches which have proved useful, although the choice of approach depends on the problem and the people involved.

1. Market mapping

This technique is particularly relevant to technology transfer and it has been applied in ENTTRANS (2008). It allows an exploration of the chain of market actors for the technology and the surrounding enabling business environment (in terms of policies and regulations, etc.) and the activities which support the market (e.g., professional consultancies, information exchanges, quality control standards, research and development, etc.). It therefore provides a detailed exploration for each technology of what the system problems are in terms of its transfer and integration into the country, using information from the stakeholder groups. It was developed by Albu and Griffith (2005) in a developing-country context for extending the sustainable livelihood approach to markets for rural farmers.

2. Use for workshops and focused meetings

World Café provides a very good set of methodologies to promote focused dialogue. According to the website **http://www.theworldcafecommunity.net**, "World Café is an innovative yet simple methodology for hosting conversations about questions that matter. These conversations link and build on each other as people move between groups, cross-pollinate ideas, and discover new insights into the questions or issues that are most important in their life, work, or community. The integrated design principles provide creative ways to foster dialogue in which the goal is thinking together and creating actionable knowledge."

The Involve website also provides information on "Promoting public involvement" at
http://www.invo.org.uk/Workshop_Reports.asp

3. Cognitive mapping

This helps structure a problem and to create solutions. At its simplest, it allows participants to explore a particular question by writing down their ideas on "post it" notes or something similar. Then everyone in turn places these on a board illustrating what the idea is and why. The group is then asked to cluster the notes into themes which can then be further explored. Different approaches can be found at **http://intraspec.ca/cogmap.php**, and a relatively complex approach is available at **http://www.banxia.com/dexplore/pdf/GettingStartedWithCogMapping.pdf**

4. "H Form" and action planning

This approach is a powerful way of investigating an issue through exploring a core question (e.g., how well does low emission technology transfer function in this country?). Participants can explore what is good about the current system and what is poor, and from that, derive actions to be undertaken to move forward.

The approaches to be used are fully explained in Hunsberger, C. and W. Kenyon (2008), available online at: **http://services.bepress.com/jpd/vol4/iss1/art1**

Other well-known processes include focus groups, citizen panels, brainstorming, etc.

5. Delphi techniques

These were developed initially for forecasting, using expert input into problems, but they can be used in a simplistic form to explore judgments of groups and then compare them, to see where they agree and disagree and why, so that there is convergence on solutions. An introductory description can be found at: **http://en.wikipedia.org/wiki/Delphi_method**

C. Techniques for supporting decision making

There are many methods for supporting a participatory group decision-making process. The approaches listed above, as well as the approach recommended in TNAssess, have the following advantages. They:

- account for different types of knowledge (monetary and non-monetary, quantitative and qualitative data);
- consider seriously the issue of inter-generational equity;
- provide opportunities for learning during the appraisal process;
- ensure transparency of each step of the appraisal process; and
- have a strong element of public and stakeholder engagement.

The main approach being used in the TNA handbook and provided in TNAssess is Multi Criteria Decision Analysis (MCDA), which belongs to a family of approaches known as Multi Criteria Analysis. MCDA with decision conferencing is most useful for complex problems involving multiple and conflicting objectives. It has its foundation in decision theory and therefore, performed properly, can provide a good basis for decision making. MCDA techniques are described and assessed in DETR (2000) at:
http://www.communities.gov.uk/publications/corporate/multicriteriaanalysismanual.

Other techniques, many based on MCDA, have been developed. These variations involve wide participation, and six techniques were recently reviewed in a 2007 report for the Sustainable Development Research Network (SDRN) in the UK. The techniques assessed are Social Multicriteria Evaluation, Three-stage Multicriteria Analysis, Deliberative Monetary Valuation, Multicriteria Mapping, Deliberative Mapping, and Stakeholder Decision/Dialogue Analysis (see Stigl, 2007, **http://sdrnadmin.rechord.com/wp-content/uploads/sdrnemsvareviewfinal.pdf**).

For a detailed explanation of MCDA, see Annex 8.

Annex 2

Example of a technology needs assessment using this Handbook

The purpose of this annex is to illustrate the process in this Handbook through an example of:

- a work plan for a technology needs assessment (A2-1), and
- the deliverables to be expected from the analysis (A2-2). An example of a fully completed technology needs assessment is available in TNAssess.

A2-1. Example of a work plan for a technology needs assessment

Month	Chapter (§)	Activity	Tasks to be performed	Who	Deliverables (as described in A2-2)
1, 2	2	Scope of study Identify stakeholders	Discuss the initial scope of the study Identify stakeholders as in Box 2-2 (Handbook chapter 2) at technology, sector and national level Appoint coordinator to facilitate and manage technology needs assessment	National Team and decision makers	Initial scope of the study (mitigation/adaptation/ projects/strategies) Lists of identified stake-holders who have been contacted and made commitment to contribute Manager assigned or appointed to conduct the analysis with stakeholders
2	2	Convene opening national workshop	Meeting with selected stakeholders Initial work plan and time table	National Team	Introduction to work and main aims of TNA within country with agreed work plan and time table for tasks
2, 3	3	Data collection Identify development priorities under climate change with stakeholders	Collect information about development priorities Organize discussion session with core group Familiarize with TNAssess tool for sectors Input information to TNAssess and cluster development priorities.	National Team and stakeholders	Overview of data available and where further data gathering is required Input to TNAssess After discussions: Clear identification of country's development priorities within TNAssess

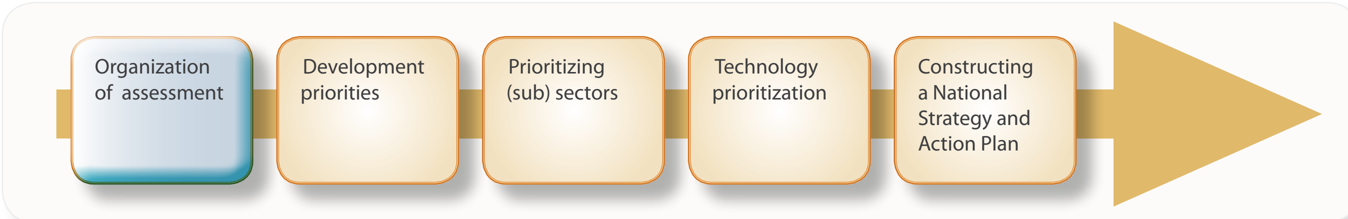
Month	Chapter (§)	Activity	Tasks to be performed	Who	Deliverables (as described in A2-2)
3, 4	4	Identify priority (sub)sectors: - Data collection - Discussion meeting for prioritization	Data collection on GHG emissions and/or adaptation capacity/vulnerability reduction potential Organize and conduct discussion meeting with National Team & stakeholder group using TNAssess	National Team and stakeholders	Ranking assessment of priority of (sub)sectors for mitigation and adaptation and sustainable development
4	5.1	List of technologies for (sub)sectors from TNAssess	Load information from Climate TechWiki into TNAssess starting with highest priority sector	National Team	Preparation of list of technologies starting with highest priority sector. The technologies are categorized into small and large scale and available in the short and medium to long term
4	5.1	Familiarization process for the technologies Input information into Technology option pages of TNAssess	Appoint "champions" from within group for specific technology/ies to familiarize the group through initial presentations Hold expert and technology champion lectures Arrange visits to demonstration projects Input information into TNAssess Technology Option Pages with the stakeholder group and champions	National Team, stakeholders including (sub)sector stakeholders involved in technology prioritization for the (sub) sector	Stakeholders will have become familiar with the full range of technologies and have sufficient knowledge of technologies within the priority (sub)sectors for mitigation or adaptation within the context of the country to carry out further assessment
5	5.1	Discussions to finalize list of technologies	Arrange discussion session	National Team and stakeholders	For each priority (sub) sector, a long list of categorized technologies (for the highest priority (sub)sector first) has been prepared for further assessment
5-7	5.2	Discussion meetings for technology prioritization and sensitivity analysis for robustness	Technology prioritization discussion meetings using TNAssess Not all the portfolios of technologies may need a full TNAssess prioritization	National Team and stakeholders	Portfolios of prioritized technologies have been prepared for each of the four categories of technologies (small/large scale and short/medium availability) for the (sub) sector. Through sensitivity analysis, uncertainties are explored and robust results obtained

Month	Chapter (§)	Activity	Tasks to be performed	Who	Deliverables (as described in A2-2)
8	5.3	Discussion of implications of benefit-to-cost ratios for final agreement on prioritization of technologies	Cost information from technology option pages is incorporated into the analysis to produce benefit (from MCDA) /cost ratios for final decisions Organize discussion meeting Preparation of summary tables for prioritized categorized technologies	National Team and stakeholders	For each portfolio of prioritized technologies per technology category in the priority (sub) sector, final decisions can be agreed for the prioritization of the categorized technologies Summary tables 5-3 to 5-6 are completed *The next priority (sub)sector is analyzed from step 1 of chapter 5 and will benefit from initial experience and avoidance of duplication*
10	6.1	Decision on objectives of analysis, stakeholder groups and type of transfer	Refresh the country's development priorities Generate milestones for (sub) sectors and technologies	National Team and stakeholders	Aspirational milestones established at (sub)sector and national level, as well as at technology level Completed worksheet with prioritized technologies from chapter 5, structured for the analysis in chapter 6
11	6.2	Characterize existing environment for prioritized technologies Explore gap between existing and desired situation Identify measures to close gap Structure into core elements	Organize discussion for system/market mapping. Reveal and explore existing enabling environment for technology development and transfer Identify inefficiencies and bottlenecks in the system Define measures to make system more efficient and accelerate technology development and transfer Structure measures identified from system mapping under core elements for a technology pathway	National Team and stakeholders	Characterization of the enabling environment for each priority technology analyzed through, e.g., a market or system map Initial lists of measures for accelerating technology innovation derived from system mapping structured under core elements
12-13	6.3	Aggregation of measures across sectors to national level Prioritize and characterize measures for technology acceleration for a national action plan	Aggregate measures identified at technology level to sector and national level Prioritize the measures for technology under each core element Assess prioritized measures according to resources needed, timing of implementation, responsibilities, and monitoring and reporting requirements	National Team and stakeholders	Prioritized measures aggregated at sector and national level These measures are characterized using structure of Table 6-2

Month	Chapter (§)	Activity	Tasks to be performed	Who	Deliverables (as described in A2-2)
13	6.3	Incorporate technology investment costs and benefits	Import and revise technology potentials from chapter 5, with technology cost estimates from Tables 5-3 to 5-6 and overall estimated mitigation and adaptation potential Combine this information from chapter 5 with characterized measures for technology accel-eration compiled in chapter 6 to form national strategy	National Team and stakeholders	National strategy with combined technology acceleration and implementation action plan
13-14	6.3	Finalize national strategy	Decide on resource allocations for the action plan Appraise capacity needs for tech- nology adoption Prepare timeline for technology implementation and acceleration Compile monitoring, reporting and verification plan for the implementation of measures for technology acceleration Assess risks and uncertainties Revise technology milestones for (sub)sectors from step 1 in chapter 6	National Team and stakeholders	Where chapter 5 has resulted in prioritized technologies for mitigation and adaptation for achieving the country's long term development objectives, this chapter results in a strategy or strategies to realize those objectives with concrete action plans for successful implementation of the strategy
15	Writing of final report (chapter 7)		Import outputs from TNAssess Use template for final report	National Team (with feedback from stakeholders)	Final report prepared and endorsed

A2-2. Example of the outputs expected from an analysis following the steps outlined in the Handbook and the work plan

Getting organized for a technology needs assessment (chapter 2)



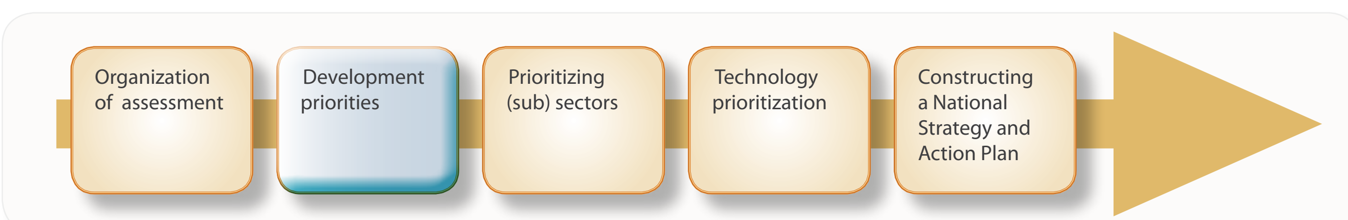
Scope: From the work plan the first task for the decision makers is to scope the assessments to be made. This may be limited to identification of projects for mitigation and /or adaptation for implementation with identification of the barriers and actions to overcome them, and/or may go further to generate activities for accelerating technology transfers to contribute to national or sectoral mitigation and adaptation development strategies.

Identify stakeholders: The National Team will identify stakeholders in mitigation and/or adaptation sectors and expertise and national viewpoints as in Box 2-2 in chapter 2. Stakeholder analysis may be carried out to assist selection (Annex 1). The stakeholders for the analysis would contribute to the assessments and also provide local expertise and knowledge. These can be organized in a variety of ways to ensure good communication with the wider stakeholder communities, such as, for example:

a) a core group of representatives from technologies/sectors/national interests for all discussions and assessments;
b) sets of stakeholder groups for each sector for assessments plus core group of stakeholders for higher level discussions; or
c) a mixture of specific sector expertise added to the core group when required for all discussions and assessments.

Opening national workshop: A meeting organized with the selected stakeholders to introduce the concept and derive feedback on the proposed work plan and main aims with agreement on the time table. Most activities will be participatory with stakeholder involvement.

Identifying development priorities in light of a changing climate (chapter 3)



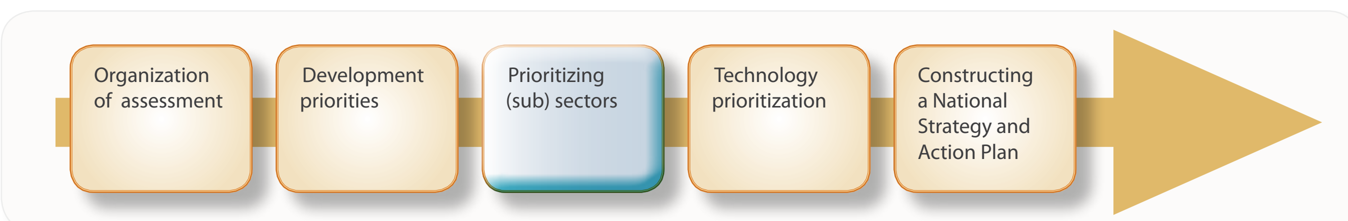
Data collection: Collection of existing information on development priorities and long term views from official documents can be carried out to provide overview.

Identify and cluster development priorities under climate change: Organize discussion session with stakeholders on short and long term implications of climate change on the development priorities, with agreed inputs to TNAssess. Most of this information should already be available. The output of this process is illustrated in Figure A2-1 below. There is no implied priority in the order presented below.

Figure A2-1. Example of development priorities table in TNAssess (corresponds with Table 3-1 in chapter 3)

Environmental Development Priorities	
Reduced air pollution	Pollution due to emissions of particulates, SO_2, etc., in larger cities
Reduced soil degradation	Soil degradation due to unsustainable harvesting
Reduced water pollution	inappropriate cleaning techniques have caused water pollution
Economic Development Priorities	
Increased energy security of supply	Energy demand has increased considerably to capacity limits
Improved employment	This holds for both quantity of jobs and human capital transfer
Affordable energy supply	Energy supply must be available for rural and urban areas
Social Development Priorities	
Improved health conditions	Health problems occur in houses where firewood is used
Strengthened empowerment	Improved access for women to labor markets is stongly needed for cooking and/or heating

Priority (sub)sectors for climate change mitigation and adaptation (chapter 4)

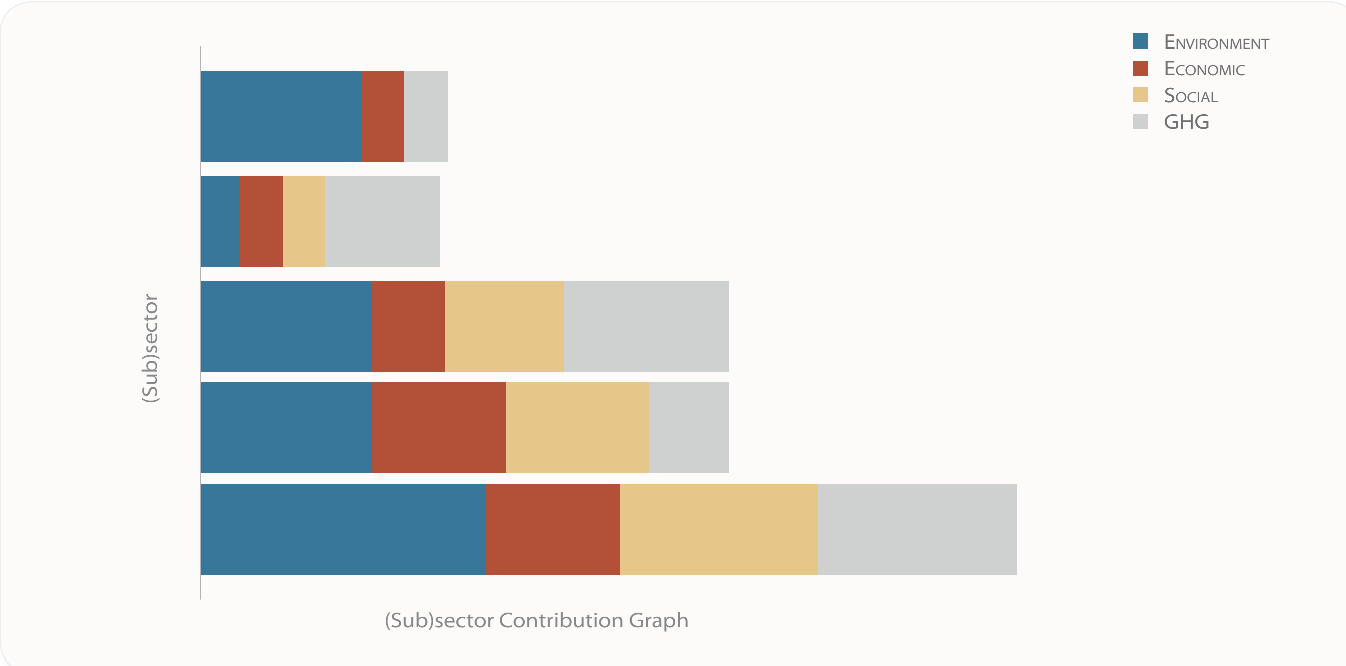


Data collection: Information on GHG emissions or vulnerability reduction potential for (sub)sectors needs to be collected and utilized as input to TNAssess

Discussion meeting for prioritization of (sub)sectors using TNAssess: The data collected is inserted into TNAssess so that stakeholders can identify (sub)sectors that make the largest contribution to GHG emissions in the country or those that are most vulnerable to climate change. Next, with help of TNAssess, it is assessed how improvements in these (sub)sectors would contribute to achieving the country's development priorities. The result is a list of priority (sub)sectors for the country for mitigation and adaptation.

