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Quantitative and monetary benefit assessments - Assessing improved water resource use and its adaptation to climate change

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Introduction

This paper illustrates one aspect of the ongoing project "Analysis for the European Neighbourhood Policy Instrument (ENPI) Countries on social and economic benefits of enhanced environmental protection" which is funded by the EU through EuropeAid. The study assesses the potential qualitative, quantitative and monetary benefits of enhanced environmental protection as a result of the convergence of ENP countries' environmental policies and legislation with those of the EU.

The study has been initiated as key international financial institutions (IBRD, EIB) as well as officials in Ministries of Environment in ENP countries have signalled that they had difficulties in concretely demonstrating the importance of environmental actions to their governments, which frequently resulted in barriers to progress. This study covers the following ENP countries in the MENA region: Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestinian Authority, Syria and Tunisia.

As such, the overall study aims to:

- improve understanding and awareness of the economic and social benefits of environmental improvement,
- improve the capacity of beneficiary countries to assess the economic and social benefits of environmental improvement and integrate environmental considerations into wide policy development,
- improve the capacity of beneficiary countries to set strategies and prioritise convergence of their environmental policies and legislation with those of the EU under the ENP Action Plans.

While the centralised methodology for the benefit assessment, which is applied to all ENP countries, allows for comparability across countries, it does not take the particularities of each ENP country into account and as a consequence may not be able to offer a centralized methodology for all environmental issues. As such, no methodology for the quantification and monetization of benefits for improving water resources scarcity, nor their benefits of adaptation to climate change, are included.

Following a brief introduction of the central methodology, this paper illustrates ways in which the quantitative and monetary benefits of improving water resource use can be assessed by using the country study of Israel. Quantitative benefits can be assessed by means of an in-depth assessment of water footprints in the agricultural sector, including production and trade patterns. The monetary benefits can be assessed by the application of the rationales of "costs of water supply uncertainty" in agriculture and of "costs avoided" from water produced by desalination.

It needs to be stressed that as the project is still ongoing, the results of the central methodology as well as certain background information may not be included in this paper. The project is expected to be completed in mid-2011, which is when all information will be made publicly available.

Methodology

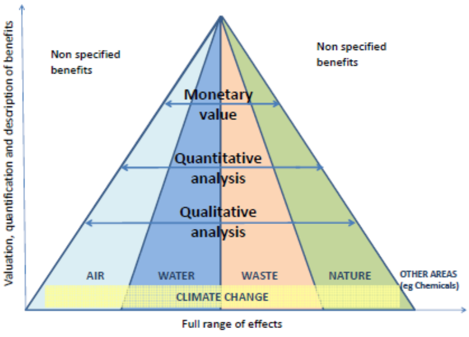
The methodology underlying the benefit assessment undertaken in this project is combining a refined version of the World Bank (2010) study on the costs of environmental degradation and the combined studies on the quantification of the environmental benefits when complying with the environmental Acquis of the EU (ten Brink and Bassi, 2008). The unified methodology is used for all country assessments.

The benefit assessment can be broken down into five key methodological steps, which are applied to the analysis of each parameter, if the data situation allows this. In the first step, the reference point of the current state of the environment from which the improvements are to be assessed is documented. The baseline to 2020, i.e. projections on how the state of the environment is expected to change by 2020 when considering economic and demographic changes and assuming no changes in environmental policies, is assessed in the second step. Then, theoretical targets are set for each of the parameters in order to provide insights into the potential environmental improvements, which could be achieved by adopting EU environmental acquis or similar environmental targets. The targets, and the target assessment timeline to 2020, are set at common levels across all ENP countries to ensure comparability. Consequently, the necessary effort and benefits of meeting these targets differ for each country. The fourth step involves the comparison of the targets to the reference point and baseline. The final step assesses the types of benefits that would result if the targets were met.

Four types of benefits are assessed, namely: economic, social, health and environmental benefits. These benefits can be linked to the concept of ecosystem services developed by the Millennium Ecosystem Assessment (2005), i.e. the benefits that people obtain from ecosystems.

