United Nations Development Programme
Global Environment Facility

Assessing Technology Needs for Climate Change

Final Draft
August 2003

NATIONAL COMMUNICATIONS SUPPORT UNIT HANDBOOK

This report does not reflect the views of UNDP nor the GEF Secretariat. Please send comments on this Handbook to:

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C O N T E N T S

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1. PRELIMINARY ISSUES

1.1 Introduction

This handbook has been developed by the UNDP in co-operation with the Climate Technology Initiative (CTI) and with input from a wide range of multilateral agencies and country experts[1]. 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 TNA. The primary purpose is to help countries find ways of encouraging technology transfer as defined by the UNFCCC. The Handbook is structured as follows:

- *Section 1* explains the origins of the handbook. It also provides an introduction to the concept of a methodology for TNA;
- *Section 2* discusses the processes involved in preparation of TNA[2];
- *Section 3* considers stakeholder and institutional issues;
- *Section 4* considers the TNA process in detail;
- *Section 5* considers implementation issues;
- *Annex 1* provides a brief review of mitigation and adaptation options; and
- *Annex 2* provides an introduction to some technology information sources.

The handbook should not be seen as a self contained activity or a final product, nor can it provide detail on every aspect, because TNA is a complex process. It is intended that the handbook should be allowed to evolve, and that it will be used alongside a range of training activities on TNA.

1.2 The Role of Technology Needs Assessments

TNA entails the identification and evaluation of technical means for achieving specified ends. From a climate change and developmental perspective, TNA would prioritise technologies, practices and reforms, that might be implemented in different sectors of a country to reduce greenhouse gas emissions and climate vulnerability and to contribute to development goals.

Many of the technologies and practices for adapting to and mitigating climate change are well-suited to the needs of development in its broadest sense. Indeed those concerned with adaptation – such as the protection of water resources, maintaining and improving output in agriculture, providing safeguards against changes in weather patterns, etc., – are becoming a requirement of sustainable development (IPCC, Working Group II, 2001). Many of the technologies being developed in response to the needs of mitigation, especially renewable energy and energy efficiency, are also important sources of supplying and utilising energy efficiently.

TNA is a means by which development and climate response needs and opportunities are brought together and integrated. Thus TNA is not a stand-alone activity; rather, it is a continuation of the work

[1] Two draft versions were circulated to the UNFCCC Expert Group on Technology Transfer for comments. The UNDP/GEF Workshop on Technology Needs Assessments and CTI/EGTT Workshop on Climate Technology Information for the African Region (10-12 December 2002, Dakar, Senegal) also provided a number of recommendations for improvement that are now incorporated into the Handbook

[2] 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.

countries have carried out or identified in their National Communications and through other activities to enhance technology transfer. The United Nations Framework Convention on Climate Change (UNFCCC) activity related to technology transfer identifies TNA as one of the five key elements of a framework to enhance technology transfer[3]. The elements are: technology needs and needs assessment, technology information, enabling environments, capacity building, and mechanism for technology transfer.

Technology transfer (defined as the flow of experience, know-how and equipment between and within countries, IPCC 2000) has long been a priority under the UNFCCC. Article 4.5 of the Convention mandates 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. 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,*[4]*,* discusses a wide range of activities to enhance technology transfer.

1.3 Why This Handbook?

This handbook has been prepared in response to a UNDP-GEF survey of countries undertaking assessment of technology needs. The survey found that there was a need for a practical and integrated approach for TNA. Without such an approach, there was a danger that countries might:

- Focus on the wrong sectors and/or push projects on the basis of predetermined priorities that may not reflect the full range of opportunities available;
- Gather data without a clear understanding of its relevance and relative importance;
- Carry out detailed studies on technologies without a clear picture of how these suit relative needs and priorities – and as a result adopt ill-suited technologies; and
- Engage stakeholders without a clear understanding of goals.

A number of organisations have looked at methodological issues in technology transfer, including those that surround TNA (see UNEP/Risoe 1998, UNEP 1998, Zou 2002, CTI 2002, IPCC 2000). However, few of these have looked in detail at climate response needs *assessment* processes and activities, but are either concerned with the nature of the technologies and practices themselves, or with the process of technology transfer more generally. Therefore the handbook draws upon relevant resources, including CTI and UNEP, and seeks to complement those reports that deal with particular technologies and practices.

While countries may identify a wide range of issues to improve the development and transfer of technologies – TNA is only one aspect -- the handbook is concerned with this aspect alone. It is important to note that the handbook does not set out to prescribe a single, inflexible means by which TNA may be delivered. Country circumstances differ widely, and steps, sectors and options that apply in some countries may be inappropriate in others. This diversity of circumstance is often captured in the expression ‘one size does not fit all’. However, there are many steps and considerations that *are* common to all, and the approach set out here is designed, as far as is practicable, to be modified and adapted to suit circumstances.