In TNAssess a short cut is available to skip this step in case a country has already identified its priority (sub)sectors in an earlier exercise.

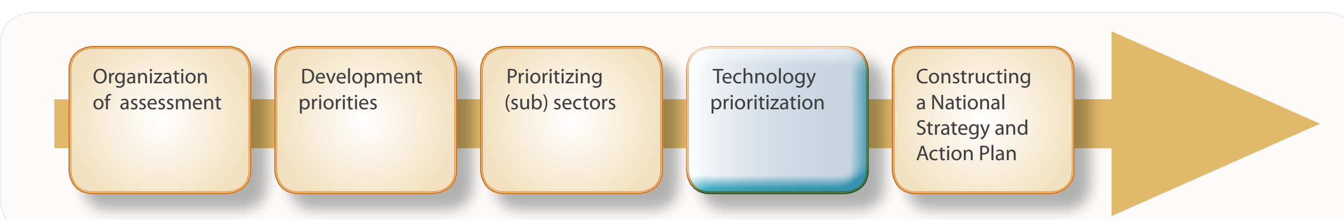
Figure A2-2. Example of a criteria contribution graph (corresponds with Figure 4-2 in chapter 4)



An example of the output from this analysis as produced from TNAssess is shown in Figure A2-2 above. This is a criteria contribution graph showing the overall performance of the (sub)sector by the length of the bar, and the individual contributions of the criteria from the different colors along its length. The longer the bar the more preferred the (sub)sector is. In addition, the graph shows the balance across criteria. Normally, a (sub)sector is more preferred if it scores well across criteria. However, this judgment is context dependent and not always desirable or possible and stakeholders always need to take the final decision on how they rank the (sub)sectors.

Subsequently, for the highest ranked (sub)sector(s) a prioritization of technologies will be performed, such as for example for the sector represented by the lowest bar in Figure A2-2. This is explained below.

Priority technologies for climate change mitigation and adaptation (chapter 5)



Information on relevant technologies in (sub)sector: This information is available from ClimateTechWiki and can be imported to TNAssess through a direct link for the highest priority (sub)sector first. These technologies are already categorized into small or large scale and their availability in short or medium to long term. The categorized lists can be discussed by the group but should not be judged or edited without first ensuring that the stakeholders are well informed about their current status by familiarizing the group with all the technologies.

Familiarization with technologies: This is carried out under the direction of the project coordinator through a range of activities, e.g., by appointing stakeholders as "champions" for the technology with the task of gatherin the information for other stakeholders, and organizing expert lectures where required and group visits to demonstration projects. The proposed technology centers would be invaluable in this process.

Technology option pages: In this part of TNAssess each technology can be described with all the relevant information gathered. The pages are structured so that the information requirements are clear. Much of this information will be obtained easily through the ClimateTechWiki website and its links. This information is the basis for assessments and should be utilized as input by the facilitator or by the champions for the technologies.

Final list of technologies for assessment: At this point, list of the technologies can be edited. Some technologies may be interdependent and should be bundled; others may be missing and can be added. This list should be discussed and agreed with stakeholders in a discussion session. An example is given in Figure A2-3 below. The Figure contains the final list of technologies after discussion and agreement among stakeholders for a priority (sub)sector. The Figure also shows how technologies are categorized by TNAssess in terms of availability in time (short or long term) and scale of application (small or large scale).

The final categorized lists are then assessed in the next step using the TNAssess MCDA-supported approach.

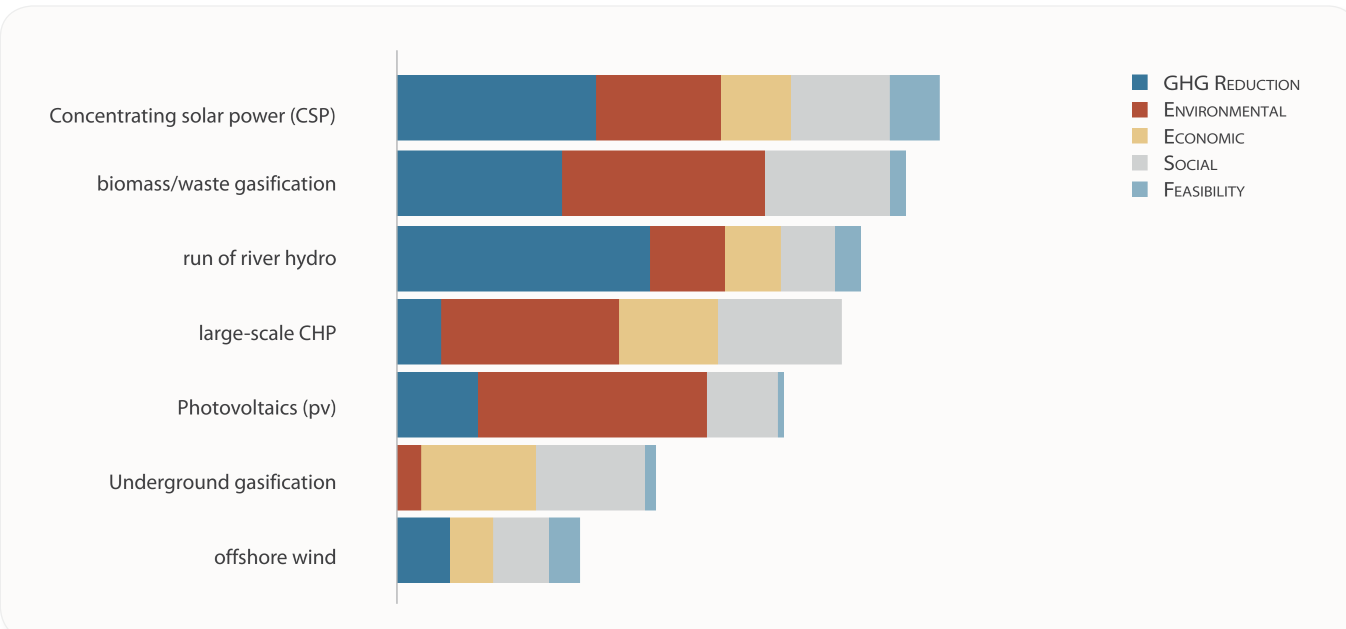
Figure A2-3. Example of long list of technologies for adaptation, identified and categorized for a prioritized subsector (corresponds with Figure 5-2 in chapter 5)

Priority sector		Technology identification		
Sector	**Subsector**	**Technology**	**Scale of application**	**Short-, medium/ long term availability**
AGRICULTURE	FOOD PRODUCTION	SMALL SCALE /SHORT TERM		
		Water saving measures	Small scale	Short term
		Irrigation strategies	Small scale	Short term
		Animal feed changes	Small scale	Short term
		LARGE SCALE/ SHORT TERM		
		Improved drought resistance of crop strains	Large scale	Short term
		Improved animal husbandry practices	Large scale	Short term
		Irrigation and water collection	Large scale	Short term
		LARGE SCALE/ MEDIUM TO LONG TERM		
		Advanced seed varieties	Large scale	Long term
		Land use practices	Large scale	Long term
		Changes in consumer behavior to food	Large scale	Long term
		SMALL SCALE/ MEDIUM TO LONG TERM		
		Changes in location or animal type	Small scale	Long term

Technology prioritization using TNAssess: This should be conducted with the stakeholders in a participatory meeting (as for all steps) for each category of technologies for the (sub)sector using TNAssess which supports and guides the process for eliciting the inputs and performing the analysis. This is fully described in Annex 8 and also in the Handbook. If only a few technologies are relevant, then a full process is not required in TNAssess but technology lists should always be as complete as possible. Justifications have to be made at all stages and an audit trail will be available for the whole process. The technologies are assessed on development and other criteria with a core suggested set provided in TNAssess.

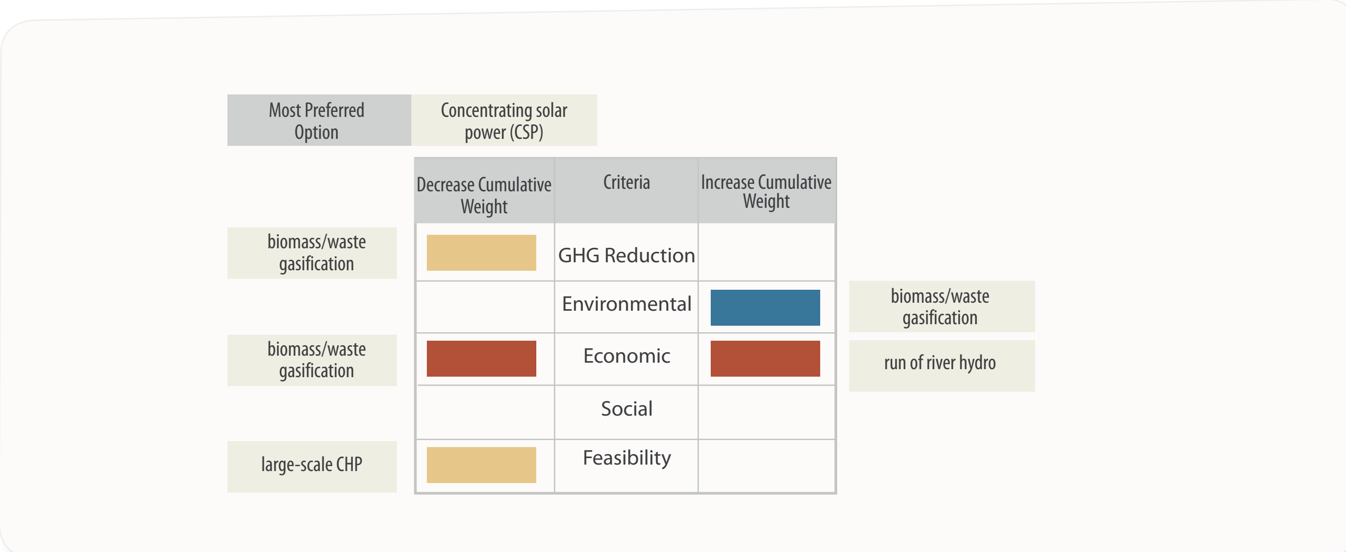
An example of results is given in Figure A2-4. This is the same format as for the (sub)sectors (see Figure A2-2 above) where the length of the bar denotes the most preferred and the contributions from the main criteria can be seen. ***Figure A2-4 shows results for technologies in the category of large scale technologies available in the short term in the (sub)sector energy supply.***

Figure A2-4. Example of criteria contribution graph for technologies in TNAssess



In order to come to an agreed priority order for the technologies, initial results are subsequently subject to sensitivity analysis, as explained below, to test assumptions and the effect of uncertainties in scoring or weighting, as well as by asking "what if" questions. In Figure A2-5 below, ***for the technologies in Figure A2-4***, an example is shown of the impact of changing the weights on criteria on the overall scores of a technology. In this example, it becomes clear that increasing the weight on the "economic benefits" criterion results in a decision to switch from concentrating solar power to run of river hydro. On the other hand, lowering the weight on "economic benefits" results in a shift to biomass/waste gasification. At the same time, the example shows that concentrating solar power is robust to changes in the weight on contribution to social development.

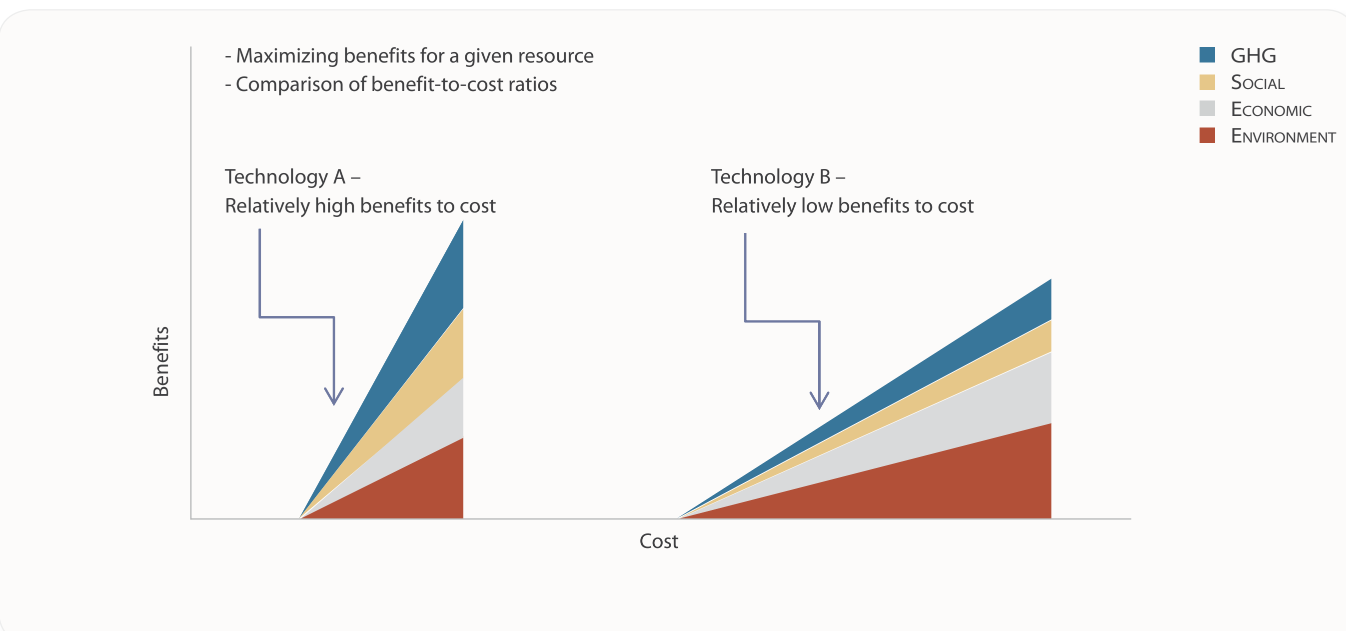
Figure A2-5. Example of sensitivity analysis on weights on criteria for technologies in TNAssess



Final decisions incorporating costs: In participatory stakeholder meetings, the impact of incorporating costs information (from the technology option pages) can be seen through a benefit-to-cost ratio approach using the results from the benefits assessment already performed. This provides the basis for final decisions ensuring that there is efficient use of resources.

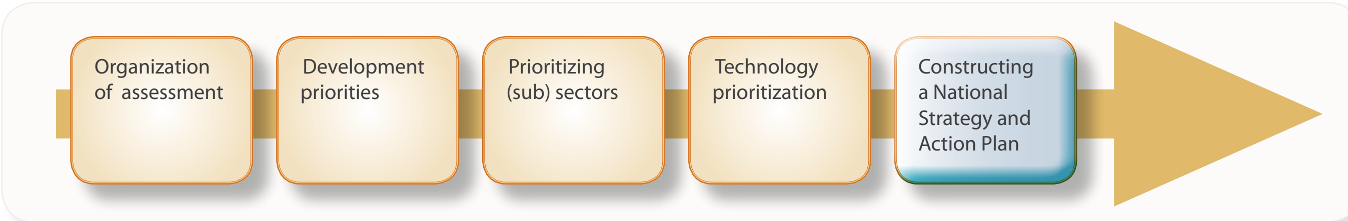
Figure A2-6 below illustrates what benefit-to-cost ratios may look like. A technology with a relatively high benefit-to-cost ratio shows a steep slope, whereas a relatively low benefit-to-cost ratio is illustrated by a flat slope. However, in TNAssess only the ratio will be provided for use during the decision making process.

Figure A2-6. Examples of benefit-to-cost ratios for different technologies



The prioritization process is repeated for each of the categories of technologies in the highest priority (sub)sector depending on the number of technologies to be assessed. The group can then iterate for the other priority (sub)sectors in the list. The process can speed up through avoidance of duplication and experience with the process.

Strategy and capacity development for technology innovation (chapter 6)



This Handbook has identified development priorities for the country in light of a changing climate. These priorities have been used as criteria for selecting strategic (sub)sectors for the long term development of the country and for prioritizing technologies for mitigation and adaptation within those sectors. Therefore, at the end of chapter 5, not only has information been collected on the country's long term development objectives, but this information has been specified with portfolios of technologies needed for realizing these objectives.

However, the process of technology transfer is complex. Each country has specific national institutional structures and social networks of actors (e.g. technology providers and private project developers) who operate under their respective policies and regulations. These actors are supported by a range of market services including quality & assurance practices, R&D, financial services that underpin operation of the system. This chapter therefore focuses on what is needed for successful development and transfer of the technologies and how this can be formulated into a national strategy and action plan.

The country's development priorities identified in chapter 3 are used as the starting point for the analysis in this chapter. These are revisited and refreshed to ensure that the objectives of the analysis are clear. Aspirational intermediate milestones can then be generated at the (sub)sector and technology levels to reach those priorities. A national strategy is then compiled through a process of analysing how the development and transfer of prioritised technologies can be accelerated to meet these milestones

The analysis is based on the prioritized technologies from chapter 5 by exploring the gap between existing and desired systems for successful technology implementation to support achievement of the milestones. This is followed by identification of measures to close the gap, such as measures to remove barriers and system inefficiencies. In this process, a distinction is made between technologies in different stages of development, such as research and development, deployment and diffusion. These measures for acceleration of innovation of the priority technologies are structured under core elements of capacity development and enabling frameworks, which function as key building blocks for the strategy.

Bringing these measures together across technologies, (sub)sectors and sectors, helps the country formulate a national strategy for the short, medium and long term. The implementation of the strategy is supported by an action plan in which factors are specified such as: estimated resources, allocation of responsibilities, requirements for monitoring and verification of the measures, and envisaged timeline for each activity. Some measures will require characterization at the technology level as illustrated in Figure A2-7 and then aggregated to the national level while others may be common across technologies and (sub)sectors. The strategy can have a range of focus, e.g., strategies for adaptation or mitigation or both or for stage of innovation, etc. All relevant information for these strategies is collected from the analysis in this chapter using spreadsheet support (see Figure A2-8 below).

In addition to a national strategy, the process of this chapter could lead to a pathway for implementing technologies as demonstration projects. For such projects, stakeholders can follow the same process of characterizing the existing system for the technology and exploring what is needed to overcome barriers for successful implementation.

Finally, the aspirational milestones for the technologies set at the start of the exercise can be revised to derive final milestones for the national strategy to reach the development and climate goals. This can be done in the light of the analysis and action plan information on costs, benefits and timelines for acceleration of innovation through the country system.

Figure A2-7. Table for preparing action plans for technology acceleration activities (corresponds with Table 6-2 of chapter 6)

Sector: Agriculture							
Specific Technology and category: Crop rotation system – small and large scale – short term							
Innovation stage: Deployment – Diffusion							
Measure (grouped under core elements)	Priority	Why is it important?	Who should do it?	How should they do it?	Time scale	Monitoring, reporting and verification for acceleration measures	Estimated costs
Formation of networks							
Identification of existing networks	1						
Creation of hubs	2						
Policies and measures							
Demand driven innovation policies	1						
Other core elements as listed eg. skills training etc.							
Measure 1 etc	3						

Final report (chapter 7)

Compile final report: This can be done from the data gathered during the exercise and the analysis which can be made available from TNAssess including the audit trail using the template suggested in the Handbook.

