STRENGTHING THE CAPACITY OF THE SWIM PARTNERS COUNTRIES IN THE ASSESSMENT OF THE COST OF WATER RESOURCES DEGRADATION AT THE BASIN LEVEL

CASE STUDY 1: COST ASSESSMENT OF WATER RESOURCES DEGRADATION OF THE MANN BASIN

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.....Water is too precious to Waste

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Exchange Rate:
€ 1 = US$ 1.321 (December 2012)
€ 1 = US$ 1.376 (December 2013)

ACRONYMS

BA	Benefit Assessment
B/C	Benefit/Cost
BCA	Benefit/Cost Analysis
BCM	Billion cubic meter
BFT	Benefit Function Transfer
CAWRD	Cost Assessment of Water Resources Degradation
CBD	Convention on Biological Diversity
CH_4	Methane
CO_2	Carbon Dioxide
COED	Cost of Environmental Degradation
CV	Contingent valuation
DALYs	Disability Adjusted Life Years
DCCV	Dichotomous choice contingent valuation
EC	European Commission
E. coli	Escherichia Coli
EPA	Environmental Protection Agency of the United States
EU	European Union
FAO	Food and Agriculture Organisation
GES	Good Ecological Status
GDP	Gross Domestic Product
GIS	Geographical Information System
Ha	Hectare
IRR	Internal Rate of Return
Kg	Kilogram
Km	Kilometre
Km^2	Square Kilometre
kTOE	Kiloton of oil equivalent
m	Meter
m^2	Square meter
m^3	Cubic meter
MCM	Million cubic meter
mm	millimeter
MSW	Municipal Solid Waste
NPV	Net Present Value

O&M	Operations and Maintenance
PV	Present Value
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total economic value
TOE	Ton of oil equivalent
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
VOLL	Value of Life Lost
WE	Water Establishment
WFD	EC Water Framework Directive
WHO	World Health Organisation
WTP	Willingness to Pay
WWTP	Waste water treatment plant

1 BACKGROUND

1.1 INTRODUCTION

The EU SWIM-SM aims at supporting institutional strengthening and contributes towards ensuring that national water strategies and plans properly address issues of sustainable water resource management, water considerations are promoted and mainstreamed in other relevant sectoral policies and strategies (for example agriculture, tourism and industry), as well as in national development plans. The anticipated outcomes are that: (a) Water considerations are promoted using a participative approach, also at local level; (b) Water concerns are mainstreamed in other relevant sectoral policies and in national development plans; (c) Economic valuation is carried out to assess the costs and benefits of mitigation actions on water degradation; and (d) Climate change considerations are mainstreamed in national strategies, plans and policies, with primary emphasis on no-regret actions.

In this regards, SWIM-SM has designed and implemented a pillar on the cost assessment of water resources degradation (CAWRD) at the basin level because it is at this level that water governance can be strengthened and water can be mainstreamed in other sectors.

The general vision of this pillar is to provide the decision makers with the necessary tools for making informed decisions on water resources management based on economical cost and benefits, taking into consideration the environmental negative externalities. This pillar consists of four sub-components;

(a) Cost of water resources degradation due to water and waste water pollution with the aim to place a monetary value on the consequences of the degradation;

(b) Cost Benefit or Cost Effectiveness Analyses of Remedial Actions and Preparation of Investment Plans for one major basin in 4 Partners Countries, including estimates in monetary terms for the overall health, social, economic and environmental benefits linked to these alternatives in the selected watershed;

(c) Building the capacity of the decision makers at the sub-national/basin level and the Universities to transfer knowledge, especially with regards to the methodologies used for the preparation of investment plans; and

(d) Validation and dissemination of the Investment Plans at the Watershed/Basin Level to build consensus on the investment plans, seek the Government support to implement and replicate the investment plans.

The purpose of this current task consists of building capacity and knowledge transfer by providing technical training of practitioners as well as sensitization of policymakers and other stakeholders in the use of CAWRD. This includes the preparation of 2 case studies on the four basins that will be used as training materials in two workshops; One for the Mashrek sub-region in English and the other for the Maghreb sub-region in French. The targeted audience include: government staff working on water resources issues with relevant expertise, namely trained economists and environmental/water specialists. In addition, academics (including post-graduate students) and researchers can also be included in the desired target group. This capacity building will be carried out in collaboration with the Marseilles Center for the Mediterranean Integration as well as with the Capacity Building/Mediterranean Environment Program (CB/MEP) of Horizon 2020.

1.2 OBJECTIVE OF THE CASE STUDY

The main objective is to develop a case study to help value the cost of water resource degradation in a hypothetical watershed, MANN River, to assist decision-makers at the national and local levels to identify and prioritize specific actions to improve the management of this basin through potential funding of projects related to environmental benefits and the reduction of externalities.

The Case Study section content is divided into 3 Parts as follows:

1. **BACKGROUND**

- Section 1.1 introduces the EU SWIM-SM program.
- Section 1.2 sets the objective of the case study.

2. **IN THEORY**

- Section 2.1 gives a brief overview of basic of economic principles.
- Section 2.2 links economics and environment at various levels.
- Section 2.3 develops the framework for valuating degradation and remediation.
- Section 2.4 develops the valuation methods.

3. **IN PRACTICE**

- Section 3.1 sets the watershed case study:
    - water-related diseases.
    - water quality degradation.
    - water quantity degradation.
    - fossil aquifer replenishment.
    - solid waste degradation.
    - selective remedial costs.

2 IN THEORY

2.1 BRIEF OVERVIEW OF BASIC OF ECONOMIC PRINCIPLES

Activities of economic agents contribute to the generation of pollution. The operation of the market system is intimately related to the nature and amount of pollution generated. How markets work and why markets fail.

A market can be defined as the coming together of consumers (or buyers) and producers (or sellers) to exchange goods and services for money. In a perfectly competitive market, there are many buyers and sellers. In a monopoly/duopoly/oligopoly market, there is one or few sellers.

Characteristics of the competitive market:

- many buyers and sellers who do not affect the market price or output
- buyers and sellers are free to enter and leave the market in response to price changes
- goods and services being offered for sale are identical or homogeneous.
- All the participants in the market have perfect knowledge. That is, consumers know product prices and producers know input prices.

Consumer behavior and demand

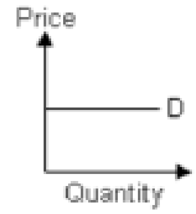
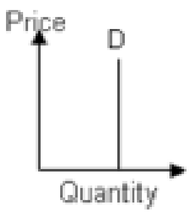
The demand function is a curve that indicates how much of a good a consumer will buy at various prices where an exists inverse relationship between price and quantity demanded (Figure 1).

The concept of elasticity

The term 'elasticity' refers to the responsiveness of the quantity demanded (or supplied) to changes in other variables (e.g., price and income). Forms of elasticities are illustrated in Figure 1. Depending on the magnitude of the elasticity parameter, own-price elasticity of demand can be perfectly elastic, relatively elastic, relatively inelastic, or perfectly inelastic

For instance, France water consumption after a 3% tariff increase was reduced from 168 liters in 2004 to 151 liters in 2008 (-10%). This corresponds to a relatively inelastic demand curve illustrated in the third graph of Figure 1.

Figure 1: Various forms of Elasticities

Type	Graph	Description
Perfectly elastic $\lvert \varepsilon^D \rvert = \infty$		A small increase in the price of the good causes the quantity demanded to fall to zero. In practice, no good has perfect price elasticity.
Relatively elastic $\lvert \varepsilon^D \rvert >1$		A small change in the price of the good causes a relatively large change in quantity demanded. In general, most luxury goods tend to be relatively price elastic.
Relatively inelastic $\lvert \varepsilon^D \rvert <1$		In this case, a change in the price of the good causes little change in quantity demanded. Necessities such as food and utilities (e.g., water and energy) tend to be relatively price inelastic.
Perfectly inelastic $\lvert \varepsilon^D \rvert =0$		A change in the price of the good does not lead to a change in quantity demanded

Source: METAP (2008).

Producer behavior and supply

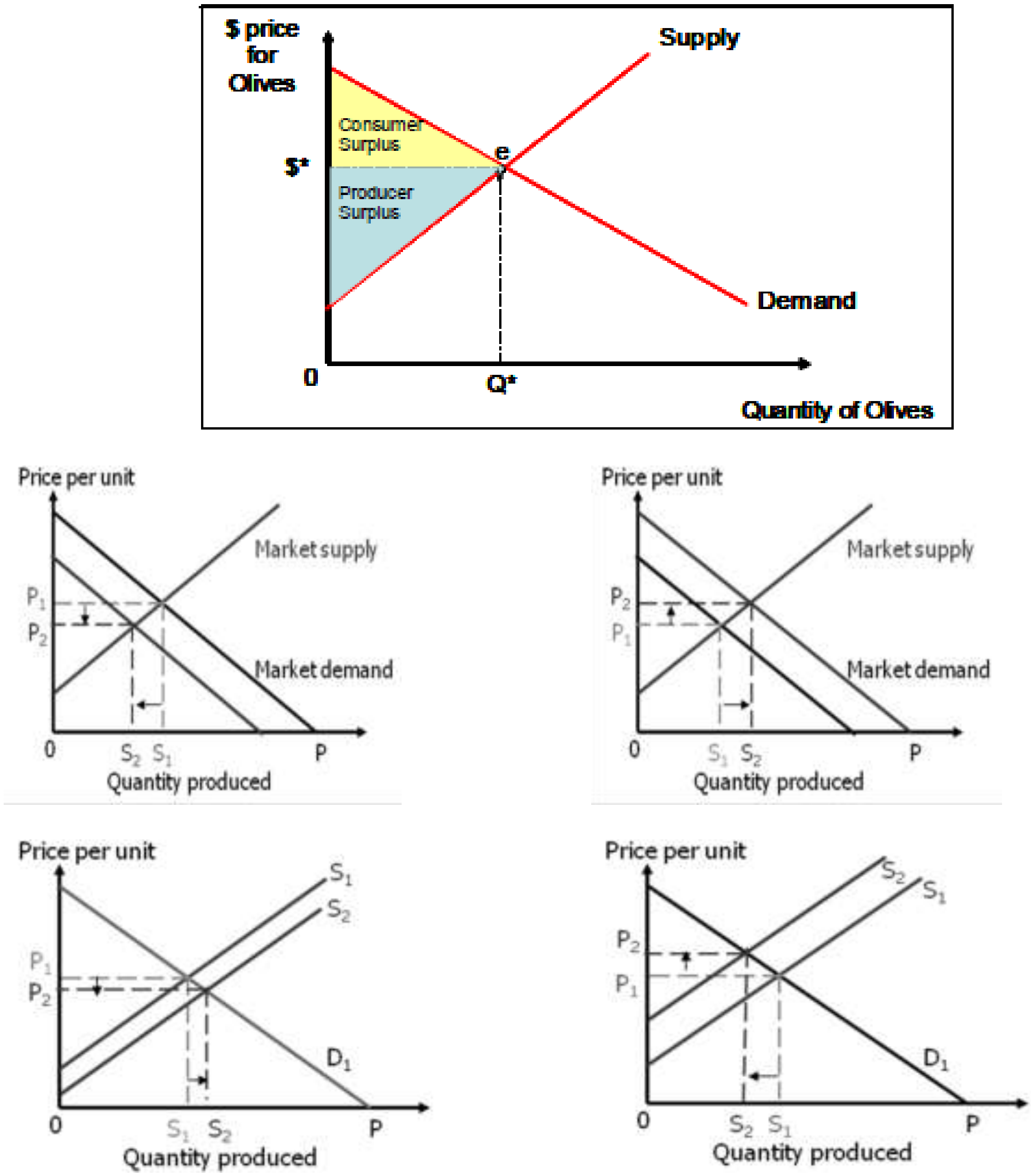
The production function of a good *Q** is a function of various inputs, including labor, land, capital, knowledge, technology and that are used in producing goods. The production function is positively sloped because producers are willing to supply more as price increases (Figure 2).

Supply and demand forces interact simultaneously in the market. Together, the forces of supply and demand determine the price of a unique balance (also called "market clearing price")

* $, and the balance amount corresponding e.

* Q, At this point the balance, and the amount of consumer demand completely equal quantity supplied by producers. Above this point, the consumer is incurring a surplus called the consumer surplus. Below this point, the producer is incurring a surplus and called the producer surplus.

Figure 2: Demand and Supply in a Perfect Competition



Source: METAP (2008).

A decrease or increase in income (consumer) will make the demand curve move downward and upward respectively. A decrease or increase in input price (producer) will make the supply curve move downward or upward respectively (Figure 2).

Main causes of market failures

Market failure is due to several causes:

- **Abuse of Market Power**: Whenever a single buyer or seller in a market is able to exert significant influence over the market there is the potential for a loss in societal well being.

- **Asymmetric Information :** Asymmetry in information refers to the situation where one side of the market knows more than the other side.
- **Externalities** are positive or negative impacts arising from an economic activity that affects somebody other than the person engaged in the economic activity and that are not reflected fully in prices. Pollution is often cited as an example of a negative externality. Efforts to 'internalize' such externalities into market prices forms a central component of environmental economics.
- **Public Goods** are the exact opposite of private goods and they are non-rival and non-excludable. Good taxonomy defined in terms of: rivalry and excludability Rivalry decreases the possibility for someone else to consume: a bottle of water follows the principle of rivalry. By comparison, a television show does not obey to the rule: if a viewer does not diminish the possibility for another viewer to watch it too.

Taxonomy of Goods

Good taxonomy is defined in terms of rivalry and excludability:

- **Rivalry** decreases the possibility for someone else to consume: a bottle of water follows the principle of rivalry. By comparison, a television show does not obey: if a viewer does not diminish the possibility for another viewer to watch it too.
- The principle of **excludability** is the possibility to exclude users. It is not always possible. It is possible to prohibit the entrance of a museum to those who do not pay by putting guards at the entrance, but it is not possible to prevent motorists to enjoy the lighting of roads, even if they do not pay anything for this lighting.

From these two properties we can distinguish four categories of goods and services (Table 1).

Table 1: Good Taxonomy

<table>
<tr><th colspan="2" rowspan="2">Good Taxonomy</th><th colspan="2">Excludability</th></tr>
<tr><th>Yes</th><th>No</th></tr>
<tr><td rowspan="2">Rivalry</td><td>Yes</td><td><u>Private Good</u>
Bottled water, Food, Clothes, Car, Cable TV, Digital radio, etc.</td><td><u>Common Good</u>
Water resources, fisheries, oil, mining, etc.</td></tr>
<tr><td>No</td><td><u>Club Good</u>
Reserve, Private garden, Private lake, Cinema, Museum, etc.</td><td><u>Public Good</u>
Air, Coast, Airwaves such shows on TV, radio, red light, etc.</td></tr>
</table>

Source: Authors.

Most environmental goods fall under the category of pure public goods or open access/common property goods. In such cases lack of well-defined property rights results in market failure. A market failure consequence is inefficient allocation of resources (e.g., excessive pollution, abuse, etc.).

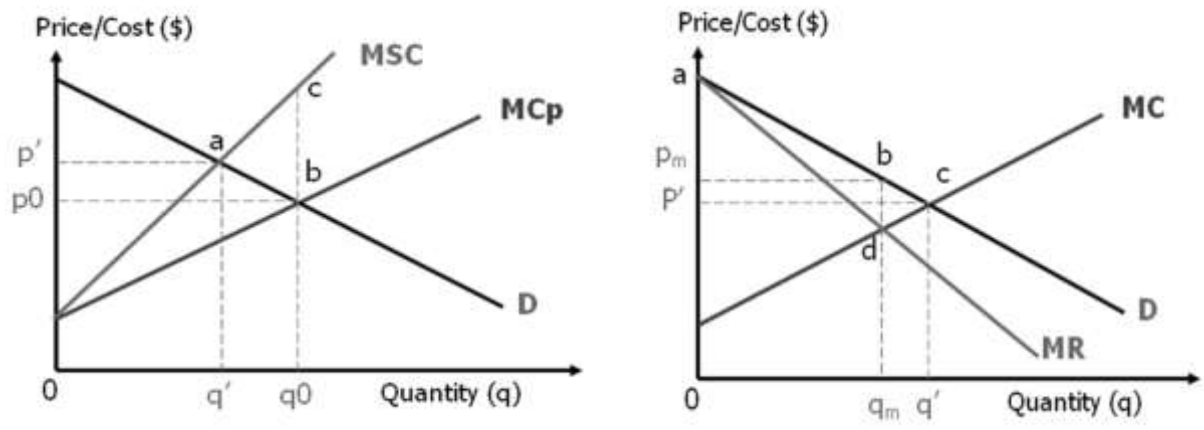
Resource allocation in a perfectly competitive market

If we consider a mineral mining company that dumps mine tailings into a nearby river without paying for clean up or treating the waste. In this case, production at the mine includes the production of the mineral as well as pollution. The mineral processing could also lead to air pollution. The river water and the air are an unpriced input in the mineral production process. Let us define the following variables:

D = demand curve for the mineral; MCp = marginal private cost of producing the mineral (i.e., the firm's supply curve); MSC= marginal social cost.

Assuming a perfectly competitive market and a system of private property rights, the price mechanism will combine to result in an efficient allocation of resources (Figure 3, 1st quadrant).

Figure 3: Resource allocation in competitive and monopoly markets with externalities



Resource allocation in a monopolistic market

The presence of monopoly rights causes market failure or inefficient allocation of resources from society's point of view. Take the case of a single monopolistic firm with a marginal cost curve, MC, facing a market demand curve, D. Under perfect competition, *q* units of the good will be supplied by setting the price = marginal revenue (MR) = marginal cost (MC). Note, however, that in the case of a monopoly, the demand curve is above the marginal revenue curve and therefore price is not equal to marginal revenue (Figure 3. second quadrant).

Monopoly profit is maximized by setting MR equal to MC. This results in less output, q_m, and a higher price, p_m. Consumer surplus under a monopoly is ap_mb, which is less than consumer surplus under perfect competition, $\Delta\ ap'c$. Recall that the demand curve (D) represents the marginal benefit of goods to consumers. The Figure above (second quadrant) indicates that for a monopolist, marginal benefit exceeds marginal cost and therefore the level of output (q_m) is inefficient. Consequently, there is dead weight loss to society represented by triangle Δbdc.

