CONDUCTING TECHNOLOGY NEEDS ASSESSMENTS FOR CLIMATE CHANGE

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FOREWORD

Climate change is among the most daunting environmental problems faced by the world today. The Third Assessment Reports of the IPCC (2001) have shown that no country and no region of the world will be unaffected, and in many countries the consequences for all human activities will be profound. Fortunately, human imagination and ingenuity are already beginning to respond to the problem, by identifying and developing technologies and practices both for mitigating climate change and adapting to it. The development and use of most mitigation and adaptation technologies would be fully consistent with the broad goals of sustainable development

The viability of many technological options for confronting climate change is becoming better established as a result of a range of national and international initiatives. Nevertheless, there is a need to find ways by which developing countries can formalise the important process of assessing the emerging technologies and practices for adapting to climate change and mitigating greenhouse gas emissions.

This process includes both hard and soft technologies and therefore encompasses "know-how" as well. This handbook is intended to be a step in this direction. It summarises guidance prepared by the United Nations Development Programme (UNDP) in co-operation with the Climate Technology Initiative (CTI) and with input from a wide range of multilateral agencies and country experts. Funding was provided by the Global Environment Facility (GEF). It has been designed to provide guidance on how to develop a straightforward approach to technology needs assessment (TNA) that may be adopted and adapted by countries undertaking such assessments.

Why this handbook?

* This handbook has been prepared because a broad survey of developing countries that were assessing technology needs indicated their need for a practical approach to this task.
- While numerous organisations have considered methodological issues in technology transfer and needs assessment, few have considered climate response needs assessment processes and activities. This handbook attempts to fill this gap by drawing upon relevant resources.

What the handbook seeks to achieve

- This handbook provides 'user-friendly' guidance on approaches, methods, and tools that can be used to conduct a TNA.
- The handbook reviews key concepts and approaches for assessing technology needs for climate change. Both mitigation and adaptation are addressed. Graphics and text boxes are used to present particularly important issues.
- Developing country circumstances differ widely with respect to the degree of technical capacity, the role of stakeholders in national development planning, and technology transfer underway. This handbook provides an approach for technology needs assessment that can be modified and adapted to best fit a country's unique circumstances.
- Ultimately, this handbook's major objective is to encourage technology transfer as defined by the UNFCCC. The handbook aims to convey a methodological framework for conducting an assessment and provide links to pertinent resources.

Who should read this handbook?

- While anyone can use this Handbook – from policymakers, to the academic community, to local stakeholders – it is primarily designed for climate change teams seeking guidance for assessing the role of technology in reducing greenhouse gas emissions and adaptation to climate change impacts.
- The Handbook can also be useful to the range of stakeholders interested in sustainable development. It can function as a resource for promoting dialogue and refining perspectives among local communities, policymakers, the private sector, and the general public regarding the linkages between technology and climate change.

In short, this handbook articulates a flexible approach for prioritising technology needs and implementing the practices and reforms required to reduce greenhouse gas emissions and to adapt to climate change, while at the same time contributing to goals for sustainable development. I am grateful to all the contributors to this process and applaud their commitment to making the technical framework and guidance useful to the developing country community.

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The National Communications Support Unit does not endorse the use of any single model or method for national-scale assessments of climate change. It encourages the use of a range of models and methods appropriate to national circumstances.

GLOSSARY

CBA	Cost benefit assessment
CGIAR	Consultative Group on International Agricultural Research
CHP	combined heat and power
COP	Conference of the Parties
CTI	Climate Technology Initiative
GEF	Global Environment Facility
GHG	greenhouse gas
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IITA	International Institute of Tropical Agriculture
IPCC	Intergovernmental Panel on Climate Change
NGO	non-governmental organisation
PV	photovoltaic
PRSP	Poverty Reduction Strategy Papers
RBA	risk benefit analysis
SANet	Sustainable Alternatives Network
SBSTA	Subsidiary Body for Scientific and Technical Advice
SIDs	Small island developing states
SPFS	Special Programme for Food Security
TNA	technology needs assessment
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United National Industrial Development Organization
UNFCCC	United Nations Framework Convention on Climate Change
USEPA	United States Environmental Protection Agency
V&A	Vulnerability and adaptation
WUE	water use efficiency

1. GETTING STARTED: HOW TO USE THIS HANDBOOK

This handbook has been designed to provide guidance on how to conduct a *technology needs assessment (TNA)* that focuses on two broad areas: mitigation of greenhouse gas emissions (GHG) and adaptation to the impacts of climate change. Its primary purpose is to promote technology transfer, as defined by the UNFCCC, in the context of meeting the needs of developing countries for climate change technology.

The handbook focuses on only one of the many dimensions associated with technology transfer – technology needs assessment. Within this dimension, only climate change technologies – a subset of the range of technologies that could be considered within sustainable development objectives - are considered. Hence, while it is certainly true that countries may identify a wide range of issues to improve the development and transfer of technologies, the handbook is concerned only with the *manner* in which technology needs are assessed and the specific topics of *mitigation and adaptation*.

The Intergovernmental Panel on Climate Change (IPCC) defines *mitigation* as an anthropogenic intervention to reduce the sources or enhance the sinks of GHGs. It defines *adaptation* as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects.[1] As discussed throughout this handbook, a technology needs assessment applies a common methodological framework to both mitigation and adaptation, while carefully accounting for their distinctive aspects and unique processes. Extensive global consultations have been led to ensure that the resulting guidance offered in this handbook is as useful and relevant as possible to developing country teams.

1.1. Approach

The approach is based on two fundamental points. First, every country's technology needs and resources are different. Country circumstances differ widely, and options that apply in some countries may not be available in others. Second, there are nevertheless many circumstances that are common across countries.

Therefore, this handbook aims for flexibility. It lays out the key steps, decisions, methods, and resources needed for assessing climate change technology needs that should be useful for all countries, but which can be modified and adapted to suit national circumstances as appropriate.

Effort is devoted to helping users identify key outputs and appropriate methods and tools, as well as to indicating the level of analytical rigor involved with decision making. Throughout the discussion, the user should clearly note that all activities should be compatible with a country's broader sustainable development context.

Finally, TNA is a complex process. The handbook does not presume to address every intricacy. Rather, the handbook aims to impart the "big picture" and should be used alongside other capacity development resources. One could view the handbook as a living document to be updated and allowed to evolve based on national experience, new knowledge, and outputs from TNA training activities. Ultimately, the handbook seeks to clearly outline a viable approach to mitigation and adaptation technology assessment that countries may apply directly, but with enough flexibility to account for their particular set of circumstances.

1.2. Target Audience

This handbook will be valuable to anyone wishing to understand how to undertake an assessment of climate change technologies, regardless of their level of familiarity with the particular technologies associated with GHG mitigation and adaptation. It will be of special relevance to Project Coordinators who may be tasked with organising policy or project formulation related to climate change technology transfer.

1.3. Structure of the Handbook

This handbook has been designed to provide users with the basic know-how and confidence to launch a technology needs assessment in their own countries. It addresses key concepts and specific tasks, as well as the potential challenges likely to emerge while carrying TNA activities. It is broadly structured to address the following:

- **Generic activities** involved in the technology needs assessment itself,
- **Distinctive issues and processes** involved in the application of the step-by-step methodology to the domains of *GHG mitigation* and *adaptation to climate change*,
- **Cross-cutting issues** involved in each step of the TNA, namely *stakeholder engagement* and *barriers analysis*,
- **Implementation issues** related to practical follow-up of the needs assessment, and
- **Supporting information** related to technological resources (in annexes).

The handbook starts with an overview of the concept of technology needs assessment as it applies to climate change. The aim of this overview is to provide a broad introduction to the concepts, issues, and challenges involved in locally undertaking a needs assessment for climate change technologies. It should be considered a quick reference to the key issues and considerations that country teams will need to bear in mind throughout the needs assessment process.

In the two sections that follow, the handbook provides separate treatments of mitigation and adaptation. The aim of these sections is to highlight the distinctive features of the

1 Various types of adaptation are possible, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation. For additional information, see the *User's Guidebook for the Adaptation Policy Framework*, UNDP/GEF, 2004

TNA methodology when applied to mitigation and to adaptation. This is important, as the set of technology considerations involved can vary significantly. A discussion of set of cross-cutting issues is then provided, followed by a brief overview of some of the major implementation issues.

2. OVERVIEW: TECHNOLOGY NEEDS ASSESSMENT

Technology transfer concerns the flow of experience, know-how, and equipment between and within countries. It has long been a priority under the UNFCCC. Assessing technology needs is one of the five key elements of an overall integrated framework to enhance technology transfer. Other elements include improving access to technology information, creating enabling environments, strengthening local capacity, and instituting technology transfer mechanisms.

2.1. What is Technology Needs Assessment?

Technology needs assessment entails the identification and evaluation of technical means for achieving specified ends. From a climate change and developmental perspective, TNA prioritises technologies, practices, and policy reforms that can be implemented in different sectors of a country to reduce greenhouse gas emissions and/or to adapt to the impacts of climate change by enhancing resilience and/or contributing to sustainable development goals.

> ***Think of TNA as an approach by which sustainable development, climate change technologies, and opportunities are integrated.***

Many of the applicable technologies for mitigating GHG emissions and adapting to climate change may also be well-suited to sustainable development priorities in a broad sense. Indeed, those concerned with adaptation – such as those that protect or improve water resources, or that maintain and improve agricultural output – are also necessary for sustainable development (IPCC, Working Group II, 2001). Similarly, many of the technologies being developed in response to the needs of GHG mitigation, especially those related to renewable energy and energy efficiency, will also help to produce and consume energy in a sustainable way.