[3] This framework is agreed in decision FCCC/CP/2001/13/Add.1, adopted at COP 7.
[4] IPCC 2000

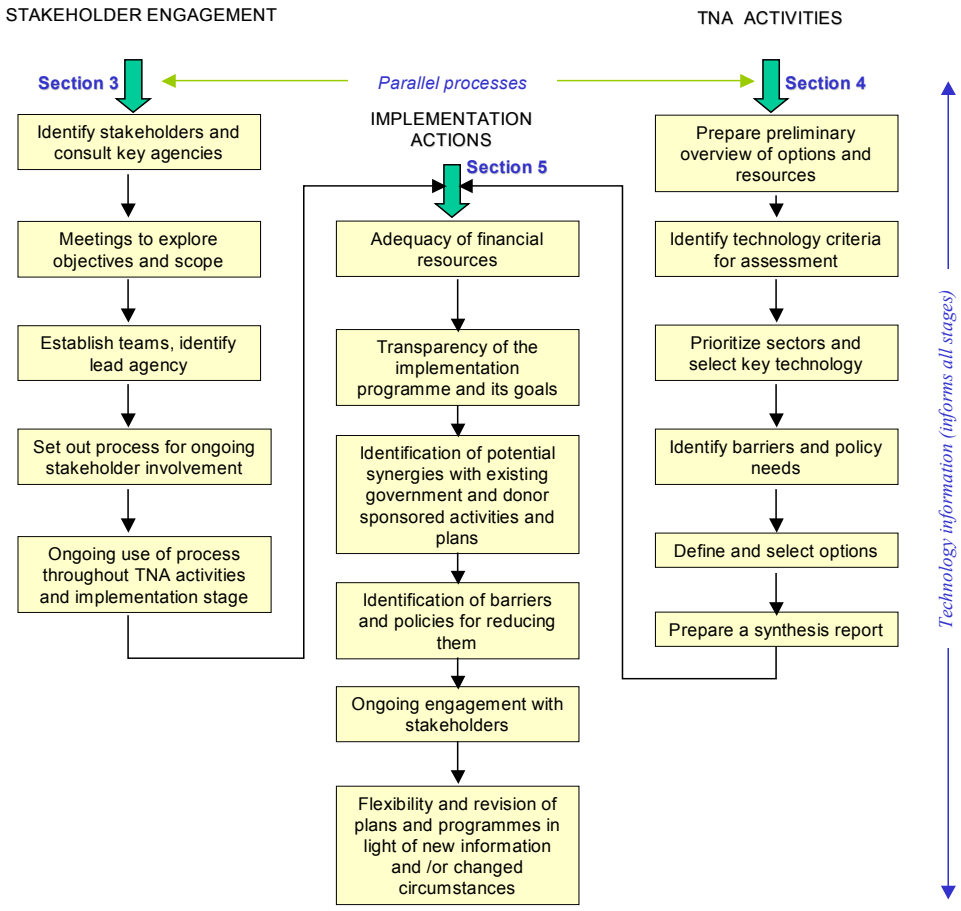
2. OVERVIEW OF THE PROCESS INVOLVED IN TNA

Three types of activity are required for effective TNA and these are the subjects of the three chapters that follow, which provide information on the following subjects:

- Stakeholder engagement
- Descriptions of TNA processes and activities
- Implementation actions[5]

This list is similar to those developed by both the CTI and UNEP in work on technology transfer (Zou 2002). These activities are clearly inter-related, and in practice there is much iteration between them; it is not uncommon, for example, to reassess options and approaches once the barriers are better understood. Sometimes there may even be a reassessment of priorities, for example, if it becomes clear during the interactions with stakeholders that there is a shortcoming in a particular aspect of policy, or alternatively a need for a new policy initiative that was not anticipated when priorities were first being set. An overview of the processes involved in each stream is provided in Figure 1.

Figure 1. Overview of the process involved in TNA



[5] This categorisation is based upon the description of TNA *processes* and *implementation,* and how they fit into wider activities for enhanced technology transfer provided by CTI (2002). A number of sources provide alternative discussions of methodologies and related issues in TNA; however the importance of these three strands of activity is uncontroversial and common to a range of methodologies (Zou 2002), so this categorisation is roughly adhered to here. Descriptions of activities, and suggestions for how to undertake them, include ideas drawn from a range of sources.

3. STAKEHOLDER ENGAGEMENT

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.

As the IPCC commented in the Third Assessment Report (Working Group II, p. 867):

> "… a key misconception is that adaptation is a task carried out by governments. Insofar as governments have property and are responsible for carrying out a variety of activities, they will be required to take adaptive actions. 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…"

For example, it is farmers and their communities who, with the help of research stations and extension services, will have to adapt to increasing variation and uncertainty in seasonal rainfalls. The same can be said of mitigation. It will be the users of energy, for example, who will pay for and implement energy efficient investments, and businesses that will undertake investments in renewable energy, facilitated by the various agencies and firms promoting energy efficiency.

A large number of diverse institutions, firms and individuals, thus have an interest in technology transfer. Providing a clear framework for interaction between and within institutions is important because effective technology transfer will be more successful if stakeholders are engaged and involved. Failure to engage with stakeholders can result in a number of problems:

- a loss of the insights that stakeholders often provide, and, as a result:
  - a failure to consider the full range of options
  - misrepresentation or omission of some sectors, options and opportunities
  - difficulties in undertaking TNA (for example, through lack of specialist knowledge);
- difficulties in implementing TNA recommendations, as stakeholders may misunderstand or object to proposed actions; and
- a lack of feedback during implementation, resulting in little learning from the efforts, and little improvement as experience grows.

3.1 Identifying Stakeholders

The list below provides a starting point for identifying stakeholders. The extent to which all are represented will differ by country, but it is important that as many of these types of stakeholder as is practical are involved from an early stage.

