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GUIDEBOOK

on the methodology for financial assessments to address climate change

CHAPTER IX: WATER SECTOR

(adaptation to climate change)

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About this publication

This methodology is an update to the first financial assessment methodology, which was released in 2009. The objective of this methodology is to support countries to implement their climate targets and to identify, reallocate, mobilize and manage the required financial resources and to create a fiscal framework conducive for climate action.

The update to this methodology was developed under UNDP's Climate Promise by the *Pledge to Impact* Programme. Delivered in collaboration with a wide variety of partners, the initiative has supported over 120 countries to enhance and implement Nationally Determined Contributions (NDCs) under the Paris Agreement. From Pledge to Impact is generously supported by the governments of Germany, Japan, United Kingdom, Sweden, Belgium, Spain, Iceland, the Netherlands, Portugal and other UNDP core contributors. This programme underpins UNDP's contribution to the NDC Partnership.

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About this Guidebook

As countries identify their national climate change targets—notably through Nationally Determined Contributions (NDCs) under the Paris Agreement—the need exists to break down targets into concrete steps of action, determine a financial framework to implement actions and achieve targets, and identify policy measures to facilitate the necessary changes that support low-emission development and a low-carbon future.

A key component to support this transformation is through assessing national investment flows and financial flows to address climate change. Many countries have used this method to articulate an effective and appropriate national response to climate change.

This Guidebook responds to the needs of countries to have a clear approach to support the implementation of national climate targets in the context of sustainable development that duly accounts for their national circumstances, capacities and resources.

Between 2008 and 2024, 60 investment flow and financial flow assessments were conducted worldwide, with more than 1,000 national stakeholders engaged in the technical and political aspects of the assessments. Since the adoption of the Paris Agreement and the development of NDCs, the methodology has helped countries utilize financial assessments to develop a pathway to NDC implementation.

While this methodology was first developed in 2008, an update has taken place in 2025. This Guidebook is a living document, which will continue to be improved based upon the experiences of those using it. Over the years, the methodology to carry out financial assessments to address climate change has been continually reviewed and updated regarding its user friendliness, feasibility of implementation and sectoral scope. Comments are invited. Please send feedback to Susanne Olbrisch (susanne.olbrisch@undp.org).

For more information, visit https://climatepromise.undp.org/tags/investment-and-financial-flows-assessments.

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List of acronyms and abbreviations

BAU	Business-as-usual
BS	Baseline scenario
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CO_2	Carbon dioxide
FDI	Foreign direct investment
FF	Financial Flow
GCF	Green Climate Fund
GEF	Global Environment Facility
GHG	Greenhouse gas
GLOFs	Glacier Lake Outburst Floods
IF	Investment Flow
IPCC	Intergovernmental Panel on Climate Change
LT-LEDS	Long-term Low-Emission Development Strategy
LULUCF	Land Use, Land-Use Change and Forestry
NAP	National Adaptation Plan
NDC	Nationally Determined Contribution
NGO	Non-governmental organization
O&M	Operation and maintenance
ODA	Official Development Assistance
REDD	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
UN FAO	United Nations Food and Agriculture Organization
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
V&A	Vulnerability and adaptation
WHO	World Health Organization

Chapters I and II of this guide provide methodology on how to carry out a financial assessment. This chapter provides additional information needed to carry out a financial assessment in the **water sector**. To avoid repetition, some of the information provided in Chapter II that is relevant to all sectors is not included in this chapter. Careful reading of Chapter II before this chapter is highly recommended.

9.1 Introduction

The impacts of climate change on the hydrologic cycle[1] cause significant changes in freshwater supply and quality. Higher temperatures, changes in the amounts and timing of precipitation, changes in evaporation and transpiration, increased melting of glaciers, changes in the timing of snowmelt, increases in glacier lake outburst floods and sea level rise all affect surface and groundwater supplies and can exacerbate water pollution, water-borne diseases, salinization and riverine and coastal siltation, meanwhile increasing the risks of flooding and drought.[2] Climate change may also increase the demand for freshwater, especially for agricultural production and for cooling of thermal power plants, resulting in increased competition for water supplies.

Significant changes in water supplies and quality, as well as the intensity and frequency of flooding and drought, affect all aspects of human life, including agriculture, human health, energy supply, fisheries, water recreation and infrastructure. The negative impacts of climate change on the water sector not only put human populations at risk but also affect aquatic ecosystems and biodiversity. Regions that are already water-stressed and are experiencing rapid increases in population and water demand are particularly vulnerable to the impacts of climate change on freshwater resources. Watersheds extending beyond the political borders of a country, and even across some sub-national jurisdictions, pose the additional challenges of sharing water resources, even if these areas already are managed through treaties, which could become difficult to fulfil in a context of scarcity and competing demands.

