Analysis for European Neighbourhood Policy (ENP) Countries and the Russian Federation on social and economic benefits of enhanced environmental protection

Israel
COUNTRY REPORT

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The benefits in this report have been assessed, using available data, the source of which may not be entirely reliable, and with considerable data gaps requiring several assumptions. The results are therefore considered indicative only, providing an order of magnitude. However, the results are considered useful for making benefits of enhanced environmental protection understandable to a wide audience.

All data used in this report refer to 2008, unless otherwise indicated

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ACRONYMS

ACRI	Association for Civil Rights in Israel
CH_4	Methane
CO_2	Carbon Dioxide
DALYs	Disability Adjusted Life Years
DCCV	Dichotomous choice contingent valuation
E. coli	Escherichia Coli
ENP	European Neighbourhood Policy
ENPI	European Neighbourhood and Partnership Instrument
EU	European Union
FoEME	Friends of the Earth Middle East
GDP	Gross Domestic Product
GES	Good ecological status
GLASOD	GLobal Assessment of human-induced SOil Degradation
IUED	Israel Union for Environmental Defence
MCM	million cubic metres (10^6 m^3)
MDG	Millennium Development Goals
MoEP	Ministry of Environmental Protection
MoFA	Ministry of Foreign Affairs
MoH	Ministry of Health
MOW	Municipal Organic Waste
MSA	Mean Species Abundance
MSW	Municipal Solid Waste
NMVOCs	Non-Methane Volatile Organic Compounds
NO_x	Nitrogen Oxides
PCCV	Payment card contingent valuation
PM	Particulate Matter
PPP	Purchasing Price Parity
RES	Renewable Energy Sources
SO_2	Sulphur Dioxide
SO_X	Sulphur Oxides
VOCs	Volatile Organic Compounds
WFD	Water Framework Directive
WHO	World Health Organisation
WTP	Willingness To Pay

EXECUTIVE SUMMARY

Introduction

The European Union, represented by the European Commission has contracted a consortium led by ARCADIS Belgium N.V. to undertake an analysis of social and economic benefits of enhanced environmental protection in the 16 countries covered by the European Neighbourhood Policy (ENP) and in the Russian Federation[1]. The other consortium partners are: Institute for European Environmental Policy (IEEP), Ecologic Institute, Environmental Resources Management Ltd. and Metroeconomica Ltd.

This is the executive summary of the benefit assessment report for Israel that has been prepared by a team consisting of an EU expert and a national expert, using a Benefit Assessment Manual (Bassi et al. 2011) developed under the project. This Benefit Assessment Manual which was originally for internal use only, has been turned into a Benefit Assessment Manual for Policy Makers for wider dissemination. The Manual provides an understanding of the methodologies applied for the benefit assessment.

All project results, including the country benefit assessment reports, regional synthesis reports and the Benefit Assessment Manual, are available from the project website www.environment-benefits.eu.

Among the countries covered by the European Neighbourhood and Partnership Instrument (ENPI), Israel stands out as a highly developed market economy, facing environmental policy challenges that do not differ very much from the challenges faced in EU countries. A recent OECD Member, Israel features a high level of economic development with a per-capita GDP of € 21,800 in 2008, and it has achieved robust economic growth in recent years.

Factors that set the situation in Israel apart from the European context are the high population growth rates, often in the region of 2-3% during recent decades, largely due to immigration. Another factor is the very high population density in parts of the country, above all in the coastal plain, with an overall urbanisation rate of 92%. Taken together with the high level of economic development and the prevailing consumption patterns, these factors create a high and growing pressure on the country's limited environmental resources.

As a policy issue, environmental protection is relatively well established in Israel, also compared to other countries in the region. At the same time, it is also a more recent and less established policy field than in some of the EU countries. With the exception of water policies, which have been a critical issue ever since the state of Israel was founded, many areas of environmental policy have only been addressed comprehensively in the last two decades. On the positive side, Israel has a relatively effective and capable administration to implement, monitor and enforce environmental policies.

1 EuropeAid DCI-ENV/2009/225-962 (EC)

Environmental policy in Israel closely follows developments in the EU and the OECD. In some areas, such as air pollution from stationary sources, Israel has implemented regulations that are modelled on EU policies (such as the IPPC Directive in the case of air pollution). In this context, Israel's recent accession to the OECD has been a strong and supportive factor, requiring Israel to align its environmental standards and reporting mechanisms to the OECD standards.

The following sections present some of the main results of the benefit assessment for Israel, structured around the five environmental themes air quality, water, waste, nature and biodiversity, and climate change.

There are considerable benefits from taking immediate action to address the environmental problems facing Israel. These include improvements to health and reductions in mortality, economic savings and the potential for new economic opportunities, and widespread gains in community well-being. This report provides a first look at the potential social and economic value stemming from these improvements across environmental sectors. The numbers2 cited in this report are indicative only, based on a rapid assessment, often using limited data and many assumptions. Looking ahead, more detailed assessments will also help to support policy-making and economically sound decision-making on environmental issues in the future.

Air Quality

Air pollution in Israel is particularly problematic due to Israel's specific conditions, i.e. the high population density and concentration of population especially in the coastal plain, which is also the region where most of the country's traffic, power generation and industry are located. Yet, after decades of increasing air pollution, the situation has improved markedly over the last ten years. More stringent air quality regulations, partly based on EU legislation, have lead to a considerable reduction in pollutant emissions and concentration levels. Lead from petrol has been virtually eliminated, for some other air pollutants – such as particulate matter – emissions have been almost halved since 2000. These improvements have been achieved despite the fact that some underlying driving forces of air pollution have intensified over the same time – such as the amount of power generated, industrial output, and the number of cars on Israel's roads.

The recent improvements in air quality are associated with real and tangible benefits for Israel's population – especially in the form of avoided impacts on human health, i.e., fewer incidences of respiratory diseases, but also in the form of reduced damage to buildings and crops. Compared to the situation in the 1990s, when studies found evidence of significant health impacts from air pollution, many of these benefits have already been realised and are being enjoyed by the Israeli population. Nonetheless, there is still considerable scope for improvements. For instance, the transport and power generation sectors, two main drivers of air pollution, continue to impose high external costs through the pollution they generate.

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2 Monetary values are adjusted for Purchasing Power Parity (PPP), except for the carbon prices used as regards climate change mitigation, which are in €. Monetary values calculated using national values (e.g. health benefits associated with avoided impacts of air pollution, or other preferences) are thus in € PPP.

Water
Due to its arid environment, scarcity of water is the overwhelming environmental concern in Israel, and has been ever since the state was founded. Pressures on water availability include population growth, growth in agricultural and industrial production, as well as general economic development. These pressures continue to put a strain on the limited water resources available, both in terms of water quality and quantity. In recent years, the existing scarcity problem has been further exacerbated by repeated drought cycles, resulting in an overuse of natural water resources beyond their natural recharge. Water scarcity in the region is expected to exacerbate further due to the impacts of climate change, which are likely to result in lower precipitation levels.

Since the management of water scarcity is a well-established policy field, there is a comprehensive and sophisticated set of regulations, standards, administrative tools and economic incentives that govern the distribution and the use of water in Israel. Israeli technologies for water management and treatment are among the most advanced worldwide, including seawater desalination, wastewater treatment producing recycled water suitable for irrigation, and efficient irrigation techniques in agriculture. Affordable and equitable access to clean water is of paramount importance, with obvious economic, social and health benefits.

Faced with the increasing water demand and the dwindling supply of freshwater, there is a risk that the environment itself is neglected as a water user: wetlands and other freshwater ecosystems depend on water supply of sufficient quality and quantity. Apart from its intrinsic value, improving the water quality of surface water bodies also generates benefits through water uses for recreation and tourism, ranging from swimming, fishing and boating to religious and spiritual uses (e.g., the Jordan River or Lake Kinneret, the Sea of Galilee). Currently, most surface water bodies in Israel (rivers and lakes) are of poor environmental quality, and are therefore neither fit for human uses like boating, swimming or fishing, nor to support dependent ecosystems. If 70% of Israel's surface water bodies could be improved to the achieve the "good ecological status" required by the EU Water Framework Directive in 2020, Israeli households would benefit in the order of € (PPP) 159 – 571 million through increased amenity and recreation opportunities.

Other water-related benefits – such as improved access to safe drinking water, improved sanitation and hygiene standards, improved connection to sewage and improved levels of wastewater treatment – are of less relevance in Israel than in some of the other countries covered by the European Neighbourhood Policy. In these categories, Israel has generally achieved fairly high standards already, leaving less scope for additional improvements. Nonetheless, some places remain without access to wastewater treatment. This includes parts of East Jerusalem, unrecognised Bedouin villages, and Israeli settlements in the West Bank,3 but also some municipalities in "green line Israel", with as many as 0.5 million people affected according to some sources. However, as most of these cases occur in

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3 This report does not intend to take any position on the status of East Jerusalem or the legality and legitimacy of the Israeli settlements in the West Bank, and mentioning East Jerusalem or settlements in the West Bank in this report should not be seen as evidence to the contrary. Still, the report does intend to raise awareness of the environmental and social damages caused by the lack of universal connection to piped drinking water and the connection to sewage networks, irrespective of the legal status and citizenship of the people affected.

legally and politically disputed situations, it is difficult to quantify the extent of the problem based on neutral and objective data.

Waste

Waste disposal and treatment is a particular concern in Israel, for two main reasons: first, some parts of Israel (especially the coastal plains) feature one of the highest population densities in the world, which means that only very limited land is available for designating sites for landfills or for extending existing sites. Second, the high (and rising) standard of living in Israel and the prevailing consumption patterns are associated with a steady and significant increase in waste generation. Waste generation per capita already exceeds the EU average, and continues to rise.

At the same time, the management of waste has seen some improvements in the last two decades. For municipal solid waste, virtually all waste is collected, even in remote locations, and disposed of in state-of-the-art sanitary landfills. Illegal dumping of municipal solid waste has been mostly eliminated, and most existing dumpsites have been closed, improved or upgraded. Nonetheless, challenges remain: the rate of recycling or composting is low (albeit growing), there is little capacity for incineration of waste, and only some 40% of the methane emitted from the existing landfills is captured and either flared or used for combustion. Methane emissions could be reduced considerably, by both redirecting biodegradable waste away from landfills and towards recycling and composting, and by capturing a larger share of the methane generated in landfills. The benefits of capturing methane take the form of avoided greenhouse gas emissions, and the use of methane as an energy source. Based on the avoided greenhouse gas emissions alone, a scenario that achieves 90% of methane capture from landfills would yield annual monetary benefits in the range of € PPP 93 – 260 million.

Nature and biodiversity

Despite its small land area, Israel boasts a remarkable biodiversity. Israel has a unique location between different bio-geographic regions (the European, Asian and African continents, the Mediterranean and the Red Sea), its flora and fauna exhibiting influences from all these regions. In addition, Israel has a remarkable diversity of climatic, geographic and physical conditions in a small area, and it serves as a major thoroughfare for migratory birds. Due to all these factors, Israel is endowed with a rich and unique variety of flora and fauna.

However, Israel's biodiversity is endangered by anthropogenic pressures. Above all, economic development and population growth result in progressive destruction of natural habitats that are converted for human uses: for instance, it is expected that the country's built-up space will double by 2020. There are ever less contiguous open spaces that give room to nature and provide untouched landscapes, and the remaining ones are subject to major development pressure. Next to the loss of habitats due to economic development, another major concern is habitat fragmentation.

If measured by the surface area designated as protected area, Israel has achieved a relatively high level of nature and biodiversity protection: 218 nature reserves and 74 national parks make up 20.7 % of the country's land area. Yet most of the currently protected areas were not chosen because of their high value in terms of biodiversity or the ecosystem services they provide, but because of their low value for development. Consequently, most of the protected area is located in the desert area in the South of Israel. Combined with Israel's limited size, the existing nature reserves appear insufficient to protect and sustain many of the endangered populations.

Several other areas are currently slated for designation as protected areas. If implemented, these would bring the share of protected areas to almost a third of Israel's land area. There are manifold benefits to nature protection: besides the protection of biodiversity itself, these include the ecosystem services that intact nature areas provide, such as amenity and recreation opportunities, revenue for tourism (including eco-tourism), but also spiritual and cultural values. The existing nature reserves and national parks are already frequented by some 4.3 million foreign visitors and Israeli tourists. An extension of protected areas to 35% of the land area could deliver an additional benefit of € PPP 11 – 28 million per year in terms of amenity values and tourist revenues alone. This number therefore does not include the manifold other benefits of nature protection, such as the value of biodiversity protection itself, which largely escapes a monetary valuation.

The preservation of forests is progressing in Israel, thanks to decades of active afforestation policies, and despite periodic setbacks through forest fires. Forests provide multiple benefits beyond the provision of timber, including a range of ecosystem services – such as purification of water and air, retention of rainfall and preservation of soils, but also opportunities for recreation and amenity. One of these benefits is the function of forests as a carbon sink: currently, Israel's forests store approximately five million tons of carbon. Based on the amount of CO_2 that was sequestrated during the growth of these trees, the value of Israel's forests as a carbon sink comes to about € PPP 354 – 990 million. This range is an illustration of one particular ecosystem service that Israel's forests provide – not necessarily the most important or the most valuable one.

Climate Change

In terms of climate policy, Israel faces similar challenges as other OECD countries. In the recent past, Israel's greenhouse gas emissions have grown steadily in line with population growth and economic development. Between 1996 and 2007, greenhouse gas emissions grew by 23%, from 62.7 million tons CO_2 eq. in 1996 to 76.9 million tons CO_2 eq. in 2007. During this period, per-capita emissions rose from 11 tons in 1996, peaked at 11.5 tons in 2000, and have since dropped to 10.7 tons of CO_2 eq. in 2007. By comparison, Israel's per capita emissions are thus some 5% above the EU average (10.2 tons in 2007). The main source of carbon dioxide emissions is fuel combustion for electricity production and fuel refining, which accounts for 65% of Israel's greenhouse gas emissions. The second source is fuel combustion for transportation (23%), and the remainder from manufacturing and construction.

Among the impacts of climate protection policies, key benefits can be obtained from increasing the use of renewable energy sources for securing Israel's energy needs. Energy from renewable sources currently plays only a modest role in Israel, with 5.5% of its energy consumption coming from renewable sources – mostly in the form of solar thermal collectors used for heating water. By increasing the share of renewable energy sources to

20%, Israel could reduce its fossil fuel consumption by 2,159 ktoe and thus cut its annual CO_2 emissions by more than 7 million tons below business-as-usual. Translated into monetary terms, this represents an annual benefit of € PPP 151 to 434 million for the avoided CO_2 emissions alone.