Figure A2-8. Format for compiling accelerating strategies (corresponds with Table 6-1 of chapter 6)

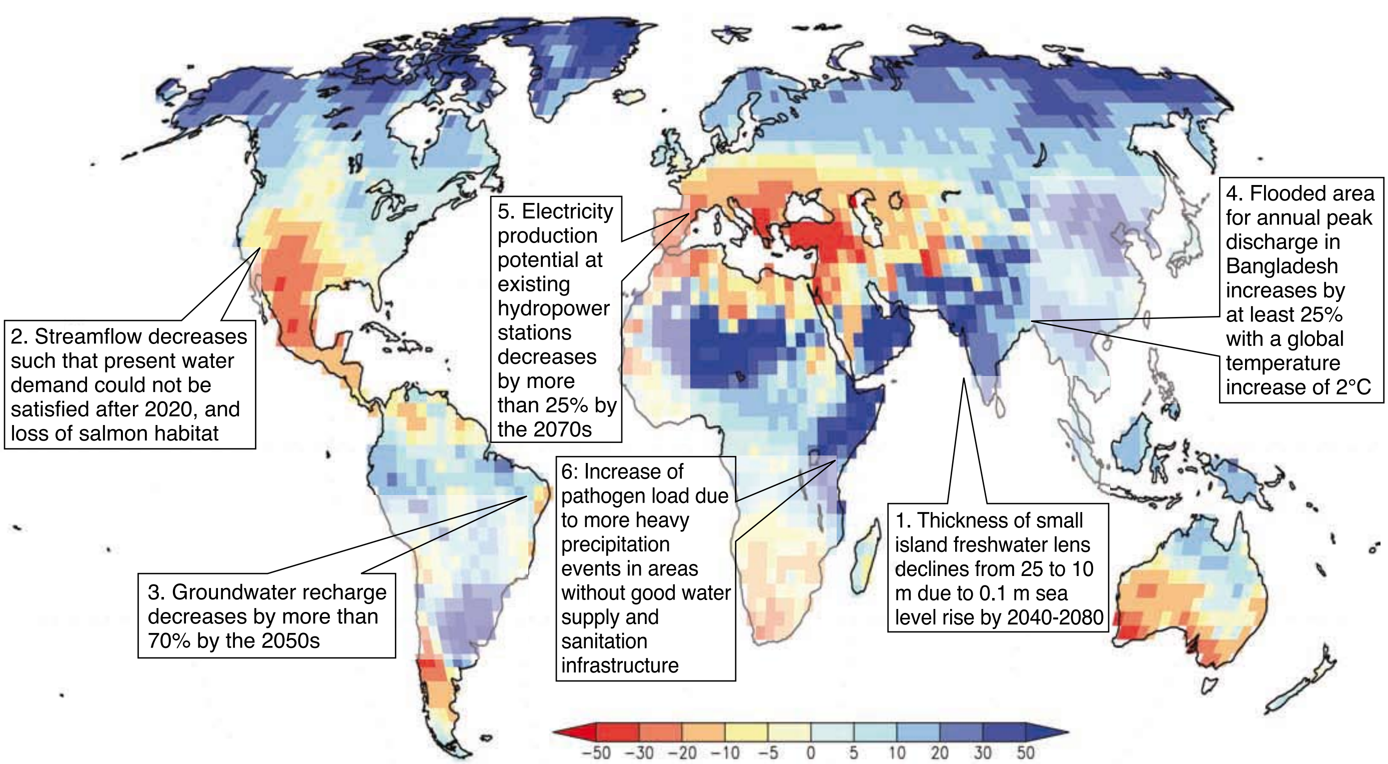
Strategic measure	Accelerating innovation R&D	Accelerating deployment	Accelerating diffusion
Formation of network			
Measure 1			
Measure 2, etc.			
Policies and measures			
Measure 1			
Measure 2, etc.			
Organizational/behavioral change			
Measure 1, etc.			
Market support actions			
Measure 1			
Measure 2, etc.			
Financing measures			
Measure 2, etc.			
Skills training and education			
Other accelerating measures			
Measure 1			

Annex 3

Climate change impacts and sustainable development

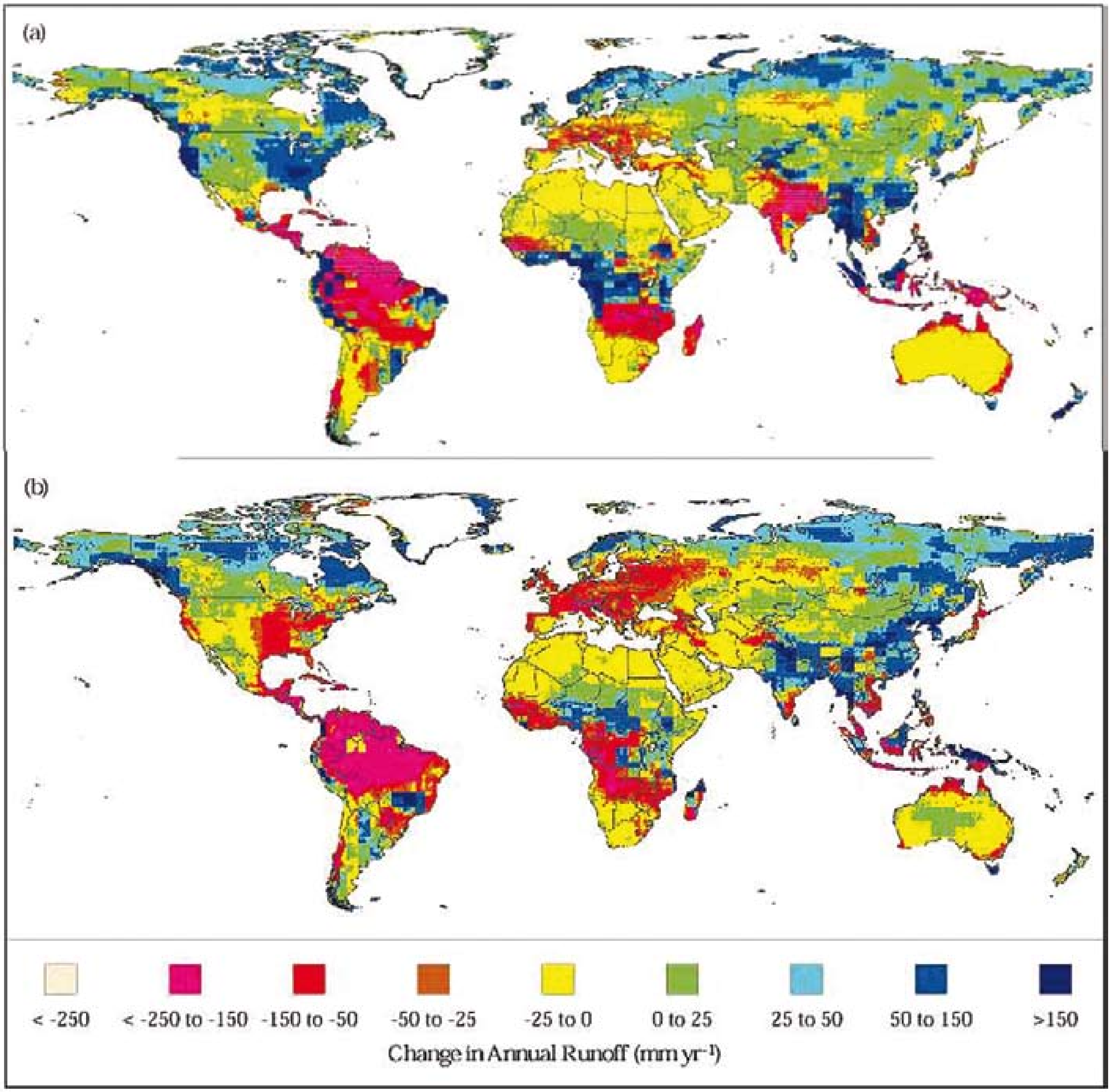
The IPCC Fourth Assessment Report for Working Group II (Kundzewicz, et al., 2007) highlighted the range of effects that climate change could have on a nation's ability to attain sustainable development. This is presented in Figure A3-1 below.

Figure A3-1. Range of effects of climate change on nations' ability to attain sustainable development
Source: Kundzewicz, et al., 2007.



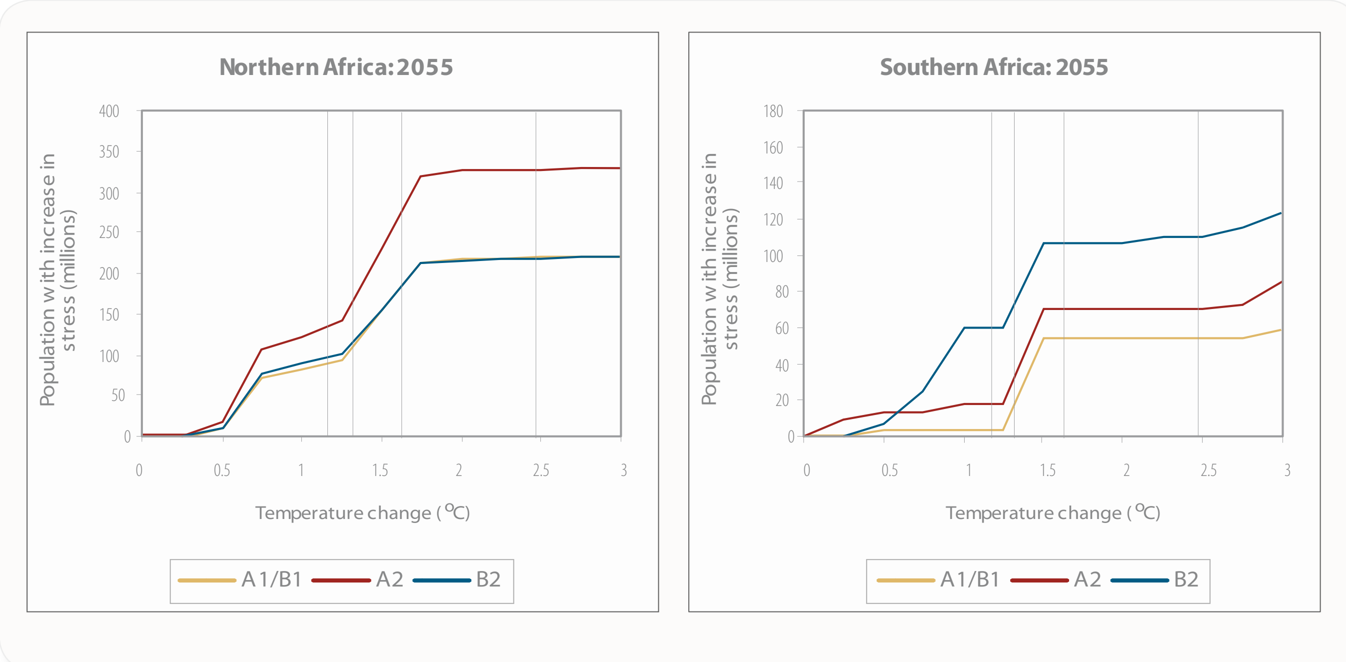
Looking specifically at the problem of water, the IPCC Fourth Assessment Report produced figures for water runoff, which indicate the severity of some of the changes expected. This work did not use the worst-case scenarios for emissions (see Figure A3-2).

Figure A3-2. Projected changes in average annual water runoff by 2050 (compared to 1960-1990)
Source: http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/figspm-3.htm



Some regional estimates of impacts have also been reported in IPCC (2007a), for Africa, Asia, South America, Small Island States and other regions. Figure A3-3 shows the number of people affected by the increases in water stress predicted in Africa. However, as the map above shows, these effects will apply not just to Africa, but also to many other developed and developing countries.

Figure A3-3. Number of people (millions) living in watersheds exposed to an increase in water stress, compared to 1961–1990
Source: Arnell, 2006[1]



Coastal effects are also of concern, with sea level rise projected to be higher and faster than predicted in IPCC (2007), according to more recent observations. The IPCC Fourth Assessment Report provides this risk map on the vulnerability of coastal deltas.

Figure A3-4. Relative vulnerability of coastal deltas as indicated by the indicative population potentially displaced by current sea-level trends to 2050 (Extreme > 1 million; high 1 million to 50,000; medium 50,000 to 5,000)
Source: Nicholss, et al., 2007.

1 Populations are exposed to an increase in water stress when runoff is reduced significantly due to climate change (i.e., below 1,000 m³/capita/year). The red, green and blue lines relate to different population projections. Projected hydrological changes vary substantially between different climate models in some regions. The steps in the function occur as more watersheds experience a significant decrease in runoff (IPCC, 2007, WGII Figure 9.3).

Annex 4

Identification of sectors and (sub)sectors for mitigation and adaptation

In chapter 4 of the Handbook, the stakeholder groups prepare an initial overview of (sub)sectors for mitigation and adaptation measures in the country. This initial assessment should involve the collection of existing data and information. It does not necessarily involve research to collect new data and information; in fact, this should be avoided because of cost implications.

Sectors and (sub)sectors for mitigation

Countries differ with respect to how various sectors are defined. For this chapter, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) is recommended for use as a starting point. These guidelines take as main sector categories: energy supply and consumption; industry; agriculture, forestry, and land use; waste; and other. Within these sector categories are divisions, which are further divided into subsectors. Table A4-1 below shows the first two levels of sector, then divisions and examples of subsectors; the full overview of sector and (sub)sectors is found in TNAssess.

It is noted that the 2006 IPCC Guidelines have been modified for the purpose of this Handbook as the guidelines are particularly meant to help countries identify GHG emission sources and calculate emissions, whereas this Handbook aims at identification of mitigation options in sectors/subsectors, such as renewable energy options. These are illustrated in Table A4-1. Also, whereas the 2006 IPCC Guidelines treat energy-related GHG emissions in industry sectors differently compared to process-related emissions (i.e., the former are included under "energy" and the latter under "industry"), this Handbook considers all technology options in industrial sectors under the category of "industry" as this allows for consideration of different technology options altogether. For example, if chapter 4 only considered industrial energy use as a priority area, then only technologies for energy-related processes would be considered; however, in practice it might be more efficient to combine these with upgrading industrial processes as well.

The advantage of using the IPCC sector identification is that it is based on the generally high relevance of these sectors for mitigation policies.

Obviously, a country's National Team, in consultation with the stakeholder groups, could decide to add some further sectors or subsectors, depending on the importance of the sector and (sub)sectors in terms of GHG emissions within the country context. These might include, for example, services, tourism, and/or government.[1]

1 As an alternative, McKinsey & Company (2009) identifies five main clusters of sectors: power, emission-intensive industries, buildings and appliances, transport, and agriculture and forestry.

TABLE A4-1. SECTORS, DIVISIONS AND (SUB)SECTORS FOR MITIGATION ACCORDING TO 2006 IPCC GUIDELINES (MODIFIED)

Energy supply and consumption (except for industrial sectors)		
	Division	*Examples of subsectors*
	Use of primary energy sources	Energy supply, transport, residential and offices
	Fugitive emissions from fuels in energy production processes	Solid fuels, oil and natural gas
Industry: energy consumption, industrial processes, and product use		
	Division	
	Mineral industry	Cement, lime, glass
	Chemical industry	Ammonia, nitric acid and adipic acid production
	Metal industry	Iron and steel, aluminium production
	Non-energy products from fuels and solvent use	
	Electronics industry	Integrated circuit or semiconductor, photovoltaics)
	Product uses as substitutes for ozone depleting substances	Refrigeration and air conditing equipment
	Other product manufacture and use	
	Other	
Agriculture, forestry, land use		
	Division	
	Livestock	Enteric fermentation, manure management
	Fishing	Fish farms, fishing
	Land	Forest land, cropland, grassland, wetlands
	Aggregate sources and non-CO_2 emissions sources on land	Biomass burning, liming
	Agriculture/forestry/land use/ "other products"	Harvested wood
waste	Solid waste disposal, waste water treatment and discharge	
Other		

Sectors and (sub)sectors for adaptation

In this step, the National Team prepares an initial overview of sectors and their (sub)sectors that could provide the most effective actions in terms of adaptation. This overview will contain areas in which improvements would contribute to reducing vulnerability to climate change impacts, and sectors where behavioral change would reduce impacts. This initial assessment should involve the collection of existing data and information. It does not necessarily involve research to collect new data and information; in fact, such exercises should be avoided because of cost implications.

To facilitate this process, it will be important to identify the key sectors and their (sub)sectors. This should be informed by existing vulnerability assessments, if they are available, or by the National Adaptation Programme of Action (NAPA), if one was carried out. Sustainable development plans are also relevant here, and should be reviewed in the light of climate impacts (if this is not already included). National Communications to the UNFCCC will also be relevant to this exercise (see for an overview: **http://unfccc.int/national_reports/non-annex_i_natcom/items/2716.php**).

Possible areas to be identified for adaptation strategies are:

- Health and social systems;
- Agriculture;
- Biodiversity and ecosystems; and
- Production systems and physical infrastructure, including the energy grid.[2]

While this is one possible classification, it is recommended that sectors are first of all identified and characterized.

Subsequently, these areas or sectors could be divided into (sub)sectors. Taking agriculture as an example, this division could be as follows:

- Food production;
- Fisheries;
- Forestry production;
- Carbon storage;
- Bio-fuels.

For adaptation, the areas of interest tend to impact across these sectors in particular ways. For example, for agriculture, projected climate change may mean water shortage and irrigation problems with implications for the location of agriculture, crop yields and livestock. The risk of extreme weather events will be increased, affecting crop production. The fisheries sector will be affected by both ocean acidification and ocean warming, leading to further stress on marine ecosystems already vulnerable from pollution and overfishing. Knock-on effects on human health and biodiversity are clear, and it will be important to account for all the direct changes within a sector or (sub)sectors and the implications for other sectors and (sub)sectors.

2. CEC, 2009.

Annex 5

Screening of (sub)sectors on GHG emissions

The urgency of mitigating GHG emissions means that screening (sub)sectors on the basis of GHG emissions before prioritizing on the basis of development priorities is important to maximize benefits from the investment. In this respect, it is important that the stakeholder group discussions also involve representatives of (sub)sectors that contribute highly to the national GHG emissions. The sector-wise GHG emission data collection and analysis process can be as follows:

- **Review national GHG inventory:** It is important to first review the country's GHG inventory, established as part of the National Communications process, to identify relatively high GHG-emitting (sub)sectors that may have significant mitigation potential, and to identify any data/information gaps. For most countries the above sources are likely to be rather dated; thus, the collection of information on new or emerging mitigation technologies is highly encouraged.

- **Identify key GHG-emitting (sub)sectors:** This step involves an analysis of the interrelationships between emission (sub)sectors to identify potential synergies. For example, mitigation options in the transport (sub) sector can have implications for fuel production and consumption, and associated GHG emissions. Moreover, certain sectors can have important linkages with poverty reduction strategies identified in national Poverty Reduction Strategy Papers.

- **Review plans:** This step involves a review of national and sectoral development plans and policies in the identified (sub)sectors. The aim is to develop an understanding of the expected future growth in GHG emissions, long term mitigation potential, as well as financial constraints that may impact on mitigation initiatives.