The list of stakeholders by function ideally includes:

- Government Departments with responsibility for:
  - relevant areas of policy, e.g. energy, environment and development
  - regulation of relevant sectors, e.g. energy, agriculture, forestry, environment
  - promotion and development of industry and international trade, and foreign direct investment
  - coastal zone management and drainage
  - finance and foreign chambers of commerce
- Industries and/or public sector bodies responsible for provision of utility services (energy, water, etc), industrial associations, and distributors

- Representative companies or bodies in other greenhouse gas intensive sectors (e.g. energy intensive industry)
- Companies, industry and financial institutions involved in the manufacture, import and sale of environmentally sound technologies
- Households, small businesses and farmers using the technologies and practices in question, and/or who are experiencing some of the vicissitudes 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
- Organised communities, media
- Country divisions of international companies responsible for investments of critical importance to climate policy, e.g. the energy sector
- International organisations and donors

Since such a large number of people are legitimately classified as stakeholders in some of these categories, only representative members ('samples') can be involved in practice.

3.2 Stakeholder Roles and Responsibilities

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 between activities that will require direct and detailed input from 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, preparation of reports and other materials. It may prove effective if, following preliminary consultations, sub-teams or sectoral working groups[6] 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 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; 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.

The wider group of affected and interested parties will participate in stakeholder consultation and engagement activities, such as workshops, public hearings, and consultation papers. The discussion below 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.

[6] In establishing the sub-teams or sectoral groups, it is important to have an assessment of the technical and institutional resources available.

3.3 The Engagement Process

The processes of stakeholder engagement have been characterised in terms of four steps[7]:

1. Identify stakeholders and consult key agencies;
2. Convene meetings to explore objectives and scope;
3. Establish core team and identify roles of lead agency, lead technical institution and other direct participants; and
4. Set out a process for ongoing stakeholder involvement.

It is important that this sequence of actions is undertaken in an iterative and flexible manner, rather than as a sequence of steps, such that there is a feedback of ideas and experiences.

Problems and pitfalls

It is almost inevitable that a number of problems and difficulties will befall the stakeholder engagement process. While it is not possible to identify all of these in advance, a number of generic issues can be identified:

- Active engagement of a relatively large number of stakeholders, some with competing interests and agendas (including those of different government departments), might give rise to conflict and some difficulty with decision-making.
- It is possible that the relatively long timeframe required for effective technology transfer may militate against continued engagement from some stakeholders, notably some private sector participants.
- It is also possible that some stakeholders will be able to drive the process to benefit their own interests – so called "capture" of the process by interest groups.
- TNA can absorb a large amount of skilled staff time and financial resources in countries where these are both in short supply.

Ways forward

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 agreed 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 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.

[7] CTI 2002

4. TNA PROCESS AND ACTIVITIES

This section provides a detailed description of activities required to undertake TNA, including an overview of the processes involved and information about how to undertake each step. In general, activities that encompass the following considerations will be required:

4.1 Prepare a Preliminary Overview of Options and Resources

A preliminary assessment of the current status of sectors and of technologies is recommended. This data gathering must be undertaken before detailed technology evaluation can be carried out. However, this exercise should not become a long and complex task. It need not provide a detailed picture of all technology options in all sectors, rather, it should provide a broad overview of the technology options that may be pursued in the sectors with the greatest scope for initial actions. When developing the preliminary assessment countries may draw upon existing work carried out – for example from National Communications, vulnerability and adaptation (V&A) assessments, and national and sectoral development plans. An important initial step is to identify information sources.

Sectors affected by climate change mitigation and adaptation

Several sectors are relevant for TNA; they include those sectors where mitigation options might be delivered and those where adaptation will be important. The range of sectors includes:

- Energy – electricity production, transmission and use, and other energy supply sectors, e.g. natural gas, LPG and other domestic fuels
- Transport – fuels, vehicles, public and private transport infrastructure
- Forestry
- Agriculture, including food security
- Energy intensive industries, such as foundries and chemical industries
- Climate technology industries or industries with potential manufacture/supply climate response technologies
- Waste management and recycling
- Buildings and construction
- Water management
- Coastal zone management
- Health

Countries may choose a limited number of sectors for more detailed assessment. The Third Assessment Report of the IPCC (2001) discusses the possible effects on each sector by region, and outlines the range of technological responses for adaptation and mitigation. A short list of options is provided in Annex I.

In order to prioritise sectors where more detailed work will be undertaken, it is recommended that countries review, in simple terms, a range of options and sectors. This review need not go into detail, but requires a brief overview of the following four factors:

- Current circumstances of key sectors – technologies in use, greenhouse gas (GHG) emissions and financial conditions;
- Potential to reduce emissions and to contribute to adaptive response by sector;
- Country-wide low carbon energy resources and main technology options, and adaptive responses and main technology options; and

- National and multinational relevant initiatives of both public and private sectors and their expected outcomes.

These factors interrelate – for instance, the potential for emissions reduction is partially determined by sectoral financial constraints. However it is suggested that countries undertake very simple assessments of each of the above factors in order to develop a preliminary view of where the greatest scope for improvement might lie, and of where there are gaps in existing knowledge.

The extent and detail of these preliminary assessments should reflect country circumstances. In some countries, data may be available from existing sectoral analyses while in others a lack of data may be an important finding. Where data is lacking, actions to remediate this might be a priority activity. It is important that countries try to avoid overlooking opportunities or resources simply because particular options are better researched or have been exploited in the past.