As regards adaptation to climate change impacts, Israel is expecting to see a marked trend towards a warmer, more arid climate, with a general decrease in average precipitation levels, greater variety in seasonal precipitation patterns, and an overall increase in extreme weather events including heat waves. Given the already noticeable lack of water resources, these patterns are expected to exacerbate existing problems. In response to this threat, Israel's government has set out to develop a national plan for adaptation, which will cover the sectors water, agriculture, coastal zone, public health, biodiversity, energy and infrastructure and the economy.

The following table provides an overview of the benefits assessed during this project:

	Qualitative	**Quantitative**	**Monetary**
Air	Reduced impact of air pollution on ecosystems and vegetation, avoided impacts on buildings and materials, improved quality of life especially in urban area (outdoor activities and recreation)	Avoided health impacts of air pollution (reduced incidence of respiratory diseases): 68 cases of avoided premature death, 130 cases of avoided morbidity	Annual monetised health benefits (reduced mortality and morbidity): € PPP 27 million
Water	Improved waste water treatment: reduced risk of eutrophication Improved surface water quality: reduced cost of pre-treatment for industry and municipalities, ecosystem services including recreational water uses and tourism	Improving 70% of surface water bodies to reach Good Ecological Status	€ PPP 159 – 571 million (WTP of households for improved amenity)
Waste	Increasing the recycling of waste increases the availability of secondary raw materials; organic waste can be used for generating energy.	Diverting biodegradable waste away from landfills and methane capture reduced methane released to the atmosphere: capture of 220,982 tons of methane, equivalent to 4.6 m tons of CO_2 eq.	Monetary benefits of reduced methane emissions: € PPP 93 – 260 million
Nature	Numerous benefits in terms of amenity and recreation, cultural and spiritual values,	1.1 – 3 million additional visits to newly protected areas 5 million tons of carbon (C)	€ PPP 11 – 28 million(WTP of visitors) Value of forests as a carbon

	Qualitative	Quantitative	Monetary
	purification of air and water	stored in Israel's forests	sink: € PPP 354 – 990 million
Climate	Reduced dependence on fossil fuel imports	Increase share of renewables to 20% - reduce fossil fuel consumption by 2,159 ktoe	Climate benefit of reducing emissions: € PPP 151 – 434 million per year

Opportunities and constraints for realizing the benefits

Currently, the two greatest challenges that Israel faces are water availability and preservation of open spaces. In terms of water availability, the country is seeking to meet the coming water scarcity primarily via desalination, as the country's natural water reserves are dire in that both surface and groundwater resources are overexploited. The main opportunities regarding water availability are increasing the efficiency and economic competitiveness of desalination, wastewater treatment and reuse technologies. The main threats in this sector, however, are the energy needs for desalination and the political situation given the trans-boundary nature of most of the country's water resources.

With regard to protection of open spaces, the small size of the country and the rapidly growing population and economy imply that open spaces and protection of ecosystems come at a significant opportunity cost. Opportunities for the protection of open space are due to the rising level of public awareness for nature preservation and increasing public demand for viable green spaces. For example, the Ministry of Environmental Protection has been very influential in preventing recent initiatives to develop tourist infrastructure along the remaining open coastal beaches on the Mediterranean coast. The threats to the protection of open spaces are the continued pressures for development of roads and housing, as well as the lack of representation of interests among the different stakeholders.

In the domain of air quality, growing public awareness and political acceptance, the recent enactment of Clean Air Law and the availability of technologies, seem to create opportunities for improving air quality, especially from stationary sources. Similarly, available technologies for recycling and producing energy from biodegradable waste, coupled with public awareness, create opportunities in this domain. In both domains, the main threats are implementation barriers and limited reinforcement capacity of the responsible government institutions.

Regarding the uptake of renewable energy sources, the increased competitiveness of renewable energy sources, partially due to the rising prices of fossil fuels and the decreased security of supply, creates both opportunities and underline the need for action in this sector. The main threats are bureaucratic lock-ins in the energy sector in Israel.

Policy recommendations

According to national experts, one of the most important recommendations to achieve the above mentioned environmental improvements is the need for sustainable and long term planning at the national level. Several national master plans have been developed for Israel, and these need to be complemented with sound environmental assessments and mandated environmental feasibility studies. The master plans should be transparent and available for public comment. It was recommended that there be dialogue on all planning procedures in the country with the public as an equal partner. Recent positive developments show a greater transparency of the planning process and greater capacity and interest on behalf of the public concerning environmental issues. NGOs seem to play a significant role as “watch-dogs” on government policy, as well as in representing the public and highlighting issues of importance. The media is also an important tool for raising issues and fostering dialogue on the environmental issues of the day.

The main challenge seems to be lack of enforcement capacity. Israel has good and strong environmental legislation, which often conforms to EU policy. Enforcement, however, remains rather weak and polluters invariably are not brought to bear full responsibility for their actions. Also, when fines are levied for environmental infractions they are usually low and the courts tend to be lenient as well. The incentives therefore for conforming to environmental legislation is therefore not strong. Hence, it is crucial to advance enforcement capacity of environmental legislation in Israel.

In addition, Israel as an OECD country is expected to develop more ambitious targets in terms of the reductions in air emissions and for the promotion and development of renewable energies. The current target for renewable energy is 10% by the year 2020 whereas for the EU it is 20%. The current pace of renewable energy development, particularly in solar energy is low and the government quotas and feed in tariffs are also low. This makes the chance for the country to reach its declared goal of 10% renewable by 2020 unlikely. In other sectors, such as wastewater treatment and reuse Israel has set ambitious targets such as 90% wastewater treatment at tertiary level for unrestricted irrigation. Israel is already at 70% and therefore has a good chance of reaching 90% within the decade. This will make Israel the world leader in wastewater treatment and reuse. The targets for desalination capacity to surpass 650 mcm/yr by 2020 are also on track as the country already produces around 350 mcm/yr.

On a final note, Israel is a unique country as it is a mix of first world development and economy with third world development characteristics of nepotism, corruption and an economic concentration of power. Special interests are hugely powerful in Israel which hampers the implementation of sustainable development policies. If Israel is to truly conform to EU policy standards on environmental protection then policy making must go hand in hand with enforcement that has teeth and that special interests are curtailed at least in terms of environmental protection, which should always be clearly placed in the public's interest first and foremost.

Opportunities for future benefit assessment studies

Linking environmental and economic benefits is a clear way to provide the right package of incentives for the government and the public alike in improving the environment. It is now understood that quality of life and environmental protection often go hand in hand, but studies and policies that show these linkages are still rare in Israel and therefore many people still perceive quality of life and protecting the environment as a trade off of one against the other. Studies such as this one therefore can do a lot to showcase that the relationship between the two is actually positive and potentially win-win. The Ministry of Environmental Protection and the country's leading NGOs understand this and are making a good effort in promoting this approach, but a lot more still needs to be done.

Overall, future benefit studies in Israel should focus on those areas where immediate investment is needed, in order to assess which solutions will have the highest benefits. These studies should be conducted in collaboration with local experts, involving the rich environmental economics expertise that is available in Israel. Given its relatively small size, Israel can build on a remarkable amount of existing research when it comes to quantifying the economic benefits of environmental policies, which has also benefitted this assessment. Future analyses would also allow a closer look on the social effects of environmental policies, such as the implications of the use of fees and other market based instruments, the link between poverty and environmental degradation, and the effects of environmental degradation on disadvantaged groups, but also the economic opportunities of environmental policies in terms of the establishment of new industries and market creation should also be further emphasised.

One area where a significant contribution can be made from enriching the pull of benefit assessments is open spaces and nature protection. Open spaces often compete with development opportunities, such as industrial development, real estate, resource extraction etc. Therefore, it would be highly beneficial to highlight the economic benefits which would be lost in cases where open spaces would be lost, such as benefits from eco-tourism, recreational benefits, loss of existence values, etc. Such case-specific assessments have the potential of influencing the debate in favour of protecting ‘valuable’ open spaces.

ANALYSIS FOR ENPI COUNTRIES ON SOCIAL AND ECONOMIC BENEFITS OF ENHANCED ENVIRONMENT PROTECTION

COUNTRY REPORT: ISRAEL

1 INTRODUCTION

1.1 This report

The European Union, represented by the European Commission contracted a consortium led by ARCADIS Belgium N.V. to undertake an assessment of the social and economic benefits of enhanced environmental protection for the 16 countries covered by the European Neighbourhood Policy (ENP) and the Russian Federation. The other consortium partners are: Institute for European Environmental Policy (IEEP), Ecologic Institute, Environmental Resources Management Ltd. and Metroeconomica Ltd.

The overall aim of the project is to move environmental issues higher up on the political agenda. Its specific objectives are to improve awareness of the benefits of enhanced environmental protection in the countries studied, and of their capacity to assess these benefits. In this way, the project is meant to encourage each country to integrate environmental considerations into policy making and to mobilise the necessary financial resources for improving the state of the environment.

This report provides an assessment of the environmental, social, health and economic benefits of environmental improvements in Israel.

This report has been prepared on the basis of information gathered during a country mission, which was undertaken by the project's experts in the period 3 – 8 October 2010, and during follow-up meetings with country officials, complemented with a desk review of national and international databases and reports. The report has also benefitted from discussion with country officials at the final event of this project on 28 and 29 June 2011, and a round of written commenting by country officials following this event.

1.2 What are environmental benefit assessments?

An environmental benefit assessment examines the potential positive outcomes for society that result from the adoption of environmental protection targets and the implementation of environmental actions to meet these targets. Such actions may include environmental policies, legislation and investments undertaken by government, industry or other stakeholders which lead to environmental improvements (e.g. improved water quality from the construction of water treatment plans).

The environmental benefit assessment undertaken for Israel comprises the following elements:

– a description of the current status of the environment and how this is expected to change given current projected trends in socio-economic factors (mainly GDP growth and demographic changes);
– an assessment of the potential direction and magnitude of environmental change if specific environmental targets were achieved;
– the identification, and where practical, quantification and monetisation of the benefits arising from such an environmental change.

The methodology applied for the country benefit assessments was developed under the project, building on previous analyses and methodologies, in particular on IEEP's ENP methodology (ten Brink and Bassi, 2008) and the World Bank's Cost of Environmental Degradation reports.

The methodology applied in this study is described in greater detail in a Benefit Assessment Manual. This document has been developed for internal use by the project experts that conducted the country benefit assessments. On the basis of this internal Benefit Assessment Manual and the experiences gained in its application, a (more concise) Benefit Assessment Manual has been developed for a wide audience of policy makers in the ENP countries.[4] Estimates and calculations by the authors in this report, are made on the basis of the methodologies described in this Manual.

1.3 Aims of the country benefit assessments

This benefit assessment report intends to help the country to evaluate the benefits of addressing environmental challenges it is facing and, where possible and appropriate, estimate their economic value – hence making benefits comparable and understandable to a wide audience. The assessment provides "order of magnitude" results, in order to communicate the scale and significance of the potential benefits of taking action.

This benefit assessment report aims to assist policymakers by providing new evidence and values on:

– key environmental issues affecting their country, i.e., the issues that could result in the greatest benefits if tackled appropriately;
– impacts of these issues on society – i.e., in terms of social (e.g., health), economic (e.g., additional social costs) and environmental (e.g., biodiversity loss) impacts; and
– benefits (health, environmental, economic and social) that accrue to society from taking actions to protect the environment.

This benefits assessment report can also play an important role in raising awareness regarding environmental problems, impacts and the benefits of action. The latter is crucial,

4 Bassi et al, 2011): Bassi, S. (IEEP), P. ten Brink (IEEP), A. Farmer (IEEP), G. Tucker (IEEP), S. Gardner (IEEP), L. Mazza (IEEP), W. Van Breusegem (Arcadis), A. Hunt (Metroeconomica), M. Lago (Ecologic), J. Spurgeon (ERM), M. Van Acoleyen (Arcadis), B. Larsen and, F. Doumani. 2011. Benefit Assessment Manual for Policy Makers: Assessment of Social and Economic Benefits of Enhanced Environmental Protection in the ENPI countries. A guiding document for the project 'Analysis for European Neighbourhood Policy (ENP) Countries and the Russian Federation on social and economic benefits of enhanced environmental protection'. Brussels.

as policy makers have often a clearer perception of what it costs to maintain the quality of the environment, than of the resulting benefits.

As such this report can stimulate policy attention, focus, action and appropriate funding.

1.4 Potential users of and target audience for this benefit assessment report

The potential users of and the target audience for this benefit assessment report include:

- Governmental institutions, responsible for a sector that will directly benefit from environmental improvements, such as the ministries responsible for environment, water, energy, land use, agriculture, fisheries, health, social affairs and tourism. This report provides evidence of the benefits of environmental improvements that can support their arguments for funding environmental actions and for environmental policy integration5.
- Regional and local authorities, for similar reasons as the above mentioned governmental institutions.
- Finance ministries, which often play an important role in deciding the funding levels for each other ministry, are also a potential user of benefit assessments. This is important, as it is the perceived benefits that drive policy decisions to allocate public resources to maintain and to improve the quality of the environment.
- Parliament: this report can help legislators responsible for environmental matters to make the case for better environmental protection and conservation legislation.
- The Judiciary (ministries of Justice) and environmental inspectorates/enforcement agencies. This report provides evidence that supports their arguments for enforcing environmental legislation.
- Communities: this report can help communities that depend for their livelihood on natural resources (e.g., forestry, fisheries) to demonstrate the value of the resources and the importance of preserving them, community management of community resources.
- The private sector, civil society and the development partner community, which jointly work on the common challenge of the transition to a resource efficient, effective, green and equitable economy. This report can help them to set priorities for action and provides evidence when advocating for enhanced environmental protection.

5 Environmental integration means making sure that environmental concerns are fully considered in the decisions and activities of other sectors, such as agriculture, tourism, industrial development, energy or transport.

1.5 The benefits of an improved environment

The country benefit assessment focuses on four categories of benefits from environmental improvements:

- **Health benefits**: these can also be interpreted as social benefits, but given the strategic importance to health of the enhanced environmental protection, they are assessed as a separate category. Direct benefits to public health include for example:
    - a reduction in the cases of illness and the avoidance of premature mortality arising from water-borne diseases,
    - a reduction in respiratory and cardio-pulmonary diseases and premature mortality associated with poor air quality.

- **Economic benefits**: benefits include for example:
    - economic benefits from natural resources (e.g. tourism benefits relating to protected areas, landscape, beaches, coral reefs),
    - eco-efficiency gains (e.g. improved fish provision from enhanced ecosystems that support fisheries directly and indirectly),
    - avoided costs (e.g. avoided costs of hospitalisation and lost days at work from health impacts; avoided climate change impacts),
    - the development of new and existing industries/sectors of the economy (e.g. renewable energy),
    - balance of payments and trade effects (e.g. reduced imports of primary material as more waste is reused and recycled),
    - increased employment through environmental investments (e.g., potential from developing the waste collection sector, from growth in eco-tourism).