2.2 LINKING ECONOMICS AND ENVIRONMENT AT VARIOUS LEVELS

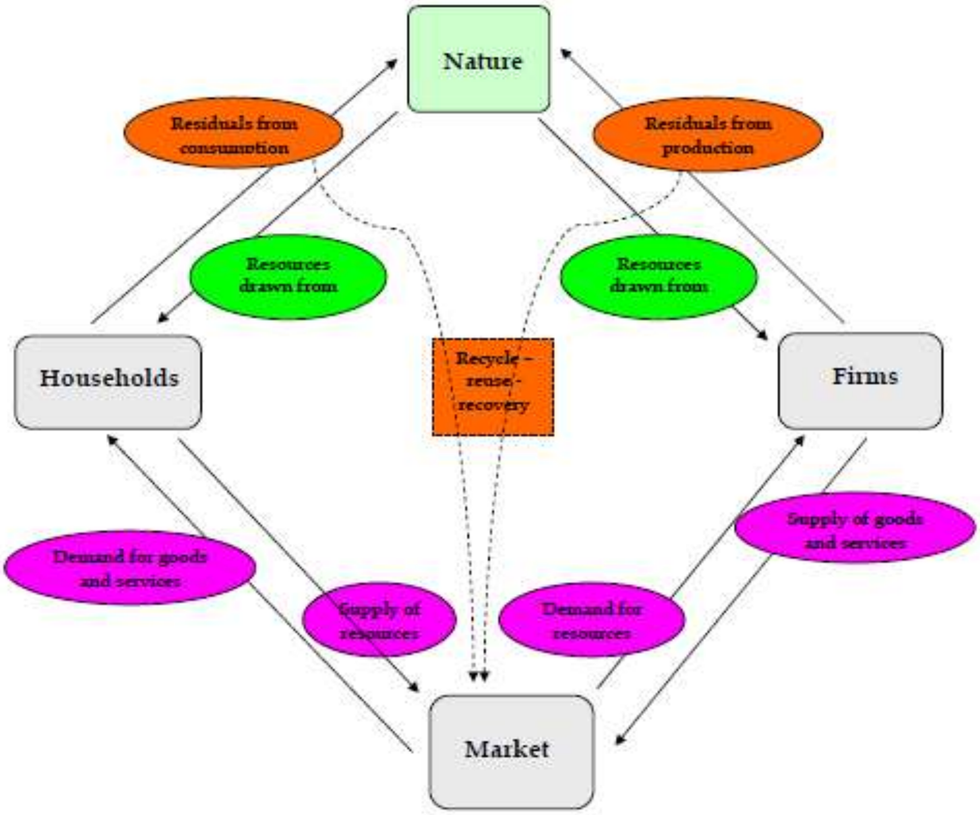
2.2.1 At the Conceptual Level

At the heart of environmental economics is the recognition that "the economy" and "environment" are fundamentally linked. The trade-offs between economic activity and the natural environment is made explicit in the Materials Balance Model. This model relies on the Laws of Thermodynamics.

Thermodynamics is a branch of physics concerned with heat and temperature and their relation to energy and work. For instance, the release of excessive greenhouse gases affects the balance between the energy the earth absorbs from the sun and the energy the earth radiates back into space -- a concept known as "radiative forcing." The bigger the difference between the amount of energy coming to the earth and the amount leaving it, the greater the global warming.[1]

Figure 4 illustrates the interaction between nature, households, firms and market that was brought to preeminence since the 1960s and culminated with the 1987 Brundtland Report and 1992 UN Rio Conference. Moreover, the 2000 World Resources Institute report provided an alarming figure where it estimated that between 1/2 to 2/3 of natural resources used were rejected in nature.

Figure 4: Economics and Environment Linkages



Source: METAP (2008).

2.2.2 At the Macro Level

Economic Indicators include the Gross Domestic Product (GDP) which accounts for the value added for goods and services in an economy or the Gross Disposable Income (GDI) which accounts for the households' disposable income. However, the national income accounts are restrictive and have a number of shortcomings when, for instance, treating the environment. For example, while the income from harvesting pine nuts is supposed to be recorded in national accounts, the depletion of pine trees

[1] Krupp. Fred. 2014. How to Make Fracking Safer for the Environment. Foreign Affairs.

due to construction is not. More importantly, all the essential life-support services provided by not only forest ecosystems but all ecosystems (water bodies, biodiversity, etc.) are not explicitly recognized at all.

To avoid providing the wrong signals for economic growth which could result in unsustainable growth/development, the response was to address these shortcomings of the national income accounts, a number of methods/instruments were developed to improve sustainable growth/green development by internalizing or underscoring environmental damages inside or outside national income accounts.

The World Bank <www.worldbank.org>**:** a sustainability indicator called the Adjusted Net Savings (ANS, late 1990s) or Genuine Savings builds on the concepts of green national accounts. ANS measure the true rate of savings in an economy after taking into account investments in human capital, depletion of natural resources and damage caused by pollution. Negative ANS means depletion is greater than the savings for future generations.

The METAP/World Bank <www.worldbank.org>**:** the Cost of Environmental Degradation (COED, early 2000s) helped present a first order of magnitude of damages for the following categories: air, water, waste, coastal zone and cultural heritage, soil and wildlife, and global externalities (notably climate change).

Yale University <http://epi.yale.edu/> developed the Environment Performance Index (EPI) in the mid 2000s, which benchmarks the environmental performance of a country relative to other countries based on a weighted scoring system (based on *environmental health* and *ecosystem vitality* aggregated scoring).

The **European Union** (EU, late 2010s; <www.environment-benefits.eu>) presented a recent simplified tool that provides the benefit that would accrue in the future by reducing the pollution/depletion for 5 categories: air, water, waste, nature and climate change.

With environmental or green national account efforts initiated in the mid-1980s, the **UN Statistical Commission** comprehensive framework for environmental accounting (UN et al., 2003), the System of Environmental and Economic Accounts (SEEA), has adopted one standardized classification called the Classification of Environmental Protection Activities that follows the System of National Accounts (SNA). MEDSTAT I and II also helped Euro-Med governments adopt green accounting procedures <http://epp.eurostat.ec.europa.eu>.

The **World Bank** is building on the SEEA effort by introducing the Wealth Accounting and Valuation of Ecosystem Services (WAVES). WAVES <www.wavespartnerships.org> is a global partnership that aims to promote sustainable development by ensuring that natural resources are mainstreamed in development planning and national economic accounts. Wealth is what underpins the income that a country generates. It includes buildings, manufactured assets such as the machinery used in factories, infrastructure such as highways and ports, and natural assets such as land, forests, fish, minerals and energy.

2.2.3 At the Policy Level

Environmental Instruments were developed over the last decades and could be regrouped along 4 categories as a selected number of instruments is illustrated in Table 2: regulatory instruments; fiscal Instruments; market instruments; and moral suasion instruments.

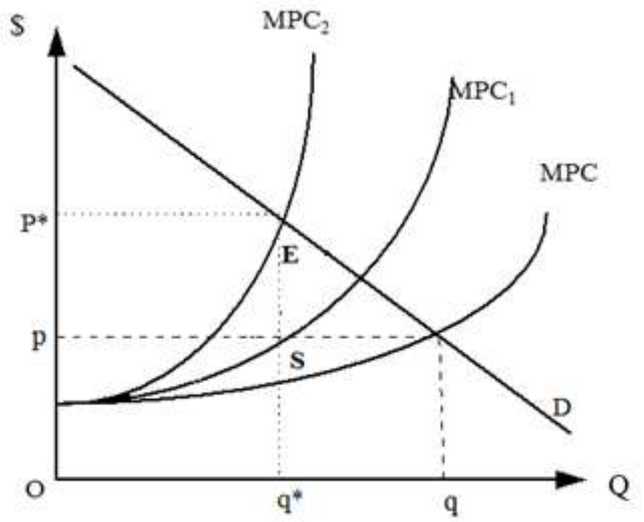
Table 2: Instrument Typology at Various Levels or Government Tiers with Selected Instruments

Instrument Level/Tiers	Regulatory	Fiscal	Market	Moral Suasion
Trans-national	Integrated Water Resource Management Drawing rights (water use)	Global carbon tax (airplane ticket)	Carbon funding (Kyoto Protocol)	Green stock trading promotion
National	Integrated Coastal Zone Management	Tax Increment Financing	National pollution rights	PROPER (Program for Pollution Control, Evaluation and Rating)
Regional	Conservatoire du Littoral	Smart-Green growth	Producer buy back scheme	Certification, Equitable commerce and labellisation
Local	Zoning	Impact Fees	*Perquazione Urbanistica* (tradable exploitation coefficient rights)	AOC (Appellation d'Origine Contrôlée) classification (controlled designation of origin)

Source: Authors.

Environmental adjustments (e.g., prices) and instruments are meant to correct natural resource pricing by internalizing 2 distortions respectively: policy failure (e.g., subsidizing water, electricity, fertilizers, etc.) and market failure (externalities) as illustrated in Figure 5.

Figure 5: Internalizing Price Distortions at the Policy and Market Levels



D = demand
MPC = Marginal Private Cost (MPC)
MPC_1 = MPC - Subsidy (policy failure)
MPC_2 = MPC_1 - External Costs (Market failure)
p* = MSC = MPC + MEC= MPC_2
= MPC + Subsidy (S) + External Costs (E)

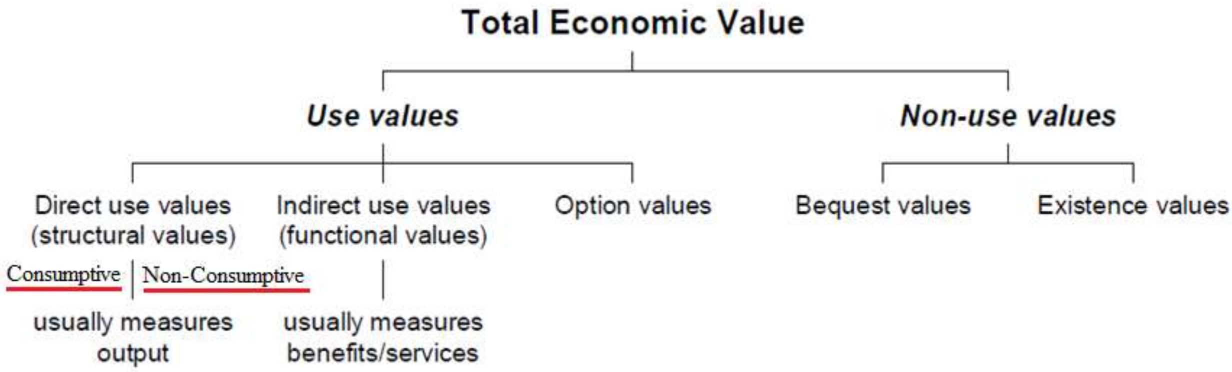
Source: World Bank Development Institute (1998).

In an open-access situation, no property rights are assigned to the resource, which results in open access to the resource for all potential users. Water from both underground and surface sources is often an open access resource. Use of the resource is subject to neither exclusion nor regulation. Individuals have complete autonomy in its use if a sovereign and regulatory body does not craft laws and enforce them.

To better Value Natural Resources

The total economic value (TEV) is calculated and includes the sum of all types associated with a resource as shown in Figure 6 (see section 2.3).

Figure 6: Total Economic Value of a Resource



Source : Adapted from Bolt et al. (2005).

2.3 VALUATION METHODOLOGY FRAMEWORK AND CATEGORIES

The CAWRD were valued by using available data source that cannot be entirely reliable. In addition, gaps in the data required to make several assumptions. Nevertheless, the CAWRD is meant to help policymakers make informed and efficient choices to maintain the integrity of the environment and promote conservation based on a common denominator: monetizing the environmental damage and remedial interventions. These results, which should be considered as preliminary order of magnitudes, could nevertheless help highlight the trade-offs between economic development and growth, well being, and the preservation of the commons. Moreover, these results, which should guide further analyses, provide policymakers with a preliminary tool for integrating environment into economic development decisions and comparing damage costs as a percentage of GDP within categories and across countries.

Moreover, it is difficult to accurately define the environmental degradation that is strictly natural and the one that is strictly anthropogenic. In some cases, there is overlap between the two causes of degradation that could lead to mutual reinforcement such as natural soil salinity and water that is exacerbated by human practices by adding fertilizers.

2.3.1 Methodology

The economic valuation of environmental projects are proven methods that are summarized in the Handbook of the World Bank on the Cost Assessment of Environmental Degradation,[2] the European Commission's Manual on the Benefit Assessment[3] and other reference sources such as The Economics of

[2] Website of the World Bank : <www.worlddbank.org>.

[3] Website of the EU ENPI BA : <www.environment-benefits.eu>.

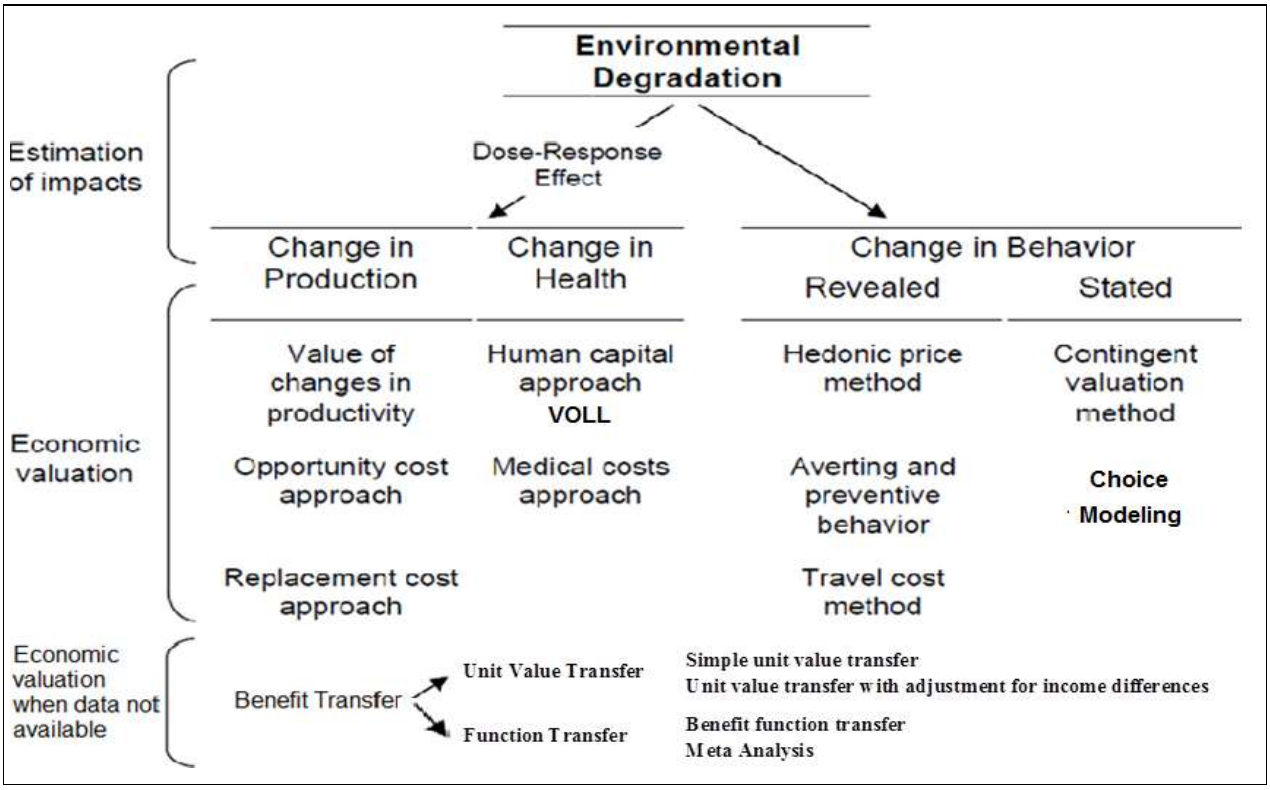
Ecosystems and Biodiversity (TEEB), also funded by the European Commission in cooperation with the German Government.[4]

The main methods for estimating impacts are grouped within three pillars with specific techniques under each pillar (Figure 7):

- Change in production.
    - Value of changes in productivity such as reduced agricultural productivity due to salinity and / or loss of nutrients in the soil;
    - Approach the opportunity cost of such shortfall of not re-selling the recycled waste;
    - Approach replacement cost when for example the cost of construction of a dam to be replaced by a dam that was silted.
- Change in condition with the dose-response function to establish between pollutant (inhalation, ingestion, absorption or exposure) and disease.
    - The value associated with mortality through two methods: the future shortfall due to premature death, and the willingness to pay to reduce the risk of premature death. Only the latter method is used in this study.
    - The approach to medical costs such as the costs when a child under 5 years is taken to the hospital to be cured of diarrhea.
- Changing behavior with two sub-techniques: revealed preferences, and stated preferences.
    - Revealed preferences by deriving the costs associated with behavior: e.g., hedonic method where for instance the lower value of land around a landfill is derived; trying to derive travel costs to visit a specific place like Lake Titicaca; and preventive behavior as when a household buys a filter for drinking water.
    - Stated preference where a contingent valuation is used to derive willingness to pay through a survey for example, improve the quality of water resources.
    - Choice modeling where respondents are asked to choose their preferred option from a set of alternatives with particular attributes (a variation on the WTP without a monetary value). Other forms also exist such as choice experiments.

[4] Website of TEEB: <www.teebtest.org>.