TNA is not a stand-alone activity. Rather, it is a continuation of the work countries have carried out or identified in their National Communications and through other activities to enhance technology transfer. It is closely linked to Article 4.5 of the UNFCCC, which requests Annex 1 parties and developed parties included in Annex II to the Convention to take steps to assist parties, in particular developing countries, in the process of technology transfer.

2.2. Adaptation and Mitigation

Conducting technology needs assessment for climate change requires a focus on two major areas, greenhouse gas (GHG) mitigation and adaptation to the impacts of climate change. It needs to be recognised at the outset that the particular processes used to assess technology needs in these two areas, though fundamentally consistent in key areas, may be operationally distinct in others.

Assessing technologies for mitigating GHG emissions is fairly "straightforward". Such technologies have a simple and clear objective – i.e., the reduction or avoidance of GHG emissions – and tend to target specific, well-known, emitting sectors such as power generation and transportation. There is a large case study literature of mitigation technology applications that yields lessons that can be learned and taken into account when assessing such technologies in a local context.

Assessing technologies for adapting to climate change poses a more complex challenge on two levels. First, there is inherently more uncertainty regarding vulnerability, as impacts tend to be highly site-specific and not easily generalisable across spatial and temporal scales. This uncertainty carries over to identification of appropriate adaptation measures, options, and technologies – as well as the stakeholders that are affected. Therefore, hard technologies may not be appropriate. Secondly, adaptation concerns have only recently moved onto centre stage of the climate change negotiations. Unlike the mitigation area, which can claim a formal protocol as a framework for North-South cooperation on reducing GHGs (i.e., the Kyoto Protocol), there is no comparable approach as yet in the adaptation area. As a result, there are limited examples of real world successes from which to draw lessons.

This handbook explicitly addresses the distinctions between mitigation and adaptation TNAs. These distinctions are important because they have a direct bearing on the scope of the methodological approaches used to assess technology needs in specific national circumstances. Specifically, the handbook treats distinctions in the application of the TNA framework in the following ways:

- **Steps:** the handbook highlights critical ways of operationalising TNA activities to meet the specific dictates of mitigation and adaptation concerns. However, it should be kept in mind that this handbook is not a cookbook of operational steps, but rather a tool for understanding the nature and scope of technology assessment activities/steps involved.
- **Case studies:** the handbook presents some case study examples of ways that different technology issues have emerged when considering mitigation or adaptation strategies, and
- **Cross-cutting issues:** the handbook describes differences in the type of stakeholders involved, the nature of the barriers faced, and the kinds of technological information that are pertinent

In summary, while the overall framework for technology assessment is common to both mitigation and adaptation, there are important modalities that will need to be considered carefully in undertaking a TNA in mitigation or adaptation.

2.3. Technology Needs Assessment Resources

At the first Conference of the Parties (COP) to the UNFCCC, the Subsidiary Body for Scientific and Technical Advice (SBSTA) requested the Intergovernmental Panel on Climate Change (IPCC) to undertake an assessment of the issues surrounding technology transfer. The subsequent report, *Methodological and Technical Issues in Climate Change*, discusses a wide range of activities to enhance technology transfer.

A number of organisations have looked at methodological issues in technology transfer, including the nature of the technologies and the process of technology transfer (UNEP/Risoe, 1998; UNEP, 1998; Zou, 2002; CTI, 2002; and IPCC, 2000). The handbook draws upon these and other relevant resources, including CTI and UNEP, and seeks to complement those reports that deal with particular technologies and practices.

2.4. Intended Outputs and Outcomes

Technology needs assessment is capable of yielding a variety of outputs, depending on how it is applied. While specific outputs depend on the particular needs and goals of the exercise, in general, a completed TNA process leads to a clarification of technology barriers, strategies, policies, and options that a country could implement to reduce GHG emissions and/or enhance the ability to adapt to climate change. These can be aimed at different levels of society, as well as at different sectoral and temporal scales. Their general purpose will be to identify and exploit the local and international opportunities for technology transfer. Several major outcomes are envisioned:

- **National Policy Development:** TNA can be used to explore governmental decisions aimed at integrating sustainable development planning with the impacts of climate change. For adaptation, this policy focus may be directed at important sectors of the national economy such as agriculture, forestry, water resources, coastal zones, etc. For mitigation, the transportation or power generation sectors could be targeted.
- **Adaptation and Mitigation Assessments:** Technology used to address mitigation issues may also have implications for addressing adaptation issues. TNA can be used to explore these potential linkages in conjunction with other initiatives aimed at analysing options and/or national plans for mitigation and adaptation.
- **Project Formulation:** The outputs of the TNA process may be linked to efforts in the formulation of specific technology transfer projects. Such projects may also be focused on specific regions or sectors of the country and aim to lessen the impacts of extreme climate events such as floods, droughts, or tropical cyclones, or reduce GHG emissions through the use of renewable energy or energy-efficient technologies.
- **Technology transfer community:** The TNA has been designed to facilitate a process of consultation between actors and sectors. Ideally, a "technology transfer community" will be created – one that is capable of supporting the implementation process put in place by the stakeholder and assessment processes of the TNA. At the end of the effort, the range of stakeholders should have a better understanding of the role and range of technologies pertinent to climate change adaptation and GHG emission mitigation.

2.5. Taking Stock

The choice of which TNA processes to undertake, as well as the selection of associated methods and tools, depends on the nature of the ultimate output desired (i.e., whether policy development, adaptation and/or mitigation focus, or project formulation). This means that careful attention should be paid to the following:

- **Tracks:** Adaptation and mitigation represent very different entry points to a needs assessment. Stakeholders involved, barriers confronted, and key affected sectors will likely be quite different and display unclear levels of overlap. Alternatively, there may be a significant amount of overlap and synergy. The track taken – i.e., whether to focus on mitigation, adaptation, or both – will depend on a country's national circumstances, including its past experience, current goals, and available resources.
- **Coverage:** TNA can vary considerably in the level of coverage. For example, one country's strategic focus may address all geographic areas and all sectors. Another's might be highly localised to a key region (e.g., coastlines) to address critical vulnerabilities (e.g., more frequent storm surges, future sea level rise) or to a particular sector (e.g., energy supply) to address institutional, regulatory, and planning issues related to the use of new technologies (e.g., solar thermal electric power generation).
- **Methods and Tools:** Methods and tools used and effort required will depend on the level of complexity and/or comprehensiveness of the TNA. For the most part, the methods and tools are focused on qualitative assessments (e.g., Delphi techniques, stakeholder consultations, focus groups) that synthesise diverse amounts of information.
- **TNA Steps:** The steps within the TNA process will depend on the approach and coverage. For example, for countries where a robust technology assessment has already been undertaken as part of some other climate change-related process, the step dealing with this activity could either be skipped or summarised by using the existing study. In countries where technology assessment activities have yet to be explored in any meaningful way, all the TNA steps could be conducted.

It is important to remember that undertaking a technology needs assessment does not necessarily require an abundance of high-quality data or generous amounts of time and funding. What is needed is stakeholder involvement and existing information and data, focused on mitigation and/or adaptation to climate change. These elements do have costs in both time and resources, but they do not represent an unmanageable burden. For some countries, addressing all the steps involved in the TNA processes will be more strategic than investing heavily in one or another of the steps.

2.6. Carrying out the Technology Needs Assessment Process

The sections that follow provide guidance on implementing a TNA process for both mitigation and adaptation. It is important to note that the steps should be applied in a way that is consistent with local circumstances. The guidance makes explicit the range and type of decisions needed in order to undertake the TNA process effectively. The material will guide the user through decisions regarding (1) an appropriate project approach and depth, (2) logical priorities in terms of steps and tasks, and (3) resources needed.

3. THE TECHNOLOGY NEEDS ASSESSMENT PROCESS: KEY ACTIVITIES

This section describes what is required in undertaking a TNA. Essentially, the process involves a common set of organising activities that should be closely linked to other relevant national development processes. At its heart, the TNA process should reflect national response to climate change technology needs that is informed by the private sector, the general public, and other stakeholders.

The TNA process directly addresses the question: "What are the key actions, priorities, and criteria with respect to GHG mitigation and adaptation to climate risks?"

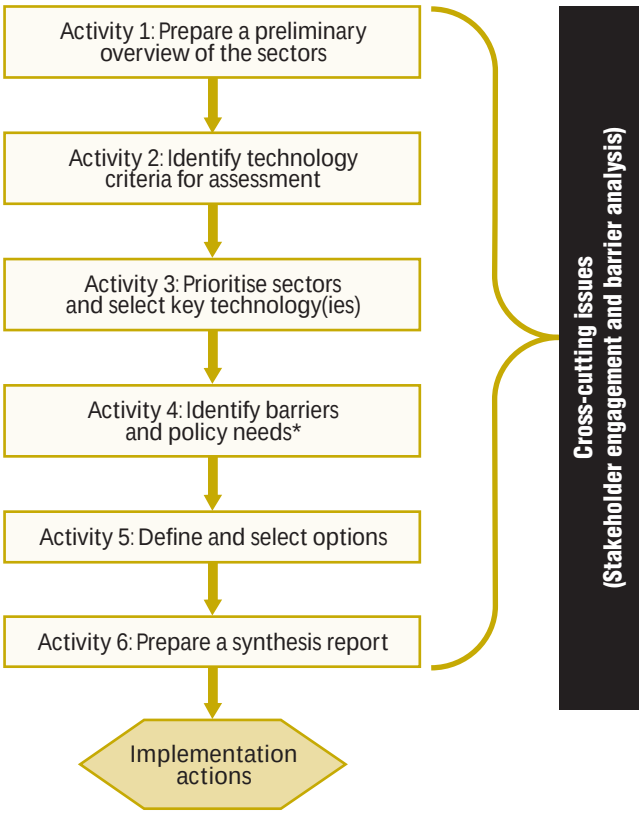
The technology needs assessment is comprised of six key activities, which are illustrated in Figure 3-1 and described in the subsections below. The arrows between the activities should not be interpreted as indicating a fixed sequence of tasks, but rather as suggesting important conceptual links.