In many cases, useful and appropriate technologies are neither expensive, nor difficult, to obtain. For instance, heat meters or insulation are examples of cheap, plentiful technologies that can generate savings for their users, and predate discussions on climate change policy. However, these technologies are still not used as widely as they could be. Assessments should not overlook seemingly modest solutions, and should consider the institutional environment in place.

Prepare a preliminary overview of options and resources

Key steps

- Review mitigation and V&A studies carried out under the National Communication and national/sectoral development plans
- Compile an overview of existing data sources for technologies and sectors
- Identify data gaps and the steps that might be needed to remediate them
- Identify the main sectors
- Identify leading technology options and policies for each sector, review sectoral strategies
- Prepare preliminary assessment report that includes:
    - current circumstances of different sectors – technologies in use, GHG emissions and financial conditions
    - potential for fuel switching and efficiency improvements by sector
    - country low carbon energy resources
    - country adaptation options
    - suitability of different low carbon technologies (including adaptability to country specific circumstances)
    - suitability of different adaptation options (including adaptability to country specific circumstances)

- Circulate preliminary assessment report to stakeholders

4.2 Identify Criteria for Technology Assessment

Identifying priority technologies requires a view of the contribution that new technologies might make to social, environmental and development goals. The first step is to determine a criterion whereby technologies may be judged against their contribution to national development goals.

At the most general level, the criteria for selecting sectors and technologies for TNA will depend upon three factors: contribution to development goals; contribution to climate change mitigation or adaptation; and market potential. Each in turn will entail deeper levels of analysis depending on the country and sector in question. For example, the analysis of:

- Development benefits
  - Food and agricultural security
  - Health improvements
  - Job and wealth creation for the poor
  - Capacity building (human, institutional, physical, environmental)
  - Sustainable use of local resources
  - Economic and industrial efficiency improvement
- Reducing harm to the environment (non climate impacts)
- Social acceptability and suitability for country conditions
- Relevance to climate change
  - GHG emissions reduction potential
  - Adaptation potential
  - Enhancement of CO_2 sinks
- Market potential
  - Capital and operating costs relative to alternatives
  - Commercial availability
  - Replicability and potential scale of utilisation
- Potential for policy intervention to improve uptake
  - Effects of pricing and regulatory policies on application
  - Barrier identification (see below)

Determining the weight and importance of each of these factors is partly a policy decision, affected by country priorities and circumstances. Three sources of opinion (facilitated by data and objective assessment) need to feed into the weighting process:

- independent expert assessments/judgements
- government assessments/judgements
- wider stakeholders such as industry, NGOs

Effective assessments, with the buy in of all stakeholders, will utilise a combination of all three. In most cases the following steps will be required:

- agreeing on a list of the factors that are to be included in the assessment criteria
- weighting factors, if, and as, appropriate
- agreeing on the process of assessment (stakeholder, expert, and government roles clearly defined)
- listing the sectors and technologies that will be assessed
- identifying how current and possible policy alternatives will impinge on the use of the technology and practices in question
- publication of the findings of the priority assessment process

Decision-making criteria used in two instances are illustrated in Box 1 (see also Box 3).

Box 1: Examples of Criteria Used to Select Priority Technologies (Zou 2002)

1. Southern Africa Development Community
The focus from18 initial possible technologies to 6 priority areas was done by ranking projects according to an agreed set of criteria which included the following considerations:

- Development benefits
- Market readiness
- GHG emissions reduction potential
- Regional application
- Local environmental benefits

Consensus on Criteria for Selecting Priority Sectors and Technologies *(Ghana Report pp6).* The procedure to prioritise the areas for Technology Transfer was defined by participants. The following three broad areas were agreed as criteria for selecting the technologies:

- Development benefits comprising mainly job creation, wealth creation for the poor, capacity building (innovation), social acceptance of technology and use of local resources (human and material).
- Market potential which included finance (capital to pay for it), affordability (money to pay for it), investment, sustainability, low maintenance – 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." (Southern Center for Energy and Environment, September 2000).

2. China
The following criteria were used:

<u>Environmental concern: global and local</u>
GHGs mitigation;
Improvement of local environmental quality

<u>Technological concern</u>
Mature degree of technologies;
Advancement degree of technologies;
Reliability of technologies;
Penetration of technology application; and
Easiness of wider use of technology.

<u>Economic concern</u>
Internal Return Rate (IRR) and the effect of pricing and fiscal policies on the IRR;
Payback period;
Mitigation and adaptation costs.

<u>Social concern</u>
Social efficiency: necessity of T&T;
Broader links with other sectors and groups;
Employment and poverty alleviation (Zou and Xu, 2002).

A variety of approaches to assessing technologies (within this broad framework) exist – these include: multi-criteria analysis, cost benefit assessments (CBA), risk benefit analysis (RBA) and so on. All of these are techniques for prioritising technologies and weighting the criteria by which they are to be assessed. 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. And whatever approaches countries use, they are only as good as the data that is fed into them. But country circumstances differ widely and in some cases the data and the scale of the decision-making problem will justify a sophisticated approach.

Box 2 provides an introduction to each of these approaches. For a more detailed discussion, see also UNEP/Risoe 1998.