One of the challenges in water resources adaptation assessment stems from uncertainties in climate change projections at sub-continental spatial scales, especially for precipitation which is the most important climatic driver of freshwater resources. Even with the same greenhouse gas emissions scenario, different General Circulation Models produce different sub-continental geographic patterns of climate change, especially precipitation change. In some cases, model results do not even agree on the sign of change (i.e., whether precipitation will increase or decrease).[3] Therefore, it is recommended that countries focus their financial assessments on adaptation measures that will increase the ability of water management systems to meet projected changes in water demand and that address existing weaknesses in the water sector. For example, countries that are already water supply constrained or drought-prone may want to focus on measures to increase supply (e.g., through water harvesting structures) and/or improve the efficiency of water use (e.g., through watershed management policies or wastewater re-use). Countries that are especially vulnerable to floods may want to focus on measures that prevent damages from flooding or that improve flood warning systems and emergency response measures. And countries with extensive low-lying coastal regions may want to focus on measures that address increased saltwater intrusion. While this approach implicitly assumes that past climate variability is at least a partial predictor of the future, this is a reasonable way to proceed in the absence of more certain projections of water basin-scale changes in the hydrologic cycle (following a sustainable 'no regrets approach').

[1] The key processes of the hydrologic cycle are: evaporation, transpiration, condensation, precipitation, and runoff.

[2] Martin Perry, *et al.* (eds.) (2007), "Climate Change 2007: Impacts, Adaptation and Vulnerability," Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.

[3] Bert Metz, *et al.* (eds.) (2007). "Climate Change 2007: Mitigation of Climate Change," Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Plan on Climate Change, Cambridge University Press, Chapter 3.

Adaptation measures for the water sector typically focus on increasing the supply of water, improving the quality of the water supply, improving the efficiency of water use and reducing or alleviating the damages of extreme events (drought and floods), though some measures can address more than one issue.[4]

Adaptation measures that **increase freshwater supplies** include:

- prospecting and extraction of groundwater, including installation of wells;
- increasing surface water storage capacity by building or expanding reservoirs and dams;
- desalination of seawater;
- increasing rainwater collection and storage;
- adopting forest protection, afforestation, reforestation, terracing and other land-use measures to improve groundwater recharge and reduce rapid runoff;
- eliminating leaks in water distribution systems; and
- removing invasive plants from surface waters.

Adaptation measures that **improve the quality of freshwater supplies** include:

- adopting forest protection, afforestation, reforestation, terracing, riparian planting, riparian buffer zone protection, wetland restoration and other land-use measures to reduce siltation and pollutant runoff;
- improving and/or expanding wastewater collection and treatment facilities (e.g., installing and/or expanding sewage lines to avoid overflows from flooding, installing and/or enhancing treatment systems to reduce contaminants such as bacteria and nutrients such as phosphorus and nitrogen, in outflows);
- improving solid waste management systems and livestock waste management systems to reduce pollutant and nutrient runoff; and
- improving fertilizer use efficiency to reduce nutrient runoff.

Adaptation measures that **improve the efficiency of water use** include:

- improving irrigation efficiency (e.g., repair leaks, convert from spray to drip irrigation, improve irrigation scheduling) and shifting crops;
- altering crop type mixes in agricultural systems and plant type mixes in landscaping to reduce water demand;
- conserving water conservation and introducing efficiency improvement measures in residential, commercial and industrial uses (e.g., water recycling, higher water efficiency appliances and fixtures, higher water efficiency industrial production processes);

[4] The lists of adaptation options are based in part on Chapter 3 of Bert Metz, *et al.* (eds.) (2007), op. cit. The lists do not include policy and/or regulatory adaptation measures since they are not directly relevant to assessing investment and financial flows. Policy and/or regulatory water adaptation measures would include, for example, restrictions of residential construction and other forms of development in flood prone areas, water pricing and metering to encourage conservation, water permitting to restrict use and wastewater discharge regulations to reduce contaminants. Policy and regulatory measures applicable to influencing investment and financial flows are discussed at the end of this chapter.

- reducing water waste in residential, commercial and industrial facilities (e.g., repair leaking water lines, faucets, toilets, showerheads); and
- improving operation of facilities, such as using weather forecasting and real-time operation.

Adaptation measures that **reduce or alleviate the damages of drought and floods** include:

- improving and/or expanding seasonal weather forecasting and early warning systems;
- improving and/or expanding glacier and glacial lake monitoring;
- adopting forest protection, afforestation, reforestation, terracing and other land-use measures to prevent landslides;
- constructing dykes;
- improving and/or expanding flood hazard mapping;
- measures to maintain dam effectiveness, including dam structural integrity inspection and repair and improving effectiveness of water storage and release in anticipation of flood and drought events;
- improving and/or expanding disaster management systems to mitigate further damages from disaster (emergency medical care, evacuation plans, distribution of clean water, provision of emergency sanitation facilities); and
- improving/expanding systems for rapid and effective recovery from disasters, such as improving systems for reconstruction of water management infrastructure.