A suggested way of limiting the effort in this step could be to list (sub)sectors by taking the (sub)sector with the largest GHG emission share first, followed by the second largest, etc., until a cumulative share of approximately 75% of the country's overall GHG emissions has been reached. This step is supported by *TNAssess*.

Annex 6

Data collection needed for prioritization of (sub)sectors for mitigation and adaptation

Characterizing (sub)sectors - the sustainability "baseline" for mitigation activities

In order to prioritize (sub)sectors in terms of contribution to sustainable development in the country, in each (sub)sector the "baseline situation" is described, i.e., what is the present status of the (sub)sector? This characterization requires two key information blocks:

1. What are the existing technologies used in the (sub)sectors?

Relevant information related to technologies currently used in the priority mitigation (sub)sectors should be collected and documented. For example, when describing the (sub)sector "electricity supply for urban areas," an inventory of the type, age, and performance characteristics of power stations and distribution network currently operating should be conducted. This description must also cover inefficiencies of the technologies used in the (sub)sector, in order to be able to assess improvements that could be brought by environmentally sound technologies.

2. What impacts do the (sub)sectors have on the country's sustainable development and where could the largest improvements be achieved?

With this question the analysis explores how the (sub)sectors, in the present situation, support the country's development priorities. For each of the high-level key objectives identified in chapter 3 of the Handbook, the present impact of the (sub) sector could be described along the following lines:

- When a high-level key objective concerns **protection of the environment,** the information should provide a qualitative and, to the extent feasible, quantitative description of the (sub)sector's environmental impact in terms of pollution (air, soil, water) and use of natural resources.

- When a high-level key objective concerns **improvements in social structures,** the information should cover the importance of the (sub)sector in terms of employment, health, building of infrastructure, knowledge gathering, empowerment, etc.

- When a high-level key objective concerns **strengthening of the economy and economic structures,** the information should cover, e.g., the importance of the (sub)sector for the country's overall economy or for the economy of a particular region within the country (should the (sub)sector mainly have a local impact) in terms of economic output (e.g., percentage of GDP), import requirements, export opportunities, international capital flows, employment (see also under social impacts).

Some high-level objectives will involve more than one of these areas.

It is worth noting that though this process identifies (sub)sectors with high GHG emissions, this picture only indicates the (sub)sectors with currently high emissions. Since future development may favor other areas, (sub)sectors that are not currently high emitters should be assessed for future plans as well.

This information should be gathered from existing sources and through a participatory process, with the involvement of relevant government departments, e.g., industry and trade; sector representatives, including hands-on managers; NGOs; and relevant industry and community representatives. Some of this information will already be available, but some will need to be gathered or will require input of local knowledge.

Characterizing (sub)sectors - the baseline sustainability situation for adaptation activities

For adaptation, there are two main areas of concern:

- Areas vulnerable to climate change where climate change impacts are expected, and
- Behavioral changes to adapt to climate change.

The preliminary assessment of the current status of (sub)sectors should be carried out by the National Team assisted by the stakeholders. It should focus on those two areas, encompassing (sub)sectors that are considered to be most vulnerable to the impacts of climate change, and (sub)sectors/areas where behavioral change can enhance resilience.

In order to assess how adaptation measures in the (sub)sectors identified will contribute to the country's sustainable development, and which (sub)sectors would provide the strongest sustainable development and resilience benefits, the present status of each (sub)sector is described ("baseline situation"). Key information required should cover the information blocks identified above:

- **(Sub)sector-specific vulnerabilities and technologies/measures in use for adaptation** - Each (sub)sector should be considered in turn and the relevant information related to the vulnerabilities of the systems within the (sub)sector (e.g., the food production chain and the technologies, including non-market technologies such as coping strategies, currently being used in the sectors) should be collected and documented. This aspect of the assessment is particularly dependent on the stakeholder group for local knowledge. For example, when describing the food production (sub)sector, an inventory of the crop and animal production types, land use practices, irrigation practices and dependencies, energy requirements, inputs, (e.g., animal feed, locations and soil conditions, etc.), should be conducted. This description should identify clearly where the vulnerabilities of the (sub)sectors lie, together with an indication of how to improve resilience, either through hard or soft technologies. This assessment is inevitably based on a range of possible futures approach, projecting the types and extent of climate change impacts, and the rate of change, as well as where it is likely to impact, as discussed earlier.

- **Adaptive capacity of vulnerable (sub)sectors** - Each (sub)sector can then be examined in the light of the above to identify where the effect on some systems will be more serious than others, either due to the presence of a wide range of alternatives or through innate resilience in the systems, or through available adaptive measures and technologies, e.g., alternative crop varieties.

- **Cross-cutting issues and indirect impacts on other (sub)sectors** – Subsequently, cross-cutting issues can be identified which are generally relevant to all sectors, such as impacts on poverty and impacts on poverty alleviation efforts. With these impacts, an indication of the sustainable livelihood situation is obtained, i.e., what are the interrelated influences that affect how people, particularly rural, poor people, create livelihoods for themselves and their households. Much of this will have emerged during the discussions on the specific (sub)sectors, but further consideration can be given to activities which would benefit several (sub)sectors at once. Indirect impacts and vulnerabilities, along with possible adaptation measures, should be discussed by the stakeholder groups to augment and develop the outcomes from the (sub)sector-specific considerations.

- **Indirect sustainable development impacts -** See above under Mitigation).

- **Environmental impacts -** This information includes a qualitative and, to the extent feasible, quantitative description of the (sub)sector's environmental impacts in terms of pollution (air, soil, water), and use of natural resources.

- **Key social impacts -** This information covers the importance of the (sub)sector in terms of employment, health, infrastructure, knowledge gathering, empowerment, etc.

- **Key impacts on economy -** This shows the importance of the (sub)sector for the country's overall economy, or for the economy of a particular region within the country (should the sector mainly have a local impact), in terms of economic output (e.g., percentage of GDP), import requirements, export opportunities, international capital flows, employment (see this also under social impacts), etc.

This information should be gathered from existing sources, in a participatory process that will include the involvement of relevant government departments, e.g., industry and trade, (sub)sector representatives including hands-on managers, NGOs and community representatives. Some of this information will already be available, but some will need to be gathered or will require input of local knowledge. The information can be summarized and collected in TNAssess that shows for each (sub)sector what the direct vulnerabilities are, any existing coping strategies or technologies, adaptive capacity in terms of resilience of the existing system, and indirect effects, as well as an indication of the measures which could be applied. This can be done, if necessary, for a range of futures on possible climate changes.

This process of identifying key vulnerable (sub)sectors will also involve extensive stakeholder consultations within each (sub) sector. This assessment is inevitably fraught with unknowns about the true extent and types of climate change impacts to be expected, as discussed in Annex 3. It will therefore be important to recognize the need for improving adaptive capacities in the relevant (sub)sectors and where possible have performed a vulnerability assessment, as described in chapter 3.

This is not intended to be a long or complex task but rather a broad overview of the adaptation services which will need to be provided.

Annex 7

Technology options for mitigation and adaptation

Technologies for mitigation

Table A7-1 provides a list of technologies which are arranged first in terms of energy service, then renewables/ fossil/energy saving, etc. The list also indicates whether technologies are small ("S") or large ("L") scale, and available in the short, medium or long term.[1] Technology descriptions are included to clarify the particular form of the technology. For those technologies which may apply to more than one energy service, these are duplicated in the list to make sure they are not omitted.

By applicability of a technology in the short term is meant that it has proven to be a reliable, commercial technology in a similar market environment. The technologies in the medium term would be pre-commercial in that given market context (5 years to full market availability) and a long term technology would still be in an R&D phase or a prototype. Small scale technologies are applied at the household and/or community level, which could be scaled up into a program. For the sake of simplicity, all technologies applied on a scale larger than household or community level are considered large scale technologies.

TABLE A7-1. INDICATIVE LIST OF TECHNOLOGIES FOR MITIGATION

Energy service	Category	Technology	Small/ large scale	Short, medium to long term potential
ELECTRICITY PRODUCTION	RENEWABLE	Micro-cogeneration systems for heat and power (1 kw, could be based on green gas)	S	Short
		Ocean, wave and tidal energy	S-L	Medium
		Energy towers	L	Long
		Wind turbines (onshore, offshore)	S-L (on) and L (off)	Short (on), short to medium (off)
		Geothermal electricity production	L	Short

1 The terms short, medium, and long term are context-specific. A technology that is fully commercial in some markets may not be a commercially viable technology in another country or market. For example, utility-scale wind power is a demonstrated commercial technology, but in smaller, isolated markets (even where there is a good resource) the technology may not be truly "commercial." Therefore, the short, medium, and long term applicability has to be defined specifically for each country.

ELECTRICITY PRODUCTION	RENEWABLE, CONT.	Biomass – dedicated, co-firing, integrated gasification combined cycle lied	L	Short to medium
		Biomass combined heat and power	S-L	Short
		Green gas (biogas from biomass purified to give calorific value = natural gas) for heat and power	L	Medium
		Solar Thermal – CSP; Central Receiver tower, parabolic trough collector and dish	S-L	Short to medium
		Solar Photovoltaic - Single Axis Flat Plate, concentrating, BIPV (Building Integrated Photovoltaics), grid-connected, stand-alone	S-L	Short
		Hydro dams for large scale electricity supply	L	Short
		Small scale hydro energy	S	Short
		Run-of-river hydro for large scale electricity supply	L	Short
		Electricity storage for intermittent - enhanced power quality, flywheels	S	Medium to long
		Pumped Storage Hydraulic Turbine Reversible	S-L	Short
		Batteries	S	Short to long
		Hydrogen	S-L	Long
		Solar Ponds (electricity and storage)	S-L	Short to medium
		Biogas from anaerobic digestion	S	Short
		Biomass Gasification	S	Short
	FOSSIL FUEL BASED ENERGY SUPPLY	Conventional natural gas combined cycle	L	Short
		Micro generation combined heat and power	S	Short
		Advanced natural gas combined cycle	L	Short
		Conventional natural gas combustion turbine	L	Short to medium
		Natural gas combined cycle	L	Medium to long
		Conventional oil combined cycle	L	Short
	RENEWABLE, CONT.	Advanced oil combined cycle	S and L	Short
		Conventional oil combustion turbine	S and L	Short
		Advanced oil combustion turbine	S and L	Short
		Integrated coal gasification combined cycle	L	Long
		Supercritical pulverized coal steam cycle	L	Medium to long
		Ultra-supercritical pulverized coal steam cycle	L	Long
		Coal-mine/ coal-bed methane recovery	L	Short
	RENEWABLE/ FOSSIL FUELS COMBINED	Combined heat and power (distributed energy; CHP in power stations/industry); could be based on, e.g., biogas, natural gas, green gas.	S and L	Short
	FUEL CELLS	Molten Carbonate Fuel Cells	S	Long
		Polymer Electrolyte Membrane (PEM) Fuel Cells	S	Long
		Direct Methanol Fuel Cells	S	Long
		Alkaline Fuel Cells	S	Long
		Phosphoric Acid Fuel Cells	S	Long
		Solid Oxide Fuel Cells	S	Long
		Regenerative fuel cells	S	Long

HEATING FOR DOMESTIC AND INDUSTRIAL USE	FOSSIL FUELS / RENEWABLES	Electric heating: controls, gas conversion	S	Short
HEATING FOR DOMESTIC AND INDUSTRIAL USE	FOSSIL FUELS / RENEWABLES	High-efficiency furnaces and boilers	S	Short
HEATING FOR DOMESTIC AND INDUSTRIAL USE	FOSSIL FUELS / RENEWABLES	Micro-cogeneration systems (1 kw; e.g. on natural gas)	S	Short
HEATING FOR DOMESTIC AND INDUSTRIAL USE	FOSSIL FUELS / RENEWABLES	Condensing boilers for space heating and domestic hot water	S	Short
HEATING FOR DOMESTIC AND INDUSTRIAL USE	FOSSIL FUELS / RENEWABLES	Combined heat and power (domestic distributed energy; CHP in power stations/industry), e.g., on biogas, natural gas, green gas, solar, wind	S and L	Short
HEATING FOR DOMESTIC AND INDUSTRIAL USE	RENEWABLE TECHNOLOGY	Solar thermal flat plate – for hot water, hot air, cooling; for domestic (small scale) and industrial use (large scale)	S and L	Short to medium
HEATING FOR DOMESTIC AND INDUSTRIAL USE	RENEWABLE TECHNOLOGY	Energy storage technologies for buildings/industry	S	Long
HEATING FOR DOMESTIC AND INDUSTRIAL USE	RENEWABLE TECHNOLOGY	Heat pumps air or ground or water sourced for industry and residential sectors (also in combination with heating and cooling; hot and cold water underground storage)	S	Short
HEATING FOR DOMESTIC AND INDUSTRIAL USE	RENEWABLE TECHNOLOGY	Biomass heating, wood pellets, district heating	L	Short
HEATING FOR DOMESTIC AND INDUSTRIAL USE	RENEWABLE TECHNOLOGY	Green gas from biomass (caloric value = natural gas) for heat and power (green gas is upgraded from biogas, with a higher methane content; can be connected to natural gas grid) for, e.g., CHP (caloric value < natural gas); not grid-connected	S and L	Short to medium
HEATING FOR DOMESTIC AND INDUSTRIAL USE	RENEWABLE TECHNOLOGY	Heat from tarmac on roads	S and L	Medium to long
HEATING FOR DOMESTIC AND INDUSTRIAL USE	ENERGY SAVING TECHNOLOGY	Ventilation: Air-to-air heat recovery, demand control systems	S	Short
HEATING FOR DOMESTIC AND INDUSTRIAL USE	ENERGY SAVING TECHNOLOGY	Insulation – exterior wall systems	S	Short
HEATING FOR DOMESTIC AND INDUSTRIAL USE	ENERGY SAVING TECHNOLOGY	High efficiency heating, venting, and air conditioning HVAC), free cooling, plants	S	Medium to long
HEATING FOR DOMESTIC AND INDUSTRIAL USE	ENERGY SAVING TECHNOLOGY	Building orientation	S	Short
HEATING FOR DOMESTIC AND INDUSTRIAL USE	ENERGY SAVING TECHNOLOGY	Energy storage technologies	S	Long
HEATING FOR DOMESTIC AND INDUSTRIAL USE	ENERGY SAVING TECHNOLOGY	Air-sealing	S	Medium to long
HEATING FOR DOMESTIC AND INDUSTRIAL USE	ENERGY SAVING TECHNOLOGY	Advanced glazing, triple or membrane technology	S	Short
COOLING - CLIMATE CONTROL	RENEWABLE	Solar thermal – water, flat plate, hot air, cooling; for domestic (small scale) and industrial use (large scale)	S and L	Short to medium
COOLING - CLIMATE CONTROL	RENEWABLE	Heat pump ground air or water sourced (in combination with PV; also in combination with heating and cooling; hot and cold water underground storage)	S	Short
COOLING - CLIMATE CONTROL	ENERGY SAVING	Air-sealing	S	Medium to long
COOLING - CLIMATE CONTROL	ENERGY SAVING	Façade technology: advanced glazing, shading, electro-chemical	S	Short to medium
COOLING - CLIMATE CONTROL	ENERGY SAVING	Insulation – exterior wall systems	S	Short
COOLING - CLIMATE CONTROL	ENERGY SAVING	Ventilation: air-to-air heat recovery, demand control systems	S	Short
COOLING - CLIMATE CONTROL	ENERGY SAVING	High efficiency heating, venting, and air conditioning HVAC), free cooling, plants	S	Medium to long
COOLING - CLIMATE CONTROL	ENERGY SAVING	High efficiency window unit air conditioners	S	Short
COOLING - CLIMATE CONTROL	ENERGY SAVING	Cogeneration in combination with liquid-desiccant systems (for indoor humidity control)	S	Medium to long

HOT WATER IN BUILDINGS	FOSSIL FUELS/ RENEWABLE	High-efficiency furnaces and boilers	S	Short
		Condensing boilers for space heating and domestic hot water	S	Short
	RENEWABLE	Solar thermal – water, flat plate, hot air, cooling; for domestic (small scale) and industrial use (large scale)	S and L	Short to medium
		Heat pump air or ground or water sourced (also in combination with heating and cooling; hot and cold water underground storage)	S	Short
LIGHTING	ENERGY SAVING	Compact Fluorescent Light Bulbs and LEDs	S	Short
		Solar lanterns	S	Short
		Light tubes	S	Short
		Smart controls	S	Short
		Day lighting and building design	S	Short
DEMAND-SIDE MANAGEMENT FOR ELECTRICITY	ENERGY SAVING	"Smart" appliances and home automation	S	Short
		Electronic power supplies	S	Short
		Compact Fluorescent Lighting, LED	S	Short
		Solar lanterns	S	Short
		Building automation/ management system optimization, improved enthalpy sensors	S	Medium to long
		High efficiency refrigeration: multi-compressor control	S	Short
		High efficiency PC monitors	S	Short
		High efficiency televisions	S	Short
		Variable Speed Motor Control (VFD)	S	Medium to long
COOKING	ENERGY SAVING	Improved cook stoves	S	Short
	RENEWABLES	Cook stoves on ethanol/methanol	S	Short
		Biomass gasification stoves	S	Short
		Biogas from waste for cooking	S	Short
		Efficient Charcoal production for cooking	S	Short
		Solar cookers	S	Short
	FOSSIL FUEL TECH-NOLOGY	LPG and LNG for household and commercial cooking	S	Short
INDUSTRIAL	ENERGY SAVING	Energy saving in cement industry	L	Short
		Energy saving in agri-food industry	L	Short to medium
		Energy Saving in Chemical Industry	L	Short to medium
		Energy saving in iron and steel industry	L	Short to medium

TRANSPORT	ENERGY SAVING / FUEL SWITCH	Hybrid technology (cars, buses)	S	Short
	ENERGY SAVING	Vehicle add-on technologies (low friction oil, fuel-efficient tires)	S	Short
		Black carbon control technologies (e.g., particulate traps)	S	Short
		Vehicle technology improvements (e.g., aerodynamics)	S	Short to medium
		Freight logistics improvements / geographic information system (GIS)	S	Short
	ENERGY SAVING	Truck stop electrification	S	Short
		Driver information technologies	S	Short
		Efficient diesel engines	S	Short
		Management technologies (traffic signal synchronization, intelligent systems)	S	Medium to long
	FUEL SWITCH	Electric plug-in technology	S	Medium to long
		LNG technology	S	Short to Medium
	FUEL SWITCH/ RENEWABLE	Low carbon alternative fuels (cellulosic ethanol, biodiesel, algae)	S	Short
		Hydrogen	S	Medium to long
	FUEL CELLS	Molten Carbonate Fuel Cells	S	Long term
		Polymer Electrolyte Membrane (PEM) Fuel Cells	S	Long term
		Direct Methanol Fuel Cells	S	Long term
		Alkaline Fuel Cells	S	Long term
		Phosphoric Acid Fuel Cells	S	Long term
		Solid Oxide Fuel Cells	S	Long term
		Regenerative fuel cells	S	Long term
	MODAL SHIFT	Mass rapid transit systems (road or rail-based)	S	Short term
		Non-motorized transport infrastructure	S	Short term
		Freight modal shift: road to rail or water-borne	S	Medium to long
	DEMAND MANAGE-MENT	Electronic road pricing technology	S	Short to medium
		Urban planning (mixed use and high density)	S	Medium to long
CO_2 CAPTURE AND STORAGE	CO_2 CAPTURE	Chemical absorption with monoethanolamine	L	Medium to long
		Oxygen-firing	L	Medium to long
		Integrated coal gasification combined cycle – with CO_2 sequestration	L	Medium to long
		Biochar (gasification of biomass through pyrolysis and mixing of residue with the soil)	S-L	Medium