Identify criteria for technology assessment

Key steps

- State the objectives of the evaluation criteria to provide a means by which technologies and sectors may be evaluated, based upon a range of sub-factors under the following headings:
  - contribution to climate change mitigation or adaptation;
  - contribution to development and wider policy goals; and
  - market potential and costs.
- State the process by which evaluation criteria are to be decided, and how the following are to be included in the process:
  - independent expert assessments/judgements;
  - government priorities; and
  - stakeholder consultation.
- Provide a discussion of the weighting of each criterion, to include whether weighting is required, and the potential means by which weights will be incorporated into decisions (CBA, RBA, etc).
- Agree on the steps above with core stakeholders.
- Define and agree on evaluation criteria.

Box 2: Decision Making Tools (Zou 2002)

In the process of assessing technology needs, a series of conventional and general analytical tools can also be useful to support decision-making. These include, among others: (1) analytic hierarchy process (AHP); (2) existing information-based approach; (3) cost-benefit analysis; (4) cost-effectiveness analysis; (5) risk-benefit analysis; (6) decision analysis; and so on.

Analytic Hierarchy Process. In order to help different stakeholders in selecting priority technologies on a basis of consistent criteria, some decision-making tools may be introduced. One of the common and often-used exercises is AHP, integrated with setting up criteria, putting weight to different items of criteria, and valuing different technologies based on a single rule. This tool can be applied during a survey among groups of experts and stakeholders.

Existing Information-Based Approach. This method relies on existing results of priority TNA that are not necessarily directly for implementation of the Convention, but have strong implication of, and obvious linkage with, climate change mitigation and adaptation. For example, many developing countries have had their own technology development program or plan for local sustainable development. They may have also developed a database of candidate projects for importing or self-developing technologies. In this case, it is also effective to draw on these databases or development plans, including some list of priority technologies if they have enough implications for climate change mitigation and adaptation.

Cost-Benefit Analysis. This widely used analytical framework allows the estimation of the costs and benefits of adopting technologies. The "best" outcome is the one with the highest net benefits derived from a specific category of technologies. However, it is not always easy to quantify all the costs and benefits of technologies.

Cost-Effectiveness Analysis. This method supposes to accept specific performance goals as given exogenously, then minimizes the cost to achieve the desired performance. It can escape from the difficulties in estimating benefits resulting from application of specific technologies, and can be favourable in the case that performance requests have been given.

Decision Analysis. Decision analysis is a formal quantitative technique for identifying 'best' choices from a range of alternatives. Decision analysis requires the development of explicit influence structures that specify a complete set of decision choices, possible outcomes, and outcome values. Uncertainty is incorporated directly in the analysis by assigning probabilities to individual outcomes (IPCC, 2001). Two major challenges for application of this technique are (1) difficulties in determining the values of all possible outcomes corresponding with different decisions (adoption of specific technology); and (2) bias derived from assigning probabilities to individual outcomes in addressing uncertainty.

Risk-Benefit Analysis. This approach can be regarded as a variation of Decision Analysis in terms of estimation of outcome values derived from identified risks as uncertain variables. Probabilities are also needed to assign to different scenarios. In general, these probabilities are estimated on a basis of subjective judgment by groups of experts.

When, where, and to which degree these analytical tools can be adopted will depend on to which degree the outcomes (benefits and costs or risks) can be defined, identified, and quantified with adequate data and information availability.

4.3 Identify Priority Sectors and Select Technologies

The preliminary assessment reports need to be presented to the *core team* (defined in 3.1 above) for prioritisation. Preliminary assessment will allow countries to come at the process of selection and prioritisation from three related, but distinct, directions. Firstly they will have a view of the sectors with potential to benefit from technology development and transfer – and/or of the need for further data. Secondly they will have a view of the technology options and resources available to them – and/or of the need for further data. Thirdly, they will be able to assess the relative merits of policies that would support the adoption of the technologies and practices identified.

Priority sectors

The identification of priority sectors will be based upon the contribution that each can make to the criteria outlined in Section 4.2. It is recommended that a limited number of priority sectors be identified for further action. How many sectors a country decides to prioritise will depend upon individual country circumstances, but two or three sectors should be selected for initial action.

It is important that the TNA feeds back to, and informs, the decision-making process about sectors, otherwise opportunities within sectors that arise from new technology options may be overlooked. With this in mind, it is important that technologies are carefully assessed and ranked in order of priority, and that priority sectors are revisited as needed.

Technology selection

As discussed earlier, a number of techniques exist by which technology ranking can be carried out, and by which the assessment factors can be weighted. An overview of these was outlined in Box 1. One tool that is compatible with all of these techniques is to develop a simple matrix of technologies and assessment factors based upon the criteria set out in section 4.2. Technologies may be 'scored' by stakeholders according to the scale of their contribution to various policy goals. Engagement with stakeholders in the ranking process may be carried out through a series of workshops or consultations (e.g., questionnaires, email).

An example of a technology-ranking matrix is provided in Table 1.

Table 1: Example of Technology Ranking Matrix

	Ranking of contribution to climate change and other policy goals, and economic viability							
Technology	GHG mit'n	Adaptation benefits	Other env't impacts	Contribution to competitiveness & economic efficiency	Develop-ment benefits[8]	Cost effectiveness	Market potential	Social acceptability

[8] This section could be subdivided to include the factors discussed in section 4.2, e.g. job creation, food security, health, use of local resources, etc.

- Technologies are ranked (for example) on a scale of 1 – 5, where 5 indicates a strongly positive or 'high' contribution to the goal in question, and 1 indicates a strongly negative or 'low' contribution.
- Factors may or may not be weighted to reflect their importance (see Section 4.2 above) and various criteria may be applied to ensure adequate contribution to key goals.
- Totals for each technology option provide an *indication* of technology rank (where factors are weighted).