In addition to the six activities presented, there are two important cross-cutting issues that are briefly discussed below and treated in more detail in a later section.

- **Stakeholder engagement:** Ensuring adequate stakeholder participation at every stage is essential. This helps to make the impacts upon them and their responsibilities clear, and also helps to facilitate implementation processes.
- **Barriers:** These exist at each step in the TNA process. Understanding them and the ways they can be effectively addressed is key to undertaking successful implementation actions based on the TNA.

Within each of these essential activities, there are several distinct steps, depending on whether a mitigation or adaptation technology assessment is being undertaken. Box 3-1, which summarises the Caribbean experience, shows how steps within the TNA can be addressed in different national circumstances.

In the following subsections, the basic TNA activities outlined in Figure 3-1 are described. The specific steps inherent in the nature of mitigation and adaptation activities are treated separately elsewhere in this handbook. It is important to note that Figure 3-1 does not intend to represent a rigid sequential set of activities. It rather aims to illustrate the process involved in conducting a TNA. Although some activities may need to be completed before moving into the next one (e.g., identifying criteria for technology evaluation before prioritising technologies), others may be conducted in parallel. The same principle applies to Figures 4-1 and 5-1, which illustrate the activities and steps for TNA in the mitigation and adaptation areas, respectively.



*note that Activity 4 (identifying barriers) is also a cross-cutting activity

Figure3- 1: Activities in the Technology Needs Assessment Process

Activity 1: Prepare a Preliminary Overview of Sectors

A preliminary assessment of the current status of identified sectors is recommended. This assessment should involve the collection of **existing data and information that pertains to the sector.** It does not necessarily involve research to collect new data and information; in act, such exercises should be avoided because of cost implications. It is essential to obtain a synopsis of the **current status** of the sector. When developing the preliminary assessment, countries may draw upon existing work. Examples of possible sources include national communications, vulnerability and adaptation (V&A) assessments, and national and sectoral development plans. An important initial step is to identify information sources.

Making a determination of the particular sectors and information sources to draw upon should involve a stakeholder

Box 3-1: Adapting the TNA Process to national circumstances – recommendations from Caribbean and low-lying states

To explore key issues and questions involved in tailoring the TNA process – as represented by Figure 3-1 – to unique national or regional circumstances, a workshop was held in Port of Spain, Trinidad on October 20-21 2003. Specifically, workshop participants discussed the usefulness of the TNA framework within the context of climate change adaptation. The discussions led to certain refinements to the TNA framework, which have been incorporated in the adaptation section of this handbook. Workshop participants recommended that the following questions be considered in an early stage of the national TNA to lend insight on how the overall process can be applied to suit national circumstances.

- Is the approach outlined in the TNA handbook adequate to engage the necessary stakeholders in TNA?
- What kind of issues should be addressed to help countries develop a set of criteria against which sectors/technologies can be assessed? How can these be represented in the methodology?
- What issues should the TNA include in addressing "soft" technologies?
- Are there other tools that may provide additional guidance or assistance in assessing technology options that should be considered? One example is the environmental technology impact assessment (Annex 3).
- Does the TNA handbook provide adequate guidance on barriers? If not, what additional issues should be considered in developing a modified TNA methodology?
- Are there any additional issues that should be considered (i.e., capacity building) to better respond to national concerns? How can these issues be fleshed out in the TNA methodology?

process that includes key individuals, groups, organisations, and networks, since the decisions taken here will inform the rest of the process. It must be remembered that **stakeholder consultation is a start-to-finish process.**

Activity 2: Identify Technology Criteria for Assessment

At the most general level, the criteria for selecting sectors and technologies for TNA will depend upon three factors, which are not necessarily mutually exclusive:

- **Contribution to development goals.** How much overlap exists between the technology and the already identified technology needs?
- **Contribution to climate change mitigation or adaptation.** How effective is the technology in reducing GHG emissions and/or increasing resilience to the impacts of climate change?
- **Market potential.** Is there a ready niche for the technology?

Each of the above factors in turn will entail deeper levels of analysis depending on the country, sector, and technology in question. For example, the contribution to development goals will likely involve an analysis of the benefits involved (e.g., food security, health improvements, protection from natural disasters, social acceptability, and potential for reducing non-climate impacts). An important consideration here is the environmental and cultural impact of the technology and may entail a more detailed analysis of environmental technology impact assessment, as described in annex 3.

The contribution to climate change mitigation will involve a quantification of the GHG emission reduction potential and/or the enhancement of carbon sinks. The contribution to climate change adaptation will likely involve an assessment of the degree to which climate change-related risks can be reduced.

The contribution to market potential will likely involve an analysis of capital and operating costs relative to alternatives, the commercial availability of the technology, and the technology's replicability, applicability, adaptability, and potential scale of utilisation.

Determining the weight and importance of each of these factors is partly a policy decision, and as such will be affected by country priorities and circumstances. Three sources of opinion (facilitated by data and objective assessment) are important components of the weighting process as they tend to be acquainted with country programming designed in coordination with UNDP and other development agencies:

- **Expert judgment.** While weighting is a value-laden exercise and should be done by stakeholders and policymakers, there can be a useful role for specialists.
- **Policymakers.** These are typically from government ministries and agencies.
- **Broader stakeholder groups.** Examples include industrial organisations, vulnerable communities, academia, and NGOs.

Activity 3: Prioritise Sectors and Select Key Technology(ies)

The identification of priority sectors will be based upon the importance of the sector in terms of the criteria as outlined in the previous activity. It is recommended that a limited number

of priority sectors be identified for further action. The number of sectors a country decides to prioritise will depend upon individual country circumstances, but two or three sectors should be selected for initial action. The process of prioritisation is based on three related, but distinct, components:

- **Sectors:** The sectors with potential to benefit from technology development and transfer, and/or of the need for further data.
- **Access and availability:** The technology options and resources available, and/or the need for further data.
- **Policies:** The potential policies that would support the adoption of the technologies and practices identified.

If priorities for technologies are being set within sectors (or within regions), the criteria can differ. In order to set priorities across sectors or regions (e.g., for a country as a whole), a common set of criteria with an agreed-upon set of weights will be needed. In most cases the following steps will be required:

- **Listing** the sectors and technologies that will be assessed
- **Identifying** barriers to implementation
- **Agreeing** on a list of the factors that are to be included in the assessment criteria
- **Developing** a set of weighting factors, if, and as, appropriate
- **Agreeing** on the process of assessment (stakeholder, expert, and government roles must be clearly defined), and
- **Publishing** the findings of the priority assessment process.

While it is not the intention of this handbook to engage in in-depth discussions on assessing technologies per se, this step provides **initial guidance as to what technologies may be applicable** and needed and what considerations should be given in identifying and prioritising such technologies. The application of the technology as part of the implementation actions would necessarily involve more detailed analysis and would include various factors such as marketability, adaptability etc. A critical part of this assessment would be access to, and examination of, **technology information.**

A variety of approaches to prioritising technologies within this broad framework exist. These include multi-criteria analysis, cost- benefit assessments (CBA), risk-benefit analysis (RBA), and so on. It is not the purpose of this handbook to discuss the relative merits of different approaches – there is a wide body of literature on that already. It is important that countries choose an approach that is appropriate for their circumstances.

In many cases, a straightforward and inclusive approach to technology prioritisation is likely to be the most effective. Simplicity can help ensure that stakeholders will be engaged, thus assisting in the implementation of TNA action plans.

Whatever approaches countries use, they are only as good as the data that is fed into them. In some cases, the data available and the scale of the decision-making problem will justify a sophisticated approach.

Whichever approach (if any) is used to examine and set priorities, it is important that analytic tools such as cost-benefit analysis are recognised as simply being tools; their role is to serve the decision-making process, not drive it. The purpose of the tools is not to produce answers out a proverbial black box, but to inform the process, e.g., by developing or displaying information in a manner that may not be obvious or that could provide useful insight.

Those managing the TNA process should be careful not to allow decision analysis tools to become an end in themselves or to overwhelm a process by detracting from reaching an improved understanding of options and developing a consensus among participants.

Perhaps in no other activity in the TNA process is the role of stakeholder more important. Prioritisation activities are inherently a normative undertaking that should be informed by as wide a group as possible. The flow of information to and from stakeholders will need to be carefully managed.