In addition to these adaptation measures, water-related extension and training programmes and public education and outreach programmes can be implemented to disseminate information about, promote and provide training on these measures.

9.2 Application of financial assessment methodology to adaptation in the water sector

This section describes how the financial assessment methodology described in Chapter II would be applied to adaptation in the water sector.

As described in Chapter II, the financial assessment involves a series of steps, which are:

Step 1. Establish key parameters of the assessment.

Step 2. Compile historical IF, FF and O&M cost data (and subsidy cost data if included explicitly) and other input data for scenarios.

Step 3. Define baseline scenario.

Step 4. Identify annual IF, FF and O&M costs (and subsidy costs if included explicitly) for the baseline scenario.

Step 5. Define target scenario.

Step 6. Identify annual IF, FF and O&M costs (and subsidy costs if included explicitly) for the target scenario.

Step 7. Calculate the changes in IF, FF and O&M costs (and in subsidy costs if included explicitly) needed to implement target scenario.

Step 8. Identify policy implications.

Step 1.

Establish key parameters of the assessment.

Define detailed scope of the sector.

In this step, the precise subsectors of the water sector for which investment and financial flows are to be assessed must be defined based on the national target that is being assessed (NDC, LT-LEDS, other). Depending on the national target, a country may choose to assess investment and financial flows for supply side options or demand side options or both and may or may not include water quality improvement options and flood and drought risk management options. The scope needs to be selected to avoid double counting among subsectors and options assessed. Countries may also choose to focus on only certain water basins, certain types of supply (e.g., reservoirs versus wells versus desalination systems versus rainwater collection systems) and/or demand (e.g., agricultural demand, industrial demand, residential urban demand, residential rural demand).

National circumstances need to be considered when selecting which subsectors of the water sector to include, acknowledging which subsectors are already stressed or are likely to be stressed given projections of demand[5] and the current supply situation, including frequency and severity of extreme events. Even if a country chooses to focus on supply options, an understanding of how demand is likely to evolve over the assessment period will be needed to assess how supplies should be altered.

Important linkages between the water sector and other sectors should be noted to avoid double-counting of investment and financial flows, as well as to identify how adaptation measures could cause damage to other sectors. Such overlaps could occur among the water and the agriculture sector e.g. through agricultural demand for freshwater or through agricultural contamination of water supplies (for example, from fertilizer and pesticide runoff and waste spills from confined animal operations). Overlaps are also possible among the water and the energy sector e.g. through water demand having an impact on hydropower production, as well as through the energy demand associated with certain water sector adaptation options (such as desalinization or pumping). Potential overlaps are also possible among the water and the public health sector the supply of clean water.

The definition of the scope should include the following information: (i) geographic scope; (ii) sub-sectors of water supply and demand to be included; (iii) a clear identification of the problem; (iv) a brief description of the present situation; (v) the expectations about the evolution of the problem in the future; (vi) a brief description of linkages between the water sector and other water and non-water sectors; and (vii) an evaluation about how climate change is expected to influence the problem.

Specify base year and assessment period.

The most recent year for which historical data is available is recommended as the base year (e.g. 2025). The assessment period should match the time horizon of the target that is being assessed. NDCs often have a time horizon until 2030, LT-LEDS often until 2050. The assessment period should have a considerable length to be sufficiently able to take into account the long lifetimes of infrastructure in the sector.

[5] Note that the projected demand due to factors associated with climate change impacts and those linked to other socio-economic factors are intertwined.

Identify the target to be assessed and adaptation measures.

A set of adaptation options should be identified for each subsector of the water sector included in the assessment, based on the national target that is being assessed (NDC, LT-LEDS, other). National targets being assessed are often general and visionary and not detailed enough to directly use them for a financial assessment. Therefore, the first step is to break down the overall national target into concrete measures and steps of action that can be used for the financial assessment. Breaking down the national target often includes technical and political considerations. Therefore, it is key to do this step in close consultation with national policymakers to ensure their ownership of and buy in to the measures that are being identified. The selection of options should also consider relevant previous work in the sector including national and sectoral plans, National Communications and National Adaptation Plans (NAPs). The selected adaptation options should be specific and broken down into concrete activities so that investment and financial flows and O&M costs can be identified in Steps 4 and 6.

Given the numerous linkages between the water sector and other sectors, the potential for synergies with mitigation and adaptation in other sectors is high. For example, forest conservation measures may reduce potential flood damages and protect water supplies. On the other hand, the construction of dams and expansion of reservoirs may result in methane emissions. Countries should be alert to such synergies and cross sectoral impacts and discuss them qualitatively in their reports.

Select analytical approach.