- **Environmental benefits**: are the positive impacts on the natural environment of meeting environmental targets. For example, if the target of secondary treatment of all urban waste water would be reached, this would result in environmental benefits, such as improved surface water quality and avoidance of eutrophication, that can lead to biodiversity loss.

- **Social benefits:** benefits to individuals and society at large, including for example:
    - the safeguarding of, and access to, the natural and cultural heritage (avoided pollution damage to historic buildings or the destruction of historic landscapes),
    - recreational opportunities (e.g., fishing and bathing),
    - benefits of trust in quality environmental service provision (e.g., water quality),
    - social cohesion due to support for employment, social learning and the development of civil society (due to increased information provision, consultation and involvement)

1.6 Scope of the country benefit assessment

The improvement of environmental conditions encompasses a vast range of environmental areas and policies. Since it was not possible to cover all these aspects, the analysis focused on a selection of the key environmental issues on which the analysis should focus.

The aim was to identify issues of importance which are sufficiently representative of the five environmental themes covered by the project, i.e. air quality, water quality, waste, nature and biodiversity and climate change (as a cross-cutting policy with several interlinkages). These policy fields are common concerns across all the countries covered by this project, and are sufficiently well-understood to be assessed rigorously.

To structure the analysis, the five themes were further subdivided into nine *sub-themes*, and for each of these sub-themes, specific *parameters* were identified that form the core of the analysis. There are a total of 14 parameters, with two parameters occurring in two themes. The benefit assessments are about assessing the benefits of improving the state of the environment for each of these parameters.

Table below provides an overview of the themes, subthemes and parameters.

Table 1.1: Overview of themes, sub-themes and parameters

THEME	SUB-THEME	PARAMETER
AIR	Air quality	Ambient air quality
WATER	Water - infrastructure and practice	Connection to safe drinking water
		Connection to sewage network and hygiene conditions
		Level of waste water treatment
	Water - natural resources	Surface water quality
		Water resource scarcity
WASTE	Waste collection	Waste collection coverage
	Waste treatment	Waste treatment
		Methane emissions from waste
NATURE	Biodiversity	Level of biodiversity
	Sustainable use of natural resources	Deforestation levels
		Level of cropland degradation
CLIMATE CHANGE	Climate change drivers	Deforestation *(covered under nature)*
		Methane emission from waste *(covered under waste)*
	Climate change responses	Uptake of renewable energy sources
		Climate change adaptation (responses to a selection of 2-3 impacts)

1.7 The level of analysis

The benefit assessments provide "order of magnitude" results, in order to communicate the scale and significance of the potential benefits.

The benefits arising from improved environmental conditions can be analysed in three ways: qualitatively, quantitatively and in monetary terms.

- In qualitative terms, providing a description of the nature of the benefit, the people, land areas, sectors and services affected, based on the views of stakeholders, published assessments and expert judgement. This approach requires least data, and is applicable to all the parameters analysed.

- In quantitative terms, whenever quantitative data are available (e.g., cases of morbidity/mortality avoided, etc), to indicate the actual, relative or proportionate scale of the benefit arising from the environmental improvement identified. For example, the improvement of ambient air quality can lead to a quantifiable reduction in the likely number of cases of respiratory disease and associated morbidity or early mortality. This approach is applicable to several but not all the parameters, depending on the data available and the possibility to link environmental improvements to actual physical effects.

- In monetary terms, when possible. This third approach multiplies the quantitative benefit identified by a standard economic value (or ranges) representing the monetary value for society of a certain environmental improvement. Where possible, such assessments were based on values obtained from studies conducted in Israel; in other instances, assessments used standard reference values from the literature or values from studies conducted elsewhere, adjusted for differences in key socioeconomic characteristics.

Such value can for instance be:

- the amount of money saved if a certain improvement is made (e.g., avoided hospitalisation costs from avoided illness; reduced cost for water purification if the quality of water improves),
- market values of products or savings (e.g., increased fish output, carbon storage)
- or a measure of people's willingness to pay (WTP) for a benefit (e.g., access to improved bathing water quality).

Such economic values may be obtained from:

- cost data for specific services (*e.g.,* hospital treatments for particular diseases),
- market values for particular commodities (e.g. fish, carbon),
- survey data documenting actual willingness to pay responses,
- modelling studies,

– applying the benefit transfer method (i.e. drawing upon valuation study results calculated elsewhere, that value similar changes, and adjusting for socioeconomic differences between the study site and the policy site).

Most benefits are identifiable in qualitative terms, but due to data availability, only a subset of them in quantitative terms and a smaller set in monetary terms.

The adoption of this three-level approach is important as the availability of suitable data varies from one parameter to another. The purpose of this three-stage approach is to ensure that the full range of benefits of enhanced environmental protection is realised, and that the benefit assessment is not constrained by focusing only on the elements that can be quantified or monetised.

In general, the aim is to have a nation-wide picture for each parameter, but in some cases, local case examples can be valuable to help communicate particular benefits. To this extent, a case study has been included in this report for the benefits provided by forests, using the Carmel forest as a site of national significance.

1.8 Assumptions

A number of assumptions have been made to carry out the country benefit assessment. Parameter specific assumptions are included in the relevant sections of this report. General assumptions, across parameters, are summarised in Table 1.2. It should be noted that a practical approach with limited sensitivities has been chosen for this study in order to keep the analysis relatively simple.

Table 1.2: Summary of key assumptions for ENP benefit studies

Issue	Assumptions
Timescale	2020
Reference year	2008 if and where data available, and note year if other than 2008.
Targets	Usually a single common target for the year 2020 that was used across all the countries analysed, for each parameter under analysis.
Baseline	Usually a set of essential factors are included in the baseline projection, such as GDP, population and their growth rates. These are kept to a minimum to keep the analysis reasonably simple.
Adjustment of monetary values for Purchasing Power Parity (PPP)	Monetary values are adjusted for Purchasing Power Parity (PPP), except for the carbon prices used as regards climate change mitigation, which are in €. Monetary values calculated using national values (e.g. health benefits associated with avoided impacts of air pollution, or other preferences) are thus in € PPP. PPPs are widely used as an alternative to monetary exchange rates when making international economic comparisons. They are, in effect, “real” exchange rates, based on a comparison of the relative purchasing power of each country’s currency. Purchasing power parities equate the purchasing power of different currencies. This means that a given sum of money, when converted into different currencies at the PPP rates, will buy the same basket of goods and services in all countries, thus eliminating differences in retail price levels between countries. To convert current-day Euro values

Issue	Assumptions
	into local currency (New Israeli Shekel), the following exchange rates were used: PPP-adjusted exchange rate: 5.24 NIS/Euro (2008); market rate: 5.26 NIS/Euro (2008).[6] All prices are expressed as 2008 prices, unless otherwise indicated. Historical values were corrected for inflation using the Israel's consumer price index.
Mortality and morbidity	Improvements in e.g. ambient air quality, drinking water, sanitation and hygiene are associated with reductions in the risk of mortality. The benefits to society of mortality risk reductions are usually valuated by people's willingness-to-pay (WTP) for such risk reductions. WTP is then converted to a value of statistical life (VSL) that is applied to estimated cases of mortality avoided from the environmental improvements to arrive an estimate of the monetary benefits of the improvements. The VSL varies across countries in proportion to GDP/capita (PPP terms)[7]. It should be emphasized that these VSLs have nothing to do with value of life, but rather reflects how people are willing to reallocate their resources from consumption of market goods and services to paying for reductions in the risk of mortality. The same WTP and benefit transfer approach is used for valuing an avoided case of illness, unless otherwise stated.
Time development of willingness to Pay (WTP)	Assumes a proportional relationship – e.g., if GDP/capita increases by a factor of 2, the WTP also increases by a factor of two.

The annual growth rate values used to estimate the projected 2020 values are given in Table 1.3. These are default values based on OECD estimates. For simplicity the same factors have been used for macro regions (ENPI South, ENPI East and Russia) under the broad assumption that these will face similar socio-economic developments. For the waste parameters, different values have been used and are referenced in the appropriate sections.

Table 1.3: Annual growth rates

Country cluster	Data	Annual growth factor
ENP South	population	1.68%
	GDP	3.75%
	GDP/capita	2.03%
ENP East	population	0.02%
	GDP	3.35%
	GDP/capita	3.33%
Russia	population	-0.55%
	GDP	3.75%
	GDP/capita	4.32%

Where: ENP South = Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Syria, Tunisia, oPt.
ENP East = Armenia, Azerbaijan, Belarus, Georgia, Moldova, Ukraine
Russia = Russian Federation
Source: unless otherwise indicated in this report, GDP projections are based on the GDP projections used in the global modeling runs (using the Globio-Image model) for the OECD 2008 Global Outlook to 2030 report[8].

[6] World Bank. 2011. World Development Indicators

7 An empirically estimated function from a recent meta-analysis of studies of VSL in over 30 countries (of which nearly half are countries with a GDP per capita in the range of that of the ENPI countries) by Navrud and Lindhjem (2010) prepared for the OECD are used to estimate VSL in ENPI countries (www.oecd.org/env/policies/VSL).

[8] OECD (2008) *Organisation for Economic Cooperation and Development: Outlook to 2030.*Paris.

Full reference to the specific values used for factors such as GDP, population, growth rates and Values of Statistical Life for each country, as well as Willingness to Pay values and carbon values common across all countries have not been included in this report, but can be found in the Benefit Assessment Manual (Bassi et al. 2011) that was developed for this project.

2 COUNTRY OVERVIEW: ISRAEL

2.1 Environment, economy and society

To understand the general context of Israel's environmental policies, it is important to realise that Israel is essentially a highly developed market economy, facing environmental policy challenges that do not differ very much from the challenges faced in EU countries. Israel features a high level of economic development with a per-capita GDP of 21,800 Euro in 2008, and robust economic growth that often exceeded the EU average in recent years.

Factors that set the situation in Israel apart from the European context are the high population growth rates, which were often in the region of 2-3% during the last decades, largely due to immigration. Another factor is the very high population density in parts of the country, above all in the coastal plain, with an overall urbanisation rate of 92%. Taken together with the high level of economic development and the prevailing consumption patterns, these factors create a high and growing pressure on the country's limited environmental resources.

The political situation in the region, i.e. the Middle East Conflict, is noticeable as a factor that has some influence on environmental policies, however much less so than it is in the occupied Palestinian Territories. In terms of regional cooperation, there is only limited cooperation on environmental issues with Egypt, Jordan and the occupied Palestinian Territories, and no cooperation with Israel's other neighbours. In terms of domestic policies, one noticeable effect is that national security issues take precedence over all other policy fields, including the environment, and that some environmental issues (especially water supply) are framed as matters of national security and geopolitics. One issue that does not feature strongly in Israeli environmental politics are the Israeli settlements in the West Banks and the (transboundary) pollution they emit to the surrounding Palestinian Territories. While this is a key concern for the Palestinian side, the issue receives less attention from the Israeli side. This is partly due to the fact that the settlements are not administered by the "normal" Israeli authorities, but fall under the "civil administration" branch of the Israeli Defense Forces, where implementation and enforcement of environmental regulations is arguably one of the lesser concerns.

As a policy issue, environmental protection is relatively well established in Israel. This is certainly true when compared to other countries in the region. At the same time, it is also a more recent and less established policy field than in some of the EU countries. With the exception of water policies, which have been a critical issue ever since the state of Israel exists, many areas of environmental policy have only been addressed comprehensively in the last two decades (with the Environment Ministry established in 1988). In comparison to other policy issues, it would seem fair to say that environment has been established as a policy area in its own right, but also represents one of the minor policy portfolios, especially when confronted with economic policy or the overwhelming national security issues. On the positive side, Israel has a relatively effective and capable administration to implement, monitor and enforce environmental policies. Implementation is particularly effective where environmental policies are connected to other policy issues, such as health. Nonetheless, implementation gaps are a common phenomenon in Israel, as in many other countries.

Environmental policy in Israel closely follows developments in the EU and the OECD. In some areas, such as air pollution from stationary sources, Israel has implemented regulations that are modelled on EU policies (the IPPC Directive in the case of air pollution). In this context, Israel's recent accession to the OECD has been a strong and supportive factor, requiring Israel to align its environmental standards and reporting mechanisms to the OECD standards

Table 2.1: Key economic indicators for Israel

Indicator	2008 (unless otherwise specified)
Country surface area	20,700 km^2 -22,072 km^2 [9]
Population size	Current: 7,308,800 Projections (2020): 8,803,000
Population and growth rate	Current: 1,78% Projections (2020): 1,56%
Number of households	Current: 2,194,835
GDP (market prices)	EUR 138,260 million
GDP/capita (market prices)	Current: EUR 18,829 Projections (2020): 23,880
GDP in Purchasing Power Parity (PPP)	Current: EUR 139,074 million Projections (2020): EUR 176,380 million
Share (%) of agriculture, forestry and fishery in GDP	2.0%
Share (%) of Commerce, restaurants and hotels in GDP	11.3%

Source: World Bank 2010. World Development Indicators

2.2 The Environment

The following section provides a brief overview of the main environmental concerns that Israel faces, structured by the following environmental themes: air, water, waste, nature and climate change).

2.2.1 Air Quality

For the last decades, air pollution in Israel has increased dramatically. Much of this increase has been due to an equally rapid increase in the driving forces, such as the amount of power generated, industrial output, and the number of cars on Israel's roads. These driving forces, in turn, are directly linked to the population growth and increase in income levels. In the last ten years, however, there have been some successes: more stringent air quality reductions have lead to a considerable reduction in pollutant emissions and concentration levels. Lead from gasoline has been virtually eliminated, for some other air pollutants – such as particulate matter – emissions have been almost halved since 2000.

The problem of air pollution is exacerbated by Israel's specific conditions, i.e. the high population density and concentration of population especially in the coastal plain, which is

9 Lower bound represents country's territory following the 1949 armistice agreement. Higher bound includes East Jerusalem and the Golan heights, which were annexed by Israel in 1980 and 1981 respectively.

also the region where most of the countries traffic, power generation and industry are located. The small land area and its geographical, topographical and climatic features further add to the problem of air pollution.

2.2.2 Water

Due to its arid environment, scarcity of water is the overwhelming environmental concern in Israel, and has been ever since the state was founded. Unlike other environmental issues, access to water is also a highly politicised issue in the area: in fact, the water issue is as much an issue of governing access to a valuable strategic resource as it is an environmental policy matter. Pressures on water availability include population growth, growth in agricultural and industrial production, as well as general economic development. These pressures continue to put a strain on the limited water resources available, both in terms of water quality and quantity. In recent years, the existing scarcity problem has been further exacerbated by repeated drought cycles, resulting in an overuse of natural water resources beyond their natural recharge (Ministry of Environmental Protection (MoEP) 2008, p. 25).