Figure 7: Estimation of Impacts and Associated Economic Valuation Techniques



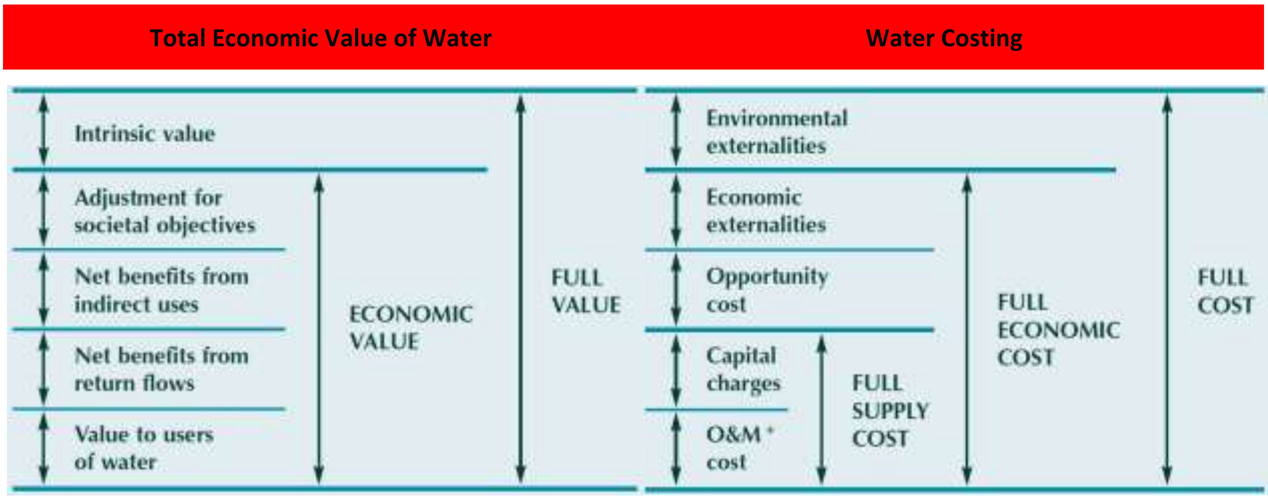
Source : Adapted from Bolt et al. (2005).

In cases where data are not available, a benefit transfer can be based on studies made in other countries by adjusting the results for the differential income, education, preference, etc. The original results that are used for the benefit transfer are based on one of the economic valuation methods under the three pillars as illustrated in Figure 7.

Some of the environmental functions are used directly, either contributing towards the production of marketed outputs or else contributing to consumption directly. For example, agricultural land provides the medium for the production of crops and timber. The environment may also be used directly for consumption purposes, for recreation or as landscape value. The third category of use values is the ecological functions of the environment, such as flood control, waste assimilation, or carbon storage. Alternatively, non-use or intrinsic values are inherent in the good.

Usually, valuing and costing water are not performed according to well established general principals and these principles are a bit more elaborated than the economic valuation techniques illustrated in Figure 8. Water resource has a range of values that need to be accounted for. The full value of water consists of its use value – or economic value – and the intrinsic value. The economic value which depends on the user and the way it is used, include: value to (direct) users of water, net benefits from water that is lost through evapotranspiration, which is not taken into consideration in the CAWRD or other sinks (e.g., return flows), and the contribution of water towards the attainment of social objectives. The full cost of providing water includes the full economic cost and the environmental externalities associated with public health and ecosystem maintenance. The full economic cost consists of: the full supply cost due to resource management, operating and maintenance expenditures and capital charges, the opportunity costs from alternative water uses, and the economic externalities arising from changes in economic activities of indirectly affected sectors (Figure 8).[5]

Figure 8: Water Valuing and Costing Guiding Principles



*Note: * O&M stands for operations and maintenance.*

Source: Integrated Water Resources Management 2000. Global Water Partnership. Technical Advisory Committee Background Paper number 4.

The base year 2012 was chosen to estimate the CAWRD Case Study.

2.3.2 Calibration and Limitations of the Valuation

In addition to resource constraints and binding time, the techniques used have their own methodological limitations. In the process of fact finding, the availability, accessibility and topicality of information relevant for the calculation usually pose problems. Information is scattered, not up-to-date and sometimes inconsistent. Inconsistencies are experienced with similar types of information from different sources. Approaching local authorities helps generate response, feedback and clarifications in terms of facts and figures.

The results allow for a margin of error through sensitivity ranges (lower bound, upper bound) that were taken into account. In addition, marginal analysis is attempted in some cases to assess the benefits (reducing the CAWRD) and investment costs.

Most valuation techniques used have inherent limitations in terms of bias, hypothetical premise, uncertainty especially when it comes to non-tradable goods. Moreover, the results are of course sensitive to the context. The use of benefits transfer could therefore exacerbate the results and uncertainties. Therefore, some results should be subject to further analysis when investments will be considered.

2.3.3 Categories Considered in the Analysis

Four main categories were selected for the watershed assessment but are not fully covered in the case study such as biodiversity and global environment: water, waste, biodiversity, and the continuum

[5] Integrated Water Resources Management 2000. Global Water Partnership. Technical Advisory Committee Background Paper number 4.

natural disasters and climate change. Sub-categories were also retained to meet the diverse impacts affecting the watershed and are shown in Table 3. Effects on coastal areas are usually covered to the extent of pollution of the marine environment (preference on improving the quality of water resources) in this study. In addition, certain investments considered for a sub-category might as well have a positive impact on other categories, for example, better landfill management (urban and rural waste) could have a positive impact on sub-category such as the quality water resources and/or biodiversity.

Thus, the CAWRD covers all sub-categories while the cost of remediation only covers four sub-categories. The selection criteria for calculating the cost of the remediation was based on sub-categories experiencing degradation.

Categories, sub-categories, impacts and methods to assess the CAWRD and remediation are developed in Table 3. The general description of the methods and specific subcategories are further developed in Annexes II and III.

Table 3: Categories, sub-categories, impacts and methods used for the valuation of degradation and remediation of the Basin Case Study

Category	Sub-category	Impact	CAWRD: Method used	Cost of Remediation: Possible intervention
Water	**Water-borne diseases:** improved drinking water supply and sanitation and change in behavior with regards to hygiene	Illness associated with drinking water supply quality and quantity as well as sanitation and poor hygiene (see Annex II for water-borne disease)	HCA/VOLL and COI	Coverage rate of improved drinking water supply and sanitation, and hygiene awareness campaign
	Quality and treatment: drinking water in urban and rural areas	Consumer preference (tap water vs. bottled water); filter use or chlorine addition; boiling water; etc.	CR and CB (additional cost of treatment)	Desalination for dilution with potable water and upstream investments ; water treatmen improvement and improvement of potable water; and tariff/charge adjustments
	Quality of services: drinking water in urban and rural areas, and irrigation	Costs of alternative sources of water (bottle, tank, wells, etc.); technical losses (financial losses are not considered as services are provided but tariff/charges are not collected) while considering the opportunity cost and economic externalities (subsidies) ; lost time hauling water	CR and CO	Improved delivery, service effectiveness; an tariff/charge adjustments
	Quality of the resource (anthropogenic): effluents and seepage (see Solid waste)	Surface water quality affecting : water use (domestic, agricultural, fisheries, industrial et mining) ; basin ecosystem and (eutrophication, etc.) coastal zones; territories ; and eco-tourism	CV (restoration of water quality)	Wastewater investments, reduction of industrial effluents) and reduction of pesticide and nitrate use (See Solid waste); and tariff/charge adjustments
		Underground water quality affecting : water use (domestic, agricultural and industrial); basin ecosystem and coastal zones; territories ; and eco-tourism	CV and RC (restoration of water quality)	Artificial recharge for dilution ; substitution wells or water desalination/transport
	Salinity (anthropogenic and	Salinity of soils, effects on health **(see Quality and**	CP (agricultural	Fertilizer increase (short term measures) an

Category	Sub-category	Impact	CAWRD: Method used	Cost of Remediation: Possible intervention
	natural): surface and underground water, marine environment and soil	**treatment**), reduction of agricultural and fishery productivity and effects on ecosystems	productivity)	land use planning (long term measures to reduce salinity)
	Quantity (anthropogenic and natural):surface water flow reduction and underground water drawdown	Surface : treated and untreated water use that could cause contamination of the food chain; and in extreme cases, substitution effects through desalination	CP (agricultural productivity and additional cost of pumping/substitution)	Opportunity cost of treated and reused water; and of desalination and water transportation; and tariff/charge adjustments
		Underground : deeper pumping, substitution wells or desalination (rapid drawdown or fossil water) to overcome domestic needs and/or agricultural productivity	CP (agricultural productivity and additional cost of pumping/substitution)	Opportunity cost of pumped/substitution water; and tariff/charge adjustments
	Erosion and Storage: soil management is affected by erosion and exacerbated by climate change	Soil nutritional losses and sedimentation of dams, hill lakes, river beds and coastal zones exacerbated upstream by poor land use management due notably to deforestation, wind and water erosion, etc.	CP et RC (dredging; increase the dam height; or construction of new dams/hill lakes)	Costs : Land use planning to prevent and reduce erosion
	Hydropower: affected by a longer drought cycle or lack of optimization of storage capacity	Reduction of production due to droughts or lack of storage capacity and substitution with fossil fueled plants (GHG emissions)	RC, CC (substitution by fossil-fuel powered plants)	Costs : increase water storage and/or substitution by renewable energy powered plants
Solid Waste	**Solid waste chain including sludge:** urban, rural, agro-industrial and agricultural	Ill wellness; health; sight, odor, noise, air, soil and water resource (leachate) pollution; and impact on land/house/apartment costs	CP, CR, RC, HA and CB	Costs : from collection, transfer stations, segregation, composting and recycling; sanitary landfill; and tariff/charge adjustments

Category	Sub-category	Impact	CAWRD: Method used	Cost of Remediation: Possible intervention
	Medical and hazardous waste chain	Ill wellness; health; sight, odor, noise, air, soil and water resource (toxic leachate and radioactive contamination) pollution; and impact on land/house/apartment costs	Not covered	Not covered
Biodiversity	**Various encroachments**	Loss of ecosystem and medicinal plants	CV meta-analysis; CR	Upstream investments (see above)
Natural Disaster and Global Environment	**Floods, droughts, forest fires, extreme events, etc.**	Exacerbation of the intensity and frequency with an impact on: health (mortality, injuries, drowning, communicable diseases); goods; services ; infrastructures; productivity; resources (water release with reduction of stored resources and impact on the ecosystem); etc.	HCA/VOLL and COI RA, CP, CR and RC	Preparedness State and effectiveness of response
	GHG Emissions	5 variables for climate change and effects on the use of soils, water, evapotranspiration, agriculture, migration, sea level rise, etc. In this particular case, only carbon sequestration (forest fire) and avoided GHG emissions (dump) are considered while that attributable to the use of fertilizer is not.	CP, CR, RC and CB	Modular adaptation, mitigation and resilient ongoing or planned investments

Note: CB: change in behavior; COI: cost of illness; CO : Opportunity cost ; CP: change in production; CR: cost of remediation; DR : dose-response ; HA: hedonic approach; CV: Contingent valuation; HCA: human capital approach; RA: risk analysis; RC: replacement cost; VSL: Value of Statistical Life ; and CC : Carbon credits.

Source: Authors.

2.4 Valuation Methods

2.4.1 CHange in Production

2.4.1.1 The Productivity Method

The production function method is one of the most widely used valuation techniques. It focuses on environmental resources as an input to the production of goods and services. It is used to estimate the economic value of ecosystem products or services that contribute to the production of commercially marketed goods. Thus, if a natural resource is a factor of production, then changes in the quantity or quality of the resource will result in changes in production costs, and/or productivity of other inputs. This may affect the price and/or quantity supplied of the final good. It may also affect the economic returns to other inputs such as soil erosion or soil/water salinity that have an impact on productivity.

2.4.1.2 Opportunity Cost

Opportunity cost, which is a key concept in economics (Buchanan, 1987; Crowards, 1998), is the forgone net benefit, because the resource providing the service can no longer be used in its next-most-beneficial use. The opportunity cost approach is a very useful technique when benefits of certain uses, such as preservation, protection of habitats, cultural or historical sites, cannot be directly evaluated.

2.4.1.3 Replacement Cost, Damage Cost Avoided and Substitute Cost Methods

These methods estimate values of ecosystem services based on the costs of avoiding damages due to lost services, the cost of replacing ecosystem services, or the cost of providing substitute services. These methods assume that the costs of avoiding damages or replacing ecosystems or their services provide useful estimates of the value of these ecosystems or services. They also assume that if people incur costs to avoid damages caused by lost ecosystem services, or to replace the services of ecosystems, then those services must be worth at least what people paid to replace them. The damage cost avoided, replacement cost, and substitute cost methods are most appropriately applied in cases where damage avoidance or replacement expenditures have actually been, or will actually be, made.

The damage cost avoided method uses either the value of property protected or the cost of actions taken to avoid damages as a measure of the benefits provided. For example, if a wetland protects adjacent property from flooding, the flood protection benefits may be estimated by the damages avoided if the flooding does not occur or by the expenditures property owners make to protect their property from flooding. The replacement cost method uses the cost of replacing an ecosystem or its services as an estimate of the value of the ecosystem or its services. As for the substitute cost method, it uses the cost of providing substitutes for an ecosystem or its services as an estimate of the value of the ecosystem or its services. For example, the flood protection services of a wetland might be replaced by a retaining wall or levee.

2.4.2 Change in Health

Environmental changes, particularly increased pollution, often result in adverse impacts on human health, which can be translated into monetary values. In estimating monetary values of changes in human health associated with environmental changes, two links need to be established: the first link is between environmental change and change in health status. This involves measuring health impacts and establishing dose-response relations and calculating the burden of disease (BoD) through disability adjusted life years (DALYs). The second link is between the change in health status and its monetary equivalent, which involves establishing willingness to pay values.

There are 4 key indicators that are used in the CAWRD: prevalence, incidence and crude birth and crude death rates (Box 1).

Box 1: Selected Health Indicator Definition

-The prevalence rate is the total number of cases of a disease existing in a population divided by the total population.

-The incidence rate is the number of new cases of a disease divided by the number of persons at risk for the disease.

-The crude birth rate is the number of live births occurring among the population of a given geographical area during a given year, per 1,000 mid-year total population of the given geographical area during the same year.

-The crude death rate is the number of deaths occurring among the population of a given geographical area during a given year, per 1,000 mid-year total population of the given geographical area during the same year.

2.4.2.1 The DALY

Impacts on health from environmental degradation are expressed as the disability-adjusted life year (DALYs). This is a methodology that has been developed in 1993 and applied by WHO and the World Bank in collaboration with international experts to provide a common measure of disease burden for various illnesses and premature mortality.[6] Illnesses are weighted by severity and time (disease length) so that a relatively mild illness or disability that take a relatively short time to heel represents a small fraction of a DALY lost, while a severe illness and a larger time to heal represents a larger fraction of a DALY lost. One lost year of healthy life represents one DALY lost, and future years lost are discounted at a fixed reference rate of 3 percent and includes the age weights whereby a year of healthy life lived at younger and older ages was weighted lower than the other ages. DALY combines in one measure the time lived with disability and the time lost due to premature mortality:

DALY = YLL + YLD

Where:

YLL = years of life lost due to premature mortality

YLD = years of life lost due to disability

The YLLs are the mortality component of the DALYs, and are proportional to the number of deaths and the average age of death:

YLL = Number of Deaths * Life expectancy at age of death

The YLDs are the morbidity component of the DALYs, and are proportional to the number of incident cases and the severity of the disease:

YLD = Number of Cases * Disease Duration * Disability Weight

[6] See Murray and Lopez (1996) for a more detailed explanation of the DALY metric.

The Disability Weights are a crucial component of the DALY calculation, as they enable the direct comparison of morbidity and mortality. The Disability Weight of a disease category or health outcome reflects its severity, on a scale from zero (perfect health) to one (worst possible health state). The higher the disease severity is, the higher the reduction in healthy life is for people suffering from the disease.

Social weighting

The basic formulas for YLDs, YLLs and DALYs may be extended by applying so-called social weighting functions. Unlike the basic formulas, the application of social weighting implies that not all life years lost are valued equally. Social weighting is therefore not accepted by all authors.

Age weighting

The initial Global Burden of Disease study, and many ensuing studies, applied non-uniform age weights, implying that the value of life depends on age. A higher weight is given to the healthy life years lived between the age of 9 and 54, as this period of life is considered to be socially more important than the younger and older life spans (Murray, 1994).

The standard age weighting formula is as follows:

Weight = 0.1658 * age * $e^{\wedge(-0.04 * age)}$

Time discounting

Time discounting discounts the years of healthy life lived in the future, at a rate of (usually) 3%. The incorporation of a time discount rate reflects similar practices in economic assessments, and would prevent policy makers from saving resources for a possible future eradication program, instead of investing in currently available, but less effective, intervention measures (the so-called "disease eradication and research paradox"; Murray, 1994).

The standard time discounting formula is as follows:

Weight = $e^{\wedge(-0.03 * [age - a])}$

Where a is the age at onset or death.

2.4.2.2 The Human Capital Approach (HCA)

The HCA considers individuals as units of human capital that produce goods and services for society. It values human life and time spent ill or recovering using forgone earnings. As such, it measures loss of productivity resulting from an individual’s death (Work Loss Days-WLD) and injury (Restricted Activity Days-RAD)

HCA = (# of Life Years Lost due to premature death or due to illness) × (Average Wage Rate)

2.4.2.3 The Value of Life Lost (VOLL)

To derive the value of life lost life (also known as the value of statistical life), which is the valuation of the reduction of risk from dying from a premature death, the hedonic pricing method (HPM) is used. It involves the valuation of incremental morbidity or mortality by identifying wage differentials due to risk differences. It is based on the theory that workers have to be paid a premium to undertake jobs that are inherently risky, which can be used to estimate the implicit value individuals place on sickness or premature death. It assumes that there is a fixed supply of jobs and a freely functioning job market where individuals choose jobs based on perfect information and with no mobility restrictions. The value of life lost in the US, estimated using the hedonic pricing method is US$ 6.9 million as used by the EPA.7 Usually, a benefit transfer is performed to use the figure in developing countries (see benefit transfer below).

2.4.2.4 Cost of Illness (COI) Approach

The cost of illness approach involves measuring two types of costs: (1) the direct costs or the costs of medication, hospitalization, and doctors' visits; and (2) the indirect costs or the forgone labor earnings due to days spent in bed, days missed from work, and days when activity was restricted due to illness. The latter are calculated following the HCA approach mentioned earlier.

The COI approach is considered a useful economic tool as it indicates the direction and magnitude of the economic flows resulting from health shocks to the economy. It is easily understood and often readily available being based on available market and expenditure data. However, COI provides an estimate of an individual welfare loss. Direct expenditures do not correspond to a drop in income or consumption for the economy as a whole, but constitute a redirection of economic activity, with some sectors benefiting from increased activity. Furthermore, COI does not provide a direct measure of disease severity. Direct medical expenditures are influenced by income distribution, whereby increased income is accompanied with increased consumption of health care. Thus direct medical expenditures reflect the ability of current medical techniques to treat the disease under consideration. Also, pain and suffering could be valued. A current approach is to apply the average Gross disposable income per year for each DALY lost.