Activity 4: Identify Barriers and Policy Needs

It is important to consider potential barriers to the priority sectors and technologies selected in Activity 3. In fact, analysis could very well be integrated into each step of the TNA as a cross-cutting issue, as barriers may exist for different aspects of the assessment. Some potential barriers are specific to the technologies themselves, while others are specific to developing country contexts. While an in-depth discussion on barrier analysis is outside the scope of this handbook, a more detailed discussion of barriers as a cross-cutting issue is presented in a later section.

It is important to remember that there is a prominent role for stakeholders in the identification of barriers and policy needs.

Activity 5: Define and Select Options

Once technology and sector priorities have been identified, barriers assessed, and stakeholders assembled, technology options can be selected for the short and long terms. This activity involves revisiting the priorities identified earlier in light of barrier analysis. In selecting technology options, countries may wish to take into account two distinct types of technology transfer and development opportunity:

- 'Win win' options that deliver both climate and other development objectives, and are available at low (even negative) costs. Special attention may need to be given to indigenous and soft technologies, which often represent a solution to local needs at low costs.
- In the longer term, new options will become available

Box 3-2: Technology Needs Assessment Synthesis Report

The synthesis report may contain the following elements:

- Objectives for the TNA in the context of national development priorities
- A description of the stakeholder process adopted
- An evaluation of sectoral needs and opportunities
- A statement of data gaps
- The criteria and process for technology assessment
- Identification and assessment of technology options (including adaptation, if appropriate)
- A list of priority sectors and key technologies for preliminary action
- A review of key barriers related to existing plans and programmes and steps to overcome them
- Capacity building measures, if applicable
- Potential sources of funding
- A discussion of implementation plans, if relevant

and the relative merits and economics of different technologies and developments in different sectors may change. Technologies that are not currently 'win win' but offer particular promise for addressing climate change and other development goals in the longer term may need to be explored.

A relatively straightforward technique to help with the selection of options is ranking by stakeholders/experts. This should involve the stakeholders who participated in the previous activities. Engagement with the ranking process may be carried out through a series of workshops or consultations (e.g., questionnaires, email).

Activity 6: Prepare a Synthesis Report

Each of the previous activities needs to be combined into a coherent whole that allows actions to be pursued and provides an overview of the basis upon which decisions have been made. This will require the compilation of a synthesis report.

It is important that all stakeholders view this report as the beginning of an ongoing process that must be integrated into wider technology transfer activities to improve the flow of climate response technologies and environmentally sustainable technologies.

As shown in Box 3-2, the synthesis report should contain a summary of the issues of concern to the technology transfer process – issues such as the key sectors affected, the types of criteria applied, the ranking and selection process applied, and the list of technologies that emerged as an output of the process.

4. MITIGATION – KEY STEPS IN THE TECHNOLOGY NEEDS ASSESSMENT PROCESS

A technology needs assessment for mitigation includes the essential six TNA activities illustrated earlier in Figure 3-1. Additional steps need to be taken that are specific to mitigation itself. These specific steps are illustrated in Figure 4-1 and summarised in the sections below.

Activity 1: Prepare Preliminary Overview of the Sectors

For mitigation, the preliminary assessment of the current status of sectors should be on the contribution each makes to the total national inventory of GHG emissions. Three steps are recommended as follows:

- **Review GHG inventory:** It is important to first review the greenhouse gas inventory established as part of the National Communications process as this serves to identify relatively high GHG-emitting sectors that may have there have significant mitigation potential. Users may want to identify any data or information gaps. The collection of new data should be avoided unless deemed to be absolutely critical by the TNA team.
- **Identify key sectors:** This step involves an analysis of the interrelationships between emission sectors to identify potential synergies options and optimisation of technology application. For example, mitigation options in the transport sector can have implications on 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 (PRSP).
- **Review Plans:** This step involves a review of national and sectoral development plans and policies in the identified sectors. The aim is to develop an understanding of the expected future growth in GHG emissions and long-term mitigation potential, as well as financial constraints that may impact on mitigation initiatives.

Activity 2: Identify Technology Criteria for Assessment

The development of criteria for choosing sectors with high mitigation potential builds off the previous activity. To facilitate this process, two steps are recommended as outlined

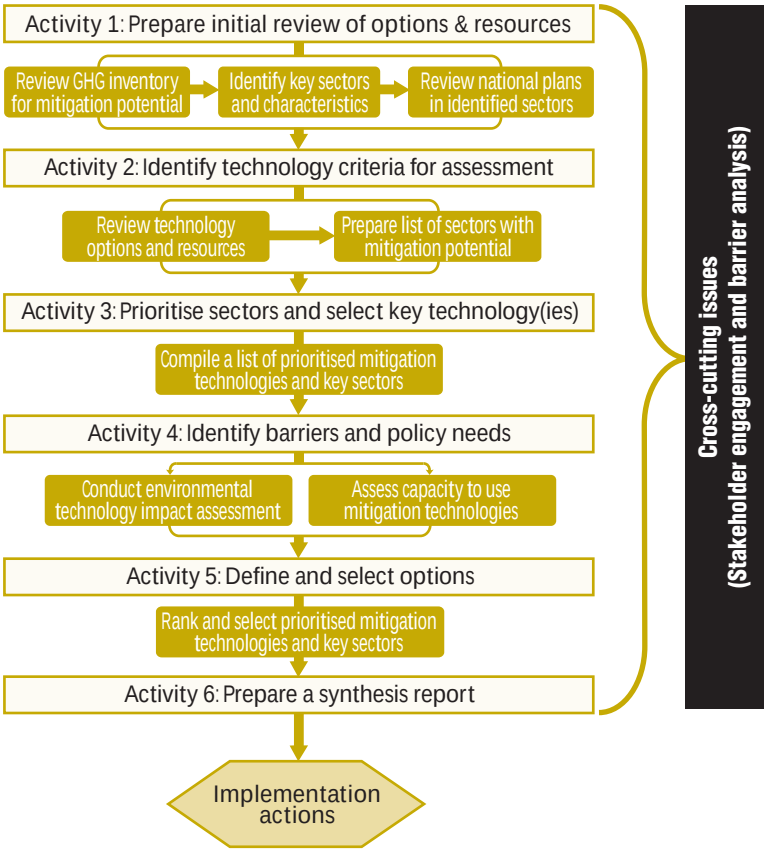


Figure 4-1: Key Steps in the Technology Needs Assessment Process for Mitigation

Box 4-1: South African and Chinese Examples of Criteria Used to Select Priority Technologies

South African Development Community

The narrowing of focus from 18 initial possible technologies to six priority technologies was done by ranking projects according to an agreed set of criteria which included the following considerations: development benefits, market readiness, GHG emission reduction potential, regional application, and local environmental benefits. The procedure to prioritise the areas for technology transfer was defined by participants. The following three broad areas were identified as criteria for selecting the technologies:

Development benefits: job creation, wealth creation for the poor, capacity building (innovation), social acceptance of technology, and use of local resources (human and material).

Market potential: finance (capital to pay for it), affordability (money to pay for it), investment, sustainability, low maintenance and durability, commercial availability and replicability.

Contribution to climate change: no or low GHG emissions, minimal harm to the environment, enhance sinks and waste resource recovery.

Source: Southern Centre for Energy and Environment, September 2002

China

The following criteria were used:

Environmental: global and local benefits, GHG mitigation potential, improvement of local environmental quality.

Technological: Commercial maturity of technologies, reliability of technologies, penetration of technology application, and replicability potential.

Economic: Internal Return Rate (IRR) and the effect of pricing and fiscal policies on the IRR, payback period, mitigation and adaptation costs.

Social: links with other sectors and groups, employment and poverty alleviation.

Source: Zou and Xu, 2002

below. Two country case studies regarding the factors that were considered in establishing criteria for technology selection – one in South Africa and the other in China – are summarised in Box 4-1.

- **Prepare list of sectors:** Once the previous TNA mitigation steps are completed, construct criteria for selecting sectoral and technology options. This is a deliberately flexible process that aims to obtain maximum representation of stakeholder perspectives. As discussed in the previous TNA process section, a combination of techniques is available, such as the integration of expert judgment, policymakers' experience, and broader stakeholder reflections. The result of this process is a preliminary list of sectors that offers strategic mitigation potential. It is advised that at this stage the widest stakeholder consultation should be conducted. This step leads directly to the next overall TNA activity, which focuses on prioritising sectors based on stakeholder consultations.
- **Review technologies:** This involves a review of technology options and resources that are applicable to GHG mitigation in the key sectors already identified. This step also includes the setting of criteria against which technologies can be assessed. In setting technology selection criteria, attention should be paid at least to the factors outlined in the previous TNA process section, namely contribution to development goals, ability to mitigate GHG emissions, market potential, and access to/availability of the technologies. Other criteria could be considered as appropriate to national circumstances.

Activity 3: Prioritise Sectors and Select Key Technology(ies)

The prioritisation of sectors and technologies based on a set of country-driven criteria is the focus of the third activity in the TNA process for mitigation. If the previous steps have been carefully undertaken with broad stakeholder involvement and attention to national development priorities, including UNDP's and other agencies' country programming objectives, the prioritisation process should be fairly straightforward. It can be summarised in the single step below.

- **Compile prioritised technology list:** The format of the list should include specific information on the technology itself (e.g., cost and performance characteristics) as well as information on the criteria setting (e.g., weighting) and prioritisation issues (e.g., analytical tools) described above.