Countries need to determine the analytical approach that will be used to develop baseline and target scenarios and associated streams of annual IF, FF and O&M costs. Various models are available that can be used to evaluate how water supplies may change over time based on changes in climate variables and water management approaches and technologies and to evaluate optimal water management adaptation measures given a likely evolution of supply and demand (see Table 9.1 for a list of models).[6]

Table 9.1: Water sector analytical models

Application	Name of model	Application	Name of model
Watershed hydrology	WEAP21	**Water resource management models (planning and operation)**	WEAP21
	SWAT		Aquarius
	HEC-HMS		RIBASIM
	USGS MMS-PRMS		MIKE BASIN
	MIKE-SHE		HEC-ResSim
	HYMOS		WaterWare
Hydraulic simulation and forecasting	HEC-RAS		RiverWare
	MIKE Water Resources		
	Delft3d, SOBEK and Delft-EWS		

Source: Elaborated by the authors.

[6] This list is compiled from lists in the UNFCCC CGE Non-Annex I National Communications Training Package for Vulnerability and Adaptation and the UNFCCC Secretariat Compendium on methods and tools to evaluate impacts of, and vulnerability and adaptation to, climate change (2005). The CGE Training Package and the Compendium provide descriptions of some of these models.

However, if countries do not already have extensive experience with a particular model or models, it is recommended that other approaches be used for developing their scenarios. For example, monthly or seasonal water balances for critical watersheds, stemming from primary (i.e., measured) and secondary (i.e., estimated from primary) data, would be a sound basis for analysis, as projections could be performed for an estimated evolution of demand (e.g., due to urban development) and supply (e.g., affected by climate change). Other simpler approaches, like sound extrapolation of trends from historical evolution, may work, though they need to be done based on expert knowledge to be reliable.

Previous work on baseline development for Vulnerability and Adaptation (V&A) assessments should also be utilized. While baselines for V&A assessments are not the same as financial assessment baselines,[7] if the sectoral scopes are similar, however, much of the data requirements are likely to overlap.

For the purpose of a conceptual illustration of the methodological procedure, simplified, conceptual examples in which the needed information is reduced to a minimum are presented throughout this chapter (see the Box).

Box 9.1: SIMPLIFIED EXAMPLE - Step 1 - Establish key parameters of the assessment.

Define detailed scope of the sector.

The specific problem to be addressed is industrial and residential urban demand for water in City A. The present provision of water is from two sources: a reservoir located on River A and a network of wells. These sources are already under stress.

Population growth and industrial development are expected to cause an increase in water demand over the next 30 years. Agricultural development through irrigation by aspersion in the upper basin of River A is already leading to an increment of groundwater consumption, directly affecting the groundwater level in the pumping area and reducing the efficiency of the extraction. Extra water to fill the demand gap is planned to be extracted from the reservoir through adjustments in the water management policy.

Pollution of River A, downstream from the reservoir, due to uncontrolled discharges from the urban area, is a related problem that needs attention, and it is expected to grow in intensity (due to both increase of loads and decrease of river discharge, the latter effect related to the increase in water supply from the reservoir), unless a specific pollutant management programme is formulated and implemented.

Climate change predictions from General Circulation Models for future scenarios indicate a decrease of precipitation in the water basin, implying a reduction of the potential water supply both from River A and from groundwater, thus increasing the stress on those water resources.

Specify base year and assessment period.

The assessment period is 26 years long, starting with 2025 as the base year.

[7] Although V&A baselines have evolved from simple scenarios of population and economic growth to more comprehensive socio-economic scenarios, they tend to cover longer periods than is used in this methodology (hence, the multiple storyline approach) and are constructed for assessing the impacts of climate change rather than the costs of adaptation measures.

Box 9.1: SIMPLIFIED EXAMPLE - Step 1 - Establish key parameters of the assessment *(continued).*

Identify the target to be assessed and adaptation measures.

The following adaptation option was selected as feasible: building a new reservoir upstream of the present one. The reservoir characteristics are a priori the following: capacity = XX hm^3; surface area = XX m^2. The dam characteristics are the following: material = XX; height = XX m; length = XX m. The reservoir could eventually be used to manage flood risk (synergy). As a drawback, the reservoir construction will imply increasing methane emissions.

Select analytical approach.

Continuous records of daily water levels for the past five years are available at a station of River A close to the selected new reservoir site. Some discharge measurements are also available for different river stages, which has led to the establishment of a water level-discharge relationship for that station. Hence, a hydrograph (time series of water discharge) can be built from the daily water records. This is being used to drive a hydraulic model of the stretch of river where the old reservoir stands (and the new one will stand), which provides results on the optimum management strategy for the discharge from the reservoir to supply water, while maintaining an adequate ecological discharge downstream.

Step 2.

Compile historical IF, FF, O&M cost data (and subsidy cost data if included explicitly), and other input data for scenarios.

Compile historical annual IF and FF data, disaggregated by investment entity and source.

The methodology recommends that countries compile ten years of historical investment and financial flows data, i.e., for the base year and the previous nine years to extrapolate information for the scenarios. At a minimum, countries should collect at least three years of data (i.e., for the base year and two years during the previous decades). Data should be compiled for each investment type and should be annual, disaggregated by investment entity and, if possible, by funding source. Data should also be divided into investment flows and financial flows (see Chapter, Table 2.3: 'Template for one year of historical investment and financial flows data').