2.4.3 Change in BEHAVIOR

2.4.3.1 Hedonic Pricing Method

The Hedonic Pricing Method (HPM) is used to estimate the value or price of an environmental feature by looking at actual markets where the attributes are traded. It is most commonly applied in relation to the public's willingness to pay for housing/property and in labor markets for health economic valuation.

The HPM is based on the assumption that people value the characteristics of a good, or the services it provides, rather than the good itself. Thus, prices will reflect the value of a set of characteristics, including environmental characteristics that people consider important when purchasing the good. For example, the price of a car reflects the characteristics of that car, in terms of transportation, comfort, style, luxury, fuel economy, etc. One can value the individual characteristics of a car or other good by looking at the different price people are willing to pay for the changes in characteristics.

The HPM assumes that the price of a product is a function of its characteristics; the range of product choices is continuous; the choice is based on perfect information and with no mobility restrictions; and the amount of a particular characteristic can be varied independently. The hedonic method is mostly used to determine the valuation of the land around a landfill.

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[7] USEPA website: <www.epa.gov>.

2.4.3.2 Travel Cost Method (TCM)

The travel cost method (TCM) is useful in planning for the provision and management of outdoor recreation, such as changes in access costs for a recreational site, elimination of an existing recreational site, addition of a new recreational site, and changes in environmental quality at a recreational site.

The travel cost method is based on the premises that the cost an individual incurs in visiting a site reflects his valuation to the site, and that individuals will react to an increase in entry fees the same way as they would react to an increase in travel cost. That is, at some high level of entry fee or travel cost, no one would visit the site. By asking visitors questions relating to where they had travelled from and the costs they had incurred, and relating this information to the number of visits they make per year, a trip function can be generated for the recreational site under question. An aggregate demand curve is then derived for visits to the sites per year. The demand curve shows how many visits people would make at various travel cost prices and is thus used to estimate the willingness to pay for people to visit the site. The curve is downward sloping, where the travel cost is inversely related to the number of visits. That is, people who live farther from the site will visit it less often, because it costs more in terms of actual travel costs and time to reach the site. Other factors that might affect the number of visitors to the site include a visitor's income, the availability of alternative sites or substitutes, and factors like personal interest in the type of site, or level of recreational experience, etc.

2.4.3.3 The Averting Behavior Method

Actions are taken to reduce or avoid the consequences and costs of environmental damage. The costs incurred due to these actions are considered equivalent to the costs of environmental degradation. Averting behaviors may include, drinking bottled water or purchasing water filters due to polluted water, frequent painting of dwellings due to smoke emissions from a nearby factory, moving away from a polluted location, installing air purifiers, staying indoors, installing soundproof walling to reduce noise, etc. In many cases, several types of aversive expenditures are undertaken simultaneously. For example, possible action in response to a noisy road may include installing double glazing and moving to another area. Thus the total benefits are estimated by summing up all expenditures.

2.4.3.4 The Contingent Valuation Method

The Contingent Valuation Method (CVM) is the most widely used method for estimating non-use values. It is called "contingent" valuation, because it is contingent on simulating a hypothetical market for the good in question. It involves directly asking individuals how much they would be willing to pay (WTP) to preserve or use a given good or service or the amount of compensation they would be willing to accept (WTA) to forgo specific environmental services. The CVM can be used to estimate economic values for all kinds of ecosystem and environmental services, for both use and non use values. The CVM has been applied to estimate the values of landscape, recreation, beaches, water quality, nature conservation, endangered species, visibility and air quality, etc. Yet, the CVM is the most controversial of the non-market valuation methods, whereby many economists, psychologists and sociologists, for many different reasons, do not believe that the dollar estimates that result from CV are valid. In addition, many jurists and policy-makers will not accept the results of CV. However, studies have shown that a carefully composed and tested study can produce answers of value.

2.4.3.5 Choice Modeling

Choice experiments are used to examine the response of the individual to changes in the attributes of the scenario as well as the scenario as a whole. They allow breaking down the relevant attributes of the situation and determining preferences over attributes and they allow for more flexibility than CVM. Choice experiments attempt to identify the utility the individuals have for the attributes of the goods and services by examining the tradeoffs that they make between them when making choice decisions.

2.4.4 Benefit Transfer

The benefit transfer method involves transferring values that have been estimated for a similar good or service from another location/context to the current location/context. It represents a useful method under budget and time constraints. There are two main approaches to benefit transfer:

1. Unit Value Transfer
   a) Simple unit value transfer
   b) Unit value transfer with adjustment for income differences
2. Function Transfer
   a) Benefit function transfer
   b) Meta Analysis

Approach 1. The unit value at the study site is assumed to be representative for the policy site; either without (a) or with (b) adjustment for differences in income levels between the two sites (using GDP per capita) and/or differences in the costs of living (using Purchase Power Parity (PPP) indices).

Approach 2. A benefit function is estimated at the study site and transferred to the policy site (a), or a benefit function is estimated from several study sites using meta-analysis (b).

Although the function transfer are more robust, the most commonly used method is the Unit value transfer with adjustment for income differences. The transfer of the unit to adjust for differences in income value is as follows:

$$VAPp = VAPs \times (Yp / Ys)^{ß}$$

Where :

VAPp = willingness to pay by household in policy country

VAPs = willingness to pay by household in study country

Yp = income in the country policy denominated in purchasing power parity dollar (PPP$)
Ys = income in the country of study denominated in purchasing power parity dollar (PPP$)
ß = income elasticity for different environmental goods and services are typically smaller than 1, and often range between 0.4 - 0.7.

2.4.5 Remediation COST

2.4.5.1 Cost Benefit Analysis

Cost benefit analysis (CBA) is one of the most widely used techniques to assess policies, programs and projects.

Economics can help weigh up the costs and benefits (CBA) or only cost (Cost-effectiveness), determine the profitability of a policy, program and project and help inform decision-making at the policy, program and project levels. The analysis is usually weighed against these indicators:

The Net Present Value (NPV) which is the difference between the discounted total benefits and cost;

The Internal Rate of Return (IRR), which is the discount rate that zeroes out the NPV or, the interest rate that makes the NPV of all cash flows equal to zero; and

The Benefit-Cost Ratio, which is the ratio of the present value (PV) of benefits over the PV of costs over the lifetime of the project.

Given a stream of benefits (B_0, B_1…B_n) and a stream of costs (C_0, C_1…C_n), the Net Present Value (NPV) is calculated using the following equation:

$$NPV = B_0 - C_0 + \frac{B_1 - C_1}{1+r} + \frac{B_2 - C_2}{(1+r)^2} + \ldots \frac{B_n - C_n}{(1+r)^n} = \sum_{t=0}^{n} \frac{B_n - C_n}{(1+r)^n}$$

where r = discount rate

The discount rate reflects society's preferences between present and future consumption. A high discount rate implies that society has a stronger preference for present consumption over future consumption, while a low discount rate implies that society has a stronger preference for future consumption over present consumption.

Project performance criteria include the following, NPV, PV benefit-cost ratio (BCR), and internal rate of return (IRR). The BCR is the ratio of the present value of project benefits to the present value of the project costs. It is calculated as follows:

$$BCR = \frac{B_0 + \frac{B_1}{1+r} + \frac{B_2}{(1+r)^2} + \ldots \frac{B_n}{(1+r)^n}}{C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots \frac{C_n}{(1+r)^n}} = \frac{\sum_{t=0}^{n} B_n/(1+r)^n}{\sum_{t=0}^{n} C_n/(1+r)^n}$$

The payback period is defined as the number of years required for a project to recover its costs. In general, it discriminates against projects with high capital expenditures and long-term benefits. It is not recommended as a measure of project worth.

The IRR is the discount rate at which the present value of project benefits equals the present value of project costs. It represents the maximum interest rate at which a project could recover the investment and operating cost and still break even. It is difficult to calculate and may not exist or may not be unique. A trial and error method must be used. The IRR can be found by finding the discount rate at which the following equation holds:

$$B_0 - C_0 + \frac{B_1 - C_1}{1+i} + \frac{B_2 - C_2}{(1+i)^2} + \ldots \frac{B_n - C_n}{(1+i)^n} = 0$$

The rule is to accept a project when NPV ≥ 0, BCR ≥ 1, and IRR > the social opportunity cost of capital. The NPV is the most preferred criterion because it provides an estimate of the size of the Pareto improvement. If two or more projects have NPVs > 0, then IRR can be used to rank them.

2.4.5.2 Discount Rate

How and why are discount rates chosen?

The real rate of interest is the appropriate discount rate for benefit cost analysis. Market interest rates should be used for discounting because they reflect the rate at which those in the economy are willing to trade present for future consumption. Market rates reflect social preferences. Nominal market interest rates are equal to the sum of the real rate of interest (i.e., the rate of return on capital), inflationary expectations and country risk. Most variations in nominal rates are due to changes in inflationary expectations since the rate of return on capital (e.g., factories, equipment) is fairly stable over time. The real rate of interest is equal to the market interest rate minus inflationary expectations and minus country risk.

The choice of a discount rate is often controversial. Environmentalists argue against high discount rates, which they believe are associated with environmental degradation. Economists tended to use long-term interest rates on government bonds as a measure of opportunity cost of capital.

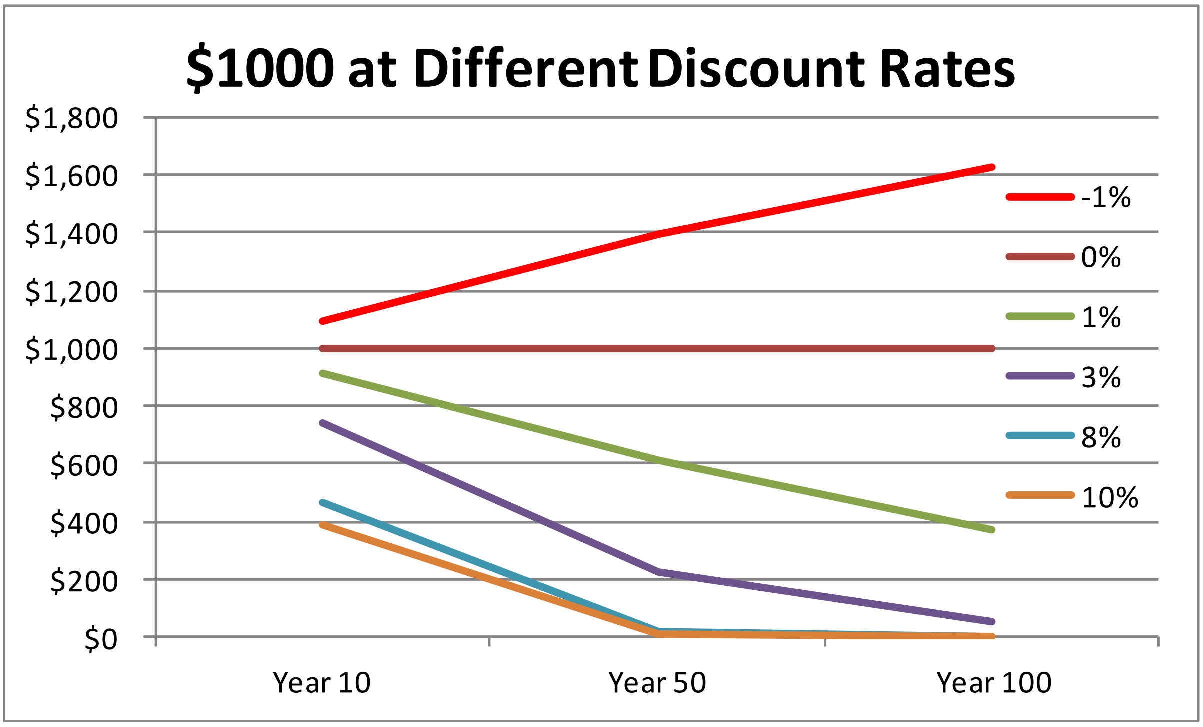
How a discount rate looks in the future?

Table 4: What is the value of $1,000 in the Future with different Discount Rates

Discount rate	Years in the Future		
	Year 10	Year 50	Year 100
-1%	$1,090	$1,392	$1,630
0%	$1,000	$1,000	$1,000
1%	$910	$608	$370
3%	$744	$228	$52
8%	$463	$21	$0.45
10%	$386	$9	$0.07

Source: adapted from Harrison, Mark. 2010. Valuing the Future Social Discount Rate in Cost-Benefit Analysis. Government of Australia.

Figure 9: What is the value of $1,000 in the Future with different Discount Rates?



Source: adapted from Harrison, Mark. 2010. Valuing the Future Social Discount Rate in Cost-Benefit Analysis. Government of Australia.

Table 4 and Figure 9 illustrate the higher the discount rate, the smaller the present value of future costs and benefits. The further in the payments are received, the greater the effect of the discount rate. A high discount rate favors projects with benefits that accrue early. Hence, for US$ 1,000, different discount rates provide a different picture.

Most discount rates used for climate change analysis are near zero as environment goods and services so which discount rate to use? Table 5 provides the discount rates used by development institutions and developed countries for development projects.

While financial analysis often considers only market costs and revenues, a full benefit cost analysis (BCA) includes two additional and very important aspects:

1. The valuation of environmental benefits. This allows the non-financial benefits of improved environmental quality, such as health and recreation, to be taken into account.

2. The *consideration of costs to society as opposed to costs to private individuals. A typical case* is that of subsidies. For example, the cost of fertilizers to the farmer may be less than the cost to society if there are subsidies.

The valuation of benefits (reduced CAWRD over a year) was used to derive the cost of remediation that are calculated for selected priority sub-categories. After determining the alternative remediation cost, the most suitable cost is selected and used in a CBA to determine the profitability of the project.

Table 5: Discount Rates Used by Development Institutions and Developed Countries

Country	Agency	Discount rate (per cent)
Philippines		15[a]
India		12[a]
Pakistan		12[a]
International Multi-lateral Development Banks	World Bank	10–12[a]
	Asia Development Bank	10–12[a]
	Inter-American Development Bank	12[a]
	European Bank for Reconstruction and Development	10[a]
	African Development Bank	10–12[a]
New Zealand	Treasury and Finance Ministry	8[g]. From 1982 to 2008 it was 10[abf]
Canada	Treasury Board	8[c]. From 1976-2007 was 10 (and test 8–12 per cent)[ab]
China (People's Republic)		8[a]
South Africa		8 (and test 3 and 12 per cent)[d]
United States	Office of Management and Budget	7 (and test 3 per cent). Used 10 per cent until 1992.[a]
European Union	European Commission	5 From 2001–2006 was 6 per cent[a]
Italy	Central Guidance to Regional Authorities	5[a]
The Netherlands	Ministry of Finance	4 (risk free rate).e
France	Commissariat General du Plan	4. From 1985-2005 used 8 per cent[ab]
United Kingdom	HM Treasury	3.5 (declining to 1 per cent for costs and benefits received more than 300 years in the future) from 2003.[a] From 1969–78 used 10 per cent[a]
Norway		3.5. From 1978–98 used 7 per cent[ab]
Germany	Federal Finance Ministry	3. From 1999–2004 used 4 per cent[ab]
United States	Environmental Protection Agency	2–3 (and test 7 per cent)[a]

Source: Harrison, Mark. 2010. Valuing the Future Social Discount Rate in Cost-Benefit Analysis. Government of Australia.

3 IN PRACTICE

3.1 MANN RIVER CASE STUDY

3.1.1 Background

N.B. Please use the Excel file associated with the Case Study in order to perform the calculations.

The Mann River is one of the most important rivers with 1 freshwater lake in the Republic of Marry. The Mann River watershed is the primary source of drinking water towns as well as villages. Lake Mar is an artificial water body that was constituted after the building of the multipurpose Dam (electricity and irrigation) in 1960. Pollution from various untreated industrial and municipal effluents and agricultural runoffs threaten the Mann River and affect the water quality of the Mar Lake, its fish and ecological services. Moreover, the solid waste is poorly managed with dumps located on the banks of the River where it is either burnt or washed out into the River especially during the rainy season. The pollution of Lake is for instance where the desire for economic development took precedence over the preservation of nature. Authorities now must weigh the environmental pressure on the watershed area and its population and determine where, what and how much needs to be done to reduce the level of pollution to an acceptable level.

3.1.2 Description

Towns are mainly agro-industrial centers that are surrounded by a vast fertile plain rich where all sorts of vegetables and fruits are cultivated. All towns are releasing their wastewater mostly untreated in the watershed. Villages rely on septic tanks. With climate change effects in the future, the frequency and intensity of rainfall has already shown the under capacity of the Lake to store the excess water in rainy years. This has led the authorities to release the excess water hence losing some economic opportunities in terms of generating more electricity and/or using the water for summer irrigation.

Mann River and Lake Mar Pollution

Excessive fertilization, and livestock and industrial waste have polluted Mann River and Lake Mar. According to unverifiable sources, pollutant load in Lake Mar comes from domestic (municipal) wastewater (58 million m^3/year), industrial wastewater (4 million m^3/year), and agricultural runoff (not available). Industries in the major towns include agro-business (dairy, olive oil, livestock, poultry, fruit and vegetable processing) as well as manufacturing of plastics, synthetic rubber, detergents and cosmetics, non metallic mineral products such as paper mills manufacturing dyeing and tanning as well as manufacturing of batteries; most of these industries are marked by high water consumption and emission of materials damaging to the environment. Most livestock facilities in the region are not equipped with water treatment facilities.

With each day of inaction, the potential for ecological degradation worsens in the Lake Mar and River Mann. The pollution of the Mann River and the Lake Mar presents numerous negative effects on the watershed environment. First, the Mann River and the Lake Mar pollution fundamentally threaten the drinking water supply for the residents of the 5 towns and other villages in the region. Second, the Lake Mar pollution has led to the ban of fishing due to the fish contamination. The agricultural runoff in particular causes anthropogenic eutrophication, in which excess nutrients (from organic waste products) cause an overgrowth of red algae which in turn decrease the amount of oxygen in the water in the irrigation canals. Third, the pollution of the Mann River and the Lake Mar is threatening tourism (recreational Lake) and mainly the restaurant industry as this region is famous for its mild weather during summertime and food variety.