Some countries may wish to limit the extent to which simplistic techniques are used to account for complex, sometimes hard to quantify, factors. Ranking exercises can help to ensure that stakeholder priorities are understood and reflected, and can *inform* the selection process. However, it is important to note that this cannot provide all of the answers; in many cases judgements will still be required. For example, it is extremely difficult to make judgements about technologies that cut across highly diverse sectors – how are opportunities in the energy sector compared to those in coastal management? Inclusion of the ranking matrix should not be interpreted as suggesting that the problems and uncertainties involved in technology selection and prioritisation can be reduced to a simplistic and mechanistic process.

An example of the use of the technology ranking matrix in practice is provided in the case study in Box 3 (below).

Box 3. Illustration of selection process: Ghana case study

Technologies within priority sectors were ranked as follows:

- Through individual expert ranking and average ranking obtained for sectoral groups
- Highest rank - 10
- Lowest rank - 1
- Selection criteria was equally weighted

The results of this process are ullustrated in the following tables.

Table 1. detailed evaluation matrix for energy technologies

CRITERIA	TECHNOLOGY		
	Landfill	Biomass	Incineration
Development Benefits			
Job Creation	2	4	2
GDP Growth	2	3	2
Wealth creation	1	3	1
Capacity Building	4	3	3
Health Improvement	4	4	3
Social Acceptance of Technology	3	4	3
Effect on balance of trade	1	2	1
Use of local resource	4	4	3
Market Potential			
Capital to Finance	3	3	3
Affordability	2	2	2
Investment sustainability	3	3	3
Durability (low maintenance)	2	2	2
Commercial availability	4	4	4
Replicability	4	4	4
Climate Change/Environmental Protection			
Low GHG emissions	3	3	2

Box 3. Illustration of selection process: Ghana case study (continued)

Table 2. Overview of leading energy options rankings

Priority	Technology	Average	High	Low
1	Industrial efficiency improvements and demand side management	2.4	1	6
2.	Photovoltaics	4.5	1	7.5
	Natural Gas combined cycle	4.9	1	9
	Natural gas distribution	4.9	1	10
	Mini-small hydro	4.9	1	10
3.	Transport management	5.4	2	10
	Biomass	6	2	9
	Wind	6.5	3	9
	Solar Water Heating	7	4	10

In selecting priority areas, 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 objectives, and are available at low (even negative) costs. There is a wide variety of technologies that offer lower costs, higher efficiency and better environmental performance than older, or more established alternatives. This is true in almost all countries (developed and developing) for end use domestic and industrial appliances, where energy efficiency can be improved considerably, and in many countries in the transport and electricity sectors, where more efficient and cleaner technologies are available, but not widely adopted. In many cases, market barriers inhibit the uptake of cost effective options – an issue returned to below.

- In the longer term, new options will become available and the relative merits and economics of different technologies and developments in different sectors will change. Some countries may wish to invest some resources in the development and/or demonstration of technologies that are not currently 'win win' but that offer particular promise for contributing to climate and other goals in the longer term.

It may also be the case that countries wish to concentrate efforts in areas where there is scope for government action to remove barriers; these are considered in the next section.

Identify priority sectors and select technologies

Key steps

- Evaluation should include a range of views to reflect:
  - Expert assessments
  - Government priorities
  - Wider stakeholders
- Technologies can be evaluated against a range of criteria, using the data from the preliminary assessment process. This should cover:
  - sectors with potential to benefit from technology development and transfer – and/or of the need for further data
  - technology options and resources available – and/or of the need for further data
- Evaluation needs to consider a broad range of options, but identify a smaller number of priority areas for implementation actions
- A ranking matrix can help to ensure each technology is assessed against each criterion in a transparent way.
- A report should be produced that states:
  - all of the technologies and sectors assessed
  - the criteria used for evaluation
  - the stakeholders involved
  - the outcome – priority sectors and technologies

4.4 Identify Barriers and Policy Needs

The options and sectors described above should be considered in the context of barriers that might be restricting uptake. There is a considerable literature on the market barriers that can prevent or reduce the uptake of more efficient technologies. Some of these are specific to climate response technologies, and some are specific to developing countries. Others may reflect specific difficulties faced by individual countries – for example, if it is difficult to adapt technologies to local needs -- but many are generic and affect the adoption of new technologies in all countries.

In some instances policies result in market barriers – for example where regulation acts to disadvantage new technologies or polluting practices are subsidised. In other cases market barriers arise from market structures – for example where monopoly powers result in entry barriers or where the nature of the marketplace can disadvantage new technologies. Finally, where the full costs of polluting technologies are not reflected in prices – that is, pollution costs are externalised – cleaner technologies may not be able to compete.