This study focuses on a selection of five key environmental themes, namely air, water, waste, nature and climate change. while understanding that the improvement of environmental conditions covers a broader range of environmental areas and policies. To standardize the assessment of each ENP country, these themes have been further divided into sub-themes for which there are "parameters to be measured", the smallest unit of analysis. This benefit assessment will analyse the benefits of improvement for each of these parameters. This study focuses on the parameter "water resource scarcity" under the sub-theme "water-natural resources" and "climate change adaptation" under the sub-theme "climate responses".

Figure 1 Benefits pyramid: qualitative, quantitative and monetary assessment



To provide a holistic picture, this study assesses benefits from improved environmental conditions in three ways: the qualitative, the quantitative and the monetary level. Most benefits will be identifiable in qualitative terms, a subset in quantitative terms and yet a smaller set in monetary terms, resulting in a pyramid structure (Figure 1).

This three-stage approach shall ensure that the full range of benefits arising from improved environmental protection, and not just the quantitative and monetized ones, will be accounted for. Ideally, the benefits shall be accounted for at a national level. However, data may only be available for certain areas and certain measures, The methodology has therefore been complemented by indicative values from the extrapolation of case studies.

The parameters "water resource scarcity" and its adaptation to climate change

While the centralized methodology described above is suitable to ensure comparability of the benefit assessments, a centralised assessment turned out to be less feasible for some parameters, such as water resource scarcity, due to the particularities of the countries situation.

Using the country study of Israel, this paper illustrates ways in which the quantitative and monetary benefits of improving water resource use can be assessed. Quantitative benefits can be assessed by means of an in-depth assessment of water footprints in the agricultural sector, including production and trade patterns. The monetary benefits can be assessed as the costs of water supply uncertainty in agriculture and as costs avoided from water produced by desalination.

The water footprint of Israel's agricultural production and trade structure is based on the "virtual water content" of the crops produced, which is the crop water requirement at field level (m^3/ha) divided by the crop yield. The crop water requirement is calculated per crop and per country by following the methodology developed by Allen et al. (1998). As the crop water requirement is defined as the "total water needed for evapotranspiration" and the virtual water content takes the crop yield into consideration, the water footprint of selected agricultural produces varies depending on agricultural efficiency and the climatic context in each country (Hoekstra and Chapagain, 2007, p. 145). The water footprint of the Israeli agricultural production and trade structure is assessed by multiplying the quantities of the top ten agricultural products (in terms of tonnes produced) by their respective virtual water content. [1] To put these numbers into an international context and assess ways to reduce Israel's water use by changes in production and trade patterns, the virtual water content of the selected crops in Israel are compared to the global average as well as those in Spain, as a European benchmark with broadly comparable climatic conditions to Israel.

Qualitative benefit assessment of improved water resource use

Improved water resource use can result in a number of economic, social and environmental benefits, a few of which are listed in the following. A cut in water use can lead to improved environmental flows, thus improving freshwater ecosystems and their related services as well as diluting pollution loads. Less demand reduces the water required to be supplied. Decreased groundwater abstractions could reduce the risk of saline intrusion in Israel's aquifers, while less water would need to be desalinated, resulting in economic and environmental benefits. Increased water security, resulting from improved water resource use can motivate farmers to plant higher value multi-year crops, such as wine instead of single season crops, such as wheat. Direct and indirect benefits arise from the increased opportunities for touristic development due to higher flows and recovered ecosystems of Israel's cultural sites, such as River Jordan. This recovery also results in social and cultural benefits to the Israeli population.

Quantitative benefit assessment of improved water resource use - A water footprint analysis in the agricultural sector

Including desalination and treated wastewater, Israel has 2,180 MCM of water available annually, of which it uses 2,702 MCM/year, leaving only 108 MCM/year unused (FAO, 2011; MoEP, 2009). Water resource scarcity is a serious issue for Israel, similarly as for other MENA countries.

Israel's total water footprint amounts to 858 MCM/year, of which 221 MCM/year of water is used domestically to produce the goods and services (internal footprint), while 637 MCM/year of water are used in the production of goods and services imported to Israel (external footprint) (Hoekstra and Chapagain, 2008). [2] In comparison to the remaining ENP countries, Israel has the highest water import dependency (74%). When assessing the composition of Israel's total water footprint in relation to total renewable water sources, it becomes apparent that Israel uses 680 MCM/year more water for the production of the products it consumes, than exist in the form of renewable water resources. This results in a water scarcity index of 482%, i.e. Israel consumes 4.82 times more water

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1 Agricultural trade and production data are taken from FAOStats (2011), while data on the virtual water content for selected crops in Israel is taken from Mekonnen and Hoekstra (2010).