SUBSTITUTION OF OZONE DEPLETING SUBSTANCES	REPLACEMENT OF OZONE DEPLETING SUBSTANCES WITH LOW-GWP ALTERNATIVES	Hydrocarbons	S	Short to medium
		Oxygenated hydrocarbons	S	Short to medium
		Carbon Dioxide	S	Short to medium
		Unsaturated HFCs (HFOs)	S	Short to medium
		Hydrofluoroethers	S	Short to medium
		Ammonia	S	Short to medium
AGRICULTURE	RENEWABLE	Improving energy capture from corn and biomass heat	S and L	Short to medium
		Bagasse CHP	S and L	Short
	ENERGY SAVING	Urban agriculture, community gardens, green roofs	S and L	Short to medium
	ENERGY EFFICIENCY	Improvements to Increase Water Conservation	S	Short
		Nutrient Management	S	Short
	CARBON SEQUESTRATION	Soil carbon management	S and L	Short
	ENERGY EFFICIENCY/ RENEWABLE	Manure management and utilization	S	Short

FORESTRY		Improved Mill Waste Recovery	S and L	Short
	RENEWABLES (IF SUSTAINABLE AND FOR ENERGY)	Improved Logging Residue Recovery	S and L	Short
	FOREST CONSERVATION	Silviculture Improvements	S and L	Short
	ENERGY EFFICIENCY	Other mill efficiency improvement technologies	S and L	Short
WASTE MANAGEMENT	RENEWABLE TECHNOLOGY	Landfill methane recovery and use for heat and power	L	Short
		Municipal solid waste combustion for district heating or electricity	L	Short
		Municipal Solid waste gasification for large scale electricity or heat	L	Short to medium term
		Digesters for biogas and turbines or engines	S and L	Short
		Recycled bio-oils	S and L	Long
	ENERGY EFFICIENCY	Advanced municipal solid waste management practices (including promotion of bioreactor technology)	S and L	Short to medium term
		Source reduction strategies	S and L	Short
		Resource management contracting	S and L	Short
		Enhanced management of organic waste	S and L	Short
		Improved commercialization of biomass conversion technologies	L	Short
		Waste water treatment plant biosolids for energy production	S and L	Short to medium
	WATER	Waste water management/ metering	S to L	Short
		Grey water use	S to L	Short
		Lower consumption and waste production/ efficient appliances	S to L	Short

	MANAGEMENT OF OZONE DEPLETING SUBSTANCES IN PRODUCTS AND EQUIPMENT AT END-OF-LIFE	Domestic Appliances	S to L	Short
		Refrigerant in commercial equipment	S to L	Short to medium
		Refrigerant in stationary air cond.	S to L	Short to medium
		Refrigerant in mobile air conditioning	S to L	Short
		Blowing agent in insulating foams	S to L	Medium to long

Technologies for adaptation

For adaptation, it is more difficult to develop an indicative set of technological options as for mitigation above. This is due to the fact that essentially the boundaries between adaptation and sustainable development are blurred. Another difficulty at present is that the science and technology of adaptation is, in some respects, in an even earlier stage of development than that of mitigation, and there is less operational experience to go on. Moreover, what is required in the context of technologies for adaptation is not just hardware but also behavioral change or other institutional and organizational changes related to improving adaptive capacity. This complexity is compounded by the context-specific nature of appropriate adaptation activities which vary immensely between regions, countries and sectors. Nonetheless, a list of technologies for adaptation is included in EGTT (2009a) and a further list with case studies is available from the Climatetechwiki and through TNAssess.

A sample of adaptation technologies is given in Table A7-2 below. As with the mitigation technologies, it is indicated whether technologies are small ("S") or large ("L") scale and availability in the short or medium to long term.

Table A7-2. Indicative list of technologies for adaptation

Sector / area	Category	Technology	Small/ large scale	Short, medium to long term potential
COASTAL ZONES	COASTAL TOPOGRAPHY AND BATHYMETRY	Mapping & surveying	S-L	Short
		Satellite remote sensing	S-L	Medium to long
		Videography	S-L	Medium to long
		Airborne laser scanning (LIDAR)	S-L	Medium to long
	HARD COASTAL PROTECTION	Dikes, levees, floodwalls	L	Short
		Seawalls, revetments, bulheads	L	Short
		Groines	L	Short
		Detached breakwaters	L	Short
		Floodgates, tidal barriers	S-L	Short
		Saltwater intrusion barriers	S-L	Short
	SOFT COASTAL PROTECTION	Periodic beach nourishment	S-L	Short
		Dune restoration	L	Short
		Wetland restoration		Short
WATER RESOURCES	SUPPLY SIDE	Increase reservoir technology	L	Long
		Desalinization	L	Medium to long
		High efficiency irrigation systems	L	Short
		Alternative system operating rules	S-L	Medium to long
	DEMAND SIDE	Increase "grey-water" use	S-L	Medium to long
		Reduce leakage in distribution systems	S-L	Short
		Non-water-based sanitation	S-L	Short
		Seasonal forecasting	S	Short
		Legally enforceable water standards	S-L	Short
		Demand management	S-L	Short
AGRICULTURE	CROPS	Drought-resistant crop varieties (biotechnology)	S-L	Long
		Improved distribution systems	L	Medium to long
		Crop rotation systems	S-L	Short
		Agricultural research and development	S-L	Long
		Gene technology	S-L	Long
PUBLIC HEALTH	THERMAL STRESS	Reduce heat island effect	S-L	Medium to long
		Air conditioning	S	Short
	VECTOR BORNE	Vaccination programs	S-L	Short
		Impregnated bed nets	S-L	Short
		Sustainable surveillance	S-L	Short
	WATER-BORNE	Genetic/molecular screening of pathogens	S-L	Long
		Improved water treatment (e.g., filters)	S-L	Long

Annex 8

Multi Criteria Decision Analysis using TNAssess

A8.1. Introduction to Multi Criteria Decision Analysis

In this annex an overview of the process of Multi Criteria Decision Analysis (MCDA) is provided before exploring the application of TNAssess to (sub)sector and technology prioritization in the Handbook.

This Handbook uses MCDA for prioritizing (sub)sectors and technologies/adaptation measures because it is the most appropriate approach for evaluation of problems involving multiple stakeholders, and tradeoffs between multiple and conflicting objectives, where assessments can be difficult to quantify and when there is uncertainty. The technique is therefore appropriate to determine to what extent a (sub)sector maximizes GHG reductions and sustainable development priorities. MCDA has been applied to many problems. It is a mature technique grounded in Decision Analysis theory. Below, the MCDA method is described in further detail.

Above all, MCDA allows focused communication on a problem so that different perspectives and experiences can be applied to its solution. It aids structured thinking, generates a shared understanding, allows negotiation within the group and develops a common purpose so that the group can agree on a way forward.

MCDA uses criteria value functions and weightings, which are necessarily subjective concepts, requiring human judgment for their determination. It therefore acknowledges the fact that there is no such thing as an objective decision. These judgments are documented and made explicit and open, and can be subject to public scrutiny. In a cost-benefit analysis, judgments are not made explicit, though many are involved. For example, selecting system boundaries, discount rates, lifetimes and other assumptions in the analysis are less obvious, less public and more technical. MCDA has a clear route from an objective performance measure to a value to a weighted value and to a final result. The route in a cost-benefit assessment from a performance measure (e.g., GHG abatement of a project) to a monetary unit can be opaque (e.g., adding monetary value to human life or biodiversity protection) and may ignore or even attribute arbitrary value to difficult to quantify criteria.

Decision groups and wider stakeholders

MCDA should always be carried out with an independent facilitator (either from within or outside an organization) and by a group of stakeholders (preferably 8–10, but more can be accommodated depending on the decision). This is called decision conferencing, and the process of managing the decision group is a vital part of the whole MCDA exercise. It is described in DETR (2000). Decision conferences can either be a series of targeted meetings with pre-set goals or a single 1- to 3-day conference, depending on the stakeholders, the problem and need for information, etc.

In order to engage a wide group of stakeholders in the process, a communication strategy may have to be worked out in advance. There are several techniques and approaches which can be used for this and these could vary from very complex to much simpler consultation structures. An example of a very elaborate approach can be found in the UK-wide consultation exercise undertaken under the Committee on Radioactive Waste management (see CoRWM, 2006).

For the technology needs assessment process described in this Handbook a relatively simple structure would be required. In this structure, the decision group is formed by a core group of representative stakeholders who are in regular contact with a broader range of stakeholders, either for information dissemination or elicitation of local knowledge, or both. Additionally, sets of stakeholder groups, each specific to the range of interests identified, such as technology assessment for each priority (sub)sector, can be used to perform specific analysis and identify robust options.

MCDA in a technology needs assessment

In order to support the National Team and stakeholders in taking decisions throughout the process of a technology needs assessment, a software tool has been made available, called TNAssess. With this tool, stakeholders can collect and evaluate data for the steps in the process and take decisions on priority (sub)sectors and technologies by assessing these against a set of criteria. The use of MCDA in TNAssess allows the group to explore the decision by performing sensitivity analysis on uncertainties and developing alternative options and scenarios. The full MCDA process consists of the following steps and is the basis for TNAssess (adapted from DETR 2000).

1. **Establish the decision context.**
   - 1.1 Establish aims of the MCDA, and identify decision makers and other key players.
   - 1.2 Design the socio-technical system for conducting the MCDA.
   - 1.3 Consider the context of the appraisal.

2. **Identify** the options to be appraised (i.e., sectors or technologies).

3. **Identify** objectives and criteria.

   - 3.1 Identify criteria for assessing the consequences of each option.
   - 3.2 Organize the criteria by clustering them under high-level and lower-level objectives in a hierarchy.

4. **"Scoring":** Assess the expected performance of each option against the criteria. Then assess the value associated with the consequences of each option for each criterion.

   - 4.1 Describe the consequences of the options.
   - 4.2 Score the options on the criteria.
   - 4.3 Check the consistency of the scores on each criterion.

5. **"Weighting":** Assign weights for each of the criterion to reflect their relative importance to the decision.

6. **Combine** the weights and scores for each option to derive an overall value.

   - 6.1 Calculate overall weighted scores at each level in the hierarchy.
   - 6.2 Calculate overall weighted scores.

7. **Examine the results.**

8. **Perform sensitivity analysis.**

   - 8.1 Conduct a sensitivity analysis to explore uncertainities: do other preferences or weights affect the overall ordering of the options? Explore "what if?" questions and scenarios.
   - 8.2 Look at the advantages and disadvantages of selected options, and compare pairs of options.
   - 8.3 Create possible new options that might be better than those originally considered.
   - 8.4 Repeat the above steps until a robust decision is obtained.

A8.2. Application to (sub)sector prioritization

Chapter 3 provides guidance on identifying the relevant development priorities of a country both in the near and long term and across the economic, social and environmental aspects. Chapter 4 is concerned with identifying (sub)sectors which will provide the highest contribution to reducing GHGs or vulnerability to climate change as well as to the sustainable development priorities of the country. The processes involved are described in chapters 3 and 4 and supported by *TNAssess*. In this part of the annex we briefly describe this process.

In terms of an MCDA, the decision is "what are the highest priority (sub)sectors which can maximize mitigation or adaptation benefits along with sustainable development priorities?"

The options are the sectors and (sub)sectors while the criteria are the sustainable development priorities identified in chapter 3 for the country and the GHG or vulnerability assessments already available or which need to be performed before going further.

The overall steps in the process in *TNAssess* involve the following:

- Input to first step of country development priorities based on analysis in chapter 3 of short and long term trends, uncertainties and consideration of social environmental and economic priorities.

- Identification of initial list of (sub)sectors for mitigation with high GHG relevance based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The GHG emissions and details are input to the second step in TNAssess for (sub)sector prioritization; or

- Identify (sub)sectors/areas that provide the most effective actions for adaptation based on NAPAs or other adaptation studies.

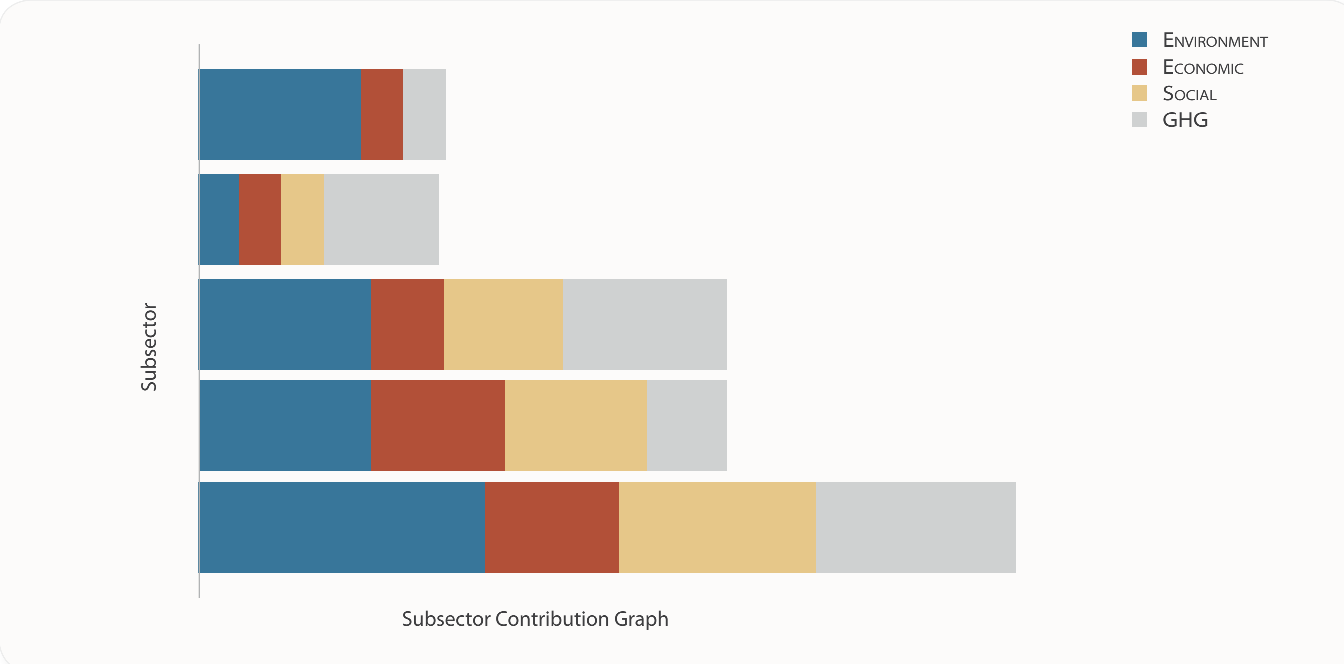
- (Sub)sectors are available to prioritize.

- In the third step the performance and desirability of improvements in the (sub)sector are scored on the criteria identified for development priorities (aggregated and defined under the environmental, social and economic aspects) and mitigation or adaptation potentials with a rationale for the scores chosen. This process involves implicit weighting of the criteria.

- Finally, the assessments can be completed and results explored through a criteria contribution graph (see Figure A8-1).

The criteria contribution graph in Figure A8-1 illustrates the overall performance of the (sub)sector through the total length of the bars. The (sub)sector at the bottom of the graph is most preferred in terms of *overall* performance. The performance of the option on the *individual* criteria can be seen from the bar lengths for the colors relating to the different criteria (in this example: environmental, economic, social and GHG emission reduction benefits). The most preferred (sub)sector in this graph is the one which has a high overall performance score and is robust to uncertainties. A well-balanced performance in terms of benefits from the diffierent criteria tends to have less problems in delivery of benefits, but this is not essential and some (sub)sectors may have value mainly from GHG reductions. This (sub)sector is represented by the lowest bar in the graph. The two least preferred (sub)sectors are the ones which have a low overall score and which are less well balanced across the benefit criteria contributions. For the (sub)sectors which have an equal overall performance score, a group could differentiate by exploring the effect of improving one criterion (e.g., economic benefits) on the overall performance of the (sub)sector.

Figure A8-1. Example of (sub)sector performance on criteria in *TNAssess*



A8.3. Application to technology prioritization

TNAssess technology prioritization is applied in chapter 5 for the process of prioritizing technologies for mitigation and adaptation when there are four or more technologies to be assessed. In this annex, the example given for mitigation technologies is also valid for technologies for adaptation, though it would be expected that the criteria will vary for the evaluation of technologies for adaptation.

The decision context is covered by chapter 3 for the climate change impact assessment and in the overall national and sector decision context including the development priorities of the country and GHG emission or vulnerability reduction. The decision on technologies to be taken is set out in chapter 5 of the Handbook and is:

"What is the best technology, within its category of timescale of availability and size, for maximizing benefits in terms of sustainable development priorities and mitigation or adaptation potential?"

Application of process

The process described in chapter 5 of the Handbook is applied first to a list of technologies within one of the four categories (small or large scale; short or long-term availability) for the highest priority (sub)sector. When the process is completed for the first category, it is then applied to one of the other technology categories until all four categories for the (sub)sector have been analyzed and each category has a prioritized list of technologies. The analysis can then be continued for each of the categories in the second highest (sub)sector and so on as required. Technologies cannot be compared across categories within a (sub)sector.

The steps in the TNAssess process for technology prioritization are the following:

. **Identify the options to be appraised:** The options to be appraised are the technologies identified in Step 1 in chapter 5 of this Handbook. The initial technology list is imported from *ClimateTechWiki,* then discussed and the information edited. After that the technologies are characterized in the technology option pages once the group members have made themselves familiar with the technologies. This results in a final list of technologies with a rationale for any initial rejections. In some cases, it makes sense to bundle technologies and assess them together. TNAssess facilitates this.

- **Identification of objectives and criteria for assessing technologies:** Criteria should be fundamental objectives (what you really want to achieve) and should always be fully defined so that there is no scope for misunderstanding. The criteria for assessing the sectors are decided by the group and some key issues to be included are identified in chapter 5. Additional criteria can be included and all criteria must be fully defined.

- **"Scoring" for each criterion:** Similar to the (sub)sector prioritization process in section A8.2, once the set of evaluation criteria has been established (e.g., contribution to development goals and contribution to GHG emission reduction), the options are assessed on the criteria depending on how well each option performs on that criterion. TNAssess leads the user through the process using scales of 0–100. The scores depend on how well the technology is performing on each criterion, and may require input through some background analysis or expert judgment. In each case a rationale for the scores given must be provided. This forms part of the overall audit trail for the process. In the process the analysis can point to where data are required to fill important gaps. It also provides an opportunity to explore different perspectives as stakeholders may wish to have different scores on the criteria. Assumptions and uncertainties are also identified and noted during the discussions.