2.2.3 Waste

Waste disposal and treatment is a particular concern in Israel, for two main reasons: first, some parts of Israel (esp. the coastal plains) feature one of the highest population densities in the world, which means that only very limited land is available for designating sites for landfills or for extending existing sites. Second, the high (and rising) standard of living in Israel and the prevailing consumption patterns are associated with a steady and significant increase in waste generation, an issue that Israel shares with many other developed countries (Yesha'ayahu & Arne, 2010). The disposal and treatment of waste introduces a variety of social, economic and environmental pressures, such as air, water and soil pollution from landfills, which continue to affect the environment long after the landfills have reached their maximum capacity. The coupling of high volume of waste with low availability of land and open spaces in Israel, have put waste related issues high on the environmental policy agenda within the last decade.

2.2.4 Nature and biodiversity

Despite its small land area, Israel boasts a remarkable biodiversity. Israel has a unique location between different bio-geographic regions (the European, Asian and African continents, the Mediterranean and the Red Sea), its flora and fauna exhibiting influences from all these regions. In addition, Israel has a remarkable diversity of climatic, geographic and physical conditions in a small area, and it serves as a major thoroughfare for migratory birds. Due to all these factors, Israel is endowed with a rich and unique variety of flora and fauna.

However, Israel’s biodiversity is endangered by anthropogenic pressures. Above all, economic development and population growth result in progressive destruction of natural habitats that are converted for human uses: for instance, it is expected that the country’s built-up space will double by 2020. There are ever less contiguous open spaces that give room to nature and provide untouched landscapes, and the remaining ones are subject to major development pressure. Next to the loss of habitats due to economic development, another major concern is habitat fragmentation. Given Israel's limited size, it has to be noted that the existing nature reserves are insufficient to protect and sustain many of the endangered populations.

2.2.5 Climate Change

In the recent past, Israel's greenhouse gas emissions grew in line with population growth and economic development. Between 1996 and 2007, greenhouse gas emissions grew by 23%, from 62.7 million tons $CO_{2\text{-eq}}$ in 1996 to 76.9 million tons $CO_{2\text{-eq}}$ in 2007. During this period, per-capita emissions rose from 11 tons in 1996, peaked at 11.5 tons in 2000, and have since dropped to 10.7 tons of $CO_{2\text{-eq}}$ in 2007. By comparison, Israel's per capita emissions are thus some 5% above the EU average (10.2 tons in 2007). The main source of greenhouse gas emissions is fuel combustion for electricity production and fuel refining, which account for 55% of Israel's greenhouse gas emissions. The second source is fuel combustion for transportation (20%), and the remainder from fuel combustion for manufacturing and construction and industrial processes.

As regards adaptation to climate change impacts, Israel is expecting to see a marked trend towards a warmer, more arid climate, with a general decrease in average precipitation levels, greater variety in seasonal precipitation patterns, and an overall increase in extreme weather events. Given the already noticeable lack of water resources, these patterns are expected to exacerbate existing problems. In response to this threat, Israel's government has set out to develop a national plan for adaptation, which will cover the sectors water, agriculture, coastal zone, public health, biodiversity, energy and infrastructure and the economy.

Figure 2.1: Map of Israel

Source: United Nations, http://www.un.org/Depts/Cartographic/english/htmain.htm

3 BENEFITS OF IMPROVING AIR RELATED CONDITIONS

3.1 Introduction to air quality issues

Air pollutants may be released by either stationary sources (*point* source emissions), such as those emitted from the stack of a coal-fired power plant, or by moving sources (*line* source emissions), which include, for example, automobiles, buses, trucks, rail and ship transport. Common pollutants include particulate matter,10 nitrogen oxides (NOx, including NO and NO_2 species), sulphur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2), ozone (O_3), lead (Pb), mercury (Hg), nitrate and sulfate aerosols,11 and carcinogenic substances, which include several heavy metals (nickel, cobalt, chromium, arsenic), benzene, dioxins and furans, polycyclic-aromatic-hydrocarbons (PAH), just to name a few.

In the present context, a physical impact is defined as a physiological response or reaction to an environmental stimulus, which is triggered by a pollutant emitted into the surrounding atmosphere. For this report, anthropogenic emissions are considered. The report thus focuses only on those pollutants emitted to the ambient air due to human related activities (artificial emissions). Once in the environment, pollutants are transported away from the source via different dispersion routes, including air, water, soil and uptake by living organisms (plants and animals). For the case of airborne dispersion, pollutant uptake in humans may occur via three separate pathways: inhalation, ingestion and skin absorption. Emissions to water and soil environments and exchanges between these media and air will not be considered here. We will thus only consider air pollutants that directly impact on a receptor population.

Air pollution causes a wide range of human health and environmental problems. The presence of air pollutants in the air can result in pulmonary and cardiovascular illness and early mortality. They can damage vegetation and buildings, including the cultural heritage. Over longer distances such pollutants may be deposited as acid rain leading to acidification and/or eutrophication of ecosystems such as forests and fresh waters and affect economically important resources such as fisheries.

This section will cover the following aspect of air quality: ambient air quality.

10 Typically, reported as total suspended particles (TSP) or suspended particulate matter (SPM). A particle or an aerosol particle consists of several chemical entities which are held together by inter-molecular forces and, in effect, act as a single solid or liquid unit under normal atmospheric conditions. A complete description of particulate matter requires specification of the chemical composition of its constituents and morphology (size and shape). Particles are usually identified as PMx, where x stands for the largest aerodynamic diameter (actual or equivalent) of the collective group of particles, measured in microns (a millionth of a meter).

11 Nitrate and sulfate aerosols are secondary particulates formed in the atmosphere following chemical transformations in which NOx and SO2 species react with other substances already present in the air, such as, for example, ammonia.

3.2 Benefits from improved ambient air quality

3.2.1 Current state of ambient air quality in Israel

Despite recent improvements, air pollution in Israel has increased dramatically over the last decades. Much of this increase has been due to an equally rapid increase in the driving forces, such as the amount of power generated, industrial output, and the number of cars on Israel's roads. These driving forces, in turn, are directly linked to the population growth and increase in income levels.

For instance, over the last 50 years, the number of vehicles in Israel has increased by a factor of 32, from 70,000 in 1960 to 2.3 million cars in 2007. Demand for electricity doubled between has also been soaring, with a 6.8% increase in electricity consumption in 2007 alone (of which private households contributed a less-than-average rise of 5.1%, commercial-public consumption 7.1% and industry 7.6%). Electricity generation increased by 6.5% in 2007, reaching 53.6 billion kWh. Emissions from those three sectors – transport, energy and industry – occur in the form of nitrogen oxides emissions (34% of which are from transport, 54% from electricity production), sulphur dioxide emissions (71% from electricity, 24% from industry) and particulate emissions (15% are from electricity generation, 78% from industry) (Ministry of Environmental Protection 2008, p. 20).

The problem of air pollution is exacerbated by Israel's specific conditions, i.e. the high population density and concentration of population especially in the coastal plain, which is also the region where most of the countries traffic, power generation and industry are located. The small land area and its geographical, topographical and climatic features further add to the problem of air pollution.

In terms of the state of the air pollution, the picture is therefore mixed. Since air pollution mostly results from stationary sources (industry, power generation etc.) and from transport, it is most problematic in urban conglomerations. The cities with the most significant air pollution problems tend to be those with the highest population concentration and with industrial complexes close by. These include Tel Aviv, Jerusalem, and Haifa. For example, in 2008 concentrations of PM2.5 in five large cities (Haifa, Hadrea, Ashkelon, Ashdod and Gush Dan metropolitan) were 133-151% higher than the annual standard set by the Ministry of Environmental Protection, and up to 193% higher near central transportation routes.12

Standards for fine particles were exceeded in all of Israel's monitoring stations in 2008; however PM10-emissions from point sources (power generation and industry) have decreased in 2007-2009. Sulphur dioxide emissions have seen a downward trend in recent years, mostly due to improved fuel quality in power plants, industry and transport, and due to one major power plant (Ashdod) switching to natural gas. Also, other air pollutants from power generation have decreased markedly, both in terms of absolute pollution loads, and even more so in term of specific emissions per MWh of electricity produced (Ministry of Environmental Protection 2010a).

12 Ministry of Environmental Protection's annual report on monitoring air quality in Israel: http://www.sviva.gov.il/Enviroment/Static/Binaries/ModulKvatzim/P0531_1.pdf

Air emissions from transport, including nitrous oxide, have been decreasing since 2000, despite a 30% growth in kilometres travelled in the same period. For instance, emissions of carbon monoxide, nitrogen oxides, hydrocarbons and particulate matter from transportation sources all fell by by 40%-45%. However in 2008 annual loads were still exceeding the standards in all monitoring stations in Israel (Ministry of Environmental Protection 2010a). Lead emissions from gasoline have been virtually eliminated over the last decade through the use of unleaded fuels.

Industrial air pollution is particularly problematic in the industrial hotspots – such as the Haifa Bay area in the North and Ramat Hovav in the South. To counter these trends, Israel is implementing the same rules and procedures foreseen under the EU Directive for Integrated Pollution Prevention and Control (IPPC), including the obligation for firms to apply the best available techniques (BAT). Other measures include and the promotion of energy efficiency and renewable energy, which also contribute towards Israel's effort at limiting greenhouse gas emissions.

Table 3.1 presents the trends in air pollution emissions in Israel for the 2000 – 2009 period, marking a downward trend for all pollutants except carbon dioxide (CO_2) and non-methane volatile organic compounds (NMVOC). For most other pollutants, marked reductions (in excess of 5% per year on average) have been achieved during the last decade.

Table 3.1: Trends in air pollution in Israel, from fuel combustion only 2000 - 2009

Air pollutant	Annual growth rate 2000 - 2009
Carbon dioxide (CO2)	0.66%
Carbon monoxide (CO)	-6.88%
Sulphur oxides (SO_X)	-7.62%
Nitrogen oxides (NO_X)	-2.17%
Hydrocarbons (HC)	-5.54%
NMVOC	0.79%
Suspended Particulate Matter (SPM)	-5.87%
Lead (Pb) from gasoline	-22.93%
Average (unweighted arithmetic)	-4.65%

Source: Central Bureau of Statistics Israel

3.2.2 Potential environmental improvements

The 2020 baseline level of emissions for each pollutant is simulated on the basis of the assumption that emissions follow the same trends as over the decade to 2009. There exist no published targets for air quality in Israel that simulate WHO limit values or that attempt to replicate the values implied by conformity to EU Air Quality (AQ) Directives, relative to a 2020 baseline. Consequently, to establish targets, we adopt reductions from the 2020 baseline that have typically been required in countries adopting the EU AQ Framework

Directive. In the case of air quality, a 50% intensification (reduction) in the current rate of change is assumed. The baseline and target data are presented in Table 3.2.

Table 3.2: Emissions for baseline scenario and target compliance scenario in 2020

Pollutant 13	**Emissions 2008 (million tons)**	**Baseline Emissions 2020 (million tons)**	**Baseline assumptions on decrease rate[14]**	**Target Emissions 2020 (million tons)**	**Target compliance assumptions on decrease rate**
NH3	29	15	Based on average annual reduction for all air pollutant emissions, i.e. **5.3%** per year	11	Based on average annual reduction of **8%**
NMVOC	254	279	Based on average annual increase rate for NMVOC, i.e. **0.8%**	188	Based on average annual reduction of **2.5%15**
NOx	197	149	Based on average annual reduction of **2.2%**	130	Based on average annual reduction of **3.4%**
PM	14	7	Based on average annual reduction for suspended PM, i.e. **5.3%**	5	Based on average annual reduction of **8%**
SOx	184	96	Based on average annual reduction for SOx, i.e **5.2%**	68	Based on average annual reduction of **7.9%**

The environmental improvements are the difference in total emissions between baseline and target compliance scenarios in 2020. The environmental improvements for each of the six pollutants are presented in Table 3.3.

13 Data for NOx and SOx is from Israel's Central Bureau of statistics: http://www1.cbs.gov.il/shnaton61/st27_03.pdf . Data for other pollutants is complemented by EDGAR Database (see disclaimer above).
14 Average annual decrease rate was calculated according to 2000-2009 data, unless mentioned otherwise.
15 Based on annual reduction rate for EU-27 between 1990-2008: http://www.eea.europa.eu/data-and-maps/indicators/eea-32-non-methane-volatile-1/assessment

Table 3.3: Environmental Improvements, expressed in difference of total emissions between baseline and target compliance scenario in 2020

Pollutant	Environmental Improvements (million tons)
NH3	4
NMVOC	91
NOx	19
PM	2
SOx	28

The estimated health benefits of the emission reductions will be expressed in physical and monetary terms. The benefits from reduced crop damage and material soiling are included in the overall estimates of monetary benefits resulting from the emission reductions.

3.2.3 Qualitative assessment of the benefits of improving ambient air quality

Environmental benefits

Ecosystems: SO_2 and NO_x lead to acidification, which damages forests, lakes and rivers and thus has a major impact on the health of ecosystems and biodiversity in general. In some cases, acid deposition may have exceeded critical loads, causing irreparable damage to ecosystems. High concentrations of lead also adversely affected domestic animals, wildlife and aquatic life.

Crop damage: SO_2 and NO_x also have damaging effects on crops through the degradation of chlorophyll. Reducing the release of these gases into the atmosphere will bring tangible benefits to agriculture, agro-forestry and fisheries industries.

Vegetation: Ozone has an impact on vegetation at concentrations not far above ambient background levels. It can cause damage to natural ecosystems and to crops. The effects of ground-level ozone on long-lived species such as trees are believed to add up over many years so that forests or ecosystems can be affected in the long term. For example, ozone can adversely impact ecological functions such as water movement, mineral nutrient cycling, and habitats for various animal and plant species. Ground-level ozone can kill or damage leaves so that they fall off the plants too soon or become spotted or brown.

These various impacts will be reduced as a consequence of air pollution emission reductions, as summarised in Table 3.4.

Table 3.4: Environmental benefits of reduced air pollution

Environmental benefits	Description
Ecosystem condition improvements	– Reduced climate change impacts on impacts from lower SO_2 and NO_x emissions – Reduced damage to vegetation from low level ozone

Source: Authors' own compilation

Health benefits

The health consequences of exposure to air pollution are considerable and span a wide range of impact pathways of different severeness – from respiratory track sensitisation and irritation, coughing and bronchitis to an increased risk of heart disease and lung cancer.

Vulnerable groups include infants, the elderly, and those suffering from chronic respiratory conditions including asthma, bronchitis, or emphysema.