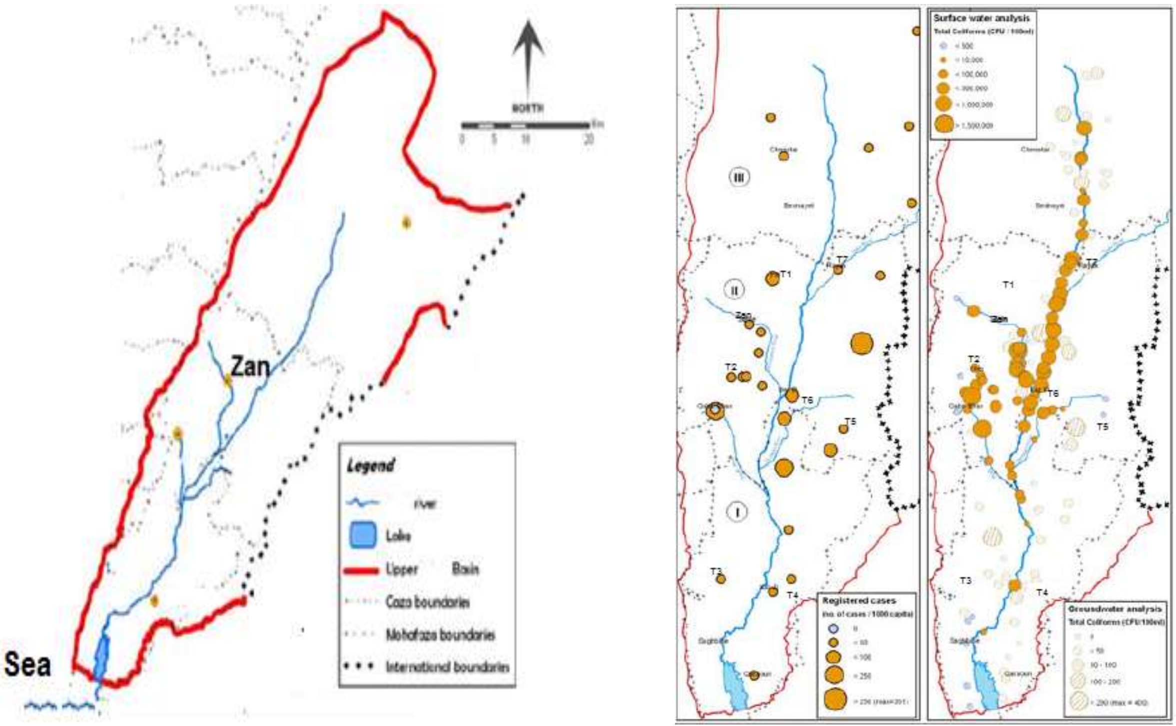
Untreated wastewater is a major cause of diseases such as diarrhea. However, it is difficult to link modern diseases (e.g., cancer) to the quality of water.

The Central Government is responsible for infrastructure investments that are being realized with poor sequencing and coordination. The Water Utilities lack the capacity and means to improve the service. The autonomous agency responsible for the Mann River and the Lake Mar has the authority to manage irrigation water distribution the hydropower production but has no authorities over polluters whereas the Ministry of Environment lacks the means to enforce pollution standards. Municipalities are struggling to balance their meager budget and can barely afford any investment in infrastructure.

Due to poor municipal and utility services, a public sector laissez-faire attitude has led to self-reliance that has gained grounds among communities. Shortages in water are affecting communities as well as the agricultural and the industrial sector alike. The irregularity of water supply is due to poor service, an old and below capacity infrastructure. The shortage of water led to the increase of actors relying on several sources of water: wells leading to the drawdown of the water table, trucks and containers/bottles mainly for water. Moreover, the poor municipal management service when it comes to disposal is pushing municipalities and/or communities to burn the wastes released on the banks of the Mann River. Uncontrolled fertilization is increasing soil salinity that in turn is reducing yields.

From the case described above, the Mann watershed has degradation that is reflected in terms of water related health effects; water quality issues and water quantity issues. The *Main Characteristics of the Mann Basin* are illustrated in Figure 10

Figure 10: Mapping Pollution and Water-related Diseases in the Mann Basin



Canal Algae Concentration **Water Quality** **Impact on Wetland**



The high demand for freshwater has led to the tapping of non-renewable coastal aquifer next to the Mann basin. Although the aquifer is not part of the basin, water extraction is supplemented by desalinated water for municipal use and coastal irrigation. The groundwater (which is mainly a fossil source is becoming increasingly saline and is currently around 1,200-5,000 mg/l of total dissolved solids (TDS) for the aquifer. Nevertheless it is considered a strategic resource in case one or more desalinization facilities fail or the sea water on which they depend is polluted.

There is some concern about the impacts of the desalinization plants on the marine environment, due to thermal discharges as well as discharges of brine. There is unfortunately no quantitative information although there are several studies that indicate some impacts occur. Hence a monetary value of damages will not be possible.

3.1.3 Dataset

The socioeconomic dataset used in the analysis considers the 2012 population and indicators are illustrated in Table 6.

Table 6: Socioeconomic Dataset for the Mann Basin, 2012

Input	Unit	Total
Total Population	#	2,085,810
Urban Population	#	479,736
Rural Population	#	1,606,074
Avg. Household size urban	#	5.0
Avg. Household size rural		6.0
Improved Water	% pop	94%
Bottled Water	% pop	95%
Wastewater Improved	% pop	87%
Waste	t/day	1,277
Dumpsite	#	37

The total population exceeds two million while only 23% is urban and 77% is rural, which suggests that 27%. Improved water and sanitation are 94% and 87% respectively. Also, 37 dumpsites are active or passive.

3.1.4 Quantification and Valuation

The major sources of pollution in the Basin are:

- Municipal waste water
- Industrial waste water
- Municipal and industrial waste
- Agriculture run-offs
- Solid waste.

The major effects of pollution in the Basin are associated with:

- Water-related health issues
- Water quality;
- Water quantity; and
- Solid waste.

The major effects of the degradation to the coastal none renewable fossil aquifer next to the Mann basin is due to:

- Excess irrigation and municipal pumping depletion of this strategic source of water.

The Terms of Reference of the consultants include:

Water-Related Health Issues

Application of the Change in Health concepts: HCA, VOLL, DALY and COI

Health problems related to water: 138 cases or incidence of mortality of children under 5 years due to diarrhea, 30,225 cases or incidence of diarrhea in the age group under 5 years 7.2 million cases of serious diarrhea for ages 5 and older individuals.

Calculate the value associated with the mortality of children under 5 years due to diarrhea using:
-The DALY metric to determine the burden of disease due to premature mortality among children less than 5 years (Excel Diarrhea DALY) considering an equal number of boys and girls.

-The human capital approach (see Excel file to calculate the HCA income) for the lower bound. The approach of the value of life lost (Excel VOLL) for the upper bound.

-The DALY metric to determine the burden of disease due to premature morbidity in children under 5 years (Excel Diarrhea DALY) considering an equal number of boys and girls.

The approach of cost of illness (Excel COI1 and Excel COI2) for diarrhea for <5 years (estimated at US$ 45 per case) and> = 5 years estimated at US$ 20 per case (Excel Diarrhea Alternative).

Knowing that the reduced risk of diarrhea can be reduced by improving 100% coverage of safe drinking water, sanitation and hygiene, consider the table below to suggest the technique used. The benefits generated in 2013 are calculated in (Excel Diarrhea).

Table 7. Diarrheal morbidity and mortality reduction with improved services

Current water supply and sanitation Coverage in Studied Country	%	Improved Water and Sanitation Definition	Benchmark Expected average reduction in diarrheal disease and mortality	
			Already good hygiene	Substantial scope for hygiene improvement
Piped water supply and sewage connection	**56%**	Improvement in reliability and quality of piped water (so as to ensure plentiful and safe water supply) for those of this population currently having water reliability and quality problems	15%	45%
Piped water supply but no sewage connection	**21%**	a) Improvement in reliability and quality of piped water (so as to ensure plentiful and safe water supply) for those of this population currently having water reliability and quality problems. b) Sewage connection for all of this population.	**35%**	**65%**
Not piped water supply but sewage connection	1%	Reliable and safe piped water supply to premises for all of this population	25%	55%
Not piped water supply and no sewage connection	**22%**	Reliable and safe piped water supply and sewage connection for all of this population	**45%**	**75%**
Total	**100%**		**28%**	**60%**

Source: cited in Arif and Doumani (2013).

Drinking Water Quality

Considering 95% of households (see Table 1) uses bottled water due to the lack of confidence in the water quality of the service, calculate the consumer surplus should the water quality is improved leading to 80% of households to rely exclusively on the water network for potable water while the remaining 10% of households maintain the use of bottled water (Excel Potable Water).

Quality of Surface Water

The Government intends to reduce pollution from municipal and industrial effluents and landfills affecting water resources of the basin. In the absence of engineering studies in order to reduce each source of pollution, which valuation method would you use to put an approximate cost on the cost of degradation of the water? Answer and check Excel Water Resources.

Uncontrolled irrigation has led to less productive soils due to salinity. What is the method used to calculate the cost of degradation?

Estimating an initial production of 366,667 tons per year and a reduction in tomato production by 10% due to 3.5 deciSiemens/meter salinity. What is the method used? calculate the cost of degradation (Excel Saline Water).

Water Quantity

- Leakage of 26% in water supply networks: The lost volumes amount to 19.4 million of m^3 The cost per m^3 is below operations and maintenance cost and is US$ 0.3. What is the method to be used if we reduced the leakage from 26% to 10%? Calculated the CAWRD by mentioning the cost to be used (Excel UfW).

- Lowering of the water table: The overexploitation of groundwater leads to a drawdown of 0.4 m per year (Excel Drawdown). The cost of diesel per m^3 pumping is given. What is the recommended method? Is this practice sustainable in the future? If not, what should be done?

- Dam Siltation: Calculate the cost of degradation in 2012 due to sedimentation of 10.8 Million m^3 (Excel Sedimentation) where the original basin volume of 600 million of m^3. What is the techniques used?

- Erosion is a growing issue in the basin. What method do you recommend using and what is the CAWRD with a loss of 14.5 tons/ha (Excel Erosion).

Fossil Aquifer Replenishment

In the coastal aquifer next to the Mann basin, there is an increasing deficit attributable to municipal and irrigation water that could come from either the potential tertiary treatment (0.5 million m^3), planned tertiary treatment (1.7 million m^3) and additional desalination to compensate for the annual municipal and irrigation needs that amounts to 2.3 million m^3. For 2012, the volume of depleted water for the coastal fossil aquifer that needs to be substituted is the municipal and irrigation use of 2.3 million m^3. One proposed measure to address the depletion of the non-renewable coastal groundwater source and preventing it becoming more saline is to artificially recharge it with treated effluents produced by tertiary treatment (0.5 million m^3) employing reverse osmosis (RO). Such water is normally considered to be of drinking water quality but there is an aversion to using it for that purpose. The gap of 1.7 million m^3 should be compensated by recharging the aquifer with desalinated water where the balance between RO and desalination could be adjusted in the future pending the increase in reuse availability. If the 2.3 million m^3 volume could be used to recharge the aquifer the latter could become a sustainable reserve resource and salinity could also be reduced as agriculture production will probably be reduced to a bare minimum in the future.

The approximate cost of tertiary treatment and desalination is US$ 0.74/m^3 and US$ 0.83/m^3 respectively. Yet, these are no alternative but to reduce the tremendous water resources Marry's Coastal zone is consuming through a number of new policies, however, the RO and desalination cost are used as an alternative cost to recharge and balance the annual outflow for domestic and irrigation purposes. What is the technique used? Calculate the cost of the fossil resource (Excel Fossil Resource).

Solid Waste

Categories of household waste is broken down as follows:

Recyclable and Compostable Waste	Metal	Glass	Paper/ Cardboard	Plastic	Certified Compost
Percentage of total waste generated	5.00%	3.00%	10.00%	10.00%	15.00%

Note: plug in the percentages in the Excel sheet.

What valuation method do you recommend and is the cost of degradation using the market cost of recyclable and compostable materials (Excel Recyc)?

The price of land around the landfill is depreciated. Which method you suggest to calculate the depreciation corresponding to the degradation associated with 37 dumps with an area of 0.5 ha each (Excel Waste).

Remedial Investments

Use the composted and recycled material opportunity loss starting year 2 over a 24 year as yearly constant investments where the investment cost are given in (Excel Waste Invest). Is the project viable? Why?

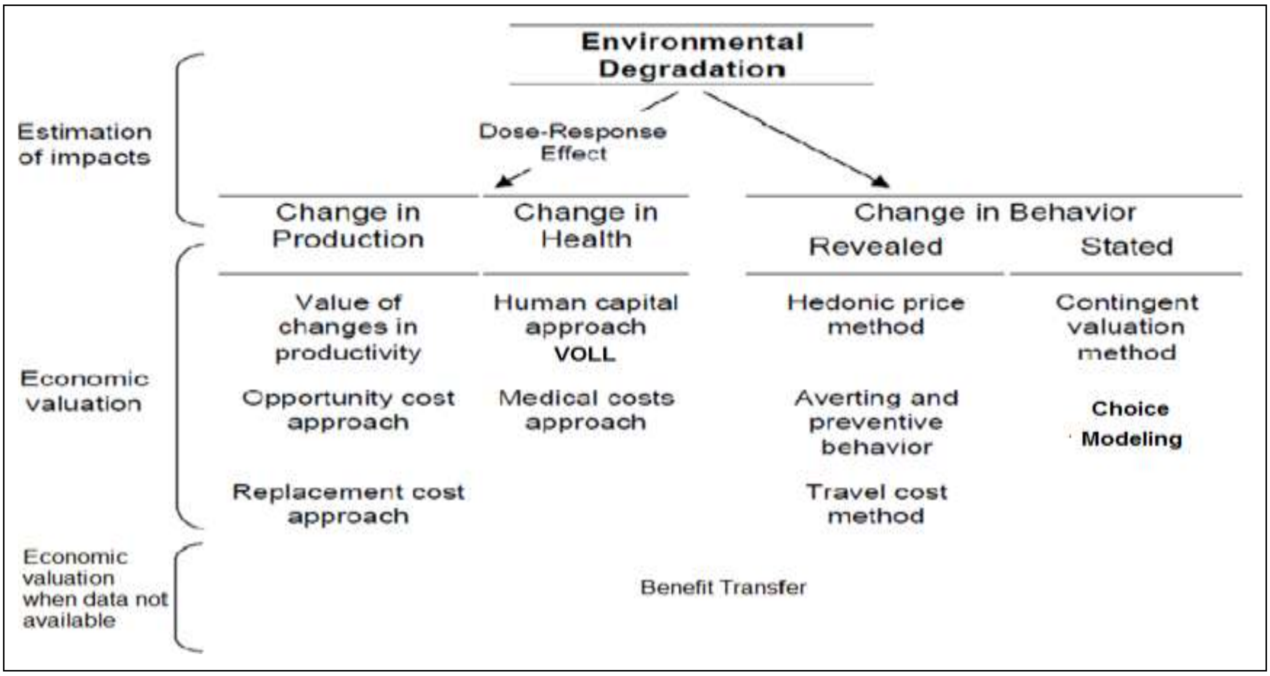
See Aggregated results in table and graph (Excel Aggregate Results).

Use the Figure of environmental assessment techniques to enumerate the necessary techniques for the assessment of damages in the case study.

The main methods for estimating impacts are grouped within three pillars with specific techniques under each pillar (Figure 11):

- Change in production.
    - Value of changes in productivity such as reduced agricultural productivity due to salinity and / or loss of nutrients in the soil;
    - Approach the opportunity cost of such shortfall of not re-selling the recycled waste;
    - Approach replacement cost when for example the cost of construction of a dam to be replaced by a dam that was silted.
- Change in condition with the dose-response function to establish between pollutant (inhalation, ingestion, absorption or exposure) and disease.
    - The value associated with mortality through two methods: the future shortfall due to premature death, and the willingness to pay to reduce the risk of premature death. Only the latter method is used in this study.
    - The approach to medical costs such as the costs when a child under 5 years is taken to the hospital to be cured of diarrhea.
- Changing behavior with two sub-techniques: revealed preferences, and stated preferences.
    - Revealed preferences by deriving the costs associated with behavior: e.g., hedonic method where for instance the lower value of land around a landfill is derived; trying to derive travel costs to visit a specific place like Lake Titicaca; and preventive behavior as when a household buys a filter for drinking water.
    - Stated preference where a contingent valuation is used to derive willingness to pay through a survey for example, improve the quality of water resources.
    - Choice modeling where respondents are asked to choose their preferred option from a set of alternatives with particular attributes (a variation on the WTP without a monetary value). Other forms also exist such as choice experiments.

Figure 11: Estimation of Impacts and Associated Economic Valuation Techniques



Source : Adapted from Bolt et al. (2005).

3.1.5 Priority Setting and Choices: Decision-maker and community debate

Third day group debate (see Agenda in Annex I).

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5 ANNEX I: WORKSHOP EVALUATION, TEST, AGENDA AND PARTICIPANT LIST

5.1 Workshop Evaluation

At the end of the workshop, participants completed an evaluation form to express their opinion about the efficiency and effectiveness of the organization of the workshop. The responses were then analyzed to draw lessons and recommendations for future activities. Below is a summary of the results of the evaluation. Of the 18 participants who attended the workshop, 16 or 89% completed the evaluation form. The Egyptian participants did not come because the authorities were late in selecting the participants who in turn did not obtain their visa on time.

Regarding organizational issues before and during the workshop

As shown in the Table 8 below, a set of eight criteria; A1 - A8 were evaluated by participants, using a grading scale from "Outstanding" to "Very Poor."