- **Weighting:** By assessing weights for the criteria, the stakeholders determine the relative importance of each criterion. It is important that the weighting is done after the scoring, because weights can only be given to criteria within the decision context. In multi-criteria assessment, evaluation criteria can be weighted by stakeholders to reflect the importance of a criterion by considering the difference between the top and bottom of the scales and how much you care about it. This is a standard “swing weighting” method and assistance is provided in the software. The process of scoring and weighting evaluation criteria involves explicit judgments made in the context of stakeholder input within the decision group and must be justified within TNAssess. The stakeholder group for the MCDA should ensure participation of experts, policymaker input, and stakeholder perspectives. Expert judgment from a number of experts could be a separate input to the group.

- **Examine results:** The weights and scores for each option are combined to derive an overall value. This calculation is performed automatically by TNAssess. The results give the overall value of the options, with the highest totals being the most preferred. From this, an initial indication of the top-ranked technology options within each portfolio set is given, relative to the evaluation criteria, weighting system, and scores applied. However, this is regarded as a “first pass” through the problem and should never be taken as the “final” answer. The decision must then be explored in terms of the uncertainties in the inputs and judgments made to check for robustness in the result, and balance in the main objectives for the preferred options and to explore possibilities for improving options. For example, if a particular option is not performing well on a key criterion, then ways to improve the option can be discussed within the decision group, which can result in new options perhaps involving compensatory or other measures. Final choices can then be made after this extended examination using sensitivity analysis.

- **Balance:** A criterion contribution graph is produced showing the overall performance and also the contribution of each criterion to that performance so that some idea about the balance across the main objectives can be assessed from the color coding of these criteria contributions. An example of the display of the results from an analysis showing the final performance of each option as a bar chart with the length corresponding to the highest preferences and the colors showing the contribution of the individual criteria to these totals is already discussed above for the sector prioritization. An option which performs well and where there is a balanced contribution to overall performance across all the main objectives/criteria is preferred but balance may not be reasonable or possible in all cases.

- **Exploring uncertainties using sensitivity analysis:** At this point in the analysis the model is used to help the group explore the decision interactively. There are a number of sources of uncertainty in any analysis and these are confronted and explicitly explored in an MCDA process. The uncertainties during the decision conferences should also be noted as the elicitation of inputs progresses.

  - Sources include uncertainties such as **variations in scores and weights**, arising either from uncertainty in information for scoring the performance of the option on some criteria, or from variations in perspectives within the group. Changes to individual scores and weights can be made within the model and the effect on the decision explored. Alternative perspectives may be modeled in this way through role playing. If it is considered that a particular viewpoint is missing from the group then it can be simulated through role play and the effect on the decision explored, identifying areas of agreement or where further improvements are needed. TNAssess provides the ability to have multiple prioritizations for a (sub)sector category with different weights and scores so that results can be compared.

  - **Future uncertainties** may also be investigated. For example, what if the economic downturn persists? How will that affect sector GHG emissions? This will lead to a change in some inputs. Where there are future uncertainties which are more complex, an overall scenario may be placed over the whole analysis and the scores and weights adjusted under the new circumstances (e.g., what if climate change impacts accelerated past worst IPCC scenario and oil was expensive?).

  - The model allows all the uncertainties to be explored, either through substitution of scores or weights, or addition of options or criteria. **The robustness of the results** can then be determined. Risk as a criterion can also be incorporated explicitly in the analysis where it is felt that there is high uncertainty and risk is a factor in the decision.

- **Improving the options:** Options can also be compared in terms of their advantages and disadvantages, which allows for consideration of ways in which options can be improved, and can lead to consideration of new options. The model allows the advantages and disadvantages of the options to be clearly identified and options can be compared relative to one another. It also allows key criteria to be identified so that the focus can be placed on what matters in the decision.

Final process and outputs

The process described above is iterative and steps may be revisited and explored until the group is satisfied that they have reached a decision which is sufficient in form and content to meet the problem in hand, i.e., requisite.

Each portfolio set **for each prioritized sector and category** (small scale/large scale and short/medium to long term) can be assessed in this way to provide a final short list in each category for each sector. It may be that in some categories there is a clear "winner" while in other there is a diverse set of technologies which are appropriate. These can be followed up at a later stage in chapter 6 after the initial priority technologies have been dealt with. In addition, comparison across the sectors or even within a sector may identify technologies which are not necessarily the highest ranked but nevertheless are highly ranked in a range of sectors, indicating that they may be a useful choice for technology transfer.

During the process a record is kept of all the judgments and justifications for the scoring and weighting and other inputs and sensitivity analysis and this is compiled into an **audit trail** for the decision within *TNAssess* using the reporting function.

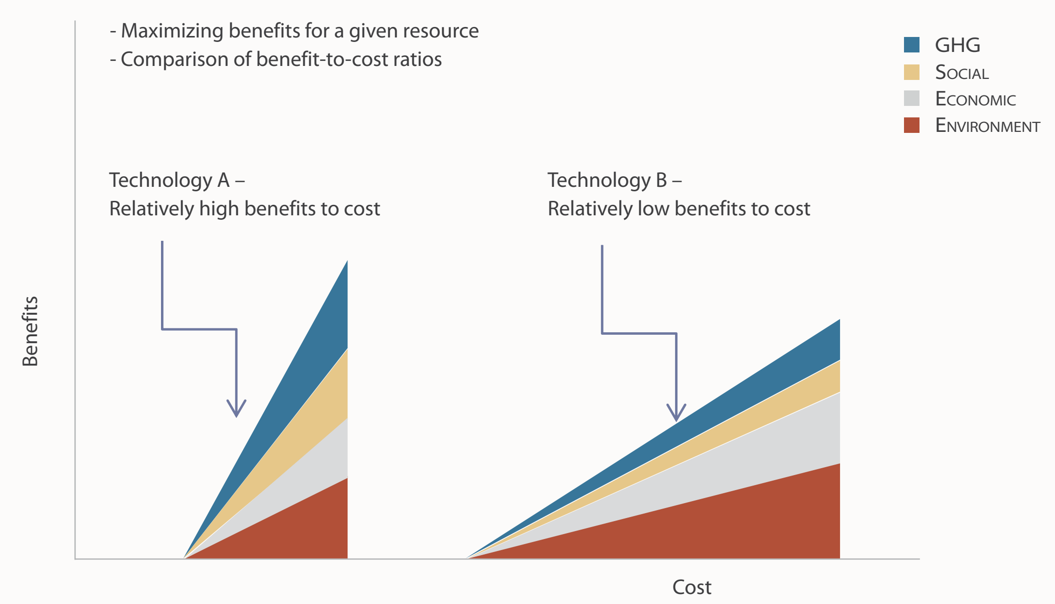
The output in this form may also be used to generate a strategy for implementation.

Cost analysis and final choice

The main analysis has examined mainly the benefits from the technologies but financial costs are also important. During the activity "**Identify the options to be appraised**" in TNAssess financial information on the technology options has been gathered and in this final stage of the process this information is firmed up and consideration given to the sector wide costs if the technology were adopted and implemented. This information is input into TNAssess and a spreadsheet will be provided to assist this calculation. The final ranked portfolios of technologies can then be displayed within their categories and (sub) sectors in terms of the benefit-to-cost ratio (from the TNAssess MCDA-assisted analysis described above), which will allow value-for-money options to be identified. Benefit-to-cost ratios are only meaningful within the category for the (sub)sector, as the benefit assessment scales have not been normalized across the categories or across (sub)sectors. Figure A8-2 shows examples of technologies with different benefit-to-cost ratios.

Further analysis of the options using other models may be required to ensure full practicality of the options chosen.

FIGURE A8-2. EXAMPLES OF BENEFIT-TO-COST RATIO DIAGRAMS.



THE FIGURE SHOWS TWO EXAMPLES OF BENEFIT-TO-COST DIAGRAMS FOR PRIORITY TECHNOLOGIES. EACH DIAGRAM SHOWS FOR A TECHNOLOGY HOW THE BENEFITS COMPARE WITH THE LIFETIME COSTS OF THE TECHNOLOGY. THE BENEFITS HAVE BEEN ASSESSED THROUGH TNASSESS (BY SCORING AND WEIGHTING) AND THEREFORE DO NOT HAVE A MONETARY VALUE. A RELATIVELY STEEP SLOPE IN THE DIAGRAM SHOWS THAT THE BENEFITS ARE RELATIVELY HIGH COMPARED TO COSTS OF THE TECHNOLOGY. THE DIAGRAMS HELP DECISION MAKERS TO MAXIMIZE BENEFITS FROM TECHNOLOGIES FOR A GIVEN RESOURCE.

Annex 9

First prioritization of technologies for mitigation and adaptation before MCDA, only if numbers are large

In chapter 5, potential technologies are identified and categorized for the priority sectors/areas, followed by a familiarization with "new" technologies with the help of a number of activities and the ClimateTechWiki. The result is a set of technologies categorized per priority (sub)sector, and in terms of their applicability in time and scale.

These technologies will be prioritized using Multi Criteria Decision Analysis (MCDA). However, in order to keep the MCDA manageable, it is recommended that the number of technologies in each of the four categories for a subsector (i.e., small scale/short term, small scale/long term, etc.) should not be larger than 10 (i.e., 40 total over the 4 categories). For categories with more than 10 technologies, a pre-screening is recommended on the basis of the following criteria (Table A9-1). If the number of technologies in each of the categories is smaller than 10, this step can be skipped.

Table A9-1. Criteria for pre-screening of technologies before MCDA

For technologies for mitigation	For technologies for adaptation
Technical potential of technology	Technical potential of technology
GHG abatement potential of technology	Increased adaptation resilience
Costs (net present value; internal rate of return) of technology	Costs (net present value; internal rate of return) of technology
Contribution of technology to key development priorities	Contribution of technology to key development priorities

For each technology, stakeholders could indicate the contributions to these criteria through the following rating scheme:

1. very small contribution
2. small contribution
3. medium contribution
4. large contribution
5. very large contribution

Annex 10

Spreadsheet example: cost assessments

Chapter 5 of this Handbook recommends that the National Team and stakeholder groups apply the cost of technology and economic viability of a technology investment as a criterion for prioritizing technologies. The second cost criterion mentioned in chapter 5 is internal rate of return (IRR), which shows the profit from an investment (expressed as a percentage) for a given period of time, e.g., 10 years. It is derived from calculating the interest rate for which the net present value[1] of an investment project for the given period of time is equal to zero:

$$NPV = \sum_{t-0}^{N} \frac{C_t}{(1+r)^t} = 0$$

where:
NPV = Net Present Value,
C_n = Cash flow in year n (which can be either positive or negative),
r = internal rate of return for which NPV for a period of n years is zero.

In combination with the USD per GHG cost figure, the IRR could provide a more complete overall cost assessment for a technology. For instance, a project with a high USD per GHG cost figure could still have a high IRR (e.g., small scale CHP), whereas a project with a low USD per GHG figure could have a low IRR (e.g., landfill gas capture). In terms of rollout potential, the IRR would be a stronger indicator of appropriateness of the technology than USD per GHG.

These calculations can be made with a spreadsheet which calculates IRRs for different technologies and, through sensitivity analysis, takes account of the impact on an IRR of the technical lifetime and prices changes (e.g., raw material, fuel, carbon credits). In the tables below, an example is shown of a spreadsheet to help in assessing the economic viability of a technology investment. The tables contain hypothetical data for the example of low-emission technologies in the cement sector:

. Table A10-1 shows the data collection sheet in which the basic data for cement production in the country concerned can be collected, such as annual cement production, price of raw material, labor costs, fuel prices, etc., as well as possible subsidies for use of low emission technologies. Table A10-1 is repeated in different worksheets for a range of new technologies with corresponding new data.

1 Net present value is the valuation of the expenses and revenues from an investment over a period of time, discounted to present-day value, thereby taking account of the time preference of money.

. Table A10-2 shows the overall annual financial performance of an existing (base case) technology in the cement sector. It calculates an IRR for that technology over a lifetime of 10 years. In the spreadsheet, Table A10-2 is repeated in different worksheets for a range of new technologies, thereby using the data collected in the data collection sheets for these technologies. It is noted that the worksheets represented by Table A10-2 are automatically completed as the formulas are already prepared; the National Team only needs to complete the worksheet represented by Table A10-1.

. Table A10-3 shows the results collected from each new technology considered in terms of capital cost, fuel savings, electricity savings, and CO_2 emission reductions. Subsequently, the effect on IRR can be analyzed under different circumstances, e.g., the IRR when only energy saving benefits are considered, the IRR when energy saving and carbon credits are included, or when subsidy schemes can be used. Users of the model can fill in "yes" or "no" for each circumstance and see what happens with the IRR. When a benchmark IRR is available for the country, i.e., the interest rate for a regular commercial market-based investment, the IRRs can be compared with this benchmark. Any IRR higher than the benchmark represents an economically viable technology.

It is noted that these calculations are meant to provide indications of the economics of different technologies and cannot be considered official values for eventual financial market decisions. However, the spreadsheet model can be a useful tool for project developers who, after the completion of the technology needs assessment, would prepare project proposals for the prioritized technologies for mitigation and adaptation. Similar cost calculations are recommended by the UNFCCC Guidebook on preparing technology transfer projects for financing (EGTT, 2008).

Table A10-1. DATA ASSUMPTIONS

BASE CASE											
Assumptions	**Year**										
	0	1	2	3	4	5	6	7	8	9	10
clinker production (tons / year)		55000	55000	55000	55000	55000	55000	55000	55000	55000	55000
cement production (tons / year)		60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
raw material need (tons / year)		96,000	96000	96000	96000	96000	96000	96000	96000	96000	96000
costs per ton clinker ($/t clinker)		15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
electricity price ($/kWh)		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
costs per ton raw material ($/ ton)		9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44
electricity for raw materials preparation											
electricity in coal mill (kWh/t clinker)		8	8	8	8	8	8	8	8	8	8
electricity for crushing process (kWh/t clinker)		2	2	2	2	2	2	2	2	2	2
electricity for raw mill (kWh/t clinker)		28	28	28	8	28	28	28	28	28	28
electricity for clinker production											
electricity for kiln & cooler (kWh/tclinker)		28	28	28	28	28	28	28	28	28	28
electricity for finish grinding											
cement mill (kWh/tcement)		30	30	30	30	30	30	30	30	30	30
electricity for miscellaneous activities											
mining and transportation (kWh/tclinker)		1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
packing house (kWh/tcement)		1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
miscellaneous		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
water		6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
other costs											
labor		84000	84000	84000	84000	84000	84000	84000	84000	84000	84000
maintenance		72000	2000	72000	72000	72000	72000	72000	72000	72000	72000
marketing and sales		18000	18000	18000	18000	18000	18000	18000	18000	18000	18000
packing and storage		270000	270000	270000	270000	270000	270000	270000	270000	270000	270000
unforeseen expenses		18000	18000	18000	18000	18000	18000	18000	18000	18000	18000
general expenses		72000	72000	72000	72000	72000	72000	72000	72000	72000	72000
total		534000	534000	534000	534000	534000	534000	534000	534000	53	534000

Table A10-1. DATA ASSUMPTIONS - continuation

Fuel											
Fuel consumption (GJ/tcement)		3.55	3.55	3.55	3.55	3.55	3.55	3.55	3.55	3.55	3.55
Fuel price ($/GJ)		0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056
Sales price cement		70	70	70	70	70	70	70	70	70	70
CO_2 price		17	17	17	17	17	17	17	17	17	17
Basic capital outlay											
equipment grinding etc.	3000000										
buildings	500000										
Subsidy	1000000										
loan	2000.000										
interest	0.08										

Table A10-2. BASE CASE: CEMENT PLANT

Year	0	1	2	3	4	5	6	7	8	9	10
Expenses											
capital outlay											
grinding	3000000										
additional equipment											
buildings	500000										
Total capital outlay	3500000										
n $2000000 (8%)		160000	160000	160000	160000	160000	160000	160000	160000	160000	160000
clinker											
tons		60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
costs per ton		15,6	15,6	15,6	15,6	15,6	15,6	15,6	15,6	15,6	15,6
Total costs		936000	936000	936000	936000	936000	936000	936000	936000	936000	936000
raw materials (slag,gypsum)											
tons		96000	96000	96.00	96000	96000	96000	96000	96000	96000	96000
costs per ton raw material		9,44	9,44	9,44	9,44	9,44	9,44	9,44	9,44	9,44	9,44
total costs raw material		906.240	906.240	906.240	906.240	906.240	906.240	906.240	906.240	906.240	906.240
electricity coal											
kWh/tclinker		8	8	8	8	8	8	8	8	8	8
tons clinker		55000	55000	55000	55000	55000	55000	55000	55000	55000	55000
total kWh for coal mill		440000	440000	440000	440000	440000	440000	440000	440000	440000	440000
price/kWh		0.1	0.1	0.1	0.1	0.1	0.	0.1	0.1	0.1	0.1
total electricity costs coal mill		44000	44000	44000	44000	44000	44000	44000	44000	44000	44000
electricity crushing											
kWh/tclinker		2	2	2	2	2	2	2	2	2	2
tons clinker		55000	55000	55000	55000	55000	55000	55000	55000	55000	55000
total kWh for crushing		110000	110000	110000	110000	110000	110000	110000	110000	110000	110000
price/kWh		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
total electricity costs crushing		11000	11000	11000	11000	11000	11000	11000	11000	11000	11000
raw mill											
kWh/tclinker		28	28	28	28	28	28	28	28	28	28

tons clinker		55000	55000	55000	55000	55000	55000	55000	55000	55000	55000
total kWh for raw mill		1540000	1540000	1540000	1540000	1540000	1540000	1540000	1540000	1540000	1540000
price/kWh		0,1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
total electricity costs raw mill		154000	154000	154000	154000	154000	154000	154000	154000	154000	154000
electricity clinker production											
kWh/tclinker		28	28	28	28	28	28	28	28	28	28
tons clinker		55000	55000	55000	55000	55000	55000	55000	55000	55000	55000
total kWh for clinker production		1540000	1540000	1540000	1540000	1540000	1540000	1540000	1540000	1540000	1540000
price/kWh		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
total electricity costs clinker		154000	154000	154000	154000	154000	154000	154000	154000	154000	154000
cement mill											
kWh/tcement		30	30	30	30	30	30	30	30	30	30
tons cement		60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
total kWh for cement mil		1800000	1800000	1800000	1800000	1800000	1800000	1800000	1800000	1800000	1800000
price/kWh		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
total electricity costs cement mill		180000	180000	180000	180000	180000	180000	180000	180000	180000	180000
transportation											
kWh/tclinker		1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6
tons clinker		55000	55000	55000	55000	55000	55000	55000	55000	55000	55000
total kWh for mining &		88000	88000	88000	88000	88000	88000	88000	88000	88000	88000
transportation											
price/kWh		0.1	0.1	0.1	0.1	0.1	0,1	0.1	0.1	0.1	0.1
total electricity costs mining and transp.		8800	8800	8800	8800	8800	8800	8800	8800	8800	8800
packing house											
kWh/tcement		1,9	1,9	1,9	1,9	1,9	1,9	1,9	1,9	1,9	1,9
tons cement		60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
total kWh for packing house		114000	114000	114000	114000	114000	114000	114000	114000	114000	114000
price/kWh		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
total electricity costs packing house		11400	11400	11400	11400	11400	11400	11400	11400	11400	11400
utilities: misc.											
kWh/tcement		2	2	2	2	2	2	2	2	2	2
tons cement		60000	60000	60000	60000	60000	60000	60000	60000	60000	60000

total kWh for misc.		120000	120000	120000	120000	120000	120000	120000	120000	120000	
price/kWh		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
total electricity costs misc.		12000	12000	12000	12000	12000	12000	12000	12000	12000	12000
total costs electricity consumption		575200	575200	575200	575200	575200	575200	575200	575200	575200	575200
water		6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
fuel											
GJ		213000	213000	213000	213000	213000	213000	213000	213000	213000	213000
price per GJ		0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056
total costs		11.28	11928	11928	11928	11928	11928	11928	11928	11928	11928
Other costs (labor, maintenance, etc.)		534000	534000	534000	534000	534000	534000	534000	534000	534000	534000
Depreciation											
10 years for equipment		300000	300000	300000	300000	300000	300000	300000	300000	300000	300000
25 years for buildings		20000	20000	20000	20000	20000	20000	20000	20000	20000	20000
total depreciation costs		320000	320000	320000	320000	320000	320000	320000	320000	320000	320000
Revenues											
Cement end product											
tons		60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
sales price per ton		70	70	70	70	70	70	70	70	70	70
sales cement annual revenu		4200000	4200000	4200000	4200000	400000	4200000	4200000	4200000	4200000	4.00000
CO2 credits											
credit price (/ton)		17	17	17	17	17	17	17	17	17	17
tons reduction		0	0	0	0	0	0	0	0	0	0
CO2 revenues		-	-	-	-	-	-	-	-	-	-
Subsidies (meeting VA)			-	-	-	-	-	-	-	-	63.435
Subsidies 20%	0										
Annual profit		750632	750.32	750632	750632	750632	750632	750632	750632	750632	814067
tax (40% of gross profit)		300.53	300253	300253	300253	300253	300253	300253	300253	300253	325627
Annual net profit	-3500000	450.379	450379	450379	450.379	450379	450379	450379	450379	450379	488440
IRR	5%										