Many of the health effects provoked by air pollution, such as bronchitis, tightness in the chest, and wheezing, are acute, or short term. Other effects are chronic, such as lung cancer and cardiopulmonary diseases. These health effects entail a significant economic cost including the cost to the economy (restricted activity days, reduced productivity) and the costs to national health services. Both acute and chronic effects and can be limited or reversed if air pollution exposures decline as a result of emission reductions.

Table 3.5: Health benefits of reduced air pollution

Health benefits	Description
Lower incidence of acute and chronic disease	– Reductions in SO_2 imply lower incidence of cardiovascular and respiratory disease – Reductions in PM_{10} concentrations imply lower emergency-room visits due to asthma, and also hospital admissions on the grounds of respiratory diseases – Reductions in NO_x, when combined with ozone, organic compounds, particulates and sunlight result in corresponding reductions of photochemical 'smog' that otherwise cause respiratory impairment, irritation of the eyes and mucous membrane, with asthma patients and young children.

Source: Authors' own compilation

Social benefits

There are manifold social benefits of reduced air pollution. They relate to improvements to improved quality of life (e.g. through reduced health risks, improved conditions for outdoor activities in urban areas), the increased amenity value of improved landscapes and nature, and reduced damage to cultural heritage such as historic building surfaces in city centres.
These benefits are described inTable 3.6:

Table 3.6: Social benefits of reduced air pollution

Social benefits	Description
Improved quality of life	– Reduced health risks – Improved conditions for outdoor activities (sports and leisure, recreation), esp. in urban areas – Increased visibility in urban areas, as a result of reduced photochemical smog – Transport emissions are a major contributor to poor urban air quality and compliance with them is one component of any comprehensive social improvement policy.
Increased amenity value of improved landscapes, nature and air quality	– Reduced air pollution improves the health of ecosystems, improving the conditions for recreational activities and enjoyment of nature.
Reduced damage to cultural heritage, including among other things, historic building surfaces in city centres.	– Black smoke from traffic is a prime cause of discolouring of buildings, including public buildings of important social cultural value, such as monuments, historic buildings, churches, museums. This issue is of particular concern in Jerusalem with its unique concentration of historic buildings, all finished in cream-coloured limestone, and the "white city" of Tel Aviv. – Exposure of building materials to SO_2 and NO_x deposition (acidification) has corroding effects on the materials, resulting in premature ageing. – Reduced blackening and erosion of surfaces (from SO_x and NO_x emissions from traffic fuel use), can improve the social appreciation and use of city centres and cultural heritage.

Source: Authors' own compilation

Informing and involving the public in environmental and health matters not only helps to build trust within communities and between communities and government (and potentially industry) and can improve social cohesion. More routine information requirements not only specify information provision to the public in general, but also to a range of listed interested groups. In many countries information supply to the public is poor, especially for socially excluded groups.

Economic benefits

A wide range of environmental technologies and new 'cleaner' primary inputs, are required to bring about cleaner production processes that will be needed to meet the standards in these directives. These industries will benefit economically from increased sales as will society from increased employment in these sectors. There will also be potential benefits derived from improved tourism in areas that were previously damaged by acid rain.

Table 3.7: Economic benefits of reduced air pollution

Economic benefits	Description
"Green technology" industries	– Increase in demand for products and processes that result in lower air pollution emissions, and subsequent employment opportunities
Increased visits to improved landscapes, natural and urban areas	– Increase in tourism and associated expenditures in local areas – Increased business opportunities for outdoor activities in urban areas (sport and leisure, street cafés etc.)
Lower material cleaning costs	– Reduced cost for cleaning building surfaces soiled by particulates
Crop damage reductions	– Reduced crop damage from lower SO_2 and NO_x emissions – Reduced crop damage from low level ozone
Lower health expenditure	– Reduced costs of morbidity and mortality attributed to air pollution (reduced treatment costs, less impacts on productivity)

Source: Authors' own compilation

3.2.4 Quantitative assessment of the benefits of improving ambient air quality

The physical and monetary estimates of the benefits of air quality improvements that are presented in this section are derived from an integrated atmospheric dispersion and exposure assessment model co-ordinated by the central project team. The model – an integrated software tool called EcoSense - assesses impacts resulting from the exposure to airborne pollutants, namely impacts on human health, crops, building materials and ecosystems. In the current exercise, it includes the emissions of 'classical' pollutants SO_2, NO_x, primary particulates, (fine and coarse), NMVOC and NH_3.

The model and overall method are documented more fully in the Benefit Assessment Manual (Bassi et al. 2011) for Policymakers which has been developed under this project.

The air quality model produces an output in terms of Euro per tonne of pollutant. Since we were unable to apply the model directly in Israel with the resources available, these unit values (Euro per tonne of pollutant) for individual pollutants were transferred from Tunisia which was judged to have broadly similar conditions (population density, geography etc). Clearly this transfer introduces an additional uncertainty in the measurement of total benefits.16

The unit value per tonne of pollutant was then multiplied by the emissions reductions projected for each pollutant, as identified above, to generate estimates of total benefits per pollutant. The benefits for all pollutants were then summed to generate estimates of total air quality benefits for 2020, assuming the reductions from projected baseline emissions stated in Table 3.3. The aggregate benefits were than apportioned to the different impact

16 The unit values for the estimation of air quality damage costs are influenced both by the geographical and climatic conditions, and by the socioeconomic conditions in the country. While the climatic and geographic conditions are broadly comparable between Tunisia and Israel, the socioeconomic condition of Israel is more comparable to some EU countries. In lack of resources to model the specific situation of Israel, it was not possible to resolve this problem in the frame of this study. The fact that socioeconomic development is significantly higher in Israel than it is in Tunisia (with a per-capita GDP about three times higher) means that the unit values for Tunisia are likely to be an understatement of the real impact in Israel.

categories, according to the outputs of the air quality model. Typical percentage splits were: mortality (70%); morbidity (20%); crops (6%) and materials (4%).

As a sensitivity exercise, we also provide indicative estimates of potential transboundary effects. These are derived again through a transfer procedure, that identifies trans-boundary effects for each pollutant as percentages of total damages from existing modelling outputs in countries that are judged to have similar relevant characteristics e.g. with respect to the wind directions and strengths, the size of the country, the existence of a large number of neighbour countries or a long coastline, and the density of the potentially affected population. The method is described more fully in the Benefit Assessment Manual (Bassi et al. 2011) for Policymakers which has been developed under this project.

Health benefits

The benefits of reduced air pollution can be quantified for the following pollutants: Ammonia (NH_3), particulate matter (coarse and fine) (PM), nitrogen oxides (NOx), sulphur dioxide (SO_2) and non-methane volatile organic compounds (NMVOCs).

The mortality and morbidity benefits of the pollution emission reductions in 2020 assumed above for Israel are shown in Table 3.8. Morbidity impacts are of a disparate nature and so cannot be expressed as a common unit. However, for illustration, the morbidity impacts are presented as equivalent number of cases of chronic bronchitis avoided. We derive the physical numbers of health impacts by dividing the derived total benefits for morbidity and mortality by their respective unit values.

Table 3.8: Physical premature mortality and morbidity impacts avoided in year 2020

Total	
Deaths	*Cases*
68	130

Economic benefits

In the case of materials, the impact quantified is the premature ageing of building materials as a consequence of exposure to SO_2 deposition. Thus, the exposed surface area to SO_2 would age at a slower rate if emission were reduced. The economic benefits are therefore estimated by multiplying the changes in aggregate damage to the surface areas by the cost of cleaning these surface areas.

Crop damage is measured primarily by the change in yield that results from the change in pollutant concentrations in the air. Thus, with knowledge of the geographical distribution of crop plantations within a country, the acreage of a given crop affected by a change in pollutant concentration can be estimated and the percentage yield change can be derived. The modelling then multiplies this aggregate yield change by the market price of the crops. As no sufficiently detailed data was available to make this estimate, the calculation resorts to average benefit values, ignoring the spatial distribution of crops and pollutant concentrations.

Additional evidence from national studies

In 2003, a study was published presenting a Comparative Assessment of Air Pollution Public Health Risk in two Israeli Metropolitan areas, Tel Aviv and Ashdod, for the years 1995-1999. The two areas are home to some 1.2 million inhabitants, about 19% of the Israeli population at the time (1999).17 The study, a coordinated project of the Ministry of Environmental Protection, US Environmental Protection Agency (EPA) and Israel Union for Environmental Defense (IUED), revealed that air pollution is a significant cause of morbidity and mortality rates in the researched areas.

In both metropolitans, mortality rates of population above 30 years old which is attributed to long-term exposure to $PM_{2.5}$, was assessed at 720 death cases per year, which correspond to 8% of the total mortality in these regions. Mortality rates of the total population due to short term exposure to PM and O_3 was assessed at 290-365 cases per year in both regions, which correspond to about 4% of the total mortality in these regions (see Table 3.9). In total, this amounts to some 1,010 – 1,085 death cases per year attributed to anthropogenic air pollution (Ministry of the Environmental Protection, 2003, p. D2).

Morbidity rates were also assessed, in terms hospitalizations of respiratory and cardiovascular diseases attributed to the exposure of anthropogenic pollutants. Morbidity rates for population over 65 due to exposure of PM_{10} and O_3, were assessed at 2,480 – 3,320 cases per year in both regions. Morbidity rates for all population due to exposure of $PM_{2.5}$ and SO_2 were assessed at 1,520 – 1,680 cases per year (see Table 3.9 below). In total, this amounts to some 4,000 – 5,000 morbidity cases per year (Ministry of the Environmental Protection, 2003, p. D3)

In addition, a significant portion of respiratory symptoms in children is attributed to anthropogenic pollutants. In Tel Aviv, it was estimated that about 20% (28,000 cases) of respiratory symptoms in children are attributed to exposure to PM_{10} and about 14% (20,000 cases) are attributed to exposure to $PM_{2.5}$. Similar rates were observed in Ashdod, with 20% and 15% of respiratory symptoms attributed to PM_{10} and $PM_{2.5}$ respectively (Ministry of the Environmental Protection, 2003, p. D4).

17 Source: Central Bureau of Statistics, http://www.cbs.gov.il/www/yarhon/b1_e.htm

Table 3.9: Mortality and morbidity rates from anthropogenic air pollution in Metropolitan Tel Aviv and Metropolitan Ashdod, annual averages for 1995 - 1999

Health effect	Pollutant	Pop. Assessed (age)	Tel Aviv Metropolitan	Ashdod Metropolitan	Total
Mortality	$PM_{2.5}$ (long term exposure)	>30	620	100	**720**
	$PM_{2.5,\ 10}$ (short term exposure)	All	180 - 230	30	**290 - 365**
	O_3 (short term exposure)	All	70 - 90	10 - 15	
Morbidity (hospitalizations)	O_3	>65	830 - 1,120	80 - 180	**2,480 - 3,320**
	PM_{10}	>65	1,570 - 2,020	NA	
	$PM_{2.5}$	All	380	80	**1,520 - 1,680**
	SO_2	All	1,000	60-220	
Total population			1,000,000	200,000	1,200,000

Source: Ministry of the Environmental Protection, 2003[18]

The estimations were carried out for the impacts of air pollution in Metropolitan Tel Aviv and Metropolitan Ashdod, home to some 1.2 million inhabitants or some 19% of the Israeli population at the time. Per 100,000 inhabitants, the study found 84 – 90 mortalities, and 333 – 416 cases of morbidity. It is debatable to what extent these figures are representative of the current-day situation in Israel. When interpreting the data, it should be kept in mind that the study was conducted in 1995 – 1999, when emissions and concentrations of most air pollutants peaked in Israel. Since then, both emissions and concentrations have been reduced considerably: for PM, one of the pollutants considered in the study, they have dropped by about 45% between 2000 and 2009, and by two thirds between 1995 and 2009. Also, the largest share of the impacts in the original study was observed in Tel Aviv, which features the highest population density in Israel. This means that for the same amount of emissions, more people will be exposed to the effects of air pollution than in other parts of the country. Still, the study underlines that the health impacts of air pollution are considerable, as are the benefits of reducing air pollution.

3.2.5 Monetary assessment of the benefits of improving ambient air quality

Health benefits – countrywide assessment

The monetary values of the benefits from reduced air pollution - as assumed above - are presented in summary form in Table 3.10. Values presented are in million Euros (2008 prices), and relate to the year 2020. Underlying unit values, unadjusted for PPP, are listed in the Benefit Assessment Manual (Bassi et al. 2011) for Policymakers which has been developed under this project.

The benefits are valued at EUR 1.9 million or NIS 10m per avoided fatality and EUR 400,000 or NIS 2,100,000 per avoided case of chronic bronchitis-equivalent. All figures are in 2008

18 All data refers to annual averages in this range (albeit not necessarily representing all of the years). Data also varied across the respective years, which is expressed in the ranges given in the table.

purchasing power parity (PPP) adjusted Euros and 2008 NIS. Table 3.10 shows that the total domestic benefits to Israel are equal to EUR 27 million each year, equivalent to 0.013% of annual GDP. These domestic benefits are understood as benefits which accrue to Israel as a result of its own emission reductions.

Table 3.10: Annual compliance benefits of improved air quality – 2020

	Euro PPP (millions)	NIS (millions)	% of GDP
Mortality	132	693	0.062
Morbidity	40	208	0.019
Crop	11	59	0.005
Material	6	30	0.003
Total Domestic	188	990	0.089

In additional sensitivity analysis we made initial estimates of the possible extent of the total transboundary benefits - the benefits outside Israel – that may result from the air pollution emission reductions in Israel. We found that these benefits can be substantial, and should be considered in assessments of regional air quality strategies. However, for the purposes of this benefit assessment and with the means available, it was not possible to deliver robust and reliable estimates of the transboundary effects.

A further sensitivity analysis is to identify the benefits that result if the assumptions relating to projected future emissions are consistent with those used across the other country studies. This assumption is that pollutant emissions increase on a linear proportionate basis to the average annual GDP growth rate given in World Bank (2010)19, such that a 1% increase in GDP leads to a 1% increase in pollutant emission levels. Adopting this assumption, the benefits are estimated to be equivalent to 0.6% of GDP in 2020. This sensitivity serves to illustrate the importance of the assumptions adopted.

Additional evidence from national Studies

1. Assessing the monetary benefits from reducing emissions in the electricity sector

Electricity generation is a major source of air pollution in Israel. In 2008, electricity generation contributed to 83%, 61% and 54% of SO_x, NO_x and PM pollutants respectively.20 In 2008, the Ministry of Environmental Protection published a study that assessed the external costs of air pollution caused by electricity generation, in order to set adequate economic tools for internalizing these externalities. Table 3.11 presents the unit cost estimates of externalities from electricity generation for the four air pollutants that were assessed in the study.