2 Water Footprint of a Nation: total volume of freshwater used to produce the goods and services consumed by its inhabitants (Chapagain et al, 2006)

than is available in the form of renewable water resources.[3] When including alternative water supply options (i.e. desalinated water and treated wastewater) the water available increases to 2.18 10^9 m^3/yr, which translates into a water scarcity index of 191%.
Assuming a 1.5°C increase in temperature by 2020, as a consequence of climate change, precipitation is expected to decrease by 10% (MoEP, 2010). The MoEP (2010) assumes that 200 MCM/year will be less available by 2020; a drastic cut in this magnitude in agricultural water is a realistic consequence which will lead to a further deterioration in the water scarcity index if no action is taken.

In 2009, the top 10 crops produced in Israel, ranked by tonnes produced, included potatoes, tomatoes, grapefruit, carrots and turnips, oranges, wheat, tangerines, mandarines and clementines, cucumber and gherkins, apples and watermelons (Table 1) (FAO, 2011).

Comparing the water required to produce these crops, the two categories "wheat" as well as "tangerines, mandarines and clementines" require 150% and 22% respectively more water than the global average for these crops. Water consumption for these crops are also significantly above the Spanish average water requirement. Potatoes, tomatoes, grapefruit and oranges are produced below global and Spanish average water requirements (Table 1).[4]

Table 1: Comparison of water footprints of Top 10 Produced Crops in Israel

Crop	Production Quantity (t) (2009)	Area Harvested (Ha) (2009)	Water footprint Israel (m^3/t) (1997-2001)	Water footprint Spain (m^3/t) (1997-2001)	Water footprint Global Average (m^3/t) (1997-2001)
Potatoes	608,832	19,000	190	202	255
Tomatoes	454,761	5,400	45	53	184
Grapefruit (inc, pomelos)	249,414	5,000	171	248	356
Carrots and turnips	233,101	3,400	129	109	131
Oranges	136,124	5,200	296	362	457
Wheat	132,963	60,000	3,331	1,227	1,334
Tangerines, mandarins, clementines,	129,989	5,300	709	405	578
Cucumbers and gherkins	116,907	1,000	82	64	242
Apples	114,378	3,600	626	501	697
Watermelons	111,243	10,000	1,303	525	2,524

Note: Colour Code: Horizontal Lines indicate a water footprint in Israel for the listed crop above the global and Spanish average; Grey fields indicate a water footprint in Israel for the listed crop is below global average; Grey fields with diagonal lines indicate that Israel's water footprint is below Spain's average.

When analysing the trend of agricultural production patterns starting in 1990 up to 2009, a reduction of some water-intensive and increase in water-efficient crops becomes apparent.

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[3] The water scarcity index is the ratio of total water footprint and total renewable water resources (Hoekstra and Chapagain, 2008).

[4] Potatoes, tomatoes, grapefruit and oranges are produced with 26%, 76%, 52% and 35% respectively below global average water requirements and 6%, 16%, 31% and 18% respectively below the Spanish average water requirements.

The production of wheat has decreased from 291,200 tonnes/year in 1990 to 132.963 tonnes/ year, a production change that reduced annual water consumption by 527 MCM/year, a decrease of 54%.[5] Of those crops that are produced below the global and Spanish average water requirements, the production of potatoes, for example, increased from 213,850 tonnes/year in 1990 to 608,832 tonnes/year in 2009, resulting in additional internal water use of 74MCM/year, an increase of 185%. In 2008, potatoes were the number one export crop in terms of quantity, with 282,583 tonnes/year (FAO, 2011).