Table A10-3. Results - ENERGY SAVING TECHNOLOGIES IN CEMENT PRODUCTION EXPLORED

1. High efficiency roller mills										
Assumptions	**Year**									
	1	2	3	4	5	6	7	8	9	10
Investment ($/ton raw material)	5.5									
electricity saving (kWh/tcement)	11	11	11	11	11	11	11	11	11	11
CO2 savings (t CO_2/tcement)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

2. Energy management and process *control*										
Assumptions	Year									
	1	2	3	4	5	6	7	8	9	10
capital costs ($/tcement)	1.7									
fuel savings (GJ/tcement)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
electricity savings (kWh/tcement)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
CO2 savings (tCO_2/tcement	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0,02	0.02
ETC										

Annex 11

A multi-polar world of innovation

This annex describes how selected developing countries can take part in the energy technology revolution as innovators rather than simply technology takers. Certain middle income countries have already demonstrated success in doing so. Below, a multi-polar innovation paradigm is presented to replace the existing model of technology development in the OECD followed by transfer (with some minimal adaptation) to developing countries.

The timely commercialization of new technologies that allow low-emission economic development and are suitable for developing country conditions will require a re-thinking of the current technology paradigm. Traditionally, new technologies emerge from OECD countries and, once established there, are transferred to developing countries. This approach has had its share of success, but also has serious limits in the context of global climate change mitigation and adaptation. One, the traditional technology commercialization process is inherently multi-stage and thus lengthy which is a problem given the urgency of climate change. Two, it produces technologies that, in their essential design, are made for conditions in industrialized countries. Three, it fails to fully make use of the emerging innovation potential that is being increasingly seen in middle income countries and low-income countries.

A preferred paradigm for new technology development allows developing country economies to be more active contributors to new technology development by involving them from the outset in design and innovation. This is already happening in certain cases for some major emerging economies such as China, India, and Brazil, but its full potential is yet to be realized. Accelerating the transition to the new innovation paradigm can be achieved through enhanced science, technology and innovation capacity in developing countries, as well as through virtual and other partnerships between major technology developers (public and private) in industrialized and developing countries. Many countries already possess the building blocks for advanced technology innovation: highly educated workforces; links with low-cost manufacturing; motivated, far-sighted governments; and local markets with high demand and a relative lack of existing infrastructure which allows entry of new products to "leapfrog" existing technology paradigms.

More active innovation from developing countries also creates a networked process of commercialization, where ideas can emerge from industrialized countries, be advanced in developing countries, and then sent back to industrialized countries for further refinement until a profitable, reliable product emerges. The contributions of Brazilian scientists to the biofuels industry and of Chinese manufacturing to the solar and wind power industries are examples of a shift towards this new paradigm.

A multi-polar, or networked, approach to innovation and technology development offers global and national benefits. On the global level, it is an effective way to get suitable environmentally sound technologies as soon as possible in developing countries where the greatest GHG growth is projected under business-as-usual. On the national level, it allows developing countries to profitably partake in the energy technology revolution, rather than simply being technology takers. This leads to economic development and creation of high-paying jobs.

Annex 12

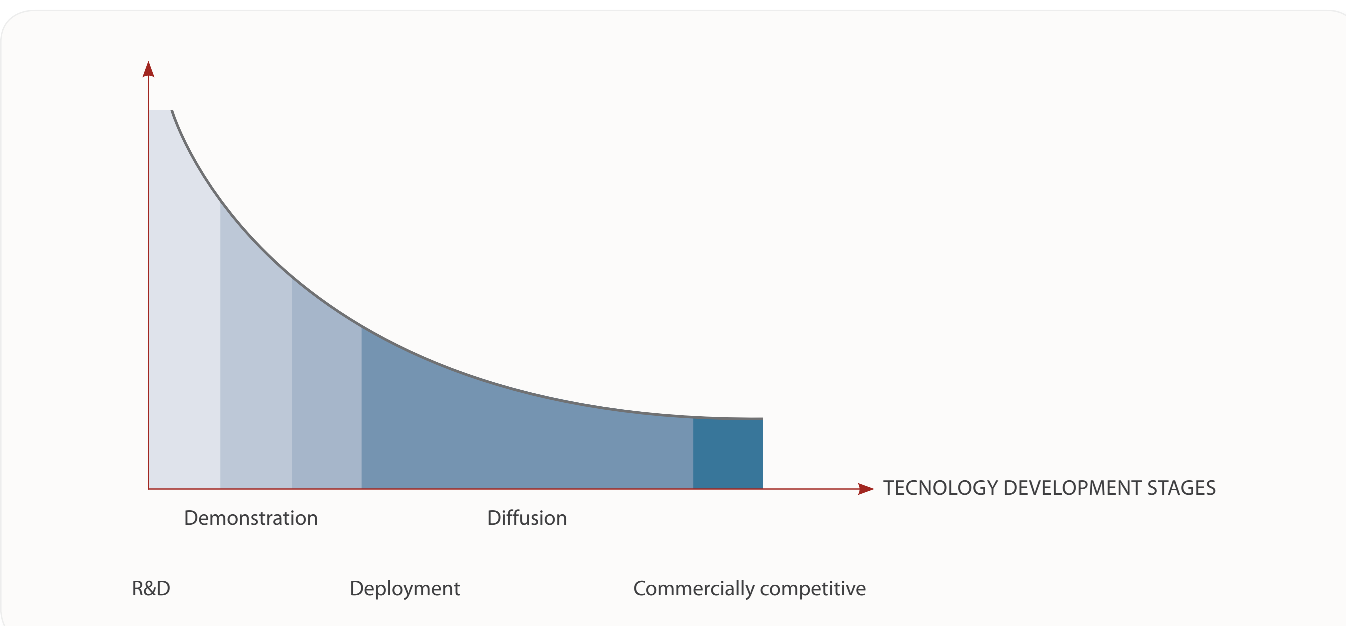
Stages in technology development and transfer

This Handbook acknowledges that a prioritization of technologies based on national development priorities and in light of a changing climate could result in priority technologies which are not yet available in the short term as these are still in a research and development (R&D) stage or in a pre-commercialization stage. Therefore, throughout the technology prioritization steps in chapter 5 in this Handbook, a distinction is made between technologies available in the short term (technologies with proven reliability in similar market circumstances), medium term (e.g., full market availability within 5 years), and in the long term (technology now in an R&D phase or existing as a prototype).

This distinction follows the definition of stages of technology innovation as applied by, e.g., EGTT (2009a):

- Research and Development (R&D), which is the very early stage of an invention;
- Demonstration, which is when prototypes are proven and scaled up to the applicable demonstration scale for final proving before;
- Deployment into a market; and,
- Diffusion of the technology within the market to the point where sufficient numbers are deployed to make the manufacture and sale commercially competitive.

Figure A12-1. Learning curve for technology innovation
Source: EGTT, 2009a



These descriptions are very broadly based as in practice they form a continuum where phase boundaries are blurred depending on the technology and circumstances. This is usually described as a learning curve for technology innovation and is illustrated in Figure A12-1.

In chapter 6 of this Handbook, since small and large scale technologies for mitigation and adaptation basically follow the same process for identifying activities to facilitate implementation of the technologies (though they may well produce significantly different types of activities), the priority technologies identified in chapter 5 will be categorized only under:

- *Priority technologies "**available in the short term**" for mitigation and adaptation:* This means that a technology is either commercially available now (in a local or other market), or is very close to market implementation, or that the measure or non-market technology is reasonably well developed. With reference to the stages of innovation, this technology may already have diffused into markets in other countries or it may be moving from a successful demonstration phase.

- *Priority technologies **"available in the medium to long term"** for mitigation and adaptation:* This category of technologies combines the pre-commercial technologies at the demonstration phase and technologies at a promising early R&D prototype stage. These may well have time to be implemented to reduce GHG emissions further, or increase climate resilience in the longer term and before severe climate effects occur, provided activities are undertaken to ensure that their progress to the commercialization stage is properly supported. In order to utilize the medium to longer-term mitigation and adaptation benefits of these technologies and measures, this process should also start at the same time as the already commercially available technologies.

For all these technology categories it is suggested that in order to analyze the activities required for each priority technology in each sector to accelerate their adoption in the country context, three main areas for consideration should be used. These areas are based on the above-mentioned key steps in the technology development cycle:

- *Acceleration of **research and development:*** For all the technology categories R&D activities are required, whether to support fundamental research for long term promising technologies at the R&D and/or demonstration phase, or existing market technologies that need to be adapted and demonstrated in the context of the country concerned. International cooperation with developing countries on enhancing in-country R&D capacity and activities is recommended.

- *Acceleration of **technology deployment** in the country*: The practicalities of deployment must recognize that transfers will be enacted mainly through private sector agents and include consideration of facilitation of the process for investors and users through such factors as funding for the technology, further familiarization with the technology on a wider scale, the type of transfer to be enacted and the other practicalities associated with supply chains and capacity building for appropriate skills and training. Within this process, the question of intellectual property rights (IPR) may arise. Protection of IPR and cooperation on this issue for the type of transfer envisaged is fundamental for sustainable technology transfer. International cooperation on building technological capacity on these and other transfer issues is another key factor. The market "pull" for these technologies is also important in terms of affordability, demand for these technologies, availability of finance, and commercial presence of entities able to deploy the technologies.

- ***Acceleration of technology diffusion in the country context***: The acceleration of technology diffusion in a country requires consideration of the whole system, including the enabling business environment of institutions, policies and regulations surrounding the transfer, the market chain involved in the sector concerned, and the supporting activities which allow the market to function. This follows the market mapping approach originally proposed by Albu and Griffith (2005) and which describes the system for technology diffusion by dividing it into three elements: the business enabling environment; the market chain; and the market supporting services. In Annex 13, the market mapping technique is explained in further detail and illustrated by an example of the type of output expected from market mapping. The UNCTAD definition of enabling environment refers to the underlying macroeconomic environment bringing together technology suppliers and consumers in a cooperative manner (UNCTAD, 1998), which is equivalent to the whole system approach described above.

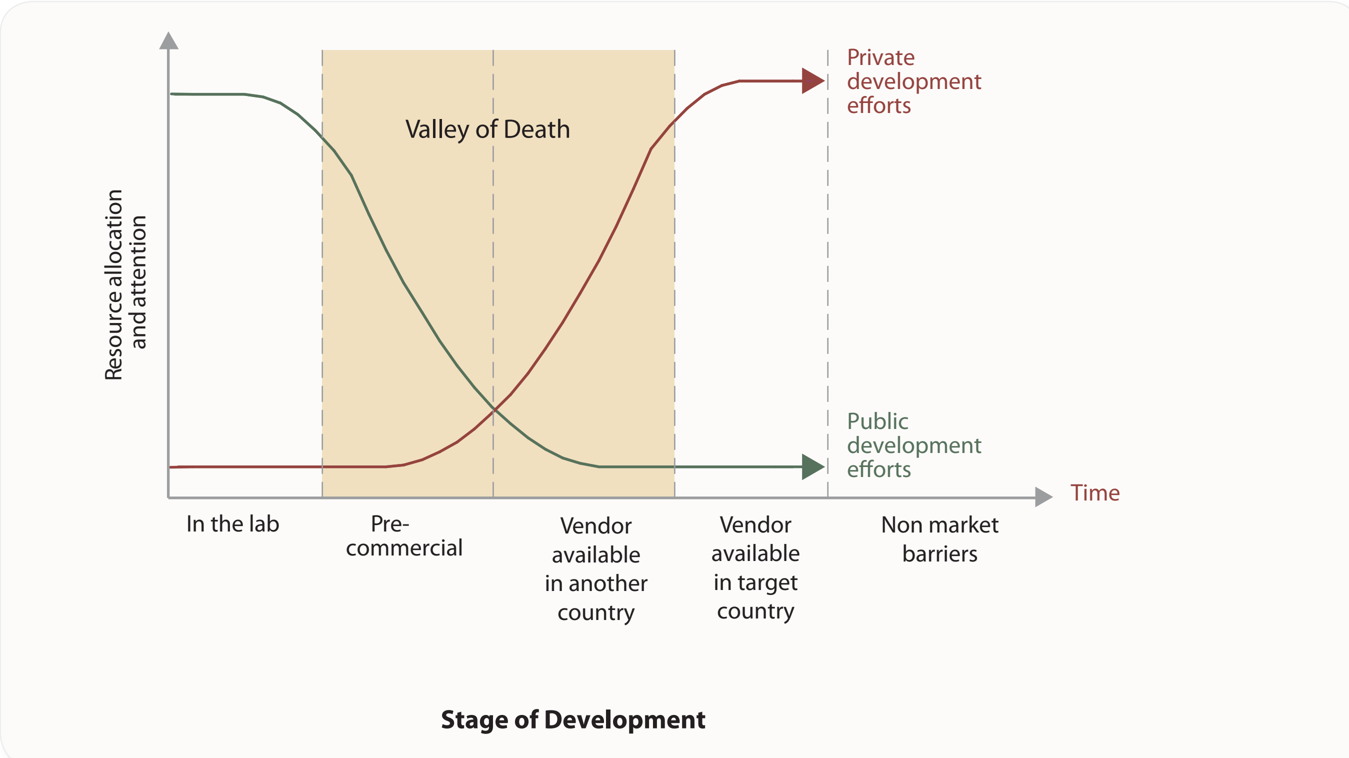
The "Valley of Death" concept

Figure A12-2 below shows an alternative representation of a learning curve for technology innovation. It indicates the division of work between the public and private sectors, with the former spending most of the resources during the research and development phases and the latter becoming more active during and after the pre-commercialization phase. Similar to Figure A12-1, it is shown that commercialization of any technology requires passing through a number of stages from basic research to widespread deployment and diffucsion. There are challenges at every stage but one part of this process represents a key stumbling block. This is the so-called "Valley of Death," which lies between proof of scientific concept—by basic, mostly publicly funded research—and uptake by the private sector to develop a commercial, profitable product. Neither government nor private sector has the proper motivation or resources to advance technologies in this stage and, as a result, otherwise promising options can languish.

While the "Valley of Death" is a substantial barrier to timely technology commercialization in various parts of the world, it is more pronounced in developing countries. In addition to the usual barriers to commercialization (e.g., lack of viable CO_2 price, management short-termism), there are conditions specific to developing countries that make energy technology commercialization particularly difficult in those contexts. These impediments include:

- Technical capacity for R&D, manufacture and O&M support;
- Overall cost of "doing business";
- Lower public spending on energy R&D;
- Subsidies for conventional fuels;
- General regulatory capacity (e.g., fair and enforceable power purchase agreements);
- Market entry;
- Intellectual property rights (IPR) concerns;
- Absence of creditworthy off-takers;
- Access to early-stage financing; and
- Fewer wealthy consumers willing to pay premiums for "green products."

FIGURE A12-2. OVERVIEW OF STAGES OF DEVELOPMENT OF A TECHNOLOGY FROM RESEARCH TO MARKET IMPLEMENTATION
SOURCE: WORLD BANK.



Annex 13

Market mapping for identifying barriers and inefficiencies

In order to explore the barriers and problems faced by innovators that prevent or slow down the progress of innovation, it is suggested that a system mapping technique is used. Such an approach allows a group of stakeholders to characterize the whole system environment into which the new technology for mitigation or adaptation must be developed, deployed and diffused. From discussions framed in this way, different stakeholders exchange information to build a picture of the whole system encompassing the enabling environment for introducing a new technology (legal, institutional, organizational, cultural), the actors involved in the system and their power and connections, as well as the supporting services (e.g., finance, quality control, enforcement, standards, etc.) needed to make the system function.

With this information the group can identify barriers and inefficiencies in the system. Subsequently, by simply voting group members can choose which barriers and inefficiencies would need to be addressed first. This is followed by assembling an implementation plan on why these activities are important; who should do it; how, when, and what resources would be required; and which monitoring and verification actions are required for making the activities successful.

The market mapping technique

This approach is based on the "market mapping" technique developed by Albu and Griffith (2005) originally extending the sustainable livelihoods approach to include characteristics of the markets into which small farmers might enter. Albu and Griffith (2005) divide the market map into three elements: the business enabling environment; the market chain; and the market supporting services. These elements are illustrated in Figure A13-1.

Figure A13-1. The market mapping method - Source: Albu and Griffith, 2005.

Business enabling environment

The business enabling environment should include the critical factors and trends shaping the market and the operating conditions such as infrastructure, policies, and institutions. The purpose is to identify the trends affecting the business environment and to identify who has the power in the market and who is driving change. An understanding of the market conditions including key drivers and incentives to help accelerate the scale and speed of technology transfer and deployment can therefore be developed. According to Albu and Griffith (2005), the enabling environment encompasses the following:

- Market demand,
- Consumption trends,
- Tax/subsidies and tariff regimes,
- Transformation activities and costs of doing business,
- Infrastructure constraints and investment policies,
- Transport policies and licensing,
- Technological development,
- Trade regime (import/export),
- Transaction activities,
- Systems of finance,
- Gender roles in business and finance,
- Registration of land and property,
- Legal requirements for contracts,
- Commercial law,
- Business licenses and regulation, and
- Standards quality control and enforcement.