19 World Bank 2010. World Development Indicators.
20 This accounts only for electricity generated from fossil fuel combustion, which in 2008 accounted for nearly 95% of final energy consumption in Israel. Source: Central Bureau of Statistics: http://www.cbs.gov.il/shnaton61/st27_05.pdf.

Table 3.11: External costs of air pollution for several pollutants

Pollutant	EUR/ton
SO_2	4,947
NOx	2,865
$PM_{2.5}$	9,905
PM_{10}	7,061

Source: Kedmi et al., 2008

Based on the results of this study, the authors estimated the monetary benefits from the environmental improvements in the electricity sector. These environmental improvements were calculated in the following way: based on emission data for 2008, and based on the projected reduction rates for baseline and target compliance scenarios (Table 3.2), we assessed total emissions from the electricity sector for baseline scenario and for target compliance scenario in 2020. The environmental improvements are the difference between emissions in baseline and target scenarios, and these could be translated into monetary benefits according to the costs of pollutants (Table 3.11). In sum, total monetary benefits from emission reductions in the electricity sector amount to some EUR 136 million, or 0.06% of the GDP in 2020 (Table 3.12).

Table 3.12: Potential monetary benefits from emission reductions in the electricity sector

Pollutant	Emissons 2008 (tons)	Emissions Baseline 2020 (tons)	Emissions Target 2020 (tons)	Env. Improvements (tons)	Price €/ton (EUR)	Monetary benefits (EUR)
SOx	124.344	48.047	28.989	19.058	4.947	94.280.924
NOx	116.063	89.235	78.073	11.161	2.865	31.977.687
PM	7.789	3.768	2.576	1.192	8.483	10.110.770
Total						**136.369.381**

Source: Central Bureau of Statistics: http://www.cbs.gov.il/shnaton61/st27_05.pdf, own calculations
Note: Unit costs for SO_2 emissions were applied to SO_x emissions, as data on SO_2 emissions was not available. For PM, the numerical average for the unit costs of $PM_{2.5}$ and PM_{10} was applied, as the PM emission data did not distinguish between different size classes for particulate matter emissions.

2. Assessing the external costs of air pollution from transportation

In 2008, an inter-ministerial committee on green taxation published a report on economic tools for internalizing the externalities of private car-use in Israel. The report included results of a study conducted in 2006, for evaluating the economic externalities from transportation in Israel. According to this study, the external cost of air pollution is estimated at 2,08% of GDP, which in 2006 corresponded to EUR 2,420 million (Economics and Planning Division, Israel Tax Authority, 2008). According to this estimate, air pollution was the single largest factor in the external costs of transport, accounting for about a third of the total external costs – and well above the external costs in the form of noise, accidents, or road construction. While the study shows that the total external costs of transport-induced air pollution are significant, it does not provide an estimate how much of these external costs could effectively be reduced through policy action.

3. Willingness to Pay for improved air quality in Metropolitan Haifa

The Haifa metropolitan has one of the highest ambient air pollution levels in Israel, with exceptionally high levels of sulphur dioxide and total suspended particulates. The high levels of air pollution are mainly caused by a number of highly polluting industries located in the Haifa bay, as well as air pollution from transportation. The high levels of air pollution in Haifa are considered to be a cause of the high rates of several health related problems, such as: coughing, wheezing, sputum emission, shortness of breath, and diseases such as asthma, bronchitis, pneumonia, and other lower respiratory tract diseases.

Schechter and Kim (1991) conducted a study that measured residents' willingness to pay (WTP) for improved air quality in metropolitan Haifa, using two approaches: a) an indirect valuation approach for modelling the effect of changes in air quality on demand for housing and medical services; and b) a direct approach which applies the contingent valuation methodology in surveying households.

Using the indirect method, household willingness to pay to avoid a 50 percent deterioration in air quality was valued at NIS_{1986} 73.25 (EUR 396 in 2008 prices), and NIS_{1986} 9.81 (EUR_{2008} 53) to obtain a 50 percent improvement. Using the direct approach (contingent valuation), the annual household willingness to pay for a 50 percent improvement ranged from NIS_{1986} 37.90 to 47.20 (EUR_{2008} 205 to 255), and willingness to pay for to avoiding a 50 percent deterioration ranged from NIS_{1986} 26 to 42.70 (EUR_{2008} 141 to 231) (Shechter & Kim, 1991). However, these values have to be interpreted with some caution, as the air pollution situation has improved considerably since the time of the study.21

21 For the conversion of NIS1986 to Euro2008: The study used NIS1986 prices and we adjusted these to NIS2008, using a 5.26 conversion factor (1986-2008 inflation rate in Israel was 526%: http://www.inflation.eu/inflation-rates/israel/historic-inflation/cpi-inflation-israel.aspx). In 2008, the EU:NIS ratio was 1:5.25, and thus 1 NIS1986 prices roughly equals 1 Euro in 2008 prices.

4 BENEFITS OF IMPROVING WATER RELATED CONDITIONS

4.1 Introduction to water quality issues

Due to its arid environment, scarcity of water is the overwhelming environmental concern in Israel, and has been ever since the state was founded. Unlike other environmental issues, access to water is also a highly politicised issue in the area: in fact, the water issue is as much an issue of governing access to a valuable strategic resource as it is an environmental policy matter.

Pressures on water availability include population growth, growth in agricultural and industrial production, as well as general economic development. These pressures continue to put a strain on the limited water resources available, both in terms of water quality and quantity. In recent years, the existing scarcity problem has been further exacerbated by repeated drought cycles, resulting in an overuse of natural water resources beyond their natural recharge (Ministry of Environmental Protection (MoEP) 2008, p. 25).

Freshwater consumption for all uses (agriculture, industry and domestic consumption) decreased from 1.5 million cubic metres (MCM) in 2000 to 1.4 MCM in 2007. Most of the freshwater consumption now goes to the domestic sector, and no longer to agriculture: the share of agriculture in total freshwater consumption decreased from 38% in 2000 to 27% in 2007, with a corresponding (relative) increase of domestic consumption (from 34% in 2000 to 37% in 2008) (MoEP, 2010a).22

Water scarcity has been a fact of life ever since the state of Israel was founded; furthermore, the available water resources are distributed unevenly throughout the country. This has resulted in a comprehensive set of advanced regulations, standards, administrative tools and economic incentives that govern the water sector, in order to use the available water resources as efficiently as possible. As a consequence, Israeli technologies for water management and treatment are among the most advanced worldwide, including seawater desalination, wastewater treatment producing recycled water suitable for irrigation, and efficient irrigation techniques in agriculture.

Up until the 1990s, the main focus of Israel's water policies was on supply management, integrating Lake Kinneret (the Sea of Galilee) as the most important surface water source, with two major groundwater sources, the coastal and the mountain aquifer. Water supply has since been extended to include two additional sources: desalinated seawater and recycled treated sewage water.

At the same time, it has become clear that the increasing water demand cannot be met by supply-side measures, especially since some existing water sources show signs of degradation due to over-use. This has given rise to a more recent set of demand-side policies, aimed at increasing the efficiency of water use. These include economic tools, incentive mechanisms such as multi-level tariffs, regulations on water use and educational measures to support water saving.

22 These figures exclude the share of non-potable water used in agriculture.

Increased efficiency in water use is a particular challenge for agriculture, which is one of the main water uses. In light of growing domestic and industrial demand, allocations of freshwater to agriculture have been declining. Due to the use of new and efficient irrigation technologies and recycling of wastewater, the falling freshwater allocation has been compensated while maintaining agricultural production at the same level. For instance, less thanhalf of the water currently used for irrigation is high quality fresh water, the remainder being recycled water and other sources of lower quality water (MoEP, 2008, p. 25).

A downside of the remarkable efficiency gain in water use is that Israel manages to use practically all of its renewable water sources (be it for domestic consumption, agriculture or industry). This means that hardly any water is left for environmental uses, with adverse impacts on ecosystems that depend on freshwater such as wetlands, and the flora and fauna that depend on them.

As regards wastewater treatment, high standards have been achieved. From the 500 MCM of wastewater discharged annually, 460 MCM are treated. Of this 31% (155 MCM) were treated to tertiary level and 55% (275 MCM) were treated to secondary level (MoEP, 2010c) 82% of the total municipal wastewater are now reused for irrigation purposes, which is the highest figure anywhere in the world (MoEP, 2010a).

This section will cover the following aspects of water quality:

- Man-made infrastructures
    - Connection to safe drinking water, sanitation and hygiene
    - Level of waste water treatment
- Natural assets
    - Surface water quality
    - Water resource use

4.2 Benefits from improved connection to safe drinking water, sanitation and hygiene

4.2.1 Introduction

This section assesses the benefits of improvements in three household water, sanitation and hygiene parameters:

- connection to a reliable and safe piped drinking water supply on premises;
- connection to a sewage network; and
- improved domestic and personal hygiene practices whenever such practices are inadequate for health protection.

Benefits of improved wastewater treatment and improved surface water quality are assessed in other sections.

The section specifies a set of targets for the three parameters to be achieved by 2020, improvements resulting from reaching the targets are estimated at the national level, benefits of these improvements are discussed qualitatively, and some of the benefits are quantitatively assessed. The quantitative assessment of the three parameters is undertaken jointly as many households will benefit from improvement in more than one parameter).

Piped water supply to premises (yard/dwelling) and connection to a sewage network are seen in most countries as the best opportunity to provide households with reliable and safe drinking water and ensure safe and hygienic removal of human excreta and other wastewater pollutants from the household and community environment.

Piped water supply from a central water intake and distribution outlet allows for treatment of water and monitoring of water quality. If source water is generally of good quality and the piped distribution networks are well-functioning, such a water supply system has the potential to provide safe drinking water with minimal risk of disease.

Connection to a sewage network provides the added opportunity of minimizing pollution of water and land resources through central treatment of wastewater.

Good hygiene practices are also of utmost important for disease prevention. The single most important hygiene practice is hand washing with soap at critical junctures (after defecation/going to toilet or cleaning a child's faeces, before cooking and eating, and before feeding a child), found in many countries to reduce incidence of diarrhoea by as much as 45% (Curtis and Cairncross 2003; Fewtrell et al 2005).

4.2.2 Current state of drinking water quality, sanitation and hygiene

As can be seen in Table 4.1, practically 100% of the population in Israel have piped water supply on premises. Further, practically 100 % of the population have flush/pour flush toilets connected to a sewage network system.

Table 4.1: Household access to drinking water and sanitation facilities, % of population 2008

Drinking water	Urban	Rural	Total
Piped water on premises	100%	98%	100%
Other improved water sources	0%	2%	0%
Unimproved water sources	0%	0%	0%
Sanitation			
Toilet connected to sewage network	100%	100%	100%
Other improved sanitation	0%	0%	0%
Unimproved sanitation*	0%	0%	0%
of which: Open defecation	0%	0%	0%

* including toilet facilities shared by households

Source: Produced from WHO/ UNICEF (2010a,b). Note: The MDG data for Israel has been adjusted by the responsible specialized agencies to ensure international comparability, in compliance with their shared mandate to assess progress towards the MDGs at the regional and global levels.

Despite these statistics, reports such as the Goldberg Report (Golberg Committe, 2008), the Sikkuy Report (Belikof et al, 2005), the annual report of IUED (2010) and the yearly report of the Association for Civil Rights in Israel (2009), state that certain "unrecognized" Bedouin villages in the Negev and as well as parts of the inhabitants of East Jerusalem do not have piped water supply on premises or flush/pour flush toilets connected to a sewage network system.

The Goldberg Report (Goldberg Committee, 2008), based on a statement from the Ministry of Interior, estimates that in 2007 62,487 people in Israel lived in "unrecognized" Bedouin settlements, which lack basic infrastructure such as access to drinking water and connection to wastewater. The yearly report of the Association for Civil Rights in Israel (2009) even estimates that 80,000 civilians lived in 'unrecognized' settlements without basic services and infrastructure in 2007. The Sikkuy Report states that, in 2004, there were no sewage networks in "unrecognized" Bedouin settlements, while 60% of the households in 'unrecognized' settlements were connected to the public water network, 39% were connected privately and 0.5% were not connected at all. In East Jerusalem it is estimated that 160,000 people of the 260,522 inhabitants of East Jerusalem lack a suitable or legal connection to the water network (ACRI, 2009).23 IUED (2010) estimates that in 2007 over 500,000 people, in around 150 settlements in Israel were not connected to a sewage network. These include around 185,000 people in Jerusalem, 19,000 residents of Baka al Garbia, an Arab village, in northern Sharon (Table 4.2).24

Table 4.2: The 10 largest polluters of crude wastewater in Israel in 2007

	Settlement	**Amount of sewage per year (1,000 m^3)**	**Size of population not connected to sewage network**	**Discharge of Wastewater**
1	Jerusalem	10,047	183,332	Crude wastewater flows into the Kidron valley
2	Baka al Garbia	1,332	19,20025	Crude wastewater flows into the Hadera river
3	Ariel	1,029	16,432	Crude and partially treated wastewater flows into Shilo river basin (part of the Yarkon basin)
4	Savyon	775	3,313	Domestic pit hole
5	Lakiya	732	8,437	Domestic pit hole
6	Ar'ara	662	12,775	Domestic pit hole

23 As East Jerusalem has been annexed to Israel and thus is under Israeli administration, East Jerusalem is considered part of Israel in this report for the sake of this benefit assessment. This report does not intend to provide political statements on territorial issues.

24 Please note that the numbers illustrated in this paragraph as well as the values in Table 3.2. are contested – however, no other data is available.

25 According to Israel Water Authority, the size of the unconnected population has gone down to 6,000 (Personal Communication, Head of Planning Division, Israel Water Authority, 2011).

	Settlement	Amount of sewage per year (1,000 m^3)	Size of population not connected to sewage network	Discharge of Wastewater
7	Tayibe	62826	33,858	Domestic pit hole
8	Hura	524	9,985	Domestic pit hole
9	Kiryat Arba	494	6,958	Crude wastewater flows into the Hevron valley

Source: IUED, 2010

It should be noted, however, that solutions for treating some of the above sewage flows are being implemented. According to Israel Water Authority, these include:27

- Baka al Garbia – sewage receives tertiary treatment
- Ariel – a trunk line is being laid down for connecting Ariel's sewage with the Shafdan (Israel's central sewage treatment plant).
- Savyon – a sewer system is currently being installed.
- Lakiya – some neighbourhoods were connected to a sewer system which receives tertiary treatment.
- Ar'ara - sewage is being treated in an activated sludge sewage treatment plant.
- Hura – sewage is treated in a tertiary sewage treatment plant.