Table 8: Criteria List A1-A8

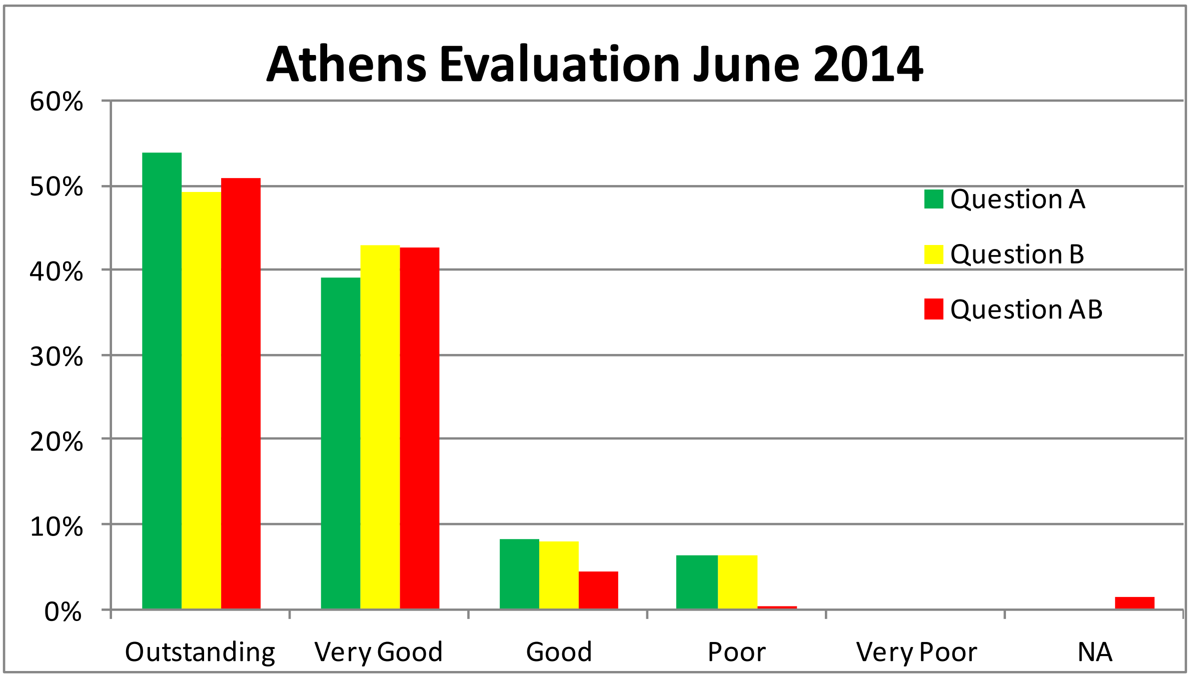
A1	Good management of invitations, Support to obtain Visa, dissemination of information and management of difficulties
A2	Smooth running of the program, effective management of emerging needs and help participants
A3	Logistics efficiency: Accommodation, Transport, Materials and Equipment
A4	Effective Communication Goals and Expectations of Participants
A5	Effective monitoring of preparations and progress towards achieving the Event
A6	Clarity, coverage and adequacy of concepts, objectives, outputs and outcomes
A7	Procedural issues: Selection and Design Methodology, Program Agenda and Work Rules
A8	Presentations reflect and contribute to the objectives set and promote understanding and participation to the discussed issues

Table 9: Evaluation Results

Athens Qualitative	Outstanding	Very Good	Good	Poor	Very Poor	NA	Total
QUESTION A1 Preparation Management	11	5					16
QUESTION A2 Program Flow	10	6					16

QUESTION A3 Logistics	12	2	2				16
QUESTION A4 Participants’ Expectations	6	9	1				16
QUESTION A5 Workshop Planning	5	9	1	1			16
QUESTION A6 Expected Results	8	7	1				16
QUESTION A7 Procedure	9	5	2				16
QUESTION A8 Presentations	8	7	1				16
QUESTION B1 Interaction	5	10	1				16
QUESTION B2 Facilitation	7	9					16
QUESTION B3 Team Spirit	8	8					16
QUESTION B4 Achievement of Planned Objectives	10	6					16
QUESTION B5 Coverage of the Workshop							19
QUESTION B6 Level of Difficulty							16
QUESTION B7 Workshop Length							16
QUESTION B8 Qualitative							0
QUESTION B9 Qualitative							0
QUESTION B10 Personal Level	7	6				3	16
Total	106	89	9	1	0	3	208

Figure 12: Evaluation Results



As seen in Table 9 and Figure 12, the chart, 94 percentile ratings were Excellent and Very Good and 4 percentiles were Good. In general, participants were very satisfied for most aspects of the organization, administration as well as the design and content (Table 8 and Figure 12).

Regarding the conduct of the workshop

The same rating scale was used to assess the set of criteria, B1-B10 (see Table 10) related to the conduct of the workshop.

Table 10: Criteria List B1-B10

B1	Performance and effective interaction of participants
B2	Effective facilitation of the workshop
B3	Effective cooperation and teamwork
B4	Satisfactory implementation of the objectives
B5	Event coverage
B6	Level of difficulty
B7	Duration of the workshop: Very long; Very short; and Fair
B8	How this workshop will allow you to use the elements of the subject
B9	Transfer of experience
B10	Overall positive impression on the participant's personal level

Similarly, participants' comments were encouraging, with a majority giving notations Excellent and Very Good with 94 percentile on issues such as interaction and 100 percentile for the quality of facilitation, the team spirit and achievement of planned objectives. The level of coverage got 94 percentile whereas difficulty was perceived to be adequate by 88% of participants and 63% sought that the workshop duration was correct and 37% sought it was too short. Many participants requested further analysis and more time for discussion and showing some interest in the activity and its results (Table 9 and Figure 12).

On personal impressions and recommendations

B8. Assessment duly completed by the participants demonstrate their interest in the subject. According to them, the knowledge acquired during the workshop training will enable them to have a more complete view when it comes to analyzing different situations and especially with regard to the identification of appropriate methods for valuing the cost of degradation of water resources. This training will help them to better monitor economic studies. These assessment concur with the pre-workshop evaluation filled in by the participants that was used for the participant selection process.

Recognizing the important contribution of costing degradation of water resources and improving the quality and quantity of water and reduce waterborne diseases, some participants suggested duplicating the experiments to other basins.

National and regional seminars for the benefit of all stakeholders in the water sector should be organized to popularize this approach. There should also be other workshops that go into more detail studies of domestic cases involving all private organizations and regional institutions.

The majority of participants agreed on the fact that only two and a half days were not sufficient for the water experts unfamiliar with economic concepts assimilate the content of the training. The duration of the training should be extended for the next training sessions and preparing practical guides summarizing economic terms would be of great help which was already included in the main text of the case study report.

B9. Participants who participated in the workshop expressed their intention to transmit and disseminate knowledge on the principles and methodologies of assessing the cost of damage to other colleagues and stakeholders in the water sector in their countries respective. They also expressed the need to raise awareness about the relevance and the need to integrate this approach: future studies of environmental impacts; the terms of reference for the studies; guiding management of water resources plans. They also stressed that the new knowledge will enable national authorities to better inform and guide the selection of certain investments.

Some participants would be involved in the next stages of studies of the cost of degradation of water resources supported by the SWIM program for other watershed in the targeted countries. Academics intend to introduce a module on the valuation of the cost of degradation of water resources in the university curriculum, and even use the case studies in subjects for doctoral students and their own staff at the relevant ministries and agencies.

Representatives of associations and NGOs have proposed to organize information days on the subject and recall whenever the opportunity presents itself the relevance and added value to quantify the benefits in decision making.

B10. Participants were invited to comment on the most popular aspects and recommendations for any improvement in the future. The summary of the results is follows:

Participants appreciated:

-The friendly atmosphere that prevailed during the training and availability of trainers who helped promote exchanges and discussions

-Simplicity of presentations

-The flow of information

-The spirit of sharing information

To improve future training sessions, the participants suggested to:

-Involve private organizations and regional institutions operating in the environmental field in the next training. -Address other topics related to environmental degradation.

-Go deeper into the analysis of case studies in different countries.

In conclusion, with 94% of participants found the workshop Excellent and Very Good, the workshop was a huge success with participants showing great enthusiasm for environmental economic theory and the application of some valuation instruments.

5.2 Workshop Multiple Choice Test

Participants were tested at the beginning and at the end of the workshop on the same 20 questions. A random exchange with the participants on the test revealed that: participants were happy to be tested before and after and thought that it was a very good incentive that led them to be more participative in the sessions. Some participants thought that the test was pretty difficult and reminded them of the times they were still at university. It should also be noted that few participants used their mobile phones to search Goolge to answer certain questions. Based on the feedback from the participants, future tests will need to be simplified and put in layman terms as most participants did not have an economic background.

The participant score increased from 50% to 73% with a +45% improvement. The multiple choice test included questions on the methods, concepts and themes covered during the workshop and especially the case study. The standard deviation was 4.3 for the first test and 3.4 for the second test which means the score was closer to the average for the second test. Difficulties were noted especially with the definition of economic concepts although they were repeatedly explained during the workshop. When sent to the participants, this report will help them get a better command of the economic concepts that were explained during the workshop.

The results could be explained by a number of factors: the participant pre-selection based on the evaluation on how they would put the new knowledge to good use proved instrumental in selecting good dedicated public and private sector as well as NGO participants; the case study groups were divided along countries on talking terms which helped in the learning process and prevented animosities; the case study and the constant presence of the facilitators helped the participants to better understand and apply the concepts; the exchanges among groups during the case studies were very dynamic and participatory; a recap session on all the concepts was organized at the beginning of Day 3; the facilitators decided to change the agenda and divided the participants in groups to resolve the entire case study and not case study categories or sub-categories as earlier planned; the facilitators were flexible and adjusted the case study based on the participant needs as suggested during Day 1.

Overall, the improvement in the test score provides a good feedback on the success of the workshop. However, some improvements and fine tuning need to be made to increase the knowledge transfer. One suggestion coming from a participant was to start with methods and concepts in the morning of Day 1 and leave the SWIM-SM objectives and comparative Basin results till the afternoon. Moreover, tailor made workshop/case studies should be developed to target different audience as some participants wanted more details and others thought it was a bit complicated. Finally, the workshop duration seemed just right but an extension of the workshop to 3 full days could have a higher impact.

5.3 Detailed Workshop Agenda

Day 1

9:00	**Registration**
9:30	Opening: SWIM Focal Point or Minister of Agriculture, and EU Representative
10:00	Overview of the training: Objectives and Content Dr. Sherif Arif, NKE
10:30	**Coffee Break**
11:00	Overview of the Cost Assessment of Water Resources Degradation Dr. Sherif Arif, NKE
11:30	Summary of the results of the CAWD of Oum Er-Rbia (Morocco), Seybousse (Algeria) Medjerda (Tunisia) and Litani (Lebanon) Dr. Sherif Arif, NKE
12:00	Questions and Answers
12:30	Methodology of Cost Assessment of Water Resources Degradation (CAWRD) (Part I) Mr. Fadi Doumani, NKE
13:15	Questions and Answers
13:30	**Lunch**
14:30	Methodology of Cost Assessment of Water Resources Degradation (CAWRD) (Part II) Mr. Fadi Doumani, NKE
15:15	Questions and Answers
15:30	**Coffee break**
15:45	Methodology of Cost Assessment of Water Resources Degradation (CAWRD) (Part III) Mr. Fadi Doumani, NKE
17:00	Questions and Answers

17:30	**Adjourn**

Day 2

8:30	Description of the Case Study: The CAWRD Mann Basin Dr. Sherif Arif, NKE
9:30-11:00	2 Parallel Working Group Sessions for estimating the CAWRD of the Mann Basin Mr. Fadi Doumani and Dr. Sherif Arif, NKEs: Sub-category How to estimate the Health impacts Sub-category How to estimate the impacts on water quality Sub-category How to estimate the impacts on water quantity Sub-category How to estimate the impacts on fossil aquifer Sub-category How to estimate the impacts of waste Remedial Cost
11:00-11:30	**Coffee Break**
11:30-13:00	Working sessions to be continued
13:00-14:00	**Lunch**
14:00-16:00	Working sessions to be continued
16:00-16:30	**Coffee break**
16:30	Presentation of the results of the CAWRD estimated by the 2 working groups Working Group Rapporteurs Mr. Fadi Doumani, NKE
16: 30	**Adjourn**

Day 3

9:00	Overview of the Institutional and Legal Arrangement of the case study Dr. Sherif Arif, NKE To Recap the 2 first days Mr. Fadi Doumani, NKE
9:30	Two Parallel Working groups Group I: Recommendations for Proposed Institutional Arrangements Dr. Sherif Arif, NKE Group II: Recommendations for the Cost Assessment of Water Resources Degradation Mr. Fadi Doumani, NKE
11:00	**Coffee break**

11:30	Presentation of the results of the 2 working groups
	Working group rapporteurs
12:30	Comparison between the findings of the working groups and the recommendations of the reports prepared by the NKEs
	Mr. Fadi Doumani, NKE and Dr. Sherif Arif , NKE
13:30	Questions and Answers
14:00	Conclusions, Evaluation and Handing of Certificates
	Mr. Fadi Doumani, NKE and Dr. Sherif Arif , NKE
14:30	**Lunch**
15:30	**Adjourn**

5.4 List of Participants

Table 11: List of Participants

	Name	Surname	Country	Institution	Position	Email
Mr.	Abdalla	Abu Kishk	Palestine	Wild Life - Palestine	Senior Programs Manager at Welfare Association a broad member of the Wildlife - Palestine	abukishka@jwelfare.org
Mr.	Ahmad	Al-Rusan	Jordan	Ministry of Environment	Director of Outreach directorate	Rusan21@hotmail.com
Dr.	Ibrahim	Alshakhanbeh	Jordan	Ministry of Water and Irrigation	Project Management Engineer, Office of the Secretary-General	Ibrahim_Alshakhanbeh@mwi.gov.jo, Alshakhanbeh@hotmail.com
Dr.	Sherif	Arif	Egypt		SWIM-SM Expert	sherifarif59@yahoo.com
Mr.	Fouad	Ejeilat	Jordan	Jordan Valley Authority	ASG Technical Affairs	fuadeijilat@yahoo.com
Mr.	Mohamad	El Baba	Lebanon	Saida Municipality	Member of the Committee on Environment	baba.m@saida.gov.lb
Ms.	Sara	Elhanany	Israel	Israel Water Authority	Director of the Water Quality Division	sarael10@water.gov.il
Mr.	Doumani	Fadi	Lebanon		SWIM- SM Expert	fdoumani@yahoo.com
Ms.	Antoinette	Ghattas	Lebanon	Ministry of Energy and Water	Head of Ground Water and Geology Service	antoinettega@hotmail.com
Dr.	Or	Goldfarb	Israel	Ministry of Environmental Protection	Chief Economist, Economics &Technology	org@sviva.gov.il
Mr.	Tabet	Hamayel	Palestine	West Bank Water Department	UFW Manager	hamayel_thabet@yahoo.com
Mr.	Munther	Hind	Palestine	Palestinian Wastewater Engineers Group (PWEG)	General Manager, Administration	monther@palweg.org
Mr.	Ali	Jammoul	Lebanon	Development for People and Nature Association	Project Manager, Environmental Department	ali.jammoul@dpna-lb.org, jammoul.ali.h@gmail.com

	Name	Surname	Country	Institution	Position	Email
Mr.	Wisam	Kanj	Lebanon	Ministry of Energy and Water	Head of Irrigation Department, General Directorate of Hydraulic and Electric Resources - Water Directorate	wisamkanj@hotmail.com
Dr.	Nader	Khatib	Palestine	Water and Environmental Development Organisation/ Friends of Earth Middle East	Palestinian Director, Management and Administration	nader@foeme.org
Mr.	Alon Mordechay	Maor	Israel	Ministry of Agriculture and Rural Development	Soil Survey and Land Evaluation, Soil Conservation & Drainage	alonm@moag.gov.il
Mr.	Alon	Messer	Israel	Israel Ministry of Finance	Manager of Water and Agriculture Unit, Budget Department	alonm@mof.gov.il
Ms.	Tala	Moukaddem	Lebanon	Society for Protection of Nature in Lebanon (SPNL)	Project Manager	tala.moukaddem@gmail.com
Dr.	Tala	Qtaishat	Jordan	The University of Jordan, Agriculture College	Assistant Professor, Agricultural Economics and Agribusiness Management Department	talaqtaishat@yahoo.com, t.qtaishat@ju.edu.jo

6 ANNEX II: METHODOLOGY FOR THE COST ASSESSMENT VALUATION

6.1 Water Category and Subcategories

Quality and treatment of drinking water. The treatment of drinking water can occur at two levels: at the drinking water treating station; and at the household level. The CAWRD is calculated by determining the change in production and thus, deriving the additional cost of treatment required at stations (for example, when the effluents discharged into the watershed without treatment) and determining revealed or stated preferences revealed at the household level (e.g., when a household incur additional cost to supplement water sources, buy bottle to ensure water quality, uses a filter, boil water, etc.). For the cost of the remediation, the benefits can be derived from water dilution (production change) when desalinated water is sought to be mixed with water for domestic consumption and other investments that cover all other sub categories in order to reduce the pollution of natural resource.

Quality of drinking and domestic water and sanitation in urban and rural areas as well as irrigation systems. The stated benefit is considered in this case and derived from the replacement costs associated with alternative sources of domestic water (bottles, wells, tanks, etc.). Or production costs associated with cleaning/scouring septic systems in the absence of services.

Quality of water resources. In this subcategory, it is exclusively anthropogenic origin and is affected by the discharge of domestic sewage, industrial effluents, mining and fisheries (fish in fresh water) as well as runoff due to nitrates and pesticides used in agriculture. The reduction of leachate is however covered under waste. Pollution of surface water and underground water affect water use (domestic, agricultural and industrial) ecosystem (eutrophication effects on direct, indirect and option values, etc.). Watershed and coastal areas, the cost of land, housing and apartments (hedonic) along the polluted areas, and eco-tourism (loss of opportunity especially along the river banks and polluted coasts). However, it is very difficult to assess the degradation of water quality by impact. Thus, using a contingent valuation surveys to derive the revealed preference (willingness to pay) of users to gauge the restoration of desired resource. This method is based on a transfer of benefits (see Annex III). Moreover, to restore the quality of the resource, investments usually include: a choice ranging from the use of simple and inexpensive WWTP processes such as natural ponds (common in wetland ecosystems) with primary treatment to secondary or tertiary treatments; industrial effluents treatment based on the polluter pay principle and a campaign to raise awareness among farmers is to optimize the use of pesticides and nitrates and promoting organic farming. In an extreme case where the resource is unrecoverable, a substitution of the resource by a remote water supply, and desalination and transportation of the water resources should be considered.

Salinity. The salinity of the surface water and groundwater is of natural and anthropogenic origin (soil erosion due to human activity), and effects on health if the water is used for domestic purposes (see above Drinking Water Quality), agricultural productivity and ecosystems. Only the effects on agriculture are taken into account in this case with the use of a production change to derive the CAWRD. The cost of remediation may include several alternatives: the salinity compensation using more fertilizer (however this is perverse because it pollutes water resources); dilution of groundwater resources by injecting normal wastewater treated; better land use by implementing a planning strategy that includes reforestation, responsible land management, prevention or mitigation of water and wind erosion soil etc. And in an extreme case where the resource is unrecoverable, a substitution of the resource by a remote water supply, and desalination and transportation of the water resources should be considered.