The market chain

For the market chain, which is the main representation of the market system, the question being asked is: who are the economic actors in the market chain? This question should elicit responses which may include: primary producer, importer, trader, processor, input supplier, financier, project developer, utility, wholesaler, retailer and customer. This is generalized to, "Who are the actors in the relevant stage of the innovation chain?"

Supporting services

Supporting services are the business and extension service providers supporting the market chain. The linkages to the market chain are shown in the diagram below to complete the market map (Figure A13-2). The purpose is to identify the needs for services and who the users are. This gives insights on what can be done in terms of supporting services to make the market more efficient. Such services are myriad but can include financial services, quality control, technical expertise and market information services.

Process of constructing a market map for technology transfer

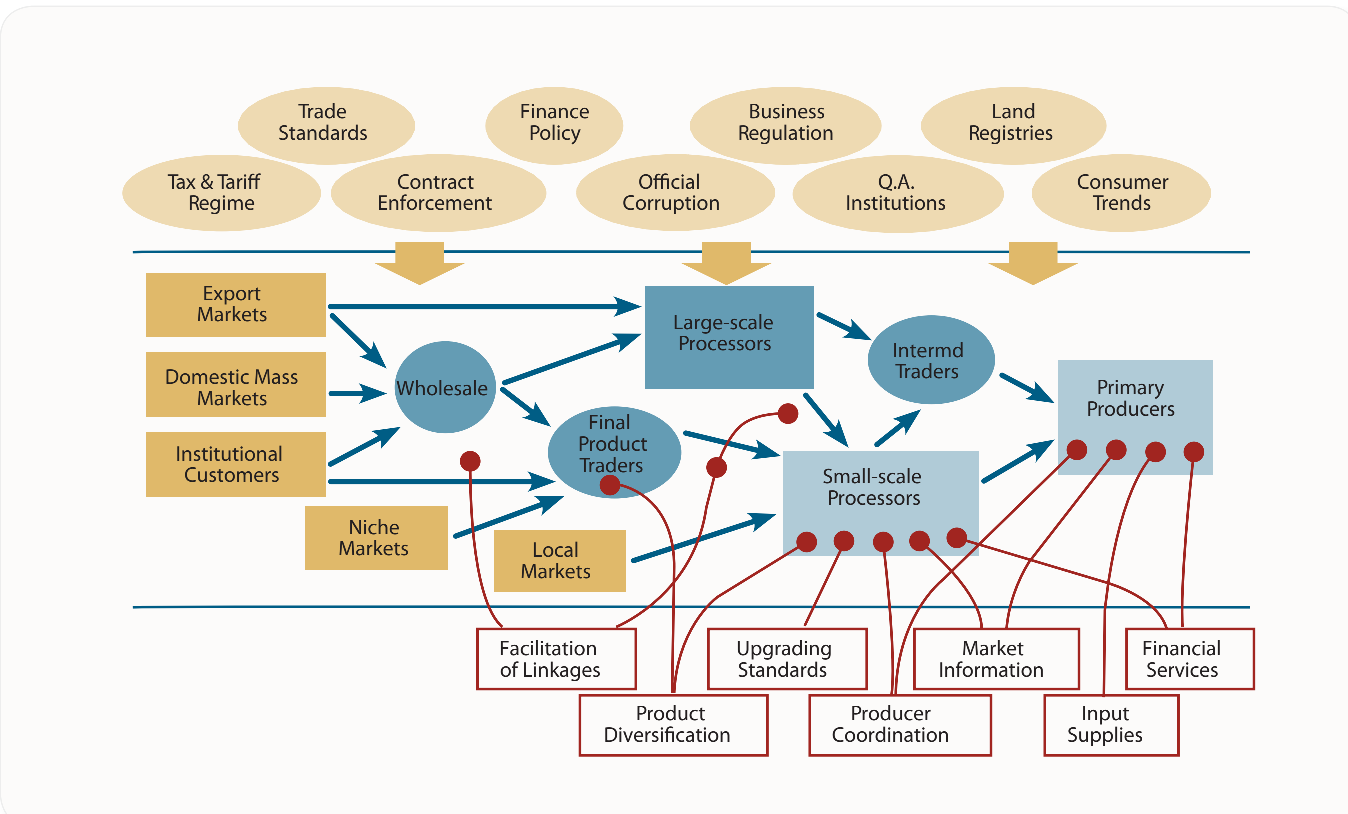
The market mapping process involves the following activities which are based on the original mapping devised by Albu and Griffith(2005) but applied to technology transfer:

- Form a stakeholder group for a sector and or technology.

- Construct a system map with the group according to the three-stage mapping methodology described above and bearing in mind examples below for a specific technology in its (sub)sector.
- Analyze the flows within the system and identify the issues, blockages, inefficiencies and key actors with the group and list. Also identify opportunities to be acted on.
- Identify with the group accelerating actions to overcome blockages and inefficiencies.
- Prioritize these accelerating actions and characterize according to Table 6-2 in chapter 6.

An example of a completed market map (in the context of extending sustainable livelihoods) with enabling environment, market chain, and supporting service aspect identified is shown in Figure A13-2.

FIGURE A13-2. EXAMPLE OF A COMPLETED MARKET MAP
SOURCE: ALBU AND GRIFFITH, 2005



The important issue addressed by using a system mapping approach is that the market mapping process allows an understanding and identification within a group of stakeholders of key activities to overcome barriers within the systems for technology innovation. As explained in chapter 6 in this Handbook, these activities can be prioritized by the group for acceleration of technology development, deployment or diffusion, followed by an implementation plan which can be assembled into a strategy.

The following sections show some examples to illustrate the kind of outputs which can be derived from market mapping.

Identify opportunities and barriers: market mapping example from Kenya

Below an example is given of a mapping exercise which considered the opportunities and barriers to the introduction of small scale biomass technology in Kenya. Table A13-1 shows the opportunities for this technology as identified by the stakeholder group; Table A13-2 shows blockages and barriers identified.

Table A13-1. Opportunities for small scale biomass stoves in Kenya

Country	Kenya
Opportunities for small scale biomass gasification	Categorize as programmatic Clean Development Mechanism
	Opportunities for technology and innovation
	For technology for adaptation
	For locals to participate
	For local capacity building
	For financial savings at household and national level
	For job creation and poverty alleviation
	For waste management utilization
	For international trade
	For scaling up
	For reduced IAP (Indoor Air Pollution) for health
	For reduced time and frequency of firewood collection

Some **blockages and barriers** identified in the system were identified from the market map and discussions in the group. These are listed in Table A13-2 as initial examples of what can be produced as a first pass through the problem. More detailed analysis would then follow.

Table A13-2. Blockages for small scale biomass stoves in Kenya

Country	Kenya business enabling environment
Blockages for small scale biomass gasification	Financial services to support investment
	Facilitative import regime, Clearance of goods problem: The goods come through the customs bonded warehouses and one normally needs an accredited company or firm to help process and handle paperwork with the revenue and custom officials before goods are released. This process is called clearance of goods.
	Infrastructure poor: communication system
	Weak policies/legal framework for enforcement of laws and regulations
	Poor extension services
	Lack of awareness among stakeholders
	Social/cultural barriers
	Lack of enforcement of standards and quality control
	Lack of capacity for operation and maintenance
	Lack of spare parts
	Lack of media interest in promoting technology
	Gender participation and integration
	Turnover tax in 2007/8 finance bill and this will affect SMEs disproportionately
	R&D needs to be reviewed
	Monitoring and evaluation
	Capacity building for design
	Trade policies
	Taxation (improved and subsidies
	Environment policies
	Science and technology policies
	Energy policy
	Ministry of Trade and Industry/ Ministry of Energy/ Ministry of Environment
	KRA/KEBS/KIRDI/KFS
	Research and training institutions
	Organization to drive the process KEREA, KAM, KHA
	Anti-dumping
	Financial restrictions of low purchasing power
	Accessing credit
	High perceived risk

Tables A13-3 and A13-4 show the support services identified by stakeholders as needed for small scale biomass gasification and market chain actors for this technology, respectively.

Table A13-3. Support services needed for small scale biomass stoves in Kenya

Country	Kenya Support Services	
Support services needed for small scale biomass gasification	Transporters	Sales reps
	Shipping Companies	Marketing in media
	Clearing and forwarding agencies	Ministry of Agriculture (MoA)
	Maintainers	Extension workers
	Pre shipment inspection	Financial institutions MFI BANKS Coops
	Insurance	NGOs
	Banks	

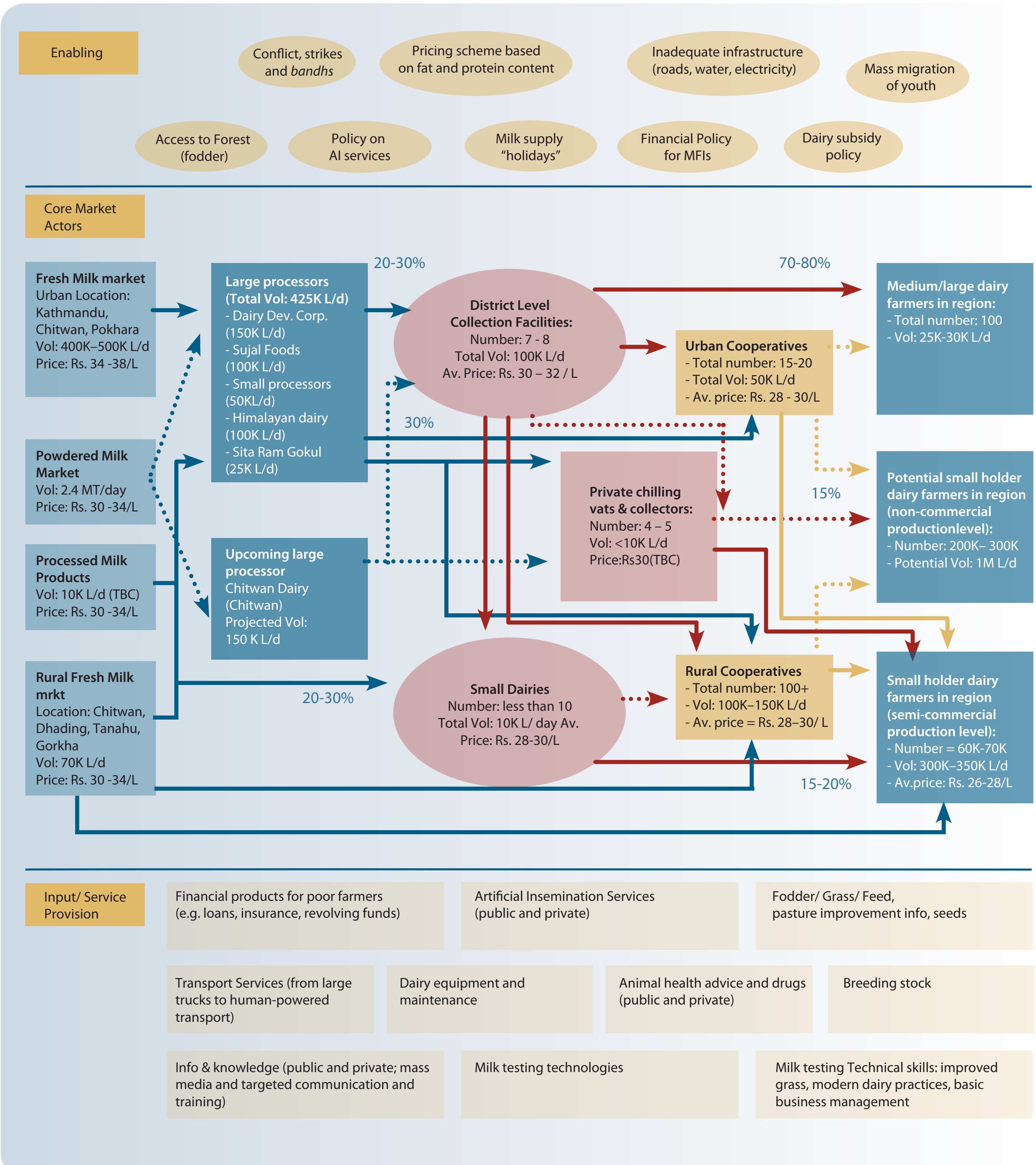
Table A13-4. Market chain actors for small scale biomass stoves in Kenya

Country	Kenya Market Chain Actors	
Market Chain Actors for small scale biomass gasification	Designers	Trade consumers
	Raw material and product suppliers	Service agents
	Producers	Financiers
	Importers	Technology owners
	Stockists/wholesalers	Consumers include Households
	Transporters	Government
	Retailers	SMEs
	Sales Agents	Institutions, e.g., schools, hospitals, hotels/restaurants, prisons
	Promoters	Social groups
	Installers	Womens groups
	Competitors	Church Groups
	Regulators for Quality control and licensing	NGOs
	Camps(IDP)/tourists	Aid agencies

Mapping example: dairy farmers in western Nepal

Figure A13-3 shows an example of market map which was prepared for the dairy market in four districts in Western Nepal provided by Alison Griffith of Practical Action. Though not an example of technology transfer, this shows the potential of more detailed quantification and identification of key issues as shown in the figure and the accompanying notes.

FIGURE A13-3. DAIRY MARKET MAP FOR FOUR DISTRICTS IN WESTERN NEPAL
SOURCE: A. GRIFFITH, PERSONAL COMMUNICATION



Notes to the map

Key

Percentages: indicate current share of volume produced by farmers and channelled by intermediaries

Arrows show flow of money from end markets to producers

Bold arrow: Dominant market channel

Normal arrow: existent market channels

Dotted arrow: potential market channels

Market chain actors

Semi-commercial farmers (60,000-70,000): Average productivity is very low, i.e., approximately 1 litre/day per cow (2.3 litres/day for buffalos). Due to poor genetics (breed), low quality feedstuffs and health problems, the milk quality is low, further eroding their prices.

Non-commercial farmers (250,000-300,000): They have at least 1 or 2 milking cows/ buffalo but either are not producing adequate amount to sell or have not seen the incentives to be linked with the market channels to sell their milk.

Co-operatives are the traditional point of milk collection. Dhading, Tanahu and Gorkha have relatively few; Chitwan has over 100, mostly formed by producers to secure their supply. Most have chilling facilities and some have technologies (though old) for pasteurization and minimal processing; however, less than a third have any storage facilities.

Large-scale processors: Dairy Development Corporation is government-owned and has been the largest and most influential actor since 1969. It dominates provision of chilling facilities, hampering private investment up to now. Private processors are now starting to emerge and even overshadow it.

Services/inputs

All the services and input included in the map have various levels of challenges in terms of outreach, affordability, appropriateness and quality.

Milk-quality testing technologies: Services mostly embedded into cooperatives and/or large processors or dairies but transparency and impartiality are dubious. Intermediate technologies like lactometers are hard to find and not used properly when available.

Financial products: Current loans and insurance products are not suitable for small holder dairy farmers. Interest rates are relatively high and repayment options are not conducive for dairy farmers (do not take into account their production cycle).

AI service: Weak or non-existent. Gorkha district has no artificial insemination (AI) service and semen is unavailable. Service providers are not well trained or equipped for rural and remote locations resulting in low success rate and at times death of cow from infection.

Breeding stock and cattle purchase markets: Improved breeds of cattle come from India and there are stringent quarantine measures. Majority of small scale farmers rely on poor supply and low quality of breeding stock.

Fodder/grass/feed: Nutrition inputs are one of the key constraints to realizing production potential. Lack of access to community forest is a problem and other options require more labour and time. Feed is not affordable as most is procured outside the district. Knowledge on improved grass cultivation is low and land to grow them scarce.

Transport services: Labor for transporting milk to local market centres is scarce and/or expensive (partly due to migration). Large scale processors use small trucks with milk cans rather than chilled tankers, further eroding milk quality.

Animal health advice and drugs (public and private): The key issues include lack of outreach, lack of quality services, and lack of resources for service providers to upgrade their skills and knowledge. Traditional healers are currently an important but low-quality channel of advice for marginalized farmers.

Dairy equipment and maintenance: As large processors expand their supply catchment areas there will be a need to ensure that local service providers are available. Trained providers (electricians and metal-workers) are hard to find due to migration.

IInformation and knowledge (public and private; mass media and targeted communication and training): Mass media, such as radio, target few products at increasing the knowledge of smallholder dairy farmers. From other sources, there is a lack of available knowledge providers for agro-vets, AI providers and other essential providers.

Embedded services: The majority of intermediary players are interested in improving bulking and chilling. Some processors have taken additional steps by hiring professional agro-vets who provide technical advice at collection point. However, the service is paid by all milk suppliers whether they ask for advice or not. Processors are open to exploring new models as long as they make business sense..

Business environment

Agriculture policies such as agriculture subsidies, import duties and quarantine laws look good in theory, but in practice create an unfavorable environment for smallholder dairy farmers.

Fat- and protein-based pricing scheme: Promoted by DDC and given its governmental nature and size this scheme acquired a "quasi-policy" status. However most farmers go down the route of low-added-value transactions where price is determined by volume.

Conflict has hit smallholder farmers the hardest as there has been very low out-reach of government extension services to rural and remote areas. Continued political unrest has resulted in frequent strikes and bandhs which force farmers to throw away their milk as they lack storage facilities.

Weak governance has made this sector highly vulnerable to corruption, bribes and bureaucratic hassles, e.g., on issues such as import of cattle and semen. Decreasing access to community and leasehold forest for smallholder dairy farmers is a further issue.

Milk holidays: During flush periods large dairy processors often stop buying milk for a set number of days. Farmers have learned to live with this practice but it has a negative impact on the efficiency of the whole system. Instead of evening out seasonal peaks, it discourages emerging farmers from taking part in this sector, hampers value addition to extra supply (e.g., powdered milk, sweets and ice creams) and reinforces national dependency on imports during dry seasons.

Typical problems across countries

Common blockages and inefficiencies, which are independent of size or technology, are presented below in Table A13-5 in terms of the different aspects of the market map.

TABLE A13-5: COMMON BLOCKAGES AND INEFFICIENCIES FOR TECHNOLOGIES IDENTIFIED ACROSS COUNTRIES

Market chain	
	Lack of technology transfer network
	Lack of awareness of stakeholders and for large projects particularly linkages and contacts to external producers
	Cost of new technologies; lack of accounting for externalities; availability of cheaper, high-carbon alternatives
	Need to demonstrate unfamiliar and adapt to local conditions
	Lack of competition especially in electricity supply
Enabling environment	
	Weak policies
	Lack of regulations, standards and enforcement
	Complex procedures
	Import procedures need to be simplified and incentivized for these new technologies
	Lack of integration across government, e.g., fiscal policies and particularly tax regimes need to be aligned to encourage their adoption
	Poor infrastructure
	Lack of incentives
Support services	
	Lack of R&D support
	Lack of market information
	Lack of good quality control
	Local capacity building to bridge expertise gaps
	Language and cultural support
	Finance availability for new technologies and small scale technologies and measures to offset the additional risks associated with these new technologies

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