As a consequence of these contradicting data sources, the benefits are assessed for two scenarios:

- Scenario 1: 100% of the population has piped water on premises and is connected to the sewage network (WHO/UNICEF, 2010a,b).
- Scenario 2: 500,000 people are not connected to the sewage network, 240,000 people do not have piped water on premises (IUED, 2010; ACRI, 2009).28

4.2.3 Potential environmental improvements

Targets for which benefits are assessed in this study are:

Drinking water:

- Achieving 100% population connection (except in isolated rural areas) to reliable and safe piped water supply at household premises.
- Ensuring that the population currently having piped water supply continuously receives reliable and safe water at household premises.
- Providing plentiful and equally safe drinking water from other improved water sources in isolated rural areas.

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26 It is assumed that 50% of the water consumption of Tayibe turns into wastewater

27 Source: Personal Communication, Head of Planning Division, Israel Water Authority 2011.

28 It should be noted that a large share of the population without access to sewage network and piped water supply are residents of East Jerusalem. This report does not intend to take any position on the status of East Jerusalem, and mentioning East Jerusalem in this report should not be seen as evidence to the contrary. Still, the report does intend to raise awareness of the environmental and social damages caused by the lack of universal connection to piped drinking water and the connection to sewage networks, irrespective of the legal status and citizenship of the people affected.

Sewage connection:

- Achieving 100% population connection (except in isolated rural areas) to a sewage network system.
- Upgrading to flush toilet (with sewage connection) for households with dry toilet or no toilet).
- Providing improved sanitation to households currently without such facilities in isolated rural areas.

Hygiene:

- Improving hygiene practices especially ensuring good hand-washing with soap at critical junctures wherever such practices are currently inadequate for protection of health.

While a piped water supply and connection to a sewage network have many advantages, these systems are, however, not necessarily free from problems. Piped water can get contaminated in the distribution network before reaching the household, and sewage may seep into the environment from leaky and broken network pipes. Thus, in order to achieve the targets, existing piped water and sewage networks may need rehabilitation to minimize water supply contamination and cross-contamination from sewage networks. Proper functioning also requires continuous appropriate pressure in existing and new piped water networks for a reliable supply of water, and the minimisation of leakage (both from freshwater supply and sewage networks).

Status of hygiene practices is generally not available in most countries unless detailed studies/surveys have been undertaken. What is clear, however, is that substantial improvements in hygiene practices can be achieved in most countries in the world. As status of hygiene practices is not well known in Israel, the assessment in this study provides a benefit range of achieving the targets that at the lower end reflects an assumption that hygiene practices are generally adequate for protection of health and at the higher end reflects an assumption that practices can be substantially improved. In reality, benefits may be expected to be somewhere in between these two values.

Baseline to 2020

To estimate the number of beneficiaries and benefits of achieving the targets, the targets are compared to the percentage of the population currently with piped water supply on premises, connection to a sewage network system, and good hygiene practices adequate for health protection. As hygiene practices are not well known, a range of 67-100% with good hygiene practices is applied. Other baseline data are presented in Table 4.3. These data represent projections or a business-as-usual scenario as if no water, sanitation and hygiene interventions were undertaken to reach the targets.

Baseline assumptions:

- Birth rates are projected to decline by 5%.
- The diarrheal child mortality rate and diarrheal incidence rates are assumed to be constant.

- The child mortality rate from other infectious diseases is projected to decline by 1% per year.
- Average household size is assumed constant over the period to 2020.

Table 4.3: Baseline assumptions for drinking water, sanitation and hygiene, 2020

	2008 (actual or estimated)	2020 (projected or business-as-usual)
Population (million)	7.31	8.80
Birth rate (births per 1000 population)	21.5	20.4
Mortality rate from diarrhea among children < 5 years (deaths per 1000 live births)	0.0	0.0
Mortality rate from other infectious diseases among children < 5 years (deaths per 1000 live births)	0.8	0.7
Diarrhea (cases/year, children < 5 years)	1.5	1.5
Diarrhea (cases/year, population >= 5 years)	0.3	0.3
Household size	3.7	3.7

Source: Data for 2008 and population projections are from World Bank (2010) and WHO (2010). Household size is from 2004. Cases of diarrhoea are estimates from comparable countries.

As a result of migration, Israel's population has doubled several times since its founding, with the 1990s marking a decade with the highest percentage if immigration worldwide (in proportion to population size) (Schneider, 2008). However, these fluctuations in population growth are not included in the baseline assumptions, due to its unpredictable nature.

Improvements achieved by reaching the targets

The improvements from reaching the targets by 2020 are the difference between the specified targets and the baseline assumptions.

Improvements include:

- An additional 0-0.29 million people or 0-0.08 million households would have reliable and safe piped water to premises, and an additional 0-0.6 million people or 0-0.16 million households would have connection to a sewage network system (Table 4.4).29
- Potentially a large share of the 8.8 million projected population that already has piped water to premises would benefit from improvements in reliability and quality of water (so as to have safe water on premises) by improved central water treatment and rehabilitation and upgrading of existing water distribution networks.

29 The lower bound is based on scenario 1 (WHO/UNICEF, 2010a,b) and the upper bound on scenario 2 (IUED, 2010; ACRI, 2009) on piped water supply and sewage network connection, projected from 2008 to 2020.

- Depending on current hygiene practices, potential beneficiaries of hygiene promotion range from 0-2.9 million people (0-33% of the population) or 0-0.8 million households.

Table 4.4: Number of beneficiaries of reaching the targets, 2020

	Number of people (million)	Number of households (million)
Reliable and safe piped water supply to premises	0 - 0.29*	0 - 0.08*
Improvement in reliability and quality of water among those currently with piped water supply	0 - 8.8	0 - 2.4
Connection to sewage network	0 - 0.6*	0 - 0.16*
Improved hygiene practices	0 – 2.9	0 – 0.8

Source: Estimates by the authors.
*lower bound is based on scenario 1 (WHO/UNICEF, 2010a,b) and the upper bound on scenario 2 (IUED, 2010; ACRI, 2009)

4.2.4 Qualitative assessment of the benefits of improving drinking water quality, sanitation and hygiene

Provision of reliable and safe piped drinking water, connection to a sewage network system (and flush toilet for those with dry toilet or no toilet), and practice of good hygiene (personal, household and community) have many benefits including health, environmental, economic and social. A generic overview of these benefits is provided in Table 4.5. Some of these benefits (environmental, recreational, improved water resources) are discussed in the sections on Wastewater Treatment, Surface Water Quality, and Water Scarcity).

Table 4.5: Benefits of improved potable water supply, sanitation and hygiene practices

	Good quality piped water supply	**Connection to a sewage network system (and flush toilet for those with dry toilet or no toilet)**
Health benefits	• Good quality piped water supply, hygienic sanitation (flush toilets connected to sewage network) and good hygiene practices reduce the presence and transmission of pathogens, thus reduce the incidence of diarrhoea and other diseases (Fewtrell et al, 2005). • Reduced incidence of diarrhoea in early childhood contributes to improved nutritional status among children (World Bank, 2008). • Good hygiene practices (especially regular hand washing with soap) also reduce transmission of respiratory infections (Rabie and Curtis, 2006; Luby et al, 2005). • Reduced chemical, heavy metal, and other toxic substances contaminating drinking water reduce the incidence of associated diseases and health disorders.	
Environmental benefits	• Piped water connection and improved piped water quality do not lead to direct environmental benefits. • However, some benefits to habitats and water resources may accrue if water utilities press for protection or	• Sewage collection provides opportunity for proper treatment of wastewater which helps improve environmental quality including cleaner communities, cleaner urban and rural waterways (e.g., canals), cleaner rivers, lakes and coastal

	Good quality piped water supply	Connection to a sewage network system (and flush toilet for those with dry toilet or no toilet)
	restoration of water quality of raw water abstraction sources.	waters, and reduced pollution of land resources (see sections on Wastewater Treatment and Surface Water Quality).
Economic benefits	• Piped water connection with reliable and continuous good quality water reduces/ eliminates the need for: o household water storage tanks o spending time and money on household point-of-use treatment/ disinfection of water prior to drinking or on purchase of bottled water. • Good quality piped drinking water also: o reduces public and private health care expenditure o improves labor productivity and reduces work absenteeism. • Access to good quality water can also provide cost savings to industries and make them more competitive, especially those relating to the food and beverage processing. • Rehabilitation of existing piped water distribution networks (to improve water quality) reduces water losses and thus costs of providing potable water.	• The environmental benefits (see above) of sewage collection and proper treatment of wastewater can provide substantial recreational, tourism, and fishery benefits. • Good treatment of wastewater can also: o allow for wastewater reuse in agriculture o provide substantial cost savings in mobilizing and treating potable water, especially important in water scarce countries (see section on Water Scarcity).
Social benefits	1. Piped water connection with reliable and continuous good quality water supply provides increased convenience from having potable water available at premises. 2. Access to good quality piped water also improves the public's perceptions of utilities and the state providing good quality services.	1. Sewage connection (and hygienic toilet on premises for those currently without it) a. increases household convenience (no needs for emptying and maintaining sewage pits/septic tanks; reduced access time to toilet facility or place of defecation), b. and reduces odours and nuisance from preventing direct sewage discharge into the local environment.

Source: Authors' own compilation

4.2.5 Quantitative assessment of the benefits of improving drinking water quality, sanitation and hygiene

As many of the benefits of reliable and safe piped water supply and connection to a sewage network are difficult to quantify, the assessment in this study is limited to: 30

- reduced incidence of diarrheal disease and

30 The predefined variable of "reduced mortality from diarrheal disease" has been excluded from Israel's benefit assessment, as it is not applicable.

- reduced mortality from infectious diseases associated with improved nutritional status in young children from reduced incidence of diarrhoea.

Table 4.6 presents the expected reduction in annual incidence of diarrheal disease and diarrheal mortality from reaching the targets, distinguished by population groups in relation to their current status of water supply, sanitation (i.e. sewage connection), and hygiene practices. Among young children, these diarrheal disease reductions are expected to somewhat improve their nutritional status and thus reduce the risk of fatality from infectious diseases.31

Some clarification of these expected disease and mortality reductions are warranted. While groups 1-2 currently have piped drinking water supply, some households are likely to have sub-optimal water quality when connected to old, leaky networks and/or networks with fluctuating pressure and irregular continuity of supply, as water will be susceptible to contamination along the water distribution network even if water is well treated at central treatment plants. A 15% reduction in diarrheal disease and mortality is therefore expected on average for these population groups from improvement in reliability and quality piped water. For population groups 3-4, which currently do not have piped water supply, a 25% reduction in disease and mortality is expected from receiving reliable and safe piped water supply to premises and in greater quantities than from their current water sources. Connection to sewage network (and flush toilets for those currently without such toilets) for groups 2 and 4 reduces the risk of pathogen transmission and is expected to reduce disease and mortality by an incremental 20%. If there also is substantial scope for improvement in hygiene practices among any of these population groups, disease and mortality reduction is expected to be an additional 30%.32 However, the benefit assessment on improved connection to safe drinking water, sanitation and hygiene follows a predefined methodology. Recognizing that Israel, with its widespread hygiene practices, is an outlier when compared to other ENP countries, it is assumed that a hygiene improvement is an option for 0-33% instead of for 0-100% of the population. This results in a disease and mortality reduction of 0-10% in the population as a whole from hygiene improvements, instead of the predefined 30%.

Based on the current distribution of population water and sanitation coverage (considering the scenarios mentioned above), reaching the targets is estimated to reduce diarrheal disease and diarrheal mortality nationwide by 15-17% if the entire population has good hygiene practices adequate for health protection, and 25-27% if hygiene practices can generally be substantially improved among 1/3rd of the population. In actuality, disease and mortality reduction likely falls somewhere in between these two values, depending on current hygiene practices.

31 See World Bank (2008) for a discussion and quantitative assessment of the nutritional impacts and associated health outcomes of repeated diarrheal infections in young children.

32 The expected diarrheal disease and mortality reductions are based on adaptations of findings reported in Arnold and Colford (2007), Clasen et al (2007), Fewtrell et al (2005), and Curtis and Cairncross (2003).

Table 4.6: Expected diarrheal disease and diarrheal mortality reduction from reaching the targets by population group

				Expected average reduction in diarrheal disease and mortality	
Groups	***Current water supply and sanitation coverage***	***Population distribution 2008***	***Water and sanitation improvement***	***Already good hygiene***	***Substantial scope for hygiene improvement***
1	Piped water supply and sewage connection	93.1%-100%	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%	25%
2	Piped water supply but no sewage connection	0%-3.6%	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 (and flush toilet for those with dry toilet or no toilet) for all of this population.	35%	45%
3	Not piped water supply but sewage connection	0%	Reliable and safe piped water supply to premises for all of this population	25%	35%
4	Not piped water supply and no sewage connection	0%-3.3%	Reliable and safe piped water supply and sewage connection (and flush toilet for those with dry toilet or no toilet) for all of this population	45%	55%
	National total	**100%**		**15%-17%**	**25%-27%**

Source: Authors. Population distribution estimated from WHO/UNICEF (2010a,b).

4.2.6 Monetary assessment of the benefits of improving drinking water quality, sanitation and hygiene

In scenario 1 (universal water and sanitation coverage), the annual benefits in year 2020 of achieving the targets amounts to 0.6-0.9 million avoided cases of diarrhoea and 1-2 avoided deaths (Table 4.7). The value to society of these benefits is estimated at EUR 124-206 million or NIS 649-1082 million, equivalent to about 0.06-0.10% of GDP in 2020.

Table 4.7: Estimated annual benefits in 2020 of meeting the water, sanitation and hygiene targets

	Annual cases avoided			
	Low	High		
Diarrhea	557,956	929,927		
Deaths	1	2		
	Annual monetized benefits			
	Million Euros (PPP)		Million NIS	
	Low	High	Low	High
Morbidity	122	203	640	1,066
Mortality	2	3	10	16
Total	124	206	649	1,082
Total (% of GDP)			0.06%	0.10%

Source: Estimates by the authors. Note: "Low" represents cases avoided and costs if the population already has good hygiene practices adequate for health protection. "High" represents cases avoided and costs if population hygiene practices can generally be substantially improved.

In comparison, the annual benefits in year 2020 of achieving the targets in scenario 2 (non-universal water and sanitation coverage) amounts to 0.6-1 million avoided cases of diarrhoea and 1-2 avoided deaths (Table 4.8). These benefits are estimated at EUR 144-227 million or NIS 753 -1,192 million, equivalent to about 0.07-0.11% of GDP in 2020.

Table 4.8: Estimated annual benefits in 2020 of meeting the water, sanitation and hygiene targets (scenario 2)

	Annual cases avoided			
	Low	High		
Diarrhea	646,599	1,023,778		
Deaths	1	2		
	Annual monetized benefits			
	Million Euros (PPP)		Million NIS	
	Low	High	Low	High
Morbidity	141	224	741	1,174
Mortality	2	3	11	18
Total	144	227	753	1,192
Total (% of GDP)			0.07%	0.11%

Source: Estimates by the authors. Note: "Low" represents cases avoided and costs if the population already has good hygiene practices adequate for health protection. "High" represents cases avoided and costs if population hygiene practices can generally be substantially improved.