Activity 4: Identify Barriers and Policy Needs

For mitigation, the identification of barriers and policy needs – the focus of the fourth TNA activity – revolves around the assessment of capacity needs for applying the prioritised technologies and understanding their environmental impacts. Two steps are recommended as follows:

- **Assess capacity**: This involves a characterisation of the institutional and socio-economic aspects associated with effective introduction and use of the prioritised technologies. These "soft" aspects are nevertheless critical for a successful application of the identified technology. For example, a particular technology may be identified as a priority plausible in a particular set of cir-

cumstances, but the "soft" requirements may be a significant barrier to its implementation. In this case, actions would need to be identified that could facilitate successful technology transfer.

- **Conduct impact assessment**: At this stage, it is useful to conduct an environmental technology impact assessment to determine the impacts of the identified technology in environmental, social, and economic terms and infrastructural requirements (see Annex 3 on environmental technology impact assessment).

Activities 5 and 6: Define and Select Options; Prepare a Synthesis Report

For ranking and selecting prioritised mitigation options, the user is referred to the discussion provided in the TNA process section (Section 3). For guidance on writing the synthesis report, refer to Box 3-2 in Section 3, The TNA Process: Key Activities.

5. ADAPTATION – KEY STEPS IN THE TNA PROCESS

The approach to conducting a technology needs assessment for adaptation follows the pattern of activities discussed in the TNA process section, differing largely from the approach to mitigation because of the distinctive issues involved in adaptation. Whereas mitigation targets well-known GHG emitting sectors for which there is a large amount of literature on available technologies, applicable technologies for adaptation issues are less well defined. In fact, there are no technologies that can be clearly labelled as adaptation, per se, except perhaps for coastal engineering technologies.

In addition to the six essential TNA activities discussed earlier and illustrated in Figure 3-1, some additional steps that fit within these broad activities must be considered. These are specific to the nature of the adaptation process itself. They are illustrated in Figure 5-1 and summarised in the subsections that follow below.

Activity 1: Prepare Preliminary Overview of the Sectors

For adaptation, the preliminary assessment of the current status of sectors should focus on those sectors that are considered to be most vulnerable to the impacts of climate change. To facilitate this process, a single step is recommended as outlined below.

- **Identify vulnerable sectors:** Identification of adaptation measures cannot be done in a vacuum. Wherever they are available, it must be informed by existing vulnerability assessments. A first step is to acquire available knowledge regarding the following: a) the extent of sector-specific vulnerabilities; b) any cross-cutting issues and indirect impacts on other sectors, along with any socio-economic implications; and c) the adaptive capacity of vulnerable sectors (i.e., their ability to withstand projected climate change effects). A compilation of information sources should be carried out at the end of this step.

Activity 2: Identify Technology Criteria for Assessment

For the process used to identify criteria for selecting technology, the user is referred to the discussion provided in the TNA process section (Section 3).

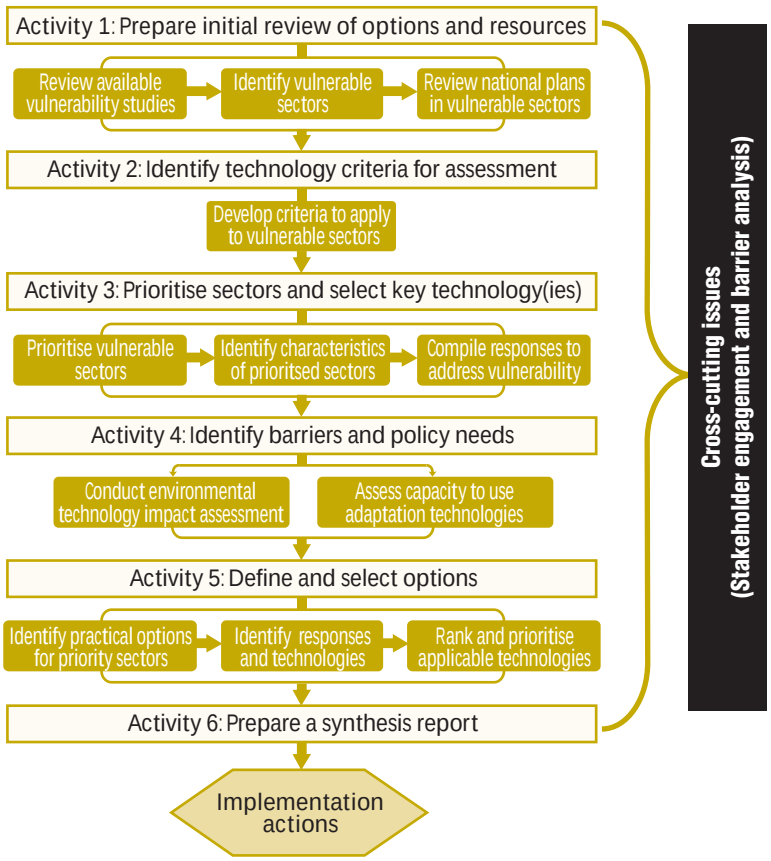


Figure 5-1: Key Steps in the Technology Needs Assessment Process for Adaptation

Activity 3: Prioritise Sectors and Select Key Technology(ies)

Sectors and technologies should be prioritised based on a set of country-driven criteria. Three steps are recommended as outlined below.

- **Prioritise vulnerable sectors:** Prioritising sectors will involve extensive stakeholder consultations. In addition, it is important to review relevant sectoral and national development plans and determine how they impact on identified vulnerable sectors (i.e., whether the plans increase the vulnerability or resilience of the sector as a whole or partly) and on interrelationships with other sectors. This output of this step is a prioritised list of sectors for which adaptation actions and measures need to be taken. In arriving at such a list, the user will need to apply some type of weighting system, as discussed earlier in the TNA process section. Additionally, consideration should be given to impact projections as estimated by the IPCC, as well as their timing.
- **Identify sectoral characteristics:** Once the vulnerable sectors have been prioritised, the next step is to identify specific characteristics of these sectors. Examples of pertinent characteristics include geographical location and the weaknesses and strengths of institutions. Identifying such characteristics is important in order to further define resilient features, competing interests and uses, overlap with other sectors, and opportunities for synergy (i.e., indirect benefits of adaptation measures taken in one sector for another related sector). This step should also culminate in an intermediate synthesis document.
- **Compile response list:** This is a list of potential adaptation measures that can be implemented to address the key identified vulnerabilities. Such response measures can include changes in established practices and do not necessarily involve the direct use of technology. Response measures might use technology in an indirect manner, such as by establishing computerised data management systems, or for a specific purpose, such as better management of a resource. The list of possible responses should be as exhaustive as possible.

Activity 4: Identify Barriers and Policy Needs

As with a mitigation TNA, there are certain parallel processes that should accompany an assessment of barriers and policy needs. Specifically, environmental technology impact assessment and the associated "soft technology" requirements (i.e., institutional capacity) should be addressed. It is arguably more important to conduct an environmental technology impacts assessment for adaptation because of the scale of application and the need to avoid or minimise the risk of implementing maladaptation options that would be costly to redress.

Activity 5: Define and Select Options

Defining and selecting adaptation options involves a three-step process. It should be kept in mind throughout the TNA exercise that suitable endogenous technologies should be included as much as possible, since tried and true approaches may be more effective. These underdeveloped technologies, where identified, should be highlighted as a priority. The following steps are recommended.

- **Prioritise options:** Having compiled a list of possible response measures to address the identified vulnerabilities, the next step involves narrowing down the list to one containing practicable options. This activity should include **wide stakeholder consultation** and can be merged with the previous step if this is convenient for the user. Issues to consider in developing this prioritised list include uncertainties related to the assessments/impacts, investment timing, and level of risk.
- **Identify technologies:** Once the prioritised list is compiled, an analysis is undertaken of these response measures in order to identify any technologies that can aid in the application of the practical options. These technologies may be "soft" (know-how) or "hard". A critical part of this analysis is having access to technology information (Annex 3) as well as doing a preliminary assessment of the technology to determine factors such as applicability and adaptability. The assessment can also include a "durability and longevity" assessment of the technology because of the timeframes of implementation, if this is deemed to be relevant.
- **Identify applicable technologies:** Bearing in mind that adaptations are country- and sector-specific, and that response and adaptation measures are largely determined by national and sector circumstances, it would be expected that there would be different applications of technology in different cases, and that what may work in one set of circumstances would be totally unsuited for another, though similar, set of circumstances. In this respect, it is best to ensure access to technology information and wide and t**horough stakeholder consultation**, including consultation with the developers of the identified technology. The discussions within this handbook for **initial technology assessment** and for mitigation both apply, including the importance of **technology information**.

Activity 6: Prepare a Synthesis Report

For guidance on writing the synthesis report, refer to Box 3-2 in Section 3, The TNA Process: Key Activities.

6. CROSS-CUTTING ISSUES: INTEGRATION ACROSS ACTIVITIES AND STEPS

This section addresses two key cross-cutting issues – stakeholder engagement and barriers analysis. Each is briefly described below in terms of its intersection with the various activities and steps involved in mitigation and adaptation TNAs.

6.1. Stakeholder Engagement

Assessing the need for technology occurs through policymaking and decisions made among stakeholders – individuals, groups, organisations (e.g., government agencies, NGOs), and networks. The TNA process considers stakeholders as fundamental, since it is stakeholders who will sustain the implementation process.