If Israel wanted to further reduce its domestic water footprint and reduce the overexploitation of its water resources, the production of crops with high water footprints, such as wheat, tangerines, mandarins and clementines, could be reduced considerably; instead, such crops could be imported. Further, it could be considered to decrease the production of crops, which have water footprints above Spanish averages, also resorting to imports. These crops could be substituted by high value crops with smaller water footprints and can be produced below the global and Spanish water footprint average, such as potatoes, tomatoes, grapefruit and oranges. Through these measures, by reducing the production of wheat, tangerines, mandarins and clementines by 80%, and the production of turnips, cucumbers, gherkins, apples and watermelons by 60%, a total of 528 MCM/year of water could be saved, approximately half of current agricultural water demand and 96% of potable water used annually in agriculture.[6] The past trend (1990-2009) of a declining production in water intensive crops described above illustrates the potential of water savings by changing agricultural patterns and thus could be intensified.

These potential water savings could lead to a number of qualitative benefits which are described above, if used adequately. Further, the achievement of the potential agricultural water savings mentioned above (528 MCM/year) can also act as an adaptation measure to climate change in Israel, which is estimated to lead to a reduction of 200MCM/year of renewable water resources. Additional (monetary) benefits, such as the decrease in water supply uncertainty in agriculture and avoided costs are described in the following.

Monetary benefit assessment of improved water resource use

Cost of water supply uncertainty in agriculture

The potential economic losses associated with droughts and reduced crop outputs can be substantial as farmers react to unreliable water supply by growing less profitable crops which require minimal agricultural capital accumulation (i.e. single-season crops) to limit their losses in the event of water scarcity. This can be used as a proxy for assessing the monetary value of improving water resource use.

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[5] As the water footprint data was accumulated for the period of 1997-2001, the water savings described do not consider technical efficiency improvements.

[6] In this calculation, the water savings for production changes in the remaining crop produced as well as the additional water requirements for the substitute crops with substantially lower water footprints are not included. A total area of 63,040 ha would become available for the production of crops with lower water footprints. With a total area of 404,187 ha being harvested, this amounts in a 15. 6% decrease.

Table 2: Price of Uncertainty – Sensitivity Analysis (NIS/m^3)

Critical water level	Interest rate		
(as % of mean annual amount)	6%	8%	10%
10%	3.58	2.93	2.48
20%	4.78	4.03	3.49
40%	6.86	6.13	5.53

Source: Lavee (2010)

Lavee (2010) analyzed the cost of water supply uncertainty in agriculture in Israel and developed two models to estimate these costs. The first model estimated a risk premium of 0.38 €/m^3 (2 NIS/m^3) for farmers growing capital-intensive crops. The second model, by estimating the critical water level leading to crop failure, assessing water supply, and the interest rate (for incorporating the credit-related costs for farmers to invest) estimates a price of uncertainty of 0.77 €/m^3 (4.03 NIS/m^3).[7] A sensitivity analysis for the latter model shows a range of prices for uncertainty with changing critical water levels (the water level which results in crop failure) and changing interest rates (higher interest rates reduce incentives to make long-term investments and thus reduce the degree of uncertainty), which are presented in Table 2.

Other than rainfall, reclaimed wastewater is a reliable water source. There is still potential for increasing water reuse in Israeli irrigation, as some irrigation districts are not yet connected to wastewater treatment facilities (Lavee, 2010). By 2020, 100% of Israel's wastewater shall be treated to a level which enables unrestricted irrigation, without risking soil and water sources, nor human health (MoEP, 2005).

For estimating the economic benefits of wastewater reuse, the conservative estimate of cost of water uncertainty will be chosen, namely 0.38 €/m^3 (2 NIS/m^3). Assuming that by 2020 100% of wastewater is reused, this increases reusable wastewater volumes from 261 MCM to 618 MCM, thus resulting in an increase of 357 MCM. With the cost of uncertainty of 0.38 €/m^3 (2 NIS/m^3), this would deliver benefits of EUR 136 million (NIS 712 million). However, for a more complete assessment, the capital and operating costs of wastewater treatment plants and the necessary infrastructure needed to enable unrestricted irrigation would need to be included.

It needs to be stated that the cost of uncertainty reflects a marginal value; the extrapolation of which may result in an overestimation of benefits if the demand for secure water supply is satisfied below the additional water supply.