In the water sector, investment flows would include assets such as hydraulic works (e.g., dams, dykes, pumping stations, wells, pluvial systems, water mains), sanitary works (e.g., wastewater treatment plants), machinery (e.g., irrigation equipments, pumps, turbines), land purchase (e.g., for watershed protection), fixtures and appliances (for residential and commercial use) and equipment for research, education, assistance and institutional adaptation (e.g., computers, hydro-meteorological gages, vehicles). Financial flows would include non-asset investments in research, education, assistance and institutional adaptation (e.g., labour costs). In the following table some IF and FF are identified, according to the type of problem to be solved.

Table 9.2: Examples of investment and financial flows that may occur in the water sector

Challenge	Investment flow	Financial flow
Water supply	Intake works	Water management plan
	Well systems	Superficial and groundwater extraction regulations
	Reservoirs*	
	Potabilization plants	
	Water mains	
	Desalination systems	
	Irrigation systems+	
Water quality	Sewage systems	Pollution control plan
	Treatment plants	Effluents regulations
	Monitoring systems	
Water efficiency	Reparation of leaks from water systems	Education programmes
	Residential and commercial fixtures and appliances	Fare rates policy
Floods	Pluvial systems	Contingency plans
	Channelization	Land-use regulations
	Dykes	
	Detention reservoirs	
	Warning systems	
Droughts	Water harvesting structures	Contingency plans
Wetlands preservation	Land acquisition	Wetlands management plans

* This could intersect with the energy sector.
+ This could intersect with the agriculture sector.

The investment and financial flows data needed will likely reside in several domestic locations (e.g., national accounts, ministry records and plans, industry records, statistical agencies, extension agencies, research institutions, etc.). Note that sectoral and subsectoral definitions and disaggregation will vary among data sources, so expert judgement need to be made to reconcile datasets and extract data needed from aggregated and/or disaggregated categories.

Compile historical annual O&M cost data, disaggregated by investment entity and source.

Historical O&M data are needed to provide a historical basis from which to extrapolate future O&M costs for new physical assets and to provide data for the first year of the scenarios. Annual O&M costs for the physical assets in operation during the historical period should be collected for the same years for which historical investment and financial flows data are collected. Information about the expected lifetimes of assets, such as dams, water distribution mains, sewage systems, etc., in operation during the historical period and annual fluctuations in O&M costs (if any) also need to be collected.

O&M data should be collected at a level of disaggregation consistent with the investment and financial flows data. O&M data for assets purchased **during** the historical period should be tracked separately from the O&M data for assets purchased **before** the historical period (see Chapter II, Table 2.4: 'Template for three years of historical O&M cost data for an investment flow in 2023').

The most significant O&M costs for the water sector are likely to be operation and maintenance of hydraulic works (dimensions of which are usually large), including associated salaries. Energy costs may be a significant portion of the O&M costs, thus improved management can also lead to GHG reductions. As, for example, irrigation systems also constitute hydraulic works, care should be taken so that this cost is not already accounted for in the agriculture sector. This type of corroboration should be performed for all sectors linked with the water sector.

The O&M data that need to be collected may reside in one or more of the same locations as investment and financial flows data (e.g., national accounts, ministry records and plans, industry records, statistical agencies, extension agencies, research institutions, etc.). If such data are not available, countries should utilize one of the estimation approaches described in Chapter II. In-country experts may be particularly useful for supplying cost estimates.

Compile historical annual subsidy cost data, if subsidies are included explicitly in the assessment.

Numerous types of water management subsidies exist, with the most significant one usually being discounts in fare rates due to construction and O&M cost subsidies. If a country chooses to include subsidies explicitly in the financial assessment, annual costs of subsidies for each investment type during the historical period should be collected for the same years for which historical investment and financial flows data are collected. Subsidies should be compiled separately for IF, FF and O&M (see Chapter II, Table 2.5: 'Template for three years of historical subsidy cost data').

Information on subsidies may be available from relevant government ministries or agencies, statistical agencies, research organizations, academic institutions and private sector entities.

Compile other input data for scenarios.

In addition to historical investment and financial flows and O&M cost data, the characterization of the scenarios and identification of annual costs for the scenarios require the collection of other historical and non-historical data relevant to the sector. What data are needed will depend on the sectoral scope. Required information may include those items described below.