> *"…Most adaptations, however, will be carried out by individual stakeholders and communities…. Therefore, the government's primary role is to facilitate and steer this process…" (Third Assessment Report, Working Group II, p. 867)*

Securing adequate stakeholder participation requires a structured approach that involves all relevant parties at an early stage, makes the impacts upon them and their responsibilities clear, and continues to engage with all stakeholders throughout the assessment and implementation process. For example, it is farmers and their communities who, with the help of research stations and extension services, will have to adapt to changes in means and variances of climate, such as changes in precipitation patterns.

A successful engagement of stakeholders can result in a number of important benefits:

- Access to the insights that stakeholders often have, with the resulting ability to address a broader range of options, sectors, options, challenges, and opportunities
- Facilitation of the implementation of TNA recommendations, as stakeholders will have already been exposed to proposed actions and provided some level of "buy-in," and
- Enhancement of the potential for learning by doing as experience and awareness of the role of technology in addressing issues related to climate change evolve.

The **purpose** of this process within the TNA is to ensure that key stakeholders are fundamentally engaged. The term 'key stakeholders' refers to those affected by climate change and those positioned most effectively to advance mitigation and adaptation priority actions.

This process will generally include five major **steps**: (1) identifying stakeholders, (2) defining objectives and scope, (3) clarifying stakeholder roles and teams, (4) establishing processes for involving stakeholders, and (5) integrating stakeholder involvement throughout the overall TNA process.

The output of this step should be an active, inclusive stakeholder dialogue that is developed and sustained over the course of the assessment.

Step 1: Identify Stakeholders

Box 6-1 provides a starting point for identifying the range of stakeholders that should be consulted in a technology assessment. The extent to which all are represented will differ by country, but it is important that as many of these types of stakeholder as possible are involved from an early stage. As a practical matter, since such a large number of people are legitimately classified as stakeholders in some of these

Box 6-1: Potential stakeholders to seek to engage in the TNA

- **Government Departments** with responsibility for policy formulation and regulation in energy management (e.g., power supply, industrial processes, waste management) and vulnerable sectors (e.g., agriculture, forestry, fisheries, human health, parks/wildlife)
- **Private and public sector industries, associations, and distributors** that are involved in the provision of utility services (i.e., responsible for GHG emissions) or are sensitive to climate change impacts (e.g., tourism, agriculture, water resources, forestry, fisheries)
- **Organisations** involved in the manufacture, import, and sale of environmentally sound technologies or other hard or soft technologies (e.g., software) appropriate for mitigation or adaptation
- **Households, small businesses, and farmers** using the technologies and practices in question, and/or who are or could experience some of the effects of climate change
- **NGOs** involved with the promotion of environmental and social objectives
- **Institutions** that provide technical and scientific support to both government and industry, e.g. academic organisations, industry R&D, think tanks, consultants, etc.
- **Labour unions, consumer groups, and media**
- **Country divisions of international companies** responsible for investments of critical importance to climate policy, e.g., the energy sector, agriculture, forestry
- **International organisations and donors**

categories, it will probably be feasible only to involve representative members ('samples').

Step 2: Define Objectives

At the outset of the process, it is essential to set up a transparent process in which the expectations and privileges of stakeholder involvement are discussed and agreed upon. The output of this step is a clear sense of the goals and objectives of the overall TNA effort.

Step 3: Clarify Roles

Defining roles and responsibilities is an important part of the process of stakeholder engagement. In many instances there is likely to be both a *core team* of direct participants and *a wider group of affected and interested parties*. It is therefore important to distinguish which activities that will require direct and detailed input from each of these two groups and to ensure that relative strengths and expertise are utilised as effectively as possible. The lead agency needs to make effective use of all members of the project team and to facilitate the active participation of all relevant stakeholders.

The *core team* will deal with the most substantive issues of the TNA process such as resource assessment, technology costing, and the preparation of reports and other materials. It may prove effective if, following preliminary consultations, subteams or sectoral working groups are formed to push ahead in specific areas. This may have advantages in terms of manageability. However, the extent and usefulness of this approach will depend on country circumstances, such as the capacities (human and financial) of the different departments and sectors involved. It is also important to ensure that the TNA assessment process does not become 'compartmentalised' or fragmented at too early a stage; the assessment must initially compare across all sectors. It is only after completing a preliminary assessment that it is likely to be appropriate for countries to identify action teams in priority areas. For example, the core team should compare vulnerabilities across sectors, regions, or populations in order to set priorities.

The wider group of affected and interested parties should participate in stakeholder consultation and engagement activities, such as workshops, public hearings, and consultation papers. The discussion that follows focuses on the core team. Identifying a wider group of stakeholders requires less detailed comment, as it is possible to allow this group to 'self-select' by publicising consultation papers and holding public fora to encourage debate.

Step 4: Establish processes for involving stakeholders

It is almost inevitable that a number of problems and difficulties can befall the stakeholder engagement process. There are a number of key points that if addressed in advance can help to establish an effective process for engaging stakeholders. These are as follows:

- **Anticipate competing priorities.** Active engagement of a relatively large number of stakeholders, some with interests and agendas (including those of different government departments) that are at odds with others, might give rise to conflict and some difficulty with decision-making.
- **Keep to a focused timeline.** It is possible that a relatively long timeframe required for effective technology transfer may militate against continued engagement from some stakeholders, notably some private sector participants.
- **Keep control of the process.** It is also possible, perhaps even likely, that some stakeholders will attempt to drive the engagement process to promote benefit for their own exclusive set of interests (a so- called 'capture' of the process by interest groups).
- **Guard resources.** TNA can absorb a large amount of skilled staff time and financial resources in countries where these are both in short supply.

Not all stakeholder groups will necessarily wish to participate in the TNA process in a productive manner. Rather than risk stalling the entire process, we suggest considering the possibility of not including such groups. That should only be done after sincere and repeated attempts are made to engage such groups in a constructive manner.

A number of steps can be taken to ensure from the outset that the stakeholder engagement process works effectively, helping to avoid some of the difficulties described above. These include:

- Enact measures to assist manageability – a small core team, and self-selection by wider consultees.
- Establish clear lines of command at an early stage, with a lead organisation identified and charged with keeping the process on track.
- Define clear objectives at an early stage.
- Ensure transparency in all decision-making and consultation activity.
- Ensure the ongoing involvement of all stakeholders.
- Set realistic goals for the scope of preliminary activity.
- Carry out outreach, education, and engagement with a wide cross-section of stakeholder groups.

Step 5: Integrate stakeholder involvement across TNA processes

This cross-cutting step is extremely important. Stakeholders need to be involved in each step of the process, not merely at the beginning to provide direction and/or at the end to provide approval to the initiatives proposed.

6.2. Barrier Analysis

Barrier analysis corresponds to Activity 4 in the TNA methodological framework. As a cross-cutting issue, it should also be carried out as a discrete step within Activities 1, 2, 3, and 5.

While the discussion that follows focuses on barrier analysis as a general activity within the overall TNA framework, the user should be alert to the need to apply this information in conducting barrier analysis within each of the relevant TNA activities, as needed.

Potential barriers to the introduction of the options and sectors that have been described previously in this Cross-Cutting Issues section should be considered. There is a considerable literature on this topic. Some of potential barriers are specific to the technologies.

In some instances, specific policies can lead to market barriers – for example, where regulation acts to disadvantage new energy technologies or where polluting or overproducing practices are subsidised. In other cases, market barriers may arise from market structures – for example, where monopoly powers result in entry barriers or where the nature of the marketplace can place new technologies at a disadvantage. Finally, where the full costs of polluting technologies are not reflected in prices – that is, the external costs of environmental damage are not accounted for – cleaner technologies may not be able to compete.

The main categories of barriers that cut across both mitigation and adaptation are as follows:

- **Policy-based barriers.** Examples of such barriers include regulations and standards that may preclude new technologies, institutional and legal obstacles, and distorting market interventions.
- **Market structure.** This involves monopoly powers or dominant (oligopoly) interests that reduce incentives to innovate and erect barriers to new entrants.
- **Consumer framework.** Barriers could be split incentives where investors are not the consumers of more efficient technologies, restricted access to capital, and informational barriers.
- **Social and cultural acceptability.** A range of cultural practices and beliefs could lead to opposition to certain options.

In all of the above categories, policies can help address market barriers. A detailed discussion of this subject is beyond the scope of this handbook. However, a number of key points stand out:

- Regulatory reform can assist in removing barriers, without any requirement for financial intervention. Options include modifying regulations in some instances and tightening regulatory standards in others.
- In other cases relatively modest financial interventions are likely to be involved – for example, in information provision and pilot/demonstration schemes.
- Collaboration with the private sector is essential. Voluntary agreements can reduce the need for new regulation and encourage compliance, and modest subsidies may be able to secure improved financing terms from private lenders, thus assisting potential purchasers in accessing capital or in stimulating research and development on efficient technologies.
- Internalisation of external costs, for example through carbon taxation, can encourage the use of climate-friendly technologies. However, cost internalisation will not, of itself, address all barriers and is unlikely to be a sufficient policy measure alone.
- "Barrier removal" therefore requires a range of carefully tailored policy measures; there is no one policy that can tackle all barriers and market failures. It is recommended that TNA first identify a range of actual barriers.

Identifying barriers can draw upon comparisons with other countries in order to identify areas where technology adoption is lower than might be expected. It can also make use of technology information to identify cost-effective measures that are not widely used and generic barriers to such options. It requires expert assessment with input from a range of stakeholders. Detailed policies to remove barriers may then be considered in the priority sectors identified for implementation actions.