The main categories of barriers are as follows:

- Policy
  - Regulations and standards that preclude new technologies
  - Institutional and legal obstacles
  - Distorting market interventions such as subsidies for polluting industries
  - Regulated markets that create disincentives for new technologies

- Social and cultural acceptability

- Market structure
  - Monopoly powers or dominant (oligopoly) interests that reduce incentives to innovate and erect barriers to new entrants

- Market
  - Split incentives (where investors are not the consumers of more efficient technologies – the classic example being the 'landlord-tenant' case, where the landlord is responsible for building investments that could improve energy efficiency but has no incentive to do so as he/she is not responsible for energy costs)
  - Access to capital (where new technologies are capital intensive, even if operating and lifetime costs are low, potential investors may lack the financial resources required to bear the 'upfront' cost)
  - Information barriers (this may take several forms; the simplest form is where potential purchasers are ignorant of new technology possibilities and/or lack access to technology information. Purchasers may also be faced with multiple and conflicting information and limited ability/time to absorb it, and thus choose a known option in preference to a new alternative)
  - Externalisation of pollution costs

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:

- In many cases regulatory reform can assist in the removal of barriers, without any requirement for financial intervention – this includes the modification of unhelpful regulations in some instances, tighter 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 will help in many instances. For example, 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, assisting potential purchasers in accessing capital.
- Internalisation of external costs, for example through carbon taxation, can encourage the uptake of climate friendly technologies. However cost internalisation will not, of itself, address each and every barrier and is therefore 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.

Barrier identification can draw upon comparisons with other countries, 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.

Identify barriers and policy needs

Key steps

- Identify generic barriers to increased deployment of new technologies by sector, including the following categories (described above);
  - Policy and regulatory structure
  - Market structure
  - Markets
  - Social and cultural acceptability
- Identify specific barriers to priority sectors (identified in step 3.3)
- Identify 'barrier removal' policy measures
- Revisit priority sectors (identified in step 4.3) in the light of barrier assessment

4.5 Define and Select Actions

Once technology and sector priorities have been identified, barriers assessed and stakeholders assembled, countries can define a programme of action to enhance technology transfer. This will benefit from the inclusion of all the implementation steps discussed below. Priority actions are likely to fall into the following categories:

1. *Capacity building*. This should include enhancing national data on resources and options, and enhancing public and private sector understanding of climate response options.
2. *Addressing barriers*. Governments can improve technology information flow to the private sector, and collaborate with industry to improve the uptake of new technologies. There will be a role for regulatory and fiscal reform, as discussed above.
3. *Direct interventions*. Direct state/donor purchase of new technologies is likely to be limited in the climate response area, but pilot and demonstration schemes may lever additional private funding.
4. A case can be made for supporting the development of new technologies, not yet commercially viable, that could bring low cost benefits in future – this will also assist countries in building human capital. Indigenous technologies may also offer benefits, not least in instances where it is not possible to adapt technologies to meet local needs.
5. Securing funding for the first three categories above.
6. Detailing priority actions into a technology transfer action plan

It is important also to ensure that the stakeholder engagement issues as described in Section 3.3 above are built into the plan – institutional factors are as important as the 'substance' (policies, measures, target technologies) of the proposed activities.

Three aspects mentioned above are worth reiteration:

- That 'delivery checks' – the means by which success can be judged -- and alternative actions are built into the action plan in order that countries can adapt to changing opportunities and/or unforeseen difficulties;
- That countries ensure that full regard is given to existing policies and programmes so that:
  - conflicting policy actions do not undermine or cancel out gains from climate response technology transfer plans,
  - complementary policy actions are identified in order that both climate response and other policies benefit from available synergies; and
- That action plans are developed with full stakeholder cooperation and agreement.

The technology transfer action plan must also be presented as part of a wider report that sets out how and why key areas are to be prioritised, and the actions have been decided. This is the subject of the final part of this chapter.

Define and select actions

Key steps –

- Produce an action plan that takes account of the following:
  - Objectives for TNA in context of national development priorities
  - Identification of priority sectors
  - Identification of leading technology options, including adaptation of indigenous options
  - Priority sectors and technologies for initial action
  - Capacity building measures
  - Barrier reduction measures
  - Direct interventions
  - Securing funding
- Ensure that the action plan includes:
  - Means by which success may be assessed (milestones) and alternative actions should progress be limited with preliminary priorities
  - Relevance and implications of existing policies and programmes
  - Processes for full stakeholder cooperation and agreement

4.6 Prepare a Synthesis Report

Each step set out in Sections 4.1 to 4.5 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. The main points that such a report should include are summarised below.

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. Nevertheless it is hoped that the processes and practicalities set out in this Chapter and in Chapter 3 can help to ensure that such a report can be produced and taken forward constructively.

Prepare a synthesis report

Key steps

- The synthesis report should include:
  - A preliminary summary of climate change technologies, broken down by sector where appropriate
  - An evaluation of sectoral needs and opportunities
  - A statement of data gaps
  - Statement of criteria and process for technology evaluation (including development, climate change and market considerations as described earlier)
  - An overview of the assessment of technologies according to the agreed priorities
  - A list of priority sectors and key technologies for preliminary action
  - A review of key barriers and steps to overcome them, with reference to existing plans and programmes
  - A technology transfer action plan (this may include capacity building and data gathering if these are of critical importance, or are key barriers), with activities, costs (if feasible), and actors clearly defined, and milestones by which success is to be assessed
  - A list of stakeholders and a programme for continued stakeholder engagement
  - A discussion of implementation plans (see section 5 below)

5. IMPLEMENTATION ACTIONS

The actions identified in TNA will not result in 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 requirements for implementing the TNA are many and varied. Some of the issues to consider in implementation actions include the following:

Adequacy of financial resources. Countries should seek out donors and other funding sources and compile a list of these, based upon the outline below.