For developing the baseline scenario

- relevant contacts, reports and databases at national and international agencies
- types of models that are suitable for the country
- current inventories of water resource characteristics, including dams, wells, surface water, rainfall, sewer and drainage networks, opportunities for dual quality water distribution systems and other pertinent information
- data for a ten-year period prior to the base year of the assessment (or longer data quality permitting) in as much detail as possible
- national water availability forecasts to 2030 by region and province, as possible

- schedule of capital improvements to 2030
- major recent policies or expected actions that might affect the baseline scenario
- information on the potential and costs for alternative water management strategies
- commissioning and retirement dates for existing infrastructure (to ensure that any replacement and upgrades are factored into the baseline scenario)
- demand forecasts

For identifying potential adaptation investments

- available databases on the characteristics of alternative water resource management strategies (e.g. drip irrigation) capable of functioning under projected climate changed conditions (e.g., rainfall, temperature) in the country
- potential models that can be used to analyse the introduction of new water management strategies, practices and technologies in water management plans
- international studies or projections regarding reducing the vulnerability of water resources (e.g., IPCC assessment reports for Working Group II)
- available databases on technologies to promote water conservation

For developing the target scenario

- relevant contacts, reports and databases at agencies, utilities and other organizations that focus on improving water management
- national studies or projections that may have been developed regarding adapting to climate change in the water sector (National Communications, NAPs, Vulnerability and Adaptation Strategies)
- information on any public and private partnerships for water investments and/or new water management demonstration projects
- major recent policies or expected actions that can affect the adaptation capacity

These data and information may be available from the domestic sources mentioned above for investment and financial flows and O&M cost data. Potential information sources are:

- Cap-Net, a network for capacity building in Integrated Water Resources Management ; and
- FAO's AQUASTAT, an information system for the collection and analysis of information on water resources and agricultural water management by country and by region, including data on dams, irrigation system investment costs and irrigated areas.

In case investment and financial flows and O&M costs are not available, they must be estimated. Table 9.3 illustrates how to estimate costs associated with an example specific measure, a flood control plan for a water basin. Issues to be noted include:

- since channelization work is developed through dredging, maintenance costs may be high;
- detention reservoirs mainly involve excavation and filling and maintenance works may be more sporadic;
- control structures include dams, gates and spillways;
- longitudinal dykes are defence works for dense urban zones;
- the control system for gate operation and the flood warning system include not only equipment (IF), but also software, model-based expertise for design, checking and eventual modification (FF); and
- the education programme is aimed at the population under flood risk.

Table 9.3: Example of estimating investment flow, financial flow and operating and maintenance costs for a flood control plan for a water basin

Items	IF	FF	O&M
Channelization	XXX		XXX
Detention reservoirs	XXX		XXX
Control structures	XXX		XXX
Longitudinal dykes	XXX		XXX
Control system	XXX	XXX	XXX
Warning system	XXX	XXX	XXX
Education program		XXX	
Total	XXX	XXX	XXX

In contrast, a control plan for glacier lake outburst floods (GLOFs) may include only some of the previous items, such as the warning system and education programme and possibly some longitudinal dykes.

The box shows the simplified example to illustrate Step 2.

Box 9.2: SIMPLIFIED EXAMPLE - Steps 2 - Compile historical IF, FF, O&M cost data (and subsidy cost data if included explicitly), and other input data for scenarios.

Compile historical annual IF and FF data, disaggregated by investment entity and source.

IF and FF for the present reservoir (built seven years ago) are available from the Basin Authority, which is the investment entity. The main funding source was an external loan, complemented with contributions from the national government annual budget.

Box 9.2: SIMPLIFIED EXAMPLE - Steps 2 - Compile historical IF, FF, O&M cost data (and subsidy cost data if included explicitly), and other input data for scenarios *(continued)*.

Compile historical annual O&M cost data, disaggregated by investment entity and source.

Historical O&M data for the present reservoir (since its construction seven years ago) are available from the Basin Authority, which is also the operation entity. The funding sources are the Basin Authority itself, through fares for water provision and the national government, from its annual budget.

Compile historical annual subsidy cost data, if subsidies are included explicitly in the assessment.

The annual contribution from the national government constitutes a subsidy in order to maintain fare rates at levels compatible with present social acceptance.

Compile other input data for scenarios.

Studies presented within the National Communication on Climate Change shows that the combined effects of reduction in total precipitation and increase in mean temperature on the Anywhere River basin could lead to a reduction of 30 percent in runoff by 2030.

Step 3.

Define baseline scenario.

This step entails describing what is likely to occur in the water sector under business-as-usual conditions without additional adaptation measures to climate change over the assessment period. It should reflect current sectoral and national plans, expected socio-economic trends and expected investments in the sector. It should include a quantitative description of the socio-economic factors that affect the sector (e.g., demographic changes, economic growth, etc.), as well as other relevant characteristics (e.g., environmental considerations). The baseline scenario description should include specific information about equipment, facility and infrastructure investments that are expected (and as are relevant) in each measure, as well as research, education, assistance and institutional investments.

The simplified example is continued to illustrate Step 3.

Box 9.3: SIMPLIFIED EXAMPLE - Step 3 - Define baseline scenario.

Taking into account the expected runoff decrease in Anywhere River basin, it is concluded that the future situation would be best represented by a hydrograph with a uniform 30 percent attenuation with respect to the present ones. The model shows that the extra water demand will not be satisfied at all times with the present reservoir, even at the cost of reducing somewhat the ecological discharge.