It is important to remember that there is a prominent role for stakeholders in the identification of barriers and policy needs. While engagement does not in itself guarantee equity, fairness, or buy-in, it will contribute to a more robust understanding of key barriers and what segments of the population are most disadvantaged by them.

7. IMPLEMENTATION: ACTIONS AND OPPORTUNITIES

This brief discussion of the implementation of the TNA outcomes is provided for orientation purposes.

Clearly, the actions identified in a TNA will not result in the delivery of enhanced technology transfer without effective implementation. Support of stakeholders will be needed after the various packages and policies proposed have been compiled. It is also likely that there will need to be a substantial 'buy in' from the private sector.

The **purpose** of this process within the overall TNA is to ensure that there is adequate follow-up to the technology priorities and the recommendations that have been established.

This process will generally include six major **steps**: (1) assessing the adequacy of financial resources, (2) ensuring transparency in the implementation programme, (3) identifying potential synergies with existing plans, (4) identifying ways to reduce barriers, (5) continuing stakeholder engagement, and (6) revising plans as needed.

The **output** of implementation steps should be a comprehensive program to implement the recommendations of the technology needs assessment.

Step 1: Assess adequacy of financial Resources

Countries should seek out donors and other funding sources and compile a list of these, based upon the priorities and options identified earlier. This list should be as comprehensive as possible. It should include not only traditional sources of international funds, such as the UN institutions and donor countries, but also the private sectors and national sources of funds, where appropriate.

Step 2: Ensure transparency

The implementation programme should set a timeframe for activities and clear 'milestones' to monitor progress. Alternative actions should be identified in case certain priority actions fail. The roles and responsibilities of different stakeholders should be clearly specified.

Step 3: Identify potential synergies

There are often numerous ways of improving the effectiveness of implementation by drawing on synergies with related programmes. Health, water resources, agricultural research and extension, and afforestation development programmes are but a few examples where a country can both strengthen its development programmes and improve its capacity to adapt. In the same vein, ongoing work on regulatory reforms in the electricity supply sector may be, if properly approached, an ideal time for including incentives for the adoption of new renewable energy and efficient end-use technologies.

Step 4: Identify ways to reduce barriers

In many cases, barrier reduction may be the most important role for the public sector in facilitating the flow of private funds.

Step 5: Continue stakeholder involvement

It is important to sustain the momentum gained and the networks established as a result of the stakeholder engagement process. These links should be considered important components of any future effort to build upon the TNA process.

Step 6: Revise plans as needed

It is likely that the TNA process will need to be revisited as circumstances change and as new technologies and options emerge. The key concern here is that the process becomes institutionalised to the extent that re-engagement is a straightforward effort and builds on the previous process, rather than invents a new one.

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UNEP/Risoe 1998, *Guidelines for Mitigation Studies*

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Zou 2002, *Tools and Methodologies in Assessing Technology Needs*

ANNEX 1: MITIGATION AND ADAPTATION OPTIONS

Mitigation Technologies

A wide range of options have been identified, of which the majority are energy sector technologies, for the simple reason that energy production and use is responsible for around 90% of GHG emissions. Some of the leading mitigation options are listed below.

Efficiency improvement

Technologies for utilisation of local resources in rural areas, such as:

- Improved cookstoves
- Improved fuel crops and soil/land management processes
- Small scale biofuel/oil production

Fossil-fired electricity generation and transmission:

- Natural gas combined cycle and advanced/improved coal fired generation technologies
- Combined heat and power schemes (CHP)
- Small-scale high efficiency electricity generation technologies ('decentralised generation'), including small-scale CHP

Industrial, commercial, and residential processes

- Domestic and commercial heating, lighting, and appliances
- Vehicles
- Building design
- Building insulation
- Passive cooling and ventilation
- Natural lighting

Renewable energy sources

Solar energy

- Photovoltaic (PV): off-grid rural electricity, grid connected building-integrated systems
- Solar water heaters
- Thermal for electricity generation
- Passive solar design in buildings

Wind:

- Large-scale electricity generation
- Small-scale off-grid rural electrification
- Water pumping

Hydro:

- Large and small scale
- Geothermal (heat and electricity generation)

Biomass:

- Domestic/local – residues and energy crops for domestic heating and cooking using improved crop management and stoves, heaters, etc.
- Industrial – residues and energy crops for electricity generation, cogeneration, and industrial process heat
- Biofuels for transport
- Landfill methane capture technologies

Adaptation Technologies

Unlike mitigation, a similar set of technological options is difficult to develop for adaptation. This is due to the fact that the boundaries between adaptation and sustainable development are essentially 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 adaptation technologies varies immensely among regions, countries, and sectors. Nonetheless, the scientific community has begun to identify adaptive measures of considerable promise both by sector and by region. For this reason, this section is deliberately left unaddressed.

ANNEX 2. TECHNOLOGY INFORMATION SOURCES

A wide range of sources of technology information exists. These include the literature of domestic and international equipment manufacturers, websites, and other outputs of international organisations and of developed countries, information sharing between developing countries, and materials developed by specialist consultancies and research organisations. A brief list of sources available on the Internet is provided below:

Technology information sources (provided by CTI and USEPA)

This brief list is intended as a starting point for research on the Web. These selected sites represent only a small portion of those available on the Internet.

Global Network on Energy for Sustainable Development (GNESD)
http://www.uneptie.org/energy/act/gnesd/
This network of ten centres of excellence in developed and developing countries promotes "research, transfer and take-up of green and cleaner energy technologies to the developing world." The site provides descriptions of programs and projects, publications, events and links to other sites.

UNIDO/Cleaner Production Centre Programme
htpp://www.unido.org/de/doc/446
The UNIDO cleaner production (CP) programme aims at building national CP capacities, fostering dialogue between industry and government, and enhancing investments for transfer and development of environmentally sound technologies.

Sustainable Alternatives Network (SANet)
http://www.sustainablealternatives.net/
This site provides case studies, best practices information, planning tools, finance information, and a directory of experts.

African Rural Energy Enterprise Development
http://www.areed.org/
AREED supports new enterprises that "use clean, efficient, and renewable energy technologies to meet the energy needs of under-served populations." The site provides information on AREED services, including training and enterprise start-up support, as well as links to related sites.

An Annotated Summary of Climate Change Related Resources
http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterResourceGuide.html
"The information contained in this resource guide is intended to assist researchers and decision makers, particularly those from developing countries, in their efforts to develop, implement, and evaluate climate change programs and conduct climate change studies (e.g., emission inventories, mitigation assessments, vulnerability and adaptation analysis").

Technology Transfer Information Clearinghouse, TT:CLEAR:
http://ttclear.unfccc.com/ttclear/security/UserLogin.jsp

United Nations Development Programme (UNDP):
http://www.undp.org/

United Nations Environment Programme (UNEP):
http://www.unep.org/

United Nations Framework Convention on Climate Change (UNFCCC):
http://unfccc.int/

United States Environmental Protection Agency (USEPA):
http://www.epa.gov/

Financing Sustainable Energy Directory
http://www.uneptie.org/energy/publ/sustfunds_files/sustfunds.htm
This directory is a listing of lenders and investors around the world that finance renewable energy and energy efficiency projects. Each entry includes the name of the lender, a brief description of the kinds of project the lender finances, and contact information. There is also a list of other financing resources available on the Web.

The following **online databases** provide descriptions and contact information for suppliers of climate-related technologies and services around the world. These sites allow you to search databases by geographical region, technology classification, or company name.

GREENTIE
http://www.greentie.org/index.php

James & James database of Renewable Energy Suppliers and Services
http://www.jxj.com/suppands/renenerg/index.html

Source Guides Renewable Energy Businesses in the World
http://energy.sourceguides.com/businesses/index.shtml

The following sites provide information on **adaptation technologies for water resource management and drought response:**

http://www.cgiar.org
"The CGIAR's research agenda focuses on both strategic and applied research. This agenda includes the entire range of problems affecting agricultural productivity and links these problems to broader concerns about poverty reduction, sustainable management of natural resources, protection of

biodiversity, and rural development. More than 8,500 CGIAR scientists and scientific staff conduct research to improve the productivity of tropical agriculture. This research focuses on higher-yielding food crops and more productive livestock, fish, and trees; improved farming systems that are environmentally benign; better policies; and enhanced scientific capacities in developing countries."

http://www.fao.org/agris/
FAO: Center Information Management for International Agricultural Research: AGRIS/CARIS works on the development and strengthening of national agricultural information management programmes using Internet-based technologies.

http://www.fao.org/spfs/
The Special Programme for Food Security: "The Special Programme for Food Security (SPFS) aims to help those living in developing countries, in particular the low-income food deficit countries (LIFDCs), to improve their food security through rapid increases in food production and productivity by reducing year-to-year variability in food production on an economically and environmentally sustainable basis…"

http://www.cimmyt.cgiar.org
CIMMYT – International Maize and Wheat Improvement Center. The CIMMYT conducts "research on maize and wheat to help people overcome hunger and poverty and to grow crops without harming the environment". CIMMYT conducts research on two crops – maize and wheat – that provide about 25% of all food calories consumed in poor countries.

http://www.cimmyt.cgiar.org/worldwide/CIMMYT_Regions/CIMMYT_Africa/index.htm
This site lists a variety studies on how improved maize varieties help increase harvests in selected African countries.

http://www.iita.org/
IITA – International Institute of Tropical Agriculture: "The International Institute of Tropical Agriculture (IITA) was founded in 1967 with a mandate for improving food production in the humid tropics and to develop sustainable production systems. It became the first African link in the worldwide network of agricultural research centres supported by the Consultative Group on International Agricultural Research (CGIAR), now known as the Future Harvest Centers."

http://www.icarda.cgiar.org/
ICARDA - International Center for Agricultural Research in the Dry Areas: "ICARDA's mission is to improve the welfare of people and alleviate poverty through research and training in dry areas of the developing world, by increasing the production, productivity and nutritional quality of food, while preserving and enhancing the natural resource base. ICARDA is committed to the advancement of agricultural research; free exchange of … information for research; protection of intellectual property rights, including indigenous knowledge of farmers; human resources development; the sustainable use of natural resources; and poverty alleviation, particularly among women and children."

http://www.icrisat.org/
International Crops Research Institute for the Semi-Arid Tropics: "CRISAT's goal is to harness the power of technology for development, food security, poverty alleviation and environmental protection, targeted at poor rural families, and women in particular."