Funding source /financing opportunity	Scale of funds available	Purpose/ restrictions	Advantages and disadvantages	Likelihood of successful contribution to TNA implementation
Domestic/internal private sector				
Domestic/internal public sector programmes				
International NGOs				
International private capital				
Bilateral Donor programmes, such as those to meet UNFCCC obligations				
Multilateral programmes, such as those of the international donor organisations				

Transparency of the implementation programme and its goals. 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, roles and responsibilities of different stakeholders.

Identification of potential synergies with existing government and donor sponsored activities and plans. 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.

Identification of barriers and policies for reducing them. In many cases, barrier reduction may be the most important role for the public sector in facilitating the flow of private funds.

Consistency with private sector investment priorities. The purpose of consistency is to ensure that TNA implementation plans are realistic and synergistic with private sector goals to help maximise technology flow.

Ongoing engagement with stakeholders (especially those engaged in the implementation). It is rare for a project or programmes to be perfect from the outset, and regular feedback from stakeholders will enable a flexible approach and adaptation of plans as lessons are learned.

Flexibility and revision of plans and programmes in light of new information and/or changed circumstances. There should be some in-built flexibility in implementation policies from the outset, and a readiness to respond to issues that are encountered during implementation.

ANNEX I: 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

- Efficient end use technologies:
  - vehicles
  - domestic and commercial heating, lighting and appliances

- Technologies for improved utilisation of local resources in rural areas, such as:
  - Improved cookstoves
  - Improved fuel crops and soil/land management processes
  - Small scale biofuel/oil production

- Efficient technologies for 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 process efficiency

- Improved building design
  - Building insulation
  - Passive cooling and ventilation
  - Natural lighting

Renewable energy sources

- Solar:
  - 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

Although humankind has long adapted to changes in climate, such as to annual shifts in rainfalls, there seems little doubt that the long term challenges posed by global warming present challenges of a different order. 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 between regions. Nonetheless, the scientific community has begun to identify adaptive measures of considerable promise both by sector and by region.

This section considers some key findings from the report of Working Group II of the IPCC (2001), and the implications for TNA. These are that:

- Adaptation can significantly reduce the adverse effects of climate change, and is an important part of societal response. Substantial reductions in climate change damages can be achieved, especially in the most vulnerable regions. Enhancement of adaptive capacity is necessary to reduce vulnerability, particularly of the lowest income groups.
- Communities will adapt autonomously to climate change in the absence of planned adaptation—but not without costs and huge residual damages, which could be substantially reduced through planned anticipatory action.
- The key features of climate change for V&A arethose arising from variability and extremes, not to changes in average conditions.
- Adaptive capacity varies among countries and socio-economic groups. Unfortunately, it is the countries and groups that are the poorest that are the most vulnerable to climate change and also have the greatest difficulties adapting to climate change.

The IPCC adds that current knowledge falls far short of what is required, but that nevertheless numerous beneficial opportunities exist in all sectors and countries. For example:

(i) Hydrology and water resources. Water resource management techniques, particularly those of integrated water resource management and 'water efficiency' through reducing waste and improving water pricing policies, can be applied to adapt to the hydrologic effects of climate change, and also to lessen vulnerabilities. Supply side approaches are being complemented by demand side approaches in water as they are in energy.

(ii) Agriculture and food security. Agronomic and husbandry adaptation options could include, for example, adjustments to planting dates, fertilisation rates, irrigation applications, cultivar traits and selection of species. Agro-forestry programmes on farmlands and watersheds also yield multiple benefits: improvement of groundwater resources and reductions of surface runoff; improvement of micro-climates and moisture and nutrient retention in soils—and thus improvements in crop yields—reduce vulnerability to climate change.

(iii) Coastal zones and marine ecosystems. Assessments of adaptation strategies for coastal zones have shifted emphasis away from hard protection structures of shorelines (e.g. seawalls) toward 'soft'

production measures (e.g. beach nourishment), managed retreat, and enhanced resilience of biophysical and socioeconomic systems in coastal regions. Some technologies that could be classified under "adaptation" include regulation of sea water intrusion into surface freshwater systems, irrigation systems that would maximise water use, desalination, development of artificial reefs to boost fish production while also offering coastal protection, use of artificial sea grass beds for coastal protection, etc. Many such technologies are closely linked to indigenous knowledge. Development of indigenous technologies and information sharing between developing countries is therefore very important. Adaptation options are most effective when incorporated with other policies such as mitigation and land use plans.

(iv) Human health. The IPCC report argues that "for each anticipated adverse health impact there is a range of social, institutional, technological and behavioural options to lessen that impact". For the most part, these take the form of improving the health infrastructure, water quality and management, food safety, and so forth. In short, climate change increases the importance of one of the highest priorities in development.

There are also adaptation opportunities in other areas, e.g. in energy and buildings, and there is a considerable body of literature on adaptation in the financial community, given the resources required for insurance (not least crop insurance in agriculture).

ANNEX II: TECHNOLOGY INFORMATION SOURCES

A wide range of sources of technology information exist. 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.

General information on sustainable development and technologies

Global Network on Energy for Sustainable Development (GNESD)
http://www.uneptie.org/energy/act/gnesd/
This network of ten centers 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, enterprise start-up support, as well as links to related sites.

An Annotated Summary of Climate Change Related Resources. "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").
http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterResourceGuide.html

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 resources 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 centers 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.

Useful publications:

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.pdfCase Study: Community Drought Mitigation Project in Zimbabwe.

http://www.onu.org.cu/havanarisk/EVENTOS/cchange3/Doe.PDF 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 (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.

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