No infrastructure investments are planned for this scenario, as only a change of management policy is performed.

Step 4.

Identify annual IF, FF and O&M costs (and subsidy costs if included explicitly) for the baseline scenario.

Identify annual IF and FF for each investment type, disaggregated by investment entity and funding source.

In this step, annual IF for the baseline scenario facility and infrastructure investments and annual FF for the baseline scenario research, education, assistance and institutional investments are identified for each subsector. As discussed in Chapter II, costs should be in real terms (i.e., inflation adjusted), in constant 2025 US$ or national currency, should be reported in the year in which they are expected to be incurred and should be discounted using appropriate public and private discount rates. The annual IF and FF values for each investment type should be disaggregated by investment entity and funding source and be divided into investment flows and financial flows. Data sources could include model output and/or government and private sector planning documents or values might be derived from historical data.

The output of this step will be a stream of annual investment flows and financial flows for each investment type in each subsector for the entire assessment period, by investment entity and funding source. These data should be organized as in Chapter II, Table 2.6: Baseline scenario: *cumulative* investment and financial flows and O&M' and Table 2.7: 'Baseline scenario: *annual* investment and financial flows and O&M.'

Identify annual O&M costs for each IF, disaggregated by investment entity and funding source.

Annual O&M costs for assets purchased during the assessment period and for assets purchased before the assessment period and that are expected to still be in operation, need to be collected for each subsector. Costs should be in real terms, in constant 2025 US$ or national currency, should be reported in the year in which they are expected to be incurred and should be discounted.

The annual O&M costs for each investment type should be disaggregated by investment entity and funding source and be divided into O&M for assets purchased during the assessment period and for assets purchased prior to the assessment period. For those assets purchased during the assessment period expected to still be in operation after the last year of the assessment period, annual O&M costs for each additional year the assets will be in operation should be identified, up to an additional five years after the last year of the assessment period. Possible data sources include those described above for IF and FF.

Identify annual subsidy costs for each investment type and for IF, FF and O&M costs, if subsidies are included explicitly in the assessment.

If a country chooses to include subsidies explicitly in the financial assessment, annual subsidy costs should be identified for each relevant investment type and for IF, FF and O&M (see Chapter II, Section 2.2.1).

The simplified example below illustrates Step 4.

Box 9.4: SIMPLIFIED EXAMPLE - Step 4 - Identify annual IF, FF and O&M costs (and subsidy costs if included explicitly) for the baseline scenario.

Identify annual IF and FF for each investment type, disaggregated by investment entity and funding source.

The IF and FF associated with business-as-usual activities are included here.

Identify annual O&M costs for each IF, disaggregated by investment entity and funding source.

O&M costs are identified based on sound extrapolation from historical O&M data, assuming no changes have been made in fare policies.

Identify annual subsidy costs for each investment type and for IF, FF and O&M costs, if subsidies are included explicitly in the assessment.

No change in fare policies means that the annual contribution from the national government (subsidy) is assumed to continue in the future.

Step 5.

Define target scenario.

This step entails developing a description of what is likely to occur in the relevant water sector, over the assessment period, with implementation of additional and scaled up adaptation measures. The additional policies and measures are based on the national target that is being assessed (NDC, LT-LEDS, other). This includes comprehensive descriptions of the specific adaptation measures that would be implemented and the implications of those measures for the evolution of the sector (e.g., satisfaction of projected water demand).

The adaptation measures need to be defined clearly and completely so that their IF, FF and O&M costs can be identified in the next step. This includes specific information about facility and infrastructure investments that would occur in each measure (e.g., dams, dykes), as well as non-asset investments (e.g., education programmes to reduce water consumption). In-country expertise and prior work on climate change adaptation (e.g., National Communications, NAPs), should be utilized in this step.

Countries should assess qualitatively the environmental and socio-economic benefits, as well as potential non-investment costs (negative externalities), of the adaptation measures. Potential environmental and socio-economic benefits might include, for instance, reduction of wastewater flow, fulfilment of ecological discharges, reduction of flood risk, etc.

Step 5 is illustrated in the simplified example below.

Box 9.5: SIMPLIFIED EXAMPLE - Step 5 - Define target scenario.

The new reservoir is introduced into the model, driven by the attenuated hydrograph. The model shows that the extra water demand can now be satisfied at all times with the present reservoir, without reducing the ecological discharge. Moreover, the model allows a re-evaluation of the reservoir dimensions initially considered (volume, surface area, height of dam, length of dam) in order to optimize its efficiency. Additionally, the model is used to analyse the increase in reservoir dimensions necessary to increase the ecological discharge and to define the reservoir management policy that could provide some attenuation to floods downstream from the dam.

This structural measure will be complemented with an education programme that can help promote the efficient use of water for both the domestic and industrial sectors.

Step 6.