There are also a variety of **useful publications** to which the reader is referred, as follows.

http://www.cgiar.org/iwmi/home/rainwater.htm
Rainwater Management: Strategies for Improving Water Availability and Productivity in Semi-Arid and Arid Areas.

http://www.iisd.org/pdf/cdmpfinalreport.pdf
Case Study: Community Drought Mitigation Project in Zimbabwe.

http://www.onu.org.cu/havanarisk/EVENTOS/cchange3/Doe.PDF
Paper: Vordzorgbe, Seth D., 'Risk Management and Adaptation: Reflections with Implications for Africa,' June 2002, presented at UNDP Expert Group Meeting, 'Integrating Disaster Reduction and Adaptation to Climate Change', Havana, Cuba, 17-19 June, 2002

http://www.irc.nl/products/planotes35/index.html
Case Studies: International Water and Sanitation Centre – Community Water Management. Covers topics such as participatory action development, women's involvement, watershed management, etc.

http://www.rainwaterharvesting.org/
Rainwater Harvesting: This CSE-sponsored site illustrates various rainwater harvesting methods according to the principle, "catch water where it falls". Traditional harvesting methods are compared with modern techniques.

http://www.rainwaterharvesting.org/methods/modern/gwdams.htm
Groundwater Dams: Explanation and diagram of harvesting water through groundwater dams. Detailed description and illustration, including discussion of construction materials.

http://www.cgiar.org/iwmi/pubs/pub037/RR037.htm
Case Study: Farmer-based financing of operations in the Niger Valley Irrigation Schemes Case Study of a pump-based irrigation system in Niger Valley (AfDB project).

http://www.cgiar.org/iwmi/challenge-program/pdf/paper1.pdf
Ensuring Food Security via Improvement in Crop Water Productivity: This study suggests concepts to improve food security by increasing water use efficiency (WUE), i.e. "more crop per drop". Also discusses opportunities as well as limits of increased WUE.

http://www.cgiar.org/iwmi/home/rainwater.htm
Rainwater Management: Strategies for Improving Water Availability and Productivity in Semi-Arid and Arid Areas.

http://www.iisd.org/pdf/cdmpfinalreport.pdf
Case Study: Community Drought Mitigation Project in Zimbabwe: Also contains pictures of more efficient planting and irrigation methods and traditional crops.

http://www.worldbank.org/html/cgiar/newsletter/Mar96/4cas2.htm
Cassava, Africa's Food Security Crop: Promotion of Cassava to combat hunger and malnutrition in Africa.

http://www.iita.org/research/high2000/proj6.htm
Improving Cassava-based systems.

http://www.iita.org/research/high2000/proj4.htm
Improving Maize-Grain legume systems in West and Central Africa. Study discusses methodologies implemented to increase yields of maize. Successful field studies have been conducted in Africa and other countries.

http://www.iisd.org/pdf/cdmpfinalreport.pdf
Case Study: Community Drought Mitigation Project in Zimbabwe: Also contains pictures of more efficient planting and irrigation methods.

http://www.worldbank.org/html/cgiar/newsletter/Mar96/4reeves.htm
Developing Sustainable Maize and Wheat Based Production Systems: Prof. Reeves of the CIMMYT discusses characteristics of improved maize varieties.

http://www.worldbank.org/html/cgiar/publications/issues/issues14.pdf
Eicher, Carl K., Institutions and the African Farmer. September 1999. In the chapter titled *The New Era of Water Resources Management: From "Dry" to "Wet" Water Savings*, the author discusses ways by which real water efficiency can be achieved. These include (a) increasing the output per unit of evaporated water (b) reducing water losses to sinks (c) reducing pollution of water, and (d) reallocating water from lower valued to higher valued uses. He also talks about evapotranspiration and seasonal crop coefficients.

ANNEX 3. ENVIRONMENTAL TECHNOLOGY ASSESSMENT

The environmental technology assessment can be applied at both the micro and macro levels to make decisions that are in keeping with a country's policies. While environmental impact assessment is a public policy tool invariably required by regulators, EnTA adopts a comprehensive systems approach that takes a broader look at the effects of technology and considers alternatives. UNEP[1] describes a ten-step approach that can be useful in considering technology needs and integrating them in the TNA. These steps are:

1. *Examine the reason for the proposed technology:* Understanding the purpose for which a technology is being applied can aid in the consideration and understanding of alternatives **(direct output of the TNA)**.

2. *Describe the technology:* Include a description of material, energy, capital and labour inputs, and engineering processes and operations.

3. *Alternative analysis:* Possible modifications that may be required. An understanding of the reason for the technology is critical **(output of the TNA as well as access to information technology)**.

4. *Examine the longevity of the technology:* How would future developments impact on the efficacy of the technology?

5. *Stakeholder participation:* Identification of individuals, institutions, and organisations that may be affected by, or can influence, the technology **(integrated into the TNA process)**.

6. *Evaluate potential impacts:* Direct impacts of the technology itself, e.g., outputs, etc.

7. *Identify key decision makers:* Those who have authority to act or influence technology.

8. *Identify action options for the framework that supports decision-making:* Regulations, economic incentives etc.

9. *Draw conclusions*

10. *Make recommendations*

1 UNEP IETC. Training Needs in Utilizing Environmental Technology Assessment (EnTA) for Decision-Making. 1995. Technical Publication Series 1.

ANNEX 4. DRAFT FRAMEWORK OF MODIFIED TECHNOLOGY NEEDS ASSESSMENT ACTIVITIES FOR ADAPTATION

Figure A-4-1 provides an illustration of the flexibility of the methodology as it applies to adaptation in Caribbean SIDs and low-lying states. This figure was developed during the UNDP/UNFCCC/CTI *Workshop on Technology Needs Assessment and Technology Information for the Caribbean Region held on 20-21 October 2003, in Port of Spain, Trinidad.*

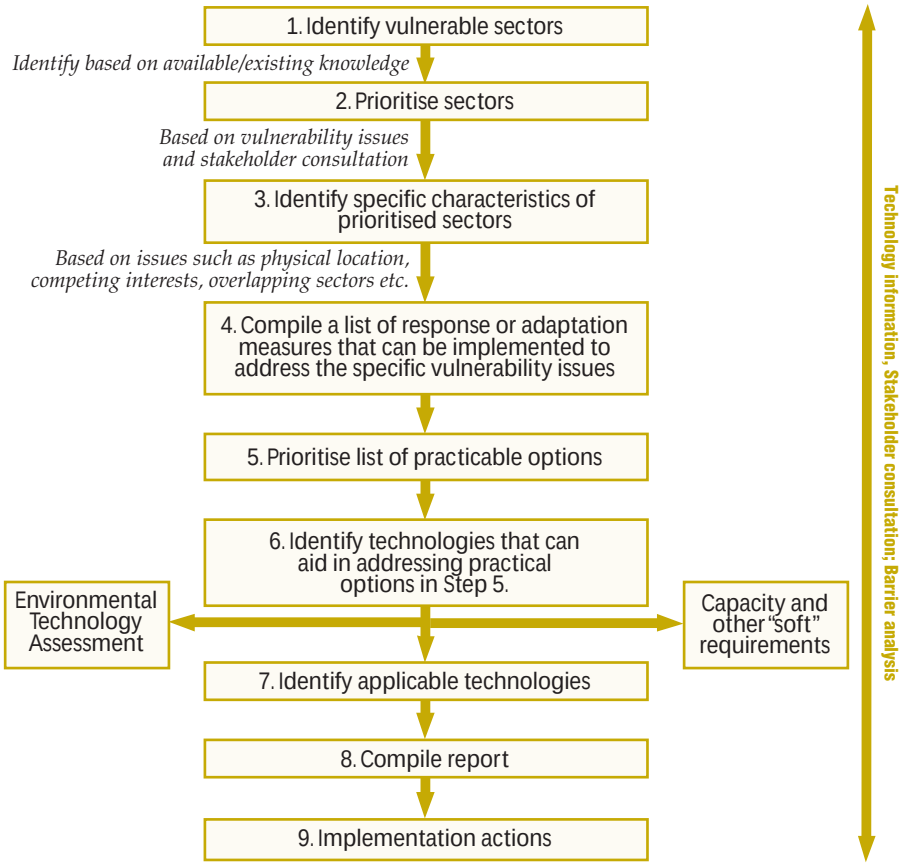

Figure A4-1: Draft Framework of Modified Technology Needs Assessment Activities, as Applied to Adaptation