Waterborne diseases. The change in health status is considered in this subcategory. Some parameters of water quality do not affect the taste of water such as the excess of dissolved solids and sulfates. However, the bacteriological quality of the water can cause diseases such as typhoid, hepatitis A, trachoma and nematodes. In addition, the physico-chemical quality of the water can cause high blood levels of methemoglobin, high blood pressure and Blue baby syndrome which are respectively due to the excess of chlorides, sodium and nitrates. However, the causality between water quality and diseases is very difficult to establish definitively especially when it comes to cases of cancer associated with the ingestion of pesticides that contaminate drinking water or the food chain. Thus, the most reliable causality is that between the diarrhea that is transmitted through biological contamination on the one hand and the lack of water quality including water drinking water, inadequate sanitation status within the household and lack of hygiene (proper use of soap) by household members. Thus, a dose-response function, which has largely been established by a large number of studies, was used to value water-borne diseases, including premature mortality and morbidity from diarrhea affecting children under 5 years and morbidity affecting the 5 year and more age group. Thus, the prevalence of diarrhea in the region and the coverage of drinking water and sanitation were considered in the dose-response function to derive the results. Regarding mortality, it is difficult to assign a value on premature death and this is usually controversial. Yet the value of a human statistical life (VSL), which represents the reduction of risk of premature death, was used. Also, the cost of illness was considered for morbidity (hospitals, doctors, nursing assistants, medication, number of days of inactivity, etc.). The cost of remediation includes investments to increase the coverage of water supply and sanitation. This should be accompanied by a good performance in terms of operations and maintenance that are accounted in the analysis and the launch of an awareness campaign for a change in behavior with regard to hygiene in the households. Effectiveness of services. Opportunity costs can also be calculated for the technical losses in the distribution network, which are considered in this study, or lost time to carry water or clean / disgorge septic tanks. Furthermore, an increase in the efficiency of irrigation systems is done using the change in productivity.

Quantity. The scarcity of water resources could be a natural phenomena and/or anthropogenic, and it manifests itself by reducing the flow or runoff, which is exacerbated by the increased use of the resource to sustain population growth and economic activities. Moreover, the lengthening and disruption of cycles of drought (frequencies and intensities) affect surface water and drawdown groundwater. The lack of flow is usually offset: in an emergency, by the spontaneous use of wastewater treated or untreated, which could cause contamination of the food chain, in an intermediate case, by in-depth pumping (rapid drawdown or use of non-renewable fossil water) underground resources necessary to address domestic needs and/or maintain agricultural productivity. In an extreme case, a substitution of the resource requires a water supply augmentation via transfers or desalination that increase the transport cost. The change in production, opportunity costs (foregone) and replacement costs are considered when calculating the CAWRD while the cost of the remediation depends on the chosen alternative.

Erosion and Storage. Management of water resources is affected by erosion and exacerbated by climate changes that reduce storage capacity. The siltation and sedimentation of dams, hill lakes, riverbeds and coasts are compounded by inadequate land use upstream (such as deforestation, irresponsible management of soil, water and wind erosion of soils, etc.) and exacerbated by climate change through the increased frequency and intensity of floods sometimes during wet seasons. Replacement costs can be calculated by considering the reduction of the nutritional value of the soil that must be compensated by fertilizer, the opportunity costs (releases required to drain overflows) of water loss and damage to the ecosystem, defensive expenditures (dredging, construction of small lakes to absorb excess sedimentation), replacement costs (higher dams or building new dams), opportunity costs (loss of income) due to the reduction the volume of water stored and reducing the life of dams and hill lakes, and reduction of ecosystem services. Moreover, the costs of remediation are in some cases the same costs used to value the degradation such as investments for the construction of new dams. But the remediation costs might also include the implementation of a land use strategy that can include instruments such as reforestation, responsible land management, prevention or mitigation of water and wind soil erosion, etc.

Hydroelectricity. Reducing the output is recorded in case of droughts that could be exacerbated by climate change. The CAWRD considers the social opportunity cost of power generation by power plants using fossil fuels. This cost includes the effects of emissions of pollutants and greenhouse gases. The cost of remediation or adaptation includes in particular the replacement of power plants using fossil fuels by power plants using renewable energy.

6.2 Waste Category and Sub-categories

The solid waste chain in urban and rural areas including sludge from WWTPs. Pollution from domestic and agricultural waste is of anthropogenic origin. Thus, the mismanagement of domestic waste as well as sludge and agricultural waste can result in several impacts such as: air, soil and water (runoff leachate), noise, odor and sight pollution as well as discomfort and ill-health. Moreover, waste released in dumps can cause explosions and fires, reduce the price of land/buildings/apartments around the dumps, etc. The degradation costs consider the entire chain of waste. Collection: allocation of 1% of household disposable income for households without coverage for solid waste while the sludge is collected by providers, but generally released in nature (wadis, landfills, etc.). Discharge: cleaning cost per m^3 of the generated waste that is not recycled or properly landfilled. Sorting and recycling: the opportunity cost of recyclables using the market rate for non- recycled materials. Shortfall of energy production when landfilling the organic waste. Reduction in land prices around the dumps (revealed preferences using the hedonic method) or wadis: lower prices for land, buildings and apartments: ± 15% in a radius up to 30 m of the discharge, and ± 10% of a circumference of 30 to 100 m around the dump. Methane capture in landfills: shortfall of energy production and carbon footprint in the absence of a sanitary landfill site. In addition, the cost of remediation depends on the selected alternatives for the collection, transfer stations, sorting stations and recycling, and landfill with or without methane capture. Chain of medical and hazardous waste. This is not considered in this study, but the impact could be more significant than domestic waste if services to manage medical and hazardous waste are not adequate.

6.3 Biodiversity Category

Various encroachments are registered along the basin resulting in loss of ecosystem and medicinal plants. TEEB has been considered for the CAWRD (loss of services) while all the interventions of other sub-categories can be considered as restoration costs.

6.4 Natural Disaster and Global Environment Category

Natural disasters and climate change impacts are considered in a continuum from short to long term.

Natural Disasters. The intensity and frequency of floods, droughts, extreme weather events, fires, etc. are exacerbated over time. The costs of impacts include: health (mortality, injury, drowning, infectious diseases, psycho-physical stress), destroyed property, impaired assets (revealed preferences using the hedonic method) in areas likely to be most affected by floods (depreciation of land prices in flood zones), swell (depreciation of land prices in coastal areas due to the swell and coastal erosion), etc., disruption of services, infrastructure affected; resources (reduced resource and ecosystem effects) dilapidated, reduced economic productivity and so on. The cost of restoration and prevention depends on the preparedness and effectiveness of the response.

Green House Gas Emissions. As a result of past emissions of CO_2 and other greenhouse gases (GHG), the world is now on course for future climate change. The World Resource Institute identifies 2 tons of CO_2 per year per capita as the threshold not to be exceeded to limit the temperature growth to 2°C, above which irreversible and dangerous climate change will become unavoidable. So, the carbon that will be considered as damage cost will be the marginal carbon emissions that exceed 2 tons of CO_2 per year per capita.

The social cost of CO_2 is the present and future (2000-2099) damage from a ton of current emissions in terms of: floods, droughts, sea-level rise, declining food production, species extinction, etc. Several estimations are available for the social cost of CO_2 emissions ranging from US$ 3 to US$ 95 (Nordhaus, 2001; Stern, 2007; and IPPC, 2007). Recently, the European Commission (EC 2008 and DECC 2009) has reported US$ 6 per ton as a lower bound value of CO_2 and the French study (Centre d'analyse stratégique, 2009) as an upper bound value of CO_2 with US$ 11 per ton in 2009. A range of US$ 11-15 per ton of CO_2 in 2008 prices was considered as lower bound and higher bound based on Nordhaus, 2011, which estimated the social cost of carbon for the current time (2015) including uncertainty, equity weighting, and risk aversion at US$ 13.6 or LP 20,509 per ton of CO_2 and equivalent to US$ 46.1 per ton of carbon in 2012.

7 ANNEX III: SPECIFIC METHOD FOR WATER RESOURCES SUB-CATEGORY

The TEV of water is a combination of use and non-use type of values (Table 12). Use values include direct use and indirect use values. Non-use values include existence values, option and bequest values. An example based on hypothetical improvements in river water quality has been chosen to explain each category:

*Use Value*s arise from the actual and/or planned use of the service by an individual, and be direct or indirect:

- Direct, such as when an individual makes actual use of the environmental asset improved, for example, fishing where it was not possible to catch a fish before the improvements in water quality took place;
- Indirect use values are the benefits derived from ecosystem functions gained, for example, where recreational activities are created or enhanced due to water quality improvements, individuals can benefit in the form of increased recreational opportunities without having to make a direct use of the resource (e.g., walking alongside the river bank).

Non-use values are often divided into:

- Existence values, which arise from knowledge that the service exists and will continue to exist, independently of any actual or prospective use by the individual. This type of use refers to the economic value people place on improvements to the quality of a river due to some moral and/or altruistic reasons, or for the mere pleasure of knowing that the river's water has been enhanced;
- Option values refer to the value place on resource's future use. Because individuals are not sure whether they will use the resource in the future, they are willing to pay to maintain the ability to use it;
- Bequest value is the value an individual places on the ability to preserve a resource so that it can be used by future generations.

Table 12: Types of benefits covered with the proposed method

<table>
<tr><th>Benefit</th><th colspan="3">Types of water uses</th><th>Example</th></tr>
<tr><td rowspan="6">Potential water quality benefits</td><td rowspan="4">Current use benefits</td><td>Direct use</td><td>In stream</td><td>Recreational activities: Fishing, swimming, boating</td></tr>
<tr><td rowspan="3">Indirect use</td><td rowspan="3">Near stream</td><td>Recreational activities: Hiking, trekking</td></tr>
<tr><td>Relaxation, enjoyment of peace and quiet</td></tr>
<tr><td>Aesthetics, enjoyment of natural beauty</td></tr>
<tr><td colspan="2" rowspan="2">Non use</td><td>Option</td><td>Preferences for future personal use of the resource</td></tr>
<tr><td>Existence</td><td>Maintaining a good environment for all to enjoy</td></tr>
</table>

		Bequest	Enjoyment from knowledge that future generations will be able to make use of the resource in the future

Source: Adapted from Baker et al. (2007).

The achievement of GES for surface waters in Lebanon is important because of the current trends in water pollution and availability. These are in most cases beyond the assimilative capacity of the aquatic ecosystems, which make freshwater quality a principal limitation for sustainable development.

Considering the benefits derived from water quality improvements is essential for making sound decisions regarding the country's aquatic ecosystems and habitats. Decisions could for example relate to efficient and equitable infrastructure investment in the water sector, to the efficient degree of waste water treatment and to the design of policy measures, including economic instruments such water pricing or taxes on water depletion and pollution.

Society's preferences for environmental improvements do not have a market value and have to be estimated in monetary terms by using valuation techniques. 'Non-market valuation' techniques must be applied to establish this portion of the TEV of water use. Valuation techniques are based either on revealed preference (based on observed market values that can be used as substitutes for the improved environmental resource) or on stated preferences (based on surveys of willingness to pay, especially for household water use and recreational services).

Determining the value of an individual's or community's use of water is very difficult, because water values are highly site-specific, dependent on type of uses, as well as season, water quality, availability and reliability. As for types of uses, people make different uses of water resources, which translate into different values. For example, the value of water for cooling purposes in hydropower is different to that of water used for irrigation in agriculture or for fishing in a lake.

Due to the lack of regional valuation studies on the topic, and the **impracticability, due to time and budget constraints,** to conduct an original valuation study, the benefit transfer function approach has been applied to estimate the TEV of cleaner water. This method allows for the incorporation of differing socio-economic and site quality characteristics between the original study site for which the original benefits estimates were obtained and the policy site under evaluation. Under this approach, typically only one original valuation study is selected. The main assumption made is that the statistical relationship between WTP values for improvements and independent variables are the same for both the study and policy site. In other words, the method assumes that preferences/tastes are the same for both locations and differences in WTP are only related to differences in socio-economic and/or environmental context variables.

For this report, the benefit functions from Baker et al. (2007) have been transferred to Lebanon. This study has recently estimated the economic value placed by English and Welsh households for water quality improvements at local and national level as a result of implementing the Water Framework Directive (WFD) in the UK. This study is one of few studies that employed a standard WFD ecological-based water quality metrics for description of baseline levels and improvements. As an additional feature, Baker et al. (2007) offers detailed results for two different WTP elicitation methods in the same survey instrument, i.e., Contingent Valuation (CV) using both payment card (PCCV) and dichotomous choice (DCCV) as payment mechanisms. The advantage behind the use of two different elicitation methods for the transfer exercise (the PCCV and the DCCV results) is the need to offer ranges of WTP estimates that are representative for policy purposes and illustrate the uncertainty surrounding the results (i.e., sensitivity analysis).

The benefits from water quality improvements covered in this section by the application of the benefit transfer method are related with the quantifiable portion of the TEV of particular use and non-use types derived from the enjoyment of good water quality by local residents of the country. The specific types of water uses covered in the model are highlighted with examples in Table 12). It is important to note that it is not possible to disaggregate values for the different types of uses outlined and that other types of water uses are valued and assessed in other sections of this report.

In order to transfer the benefit functions from Baker et al. (2007), the following variables have been adjusted from the original model:

- Current fresh water quality levels in Lebanon (below standards);
- Average income levels per household in Lebanon (World Bank);
- Education levels in Lebanon (World Bank);
- Population number, Household Gender composition and Household occupancy in Lebanon (World Bank);
- Other socio-economic data: GDP in local currency and PPP conversion factors in Lebanon (World Bank).

These parameters are used in the WTP formulae to directly calculate the annual Willingness to Pay (WTP) for set improvements in freshwater quality per household per year.

Unlike unadjusted benefit transfers where mean WTP at the policy site it is assumed to be equal to mean WTP values at the original site ($WTP_S = WTP_P$), benefit transfers attempt to adjust values by accounting for any possible differences (e.g. socio-economic and environmental quality variables included in the aggregated benefits function) between both sites. Equation 1 offers a conceptual representation of the benefits function transfer approach:

Survey site: $WTP_S = \alpha_s + \beta_{s1}X_{s1} + \beta_{s2}X_{s2}$

Policy site: $WTP_P = \alpha_s + \beta_{s1}X_{p1} + \beta_{s2}X_{p2}$

Where s denotes the survey site, p the policy site and X1, X2 vectors of specific good characteristics and population characteristics for each site (e.g., income and education levels, baseline water quality levels, etc.). Benefit transfer is regarded as a suitable tool for the adjusted transfer of WTP estimates between different locations when the vector of attributes and socio-economic characteristics (X1, X2) that determine the similarities and differences between the policy and the survey site can be established. Where these differences exist and their magnitudes are known, it is possible to substitute those known variables into the survey site's original aggregated benefits function to provide valid benefit transfer estimates. This exercise involves the choice about which factors are included and which are omitted in the analysis, which is usually limited by data availability.

The three scenarios retained in the Baker et al. (2007) study are as follows:

- Scenario 1: 33 percent Successive Improvement after 9 years, 15 years and 20 years;
- Scenario 2: 50% Improvement after 9 years, 30% after 15 years and 20% after 20 years; and
- Scenario 3: 100 percent Improvement after 9 years.

Table 13:WTP per Household Based on Payment Card and Dichotomous Choice Benefit Transfer, 2012

WTP	**HH number**	**Scenario 1** **33% Successive Improvement** **after 9 years, 15 years and 20 years** (CL: 95%; CI ±2.5%)			**Scenario 2** **50% Improvement after 9 years, 30% after 15 years and 20% after 20 years** (CL: 95%; CI ±2.5%)			**Scenario 3** **100% Improvement** **after 9 years** (CL: 95%; CI ±2.5%)		
	(#)	(US$/year)			(US$/year)			(US$/year)		
	2008	2012			2012			2012		
		Low	**Mid**	High	Low	**Mid**	High	Low	**Mid**	High
Total	4.23	50	115	181	54	124	193	62	143	224

Note: $PPP GDP per capita was used to adjust income differential between the UK and Lebanon, and the income elasticity is conservatively considered at 1.

Source: Baker et al. (2007); World Bank (2010); and Authors.

Mean WTP values for the 85% overall water quality improvement scenario in Lebanon ranges between US$ 51.4 and US$ 185 per year per household (Table 13) depending on the two payment mechanisms used in the original contingent valuation method employed in Baker et al. (2007). Results are shown in a range to illustrate the degree of uncertainty associated with the benefits estimates that were elicited through a survey that used the Contingent Valuation (CV) methodology using both payment card (PCCV) and dichotomous choice (DCCV) as payment mechanisms. The lower end of the range represents mean values of the PCCV format and the upper-bound range is derived from the DCCV model. The benefit transfer provides “order of magnitude” results, in order to communicate the scale and significance of the potential benefits arising from improved surface water quality.

Considering the benefits derived from water quality improvements is essential for making sound decisions regarding the country’s aquatic ecosystems and habitats. Decisions could for example relate to efficient and equitable infrastructure investment in the water sector, to the efficient degree of waste water treatment and to the design of policy measures, including economic instruments such water pricing or taxes on water depletion and pollution.

Society’s preferences for environmental improvements do not have a market value and have to be estimated in monetary terms by using valuation techniques. ‘Non-market valuation’ techniques must be applied to establish this portion of the TEV of water use. Valuation techniques are based either on revealed preference (based on observed market values that can be used as substitutes for the improved environmental resource) or on stated preferences (based on surveys of willingness to pay, especially for household water use and recreational services).

Determining the value of an individual’s or community’s use of water is very difficult, because water values are highly site-specific, dependent on type of uses, as well as season, water quality, availability and reliability. As for types of uses, people make different uses of water resources, which translate into different values. For example, the value of water for cooling purposes in hydropower is different to that of water used for irrigation in agriculture or for fishing in a lake.

Due to the lack of regional valuation studies on the topic, and the **impracticability, due to time and budget constraints,** to conduct an original valuation study, the Benefits Function Transfer (BFT) approach has been applied to estimate the TEV of cleaner water. This method allows for the incorporation of differing socio-economic and site quality characteristics between the original study site for which the original benefits estimates were obtained and the policy site under evaluation. Under this approach, typically only one original valuation study is selected. The main assumption made is that the statistical relationship between willingness-to-pay (WTP) values for improvements and independent variables are the same for both the study and policy site. In other words, the method assumes that preferences/tastes are the same for both locations and differences in WTP are only related to differences in socio-economic and/or environmental context variables.