Identify annual IF, FF, O&M costs (and subsidy costs if included) for the target scenario.

Identify annual IF and FF for ewach investment type, disaggregated by investment entity and funding source.

In this step, annual IF for the target scenario facility and infrastructure investments and annual FF for the target scenario research, education, assistance and institutional investments are identified for each measure. As discussed in Chapter II, costs should be in real terms (i.e., inflation adjusted), in constant values of the base year (e.g. 2025), they should be shown in US$ or national currency, reported in the year in which they are expected to be incurred and discounted using appropriate public and private discount rates. The annual IF and FF values for each investment type should be disaggregated by investment entity and funding source and be divided into investment flows and financial flows. Data sources include those listed earlier.

The output of this step will be a stream of annual investment flows and financial flows for each investment type in each subsector for the entire assessment period, by investment entity and funding source. These data should be organized as in Chapter II, Table 2.8: 'Target scenario: *cumulative* investment and financial flows and O&M' and Table 2.9: 'Target scenario: *annual* investment and financial flows and O&M.'

Identify annual O&M costs for each IF, disaggregated by investment entity and funding source.

Annual O&M costs need to be collected for assets purchased during the assessment period and for assets purchased before the assessment period and that are expected to still be in operation for each activity. Costs should be in real terms, in constant 2025 US$ or national currency, reported in the year in which they are expected to be incurred and discounted. The annual O&M costs for each investment type should be disaggregated by investment entity and funding source and be divided into O&M for assets purchased during the assessment period and for assets purchased prior to the assessment period. For those assets purchased during the assessment period expected to still be in operation after the last year of the assessment period, annual O&M costs for each additional year the assets will be in operation should be identified up to an additional five years after the last year of the assessment period. Possible data sources include those described above for IF and FF.

Identify annual subsidy costs for each relevant investment type and for IF, FF and O&M costs, if subsidies are included explicitly in the assessment.

If a country chooses to include subsidies explicitly in the financial assessment, annual subsidy costs should be identified for each relevant investment type and for all categories of cost (IF, FF and O&M) (see Chapter II, Section 2.2.1).

Step 6 is illustrated in the simplified example below.

Box 9.6: SIMPLIFIED EXAMPLE - Step 6 - Identify annual IF, FF, O&M costs (and subsidy costs if included) for the target scenario.

Identify annual IF and FF for each investment type, disaggregated by investment entity and funding source.

IF and FF are identified based on surveys made by construction companies. The funding source is assumed to be an external loan to the national government.

Identify annual O&M costs for each IF, disaggregated by investment entity and funding source.

O&M costs are derived based on O&M costs for the present reservoir.

Identify annual subsidy costs for each relevant investment type and for IF, FF and O&M costs, if subsidies are included explicitly in the assessment.

As for the present reservoir, some annual contribution from the national government is assumed to exist in the future.

Step 7.

Calculate the changes in IF, FF and O&M costs (and in subsidy costs if included explicitly) needed to implement target scenario.

The shifts and increases in IF, FF and O&M costs needed to implement the adaptation measures in each measure are calculated in this step by subtracting baseline scenario values from those of the target scenario. The two primary objectives of this step are to determine: 1) how *cumulative* IF, FF and O&M costs would change; and 2) how *annual* IF, FF and O&M costs would change. These calculations are described in detail in Chapter II.

Step 7 is illustrated in the simplified example below.

Box 9.7: SIMPLIFIED EXAMPLE - Step 7 - Calculate the changes in IF, FF and O&M costs (and in subsidy costs if included explicitly) needed to implement target scenario.

The shifts and increases in IF and FF are equal to the values of IF and FF for the target scenario, while O&M costs will arise from the difference between those associated to the target scenario and the baseline scenario.

Step 8.

Identify policy implications.

The purpose of this step is to identify the policy implications of the results of the previous step for the sector. The analysis in the previous step calculates the magnitude and timing of changes in IF, FF and O&M by each investment entity and from each funding source that are needed to implement the target scenario.

Looking at the resulting shifts and increases in investment and financial flows determined in Step 7, it needs to be determined which investment entities are responsible for the most significant (largest and/or highest priority) changes in IF and FF and the predominant sources of their funds.

Then policy measures need to be identified that are required to induce those entities to implement the proposed measures and change their investment patterns. It will be particularly important to distinguish between public and private sources of finance, as well as between domestic and foreign sources. Policy measures include a variety of instruments, including economic instruments (e.g., taxes), regulatory instruments (e.g., fuel portfolio standards), voluntary agreements, information dissemination and strategic planning, research, development and demonstration.

Step 8 is illustrated in the simplified example below.

Box 9.8: SIMPLIFIED EXAMPLE - Step 8 - Identify policy implications.

The changes in IF, FF and O&M costs are high enough to lead to considering alternative funding sources and fare rate policies. The participation of the private sector in building the dam and operating the reservoir and a progressive increment in fare rates are next analyzed as possible combined actions to diminish the costs gap.

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