At the same time, the cost of uncertainty of water supply 0.38 €/m^3 (2 NIS/m^3) can also be applied to other measures that increase the security of water supply beyond water reuse, e.g. the above-mentioned changes in agricultural production which make additional water resources available by e.g. reducing the single season crop wheat and increasing the production of capital-intensive oranges.

Avoided cost of desalination

It is current government policy to increase the desalination production capacity to 750 MCM/ year by 2020 (MoEP, 2009). Further, a program for desalinating 50 MCM brackish water shall be prepared.

While the increased water supply from desalination enhances the water supply, it also comes with a considerable environmental cost, including damage to the marine environment, increased energy consumption and associated emissions, damage to groundwater water (in case of saline water leakages), damage to soil usage, and finally, noise pollution (high pressure pumps used in reverse osmosis generate high noise levels) (Elnav and Lokiec, 2006).

Table 3: Costs of methods to augment water supply

Method	Source/ Purpose	Costs (€/m³)
Desalination	Sea water	0.36-0.48
	Saline groundwater (from 50 MCM)	0.24
Effluent Treatment	Irrigation water	0.12-0.16
Water Treatment	Potable water	0.31

Source: MoEP, 2009

Even without considering the costs resulting from potential environmental damages caused by desalination, the financial cost of desalinated water is still higher than other options for augmenting water supply, such as treating conventional water sources or wastewater effluents (Table 3) (MoEP, 2009).

The targeted water savings in the policy scenario 2020, when compared to the baseline 2020, can be monetized by calculating the avoided costs of the planned increase in water production by desalination. Considering future advances in desalination technologies, the conservative cost estimate of 0.36€/m³ should be used to monetize the benefits of improving water resource use.

Avoided cost by adaptation to climate change

Assuming no changes in the current agricultural production and trade patterns, the MoEP (2010) estimates that the climate-related decrease of renewable water resources by 200 MCM/year in 2020 can lead to a decline in agricultural income by EUR 70 mil yearly and to the loss of thousands of jobs.

The proposed changes in agricultural production structures outlined above could save around 528 MCM/year, which could easily be used as a buffer to avoid the decline in incomes and loss of jobs. [8]

Conclusion

This paper outlines the central methodology, which is applied in the EUROPEAID project to assess the qualitative, quantitative and monetary benefits of enhanced environmental protection relating to economic, social, health and environmental benefits.

Using the country study of Israel, this paper illustrates ways in which the quantitative and monetary benefits of improving water resource use and its adaptation to climate change can be assessed, as this is not covered by the central methodology due to the heterogeneity of ENP countries. Yet, water resource scarcity and the impact of climate change are highly relevant for the MENA region.

Without being able to offer definite and holistic statistics, as only part of the study has been presented in this paper, this partial analysis shows that significant quantitative and monetary benefits can be derived from an improved and to climate change adapted water resource use.

A change in the agricultural production and trade patterns e.g. could make 528MCM of water available annually. Assuming that the Israeli target of treating 100% of wastewater to a level, which enables unrestricted irrigation, will be achieved by 2020, the monetary benefits of reducing water supply uncertainty in agriculture can amount to EUR 136 million annually. The amount of water saved as a consequence of the achievement of multiple water saving targets can also be monetized, as less water will need to be produced by desalination to close the supply-demand gap in 2020. The benefits of avoiding the production of additional desalinated water can also be valued by the conservative estimate of 0.36€/m³, which reflects the cost of desalination. The reduction of 528MCM of agricultural water annually can act as a buffer to the estimated 200MCM/year climate change related

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[8] More targets and options are outlined in the final report of the project.

decrease in water availability by 2020, which is expected to mainly impact the agricultural sector. As this buffer can also avoid the estimated decline in agricultural income of EUR 70 million yearly and the loss of thousands of jobs as a consequence of the reduced water availability by 2020, these values can be used to monetize the benefits of adapting water resource use to climate change.

These estimates need to be handled with care, as synergies and overlaps have not been taken into consideration in this short paper. This paper's focus is to illustrate alternative methodologies for assessing the quantitative and monetary benefits of improved water resource use and its adaptation to climate change rather than offering concrete numbers.

While the uniqueness of individual ENP countries limits the "one size fits all" application of these findings to other countries, the illustrated ideas can be used as a basis to adapt these methodologies to the country-specific situation of the MENA countries.

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