8 ANNEX IV: EXCEL TABLES USED FOR THE CASE STUDY

YLD	((D*C+EXP(r*a))/((-0.07^2))*((EXP(-0.07*(D+a))*(-0.07*(D+a)-1))-(EXP(-0.07*(a))*(-0.07*(a)-1)))											
Morbidity	Population	Incidence	Duration	Disability	YLDs	YLD per		Age at	YLDs	YLDs	prev YLDs	Prevalent
Diarrhea			Duree	Weight		100,000		onset	(3,1)	(0,0)	(0,0)	cases
Male												
0-4	141,311		0.008	0.110	-	0.0		2.5	-	-	-	-
5-14	235,140		0.008	0.110	-	0.0		10.0	-	-	-	-
15-24	197,503		0.008	0.110	-	0.0		20.0	-	-	-	-
25-34	150,258		0.008	0.110	-	0.0		30.0	-	-	-	-
35-44	103,457		0.008	0.110	-	0.0		40.0	-	-	-	-
45-54	79,111		0.008	0.110	-	0.0		50.0	-	-	-	-
55-64	54,463		0.008	0.110	-	0.0		59.9	-	-	-	-
65-74	29,361		0.008	0.110	-	0.0		69.8	-	-	-	-
75+	10,585		0.008	0.110	-	0.0		78.0	-	-	-	-
Total	**1,001,189**	**-**			**-**	**-**	**-**		**-**	**-**	**-**	**-**
Female												
0-4	153,687		0.008	0.110	-	0.0		2.5	-	-	-	-
5-14	252,094		0.008	0.110	-	0.0		10.0	-	-	-	-
15-24	209,249		0.008	0.110	-	0.0		20.0	-	-	-	-
25-34	157,897		0.008	0.110	-	0.0		30.0	-	-	-	-
35-44	113,875		0.008	0.110	-	0.0		40.0	-	-	-	-
45-54	89,051		0.008	0.110	-	0.0		50.0	-	-	-	-
55-64	61,211		0.008	0.110	-	0.0		59.9	-	-	-	-
65-74	34,566		0.008	0.110	-	0.0		69.9	-	-	-	-
75+	12,992		0.008	0.110	-	0.0		78.0	-	-	-	-
Total	**1,084,621**	**-**			**-**	**-**			**-**	**-**	**-**	**-**
Both												
0-4	294,998	-	0.008	0.110	-	-		2.5	-	-	-	-
5-14	487,234	-	0.008	0.110	-	-		10.0	-	-	-	-
15-24	406,751	-	0.008	0.110	-	-		20.0	-	-	-	-
25-34	308,155	-	0.008	0.110	-	-		30.0	-	-	-	-
35-44	217,332	-	0.008	0.110	-	-		40.0	-	-	-	-
45-54	168,162	-	0.008	0.110	-	-		50.0	-	-	-	-
55-64	115,674	-	0.008	0.110	-	-		59.9	-	-	-	-
65-74	63,927	-	0.008	0.110	-	-		69.9	-	-	-	-
75+	23,577	-	0.008	0.110	-	-		78.0	-	-	-	-
Total	**2,085,810**	**-**			**-**	**-**	**-**		**-**	**-**	**-**	**-**

YLL Mortality	Population	Incidence	Duration	Disability Weight	YLLs	YLL per 100,000		Age at onset	YLLs (3,1)	YLLs (0,0)	prev YLLs (0,0)	Prevalent cases
Males												
0-4	141,311		77.5	1.000	-	-		2.5	-	-	-	-
5-14	235,140		70.0	1.000	-	-		10.0	-	-	-	-
15-24	197,503		60.0	1.000	-	-		20.0	-	-	-	-
25-34	150,258		50.0	1.000	-	-		30.0	-	-	-	-
35-44	103,457		40.0	1.000	-	-		40.0	-	-	-	-
45-54	79,111		30.0	1.000	-	-		50.0	-	-	-	-
55-64	54,463		20.1	1.000	-	-		59.9	-	-	-	-
65-74	29,361		10.2	1.000	-	-		69.8	-	-	-	-
75+	10,585		2.0	1.000	-	-		78.0	-	-	-	-
	1,001,189	**-**			**-**	**-**	**-**		-	**-**	**-**	**-**
	-											
Females	-											
0-4	153,687		80.0	1.000	-	-		2.5	-	-	-	-
5-14	252,094		72.5	1.000	-	-		10.0	-	-	-	-
15-24	209,249		62.5	1.000	-	-		20.0	-	-	-	-
25-34	157,897		52.5	1.000	-	-		30.0	-	-	-	-
35-44	113,875		42.5	1.000	-	-		40.0	-	-	-	-
45-54	89,051		32.5	1.000	-	-		50.0	-	-	-	-
55-64	61,211		22.6	1.000	-	-		59.9	-	-	-	-
65-74	34,566		12.6	1.000	-	-		69.9	-	-	-	-
75+	12,992		3.5	1.000	-	-		79.0	-	-	-	-
	1,084,621	**-**			**-**	**-**	**-**		-	**-**	**-**	**-**
	-											
Both	-											
0-4	294,998	-	78.8	0.110	-	-		2.5	-	-	-	-
5-14	487,234	-	71.3	0.110	-	-		10.0	-	-	-	-
15-24	406,751	-	61.3	0.110	-	-		20.0	-	-	-	-
25-34	308,155	-	51.3	0.110	-	-		30.0	-	-	-	-
35-44	217,332	-	41.3	0.110	-	-		40.0	-	-	-	-
45-54	168,162	-	31.3	0.110	-	-		50.0	-	-	-	-
55-64	115,674	-	21.4	0.110	-	-		59.9	-	-	-	-
65-74	63,927	-	11.4	0.110	-	-		69.9	-	-	-	-
75+	23,577	-	2.8	0.110	-	-		78.0	-	-	-	-
Total	**2,085,810**	**-**			**-**	**-**	**-**		-	**-**	**-**	**-**

DALY	Population	Incidence	Duration	Disability Weight	DALYs	DALY per 100,000		Age at onset	DALYs (3,1)	DALYs (0,0)	prev DALYs (0,0)	Prevalent cases
Males												
0-4	141,311	-			-	-		2.5	-	-	-	-
5-14	235,140	-			-	-		10.0	-	-	-	-
15-24	197,503	-			-	-		20.0	-	-	-	-
25-34	150,258	-			-	-		30.0	-	-	-	-
35-44	103,457	-			-	-		40.0	-	-	-	-
45-54	79,111	-			-	-		50.0	-	-	-	-
55-64	54,463	-			-	-		59.9	-	-	-	-
65-74	29,361	-			-	-		69.9	-	-	-	-
75+	10,585	-			-	-		78.0	-	-	-	-
	1,001,189	**-**	**-**	**-**	**-**	**-**	**-**		**-**	**-**	**-**	**-**
	-											
Females	-											
0-4	153,687	-			-	-		2.5	-	-	-	-
5-14	252,094	-			-	-		10.0	-	-	-	-
15-24	209,249	-			-	-		20.0	-	-	-	-
25-34	157,897	-			-	-		30.0	-	-	-	-
35-44	113,875	-			-	-		40.0	-	-	-	-
45-54	89,051	-			-	-		50.0	-	-	-	-
55-64	61,211	-			-	-		59.9	-	-	-	-
65-74	34,566	-			-	-		69.9	-	-	-	-
75+	12,992	-			-	-		78.0	-	-	-	-
	1,084,621	**-**	**-**	**-**	**-**	**-**	**-**		**-**	**-**	**-**	**-**
	-											
Both	-											
0-4	294,998	-			-	-		2.5	-	-	-	-
5-14	487,234	-			-	-		10.0	-	-	-	-
15-24	406,751	-			-	-		20.0	-	-	-	-
25-34	308,155	-			-	-		30.0	-	-	-	-
35-44	217,332	-			-	-		40.0	-	-	-	-
45-54	168,162	-			-	-		50.0	-	-	-	-
55-64	115,674	-			-	-		59.9	-	-	-	-
65-74	63,927	-			-	-		69.9	-	-	-	-
75+	23,577	-			-	-		78.0	-	-	-	-
Total	**2,085,810**	**-**	**-**	**-**	**-**	**-**	**-**		**-**	**-**	**-**	**-**

Human Capital Appr																YEAR															
000 US$	1	2	3	4	5	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	45	55	65	66	67	68	69	70	71	72
Age 0	3	3	3	3	3	3	3	3	3	3	3	10	10	10	10	10	10	10	10	10	10	10	10	5	5	5	5	5	5	5	5
NPV 3%	189																														
Age 15						3	3	3	3	3	3	10	10	10	10	10	10	10	10	10	10	10	10	5	5	5	5	5	5	5	5
NPV 3%	229																														
Age 21												10	10	10	10	10	10	10	10	10	10	10	10	5	5	5	5	5	5	5	5
NPV 3%	252																														
Age 30																					10	10	10	5	5	5	5	5	5	5	5
NPV 3%	227																														
Age 45																						10	10	5	5	5	5	5	5	5	5
NPV 3%	168																														
Age 55																							10	5	5	5	5	5	5	5	5
NPV 3%	111																														
Age 65																								5	5	5	5	5	5	5	5
NPV 3%	35																														
HCA per DALY lost =	GDP/DALY lost		$10,000																												

Benefit Transfer Value of Lost Life (VOLL)	Unit	Source
Average VOLL in OECD (million US$) 2012	3.1	Navrud and Lindhjem, 2011
Average GDP/capita in OECD (PPP in 2012)	36,208	WDI, 2014
Average VOLL in EU (million US$) 2012	3.8	Navrud and Lindhjem, 2011
Average GDP/capita in EU (PPP in 2012)	34,164	WDI, 2014
GDP per capita in Studied Country (PPP in 2012)	14,473	WDI, 2014
Income elasticity	0.8	Various Sudies
Benefit Transfer VOLL Based on OECD (million US$)	1.19	Calculation
Benefit Transfer VOLL Based on EU (million US$)	1.46	Calculation
Midpoint Benefit Transfer VOLL (million US$)	**1.33**	Calculation
VOLL per DALY lost divided by 20 DALYs =		
Considered as an upper bound (US$ million)	0.07	Calculation

Cost of Illness Input	Unit	Unit Cost in 2012	BOD Death DALY	BOD Death DALY	Number of Visit from total incidence	Number of patients Derived from Incidence	Average Health Care days	Hosp, Emerg and Doctor Cost	RAD * Incidence * 3 day	Grand Total
Hospitalization	*$/day*	*200*			*3%*	-	*3*	-		-
Emergency Visit	*$/visit*	*118*			*1%*	-	*1*	-		-
Doctor Visit	*$/visit*	*59*			*30%*	-	*1*	-		-
RADs: Day = GNI/365	*$/day*	*26*							-	-
COI										**-**
HCA for morbidity DALY lost LB	*$/DALY Lost*	*10,000*								-
VOLL for premature mortality UB	*$/DALY Lost*	*73,179*								-
Premature death Midpoint										**-**
Grand Total										**-**

Water and Sanitation health-related degradation

Population rural	2012	Coefficient for diarrhea	Mortality due to diarrhea	Cases of diarrhea	Value per case VOLL	Cost of Ill health
	#		#	Million	$	$ million
Total population (million)	1.6					
Crude birth rate (Number of newborn per 1,000 inhabitants)	15.1	1	138		1,192,799.0	164.6
Population < 5 years (million)	0.121000	2.5		0.30	59.0	17.7
Population ≥ 5 years (million)	1.443000	0.5		0.70	26.8	18.8
Total						201.1
Lower bound						39.6
Upper bound						61.0

Water and Sanitation related remediation

Population without improved access	2012	Reduction of Diarrhea	Reduction of mortality cases	Reduction of Diarrhea cases	Value per case	Gains in 2013
	#		#	Million	$	$ million
Without Improved Sanitation (million)	0.267					
Birth rate	15.1	0.5	9		378.643	3.3
(newborn per 1,000 inhabitants)						
Population < 5 years (million)	0.025	1.25		0.03	45	1.4
Population ≥ 5 years (million)	0.241	0.25		0.06	21.2	1.3
Sub-Total						6
Without Improved Water and Sanitation (m	0.25					
Birth rate	15.1	0.6	10		378.643	3.8
(newborn per 1,000 inhabitants)						
Population < 5 years (million)	0.025	1.5		0.04	45	1.7
Population ≥ 5 years (million)	0.225	0.3		0.07	21	1.4
Sub-Total						6.9
Total						12.9

Potable water: Bottle vs Network	Population	Household Number	Annual Tariff per household for 1 m^3/day	Incremental spending by Household for Water	Total
	#	#	$/Household/Year	$/Household/Year	$ Million
Rural	1,606,074	267,679	125	254	68.1
Urban	479,736	119,934	125	254	30.5
Total	**2,085,810**	**387,613**			**98.6**
LB					*48.1*
UB					*65.1*
Consumer Surplus					

Willigness to Pay and Benefit Transfer	Population	Household	Willingness to Pay to Improve Water Resources US$/Household/Year			WTP to Improve Water Resources US$ million		
	#	#	*Lower Bound*	*Middle Bound*	*Upper Bound*	**Total**	*Lower Bound*	*Upper Bound*
Rural	1,606,074	267,679	115	124	143	**33.2**	*30.8*	*38.3*
Urban	479,736	95,947	115	124	143	**11.9**	*11.0*	*13.7*
Total	2,085,810	363,626	115	124	143	**45.1**	**41.8**	**52.0**

NB For Benefit Transfer, apply same method as VOLL

Water Salinity Tomato 2 Cycles per year	Surface Planted Area	Production	Marginal Salinity Electrical Conductivity	Yield reduction Electrical Conductivity		Wholesale price	Productivity losses at -10%			
							Total	1/3 losses not compensed by fertilizers	LB	UB
	Ha	Tonne	dS/m	-10% with dS/m at :	Ton	US$/ton	US$ Million			
Total	**916,668**	**366,667**	1.7	3.5		298	-	-	-	-

Unaccounted for Water (UfW)	Water Production	Water Distribution	Cost	Losses brought from 26% to 10%	Additional Dwellers using 30%	Total	Lower Bound	Upper Bound
	MCM/year	MCM/year	US$/m[3]	MCM/year	MCM/year	US$ million	US$ million	US$ million
Water Utility	30	10.6	0.3					
Dwellers using alternative sources (trucks and wells)		10.6	0.7					
Consumer Surplus of dwellers after substituting alternative sources (trucks and wells) with 30% reduced UfW volume						0	0	0
NB. What Cost to use? Tariff or Incremental Cost?								

Drawdown Pumping Cost	Unit	Total Underground Water	Mann Underground Water (2/3)
Water Utility Groundwater Extraction	Million of m^3	500	333.3
Private Groundwater Extraction	Million of m^3	100	66.7
Total Extraction	Million of m^3		400.0
Average Consumption of diesel	liter/meter of depth/m^3		0.004
Annual drawdown	meter		
Market price	US$/liter of diesel		1
Total	US$ Million/year		**0.0**
Lower bound	US$ Million/year		0.0
Upper bound	US$ Million/year		0.0

Dam Sedimentation	Mar Volume	Sedimentation in 2012	Allocation for Intensive Agriculture	Agriculture value-added to Intensive Irrigation	Total
	Million of m^3	m^3	m^3/ha	US$/ha	US$ Million
Total	600		5,000	1,255	0.00
LB					-
UB					-

Erosion	Cultivated	Affected Area			Annual Erosion	Fertilizer Cost	CAWRD		
	Area	10% : Middle Bound	5% : Lower Bound	15% : Upper Bound			Total	Lower Bound	Upper Bound
	Ha	Ha	Ha	Ha	Ton/ha	US$/ton	US$ Million		
Mann	200,000	20,000	10,000	30,000		449	-	-	-

Aquifer recharge to account for non-renewable water outflow				
Fossil Aquifer Recharge	**Non-renewable water outflow**	**Cost**	**Total**	
	Km^3	**$US\$/m^3$**	**US$ billion**	
Reverse osmosis			0.0	
Desalination			0.0	
Total	**0**		**0.0**	
Lower bound			-	
Upper bound			-	

Recyclables and Compostables	Collected waste but dumped in a non sanitary landfill		Metal	Glass	Paper/ Cardboard	Plastic	Compost Certified Grade	Total US$ Million
	Ton/day	Ton/year						
Total	547.64		0	0	0	0	0	
Market price/tonne (US$/tonne)			266	30	40	106	50	
CAWRD **US$ million**			-	-	-	-	-	-
LB US$ million								-
UB US$ million								-

Land Price Reduction	Number of Dumpsite with 0.5 ha per dumpsite on average	Total Area	D^2=S/Pi/4	Original Diameter	Original Radius	Radius 30 m	Radius 100 m	Area 30 m	Area 100 m	Losses 30 m	Losses 100m	Land Price	es 30 m 15% of P	s 100 m 10% of l	
		m^2		m	m	m	m	m^2	m^2	m^2	m^2	US$/$m^2$			US$
Total	0	0	-	-	-	30	69	2,827	14,957	2,827	12,130	60	**169,646**	**727,781**	**897,427**
BI US$															*717,942*
BS															*1,076,913*

		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	PV
Cost		31.3	6.37	6.42	6.47	6.52	6.57	6.62	6.67	6.73	6.79	6.85	6.91	6.97	7.04	7.10	7.17	7.24	7.32	7.39	7.47	7.55	7.63	7.72	7.80	83.1
Benefit																										-
Total		(31.3)	(6.4)	(6.4)	(6.5)	(6.5)	(6.6)	(6.6)	(6.7)	(6.7)	(6.8)	(6.8)	(6.9)	(7.0)	(7.0)	(7.1)	(7.2)	(7.2)	(7.3)	(7.4)	(7.5)	(7.6)	(7.6)	(7.7)	(7.8)	
Indicators	*i*	**Results**																								
NPV	10%	(83.1)																								
IRR		#DIV/0!																								
Benefit/Cost Ratio		-																								

Aggregate Results	
US$ Million	CAWRD 2012
Burden of water-related disease	0.0
Water quality	45.1
Water quantity	0.0
Fossil aquifer recharge	0.0
Waste	0.9
Total	**46.0**