The benefits are valued at EUR 1.9 million or NIS 9.9 million per death and EUR 219 or NIS 1,147 per case of diarrhoea. All figures are in 2008 purchasing power parity (PPP) adjusted Euros and 2008 NIS.

4.3 Benefits from improving the level of wastewater treatment

4.3.1 Current state of wastewater treatment

While WHO/UNICEF (2010) state that in Israel 100% of the toilets are connected to the sewage network, the annual report of the IUED (2010) states that estimates that over 500,000 people, in around 150 settlements in Israel were not connected to a sewage network.

Further, data from the Ministry of Environmental Protection (2008) reveal that only 92% of all wastewater discharges are treated. According to IUED (2010) 185,000 households in Jerusalem are not connected to the sewage network, with 10 MCM of raw sewage being released into the Kidron River annually.

With 19,000 residents Baka al Garbia in northern Sharon has no sewage treatment plant. The sewage of the 3,000 residents of Savyon is collected in septic tanks, despite being hydrologically sensitive as it is located above the coastal aquifer which is the main source of the region's water supplies.

In 2008, around 500 MCM of wastewater were produced annually in Israel (MoEP, 2010c). From the 500 MCM of wastewater discharged annually, 460 MCM are treated.

Of this 31% (155 MCM) were treated to tertiary level and 55% (275 MCM) were treated to secondary level (MoEP, 2010c) 82% of the total municipal wastewater are now reused for irrigation purposes, which is the highest figure anywhere in the world (MoEP, 2010a).

Regulations adopted in 1992 require that the secondary treatment reaches a minimum baseline level of 20mg/l BOD and 30 mg/l suspended solids in settlements with a population above 10,000 people (MoEP, 2010b). Table 4.9 provides an overview.

Table 4.9: Waste water discharge and treatment (2008)

	Total	Primary treatment (Mechanical treatment plants)			Secondary treatment	Tertiary treatment (if any)
		Sea outfall*	Inland water outfall	Total		
Total waste water discharged (MCM/day)	1.37 (500 MCM/year)					
# inhabitants connected to WWT plants (mil)	6.17	N/A	N/A	0.438	4.015	2.263
Total population in settlements > 2,000 inhabitants (mil)	6.7					
% connected over population in settlements > 2,000 inhabitants	92%	N/A	N/A	6%	55%	31%
Waste water treated (MCM/year)	460	N/A	N/A	30	275	155
Waste water treated (MCM/day)	1.260	N/A	N/A	0.082	0.753	0.424
% treated over total waste water discharged	92%					
# WWT plants	500	N/A				
WWT plants total capacity (m3/day)	N/A	N/A				

Source: MoEP, 2010c; author's calculations

Note: It is assumed that the proportion of wastewater treated to the respective levels is equal to the proportion of people being connected to these respective treatment plants

The Israeli government adopted a new standard for unlimited use of effluents, which encompasses 36 parameters and takes public health, soil, hydrological and flora into account. This new standard enables the reallocation of an estimated 500 MCM from agriculture to municipal and industrial sectors (Inbar).33 However, irrigation with effluent water is only permitted to non-edible crops such as cotton, fodder etc, and is regulated by a permit system by the Ministry of Health. Highly treated effluent can be used for the irrigation of orchards, such as citrus, after disinfection, while effluent is never used for the irrigation of crops which would result in a direct contact between the effluent and edible parts of the crop (Inbar).

The responsibility of the construction of wastewater treatment plants in Israel lies with the local authorities (MoEP, 2010b). In 2010, around 500 sewage treatment facilities existed in Israel, of which around 35 are advanced wastewater treatment plants with a minimum capacity of at least 0.5 MCM each (MoEP, 2010b).

In 2010, around 30 MCM/ year of untreated wastewater have been released to rivers, lakes and the sea, of which 10 MCM/ year come from Jerusalem (IUED, 2010).

33 Personal communication with Inbar in February 2011.

Particularly urban sewage can result in microbal contamination (by pathogens) and can contain high concentrations of salts, detergents, and various toxic synthetic substances in addition to acids, minerals and heavy metals which are highly toxic to flora and fauna even in low concentrations. As such, the release of untreated urban wastewater into nature can result in damages to marine and agricultural sites, closing of beaches etc. Estimates show that around 50% of the chloride in municipal sewage is added by industry, of which 30% are derived from industrial water softening processes. It is Israel's objective to treat 100% of its wastewater to a standard which enables "unrestricted irrigation in accordance with soil sensitivity and without risk to soil and water sources". (Central Bureau of Statistics, 2006)

In Israel, municipalities include wastewater charges to an aggregated bill covering water, security and maintenance charges. The 1959 Water Law allows municipalities to charge wastewater fees so that these cover their operational costs and capital costs for new sewers, but to cover the expenses related to the construction of new wastewater treatment plants (Hophmayer-Tokich, 2010).

The quantities of wastewater sludge, a waste product of wastewater treatment, amounted to 109,131 tons/year (dry weight) in 2008 (MoEP, 2010a) and is expected to increase with the construction of additional wastewater treatment plants by 2020 to around 220,000 tons/year (dry weight) (MoEP, 2005a*).* In 2008, around 46% of the untreated sludge was discharged into the sea (from Dan Wastewater Treatment Plan, Shafdan), 49% were used in the form of Class A sludge (*all* pathogens were eliminated) for agricultural practices with the remaining 5% being landfilled (MoEP, 2010a). In 2015, it is expected that no more untreated sludge will be disposed into the sea. Instead, about 60% of the sludge will be treated to Class A sludge and 30% will be treated to Class B sludge (*most, but not all,* pathogens are eliminated) for subsequent agricultural uses, while the remaining 10% of the sludge will be incinerated or heat dried (MoEP, 2005a)

An overview over the main wastewater treatment plants in Israel is provided in Table 4.10 below.

Name	Population served	Daily inflow (M^3)	Yearly inflow (MCM)	Treatment system	Treatment quality	Sludge treatment	Effluent supply
Shafdan; owned by the Dan Regional Association for Environmental Infrastructure	2,000,000	340,000	130	activated sludge with no primary settlement	secondary and tertiary (depending on the indicator)	An underground pipeline discharges the sludge 5km from the shoreline at 38 meters depth. This is only approved as a temporary solution.	The secondary treated effluent is sent to infiltration basins as an additional treatment stage to reach effluent standard deemed suitable for drinking at random. This effluent is distributed to the Negev.
Netanya; owned by the Netanya municipality and operated by Mekorot Dan regional Association for Environmental Infrastructure	240,000	38,000	13.2	activated sludge	secondary	anaerobic digestion, extraction by a film filtration and centrifuge	Agricultural irrigation in the Hefer valley
Be'er Sheva; owned by the Be'er Sheva municipality and operated by Mekorot.	230,000	48,000	14.4	activated sludge	secondary	anaerobic digestion and drying with a film filter with biogas reuse for sludge heating	Agricultural irrigation by agricultural societies Moshavi HaNegev and Mount Hebron field crops
Carmiel	120,000	25,000	8-9	activated sludge	secondary	biogenerator for electricity production by anaerobic digestion. Partial nitrification and gentrification	tertiary treatment for unrestricted irrigation
Ashkelon; owned by both the Ashkelon municipality and Mekorot who also operate the plant.	110,000	20,000	7.3	activated sludge	secondary	DAFT anaerobic digestion and centrifuge drying. the gas generated is reused to heat the sludge in the digesters.	Agricultural irrigation in the local area.

Table 4.10: Wastewater treatment plants in Israel

Source: Israel Water and Sewerage Authority and Mekorot; Inbar 2010

4.3.2 Potential environmental improvements

The wastewater volumes produced amount to 500 MCM/ year in 2008. For the purpose of the benefits assessment and for the determination of the state of the environment in 2020 it was assumed that the wastewater volumes increase proportionally with population growth.

Building on the EU Waste Water Treatment Directive (CEC, 1991), this study is focussing on settlements above 2,000 inhabitants, as it is considered that below this size, waste water management plants may be less feasible in terms of costs and management. This assumption, however, can lead to an underestimation of benefits, as also small settlements can benefit from waste water treatment plants. Waste water treatment plants can indeed make economic sense, if small settelements are located in vincinity and can thus share a plant or where the collection of waste water can provide a source for irrigation.

It is assumed that 92% of the Israeli population lives in settlements above 2,000 inhabitants (Ministry of Tourism, 2005), a percentage which reflects the national statistics of urban population. As such, it is assumed that the population living in settlements above 2,000 inhabitants increases by the same percentage as the urban population growth rate of 1.8% , compared to an overall population growth rate of 1.78% (World Bank, 2010).

Assuming the 1.8% urban population growth rate, 8.3 million people will be living in settlements above 2,000 inhabitants by 2020. To estimate the baseline 2020, it is assumed that the proportion of treatment levels in 2008 remains the same in 2020. Further, a "business as usual" scenario is assumed – all planned improvements to wastewater treatment will be considered in the following section on environmental improvements. Table 4.11 shows the estimation of population connected to the different types of wastewater treatment plants in 2020 in comparison to 2008 levels.

Table 4.11: Wastewater treatment connection of population living in settlements > 2,000 inhabitants

Population living in settlements > 2,000 inhabitants (millions)	Population not connected to wastewater treatment facilities	Population connected to primary treatment	Population connected to secondary treatment	Population connected to tertiary treatment	Total
2008	0.54	0.40	3.69	2.08	6.7
2020 (estimated)	0.66	0.50	4.57	2.57	8.3

Source: MoEP, 2010c; author's calculations

Note: It is assumed that the proportion of wastewater treated to the respective levels is equal to the proportion of people being connected to these respective treatment plants

Alternatively, the baseline 2020 estimation can be done for the volumes of wastewater, instread of for the connection levels. Applying the same assumptions as mentioned above and assuming that wastewater volumes increase linearly with population growth, Table 4.12 summarizes the estimations of wastewater volumes treated to different levels in 2020 in comparison to 2008 level.

Table 4.12: Volumes of wastewater under types of treatment, 2008 and 2020 (estimated)

Volumes of wastewater (million m³)	Volume untreated	Volume under primary treatment	Volume under secondary treatment	Volume under tertiary treatment	Total Volume
2008	40	30	275	155	500
2020	49	37	340	192	618

Source: MoEP, 2010c; author's calculations

Note: It is assumed that the proportion of wastewater treated to the respective levels is equal to the proportion of people being connected to these respective treatment plants

This baseline 2020 was compared to a policy scenario in which 100% of the wastewater is treated to at least secondary level.

4.3.3 Qualitative assessment of the benefits of improving wastewater treatment

Table 4.13: Qualitative description of the benefits of improved wastewater treatment	
Health benefits	Most health benefits are related to sewage collection, rather than treatment per se, as sewage that is not appropriately collected can cause significant health problems (such as diarrheal diseases, dysentery etc). These benefits are therefore assessed under the 'sewage connection' parameter and not here, to avoid duplication.
Environmental benefits	The increased and improved treatment of wastewater will lead to a reduction in nutrient discharges and, therefore, a reduction in eutrophication in aquatic ecosystems, which is particular problem in Lake Kinneret (Sea of Galilee). Significant improvements to the eco-systems and associated recovery of fish and other aquatic life can be achieved with secondary treatment. The danger of untreated wastewater infiltrating into the soil and damaging the aquifers and river systems in Israel is significantly reduced with the improved wastewater treatment. Further, treated wastewater can be used to substitute surface and groundwater sources for irrigation, resulting in a number of benefits which are further described under 'water scarcity'.
Economic benefits	As many drinking water sources are derived from rivers or groundwater aquifers which are currently being damaged or could be damaged in the future, a reduction of contaminants in the abstracted waters can substantially reduce the costs of treatment for potable water. Moreover it can be anticipated that, thanks to increased/improved water treatment, surface water should be more suitable for economic uses such as cooling water and industrial water. This will bring significant direct cost reductions to water intensive industries in particular. Economic benefits can be further derived from the use of grey water for agricultural purposes. For one, the production of this water is cheaper, for the other grey water can substantially contribute to increasing water security. The benefits are further detailed under 'water scarcity'. The improved quality of rivers, esp River Jordan, and the coastline can lead to increases in tourism and recreational activities resulting in economic benefits for the region.

Table 4.13: Qualitative description of the benefits of improved wastewater treatment	
	Employment can be generated by increasing the focus on environmental technologies and green investment in the water sector. Investments and skill enhancements can further establish Israel as a leading exporter for wastewater treatment technologies.
Social benefits	Most health benefits are related to sewage collection, rather than treatment per se), such as nuisance related to odours from direct discharge of sewage in the environment, etc. These benefits are therefore assessed under the 'sewage connection' parameter and not here, to avoid duplication.

4.3.4 Quantitative assessment of the benefits of improving wastewater treatment

The achievement of the target to treat 100% of the wastewater at least at secondary level, can result in substantial quantitative benefits.34

The achievement of this target in 2020 would result in 1.16 million of the population living in settlements of above 2,000 inhabitants to be connected to at least secondary treatment plants, in addition to those already connected (i.e. total of 8.3 million people). Comparing these additional connections to current connection levels, 0.94 million people would have had to be additionally connected to have reached this target in 2008.

Further, the achievement of this target would result in an additional 86.5 MCM of wastewater being treated at least at secondary level of which 49 MCM and 37 MCM would have remained untreated or treated at primary level only, respectively, otherwise. Comparing these additionally treated volumes of wastewater to current treatment levels, 70 MCM would have had to be treated additionally in 2008 so that this target would have been met.

The achievement of this target would result in an environmental improvement (i.e. additionally treated wastewater and connected people) of 14%.

4.3.5 Monetary assessment of the benefits of improving wastewater treatment

This study has not attempted to monetize the benefits of improving wastewater treatment due to the complexity of the task and the budgetary constraints of the project. However, some benefits will be assessed sewage connection and surface water quality.

34 The target of treating 100% of all wastewater to at least secondary level is not an officially declared target, but serves as a reference to illustrate the benefits of improving wastewater treatment levels. While the target of 100% treatment to at least secondary level is mentioned in official publications as a long-term aspirational objective (with no specific target date), the Israeli water authority has underlined that 90% would be a more realistic target for 2020.

4.4 Benefits from improving surface water quality

4.4.1 Introduction

This section reports on the assessment of the health, social, environmental and economic benefits to society for Israel derived from the achievement of a given policy target for surface water quality improvements by 2020. The benefits are analysed in two ways: qualitatively and monetarily, through an economic valuation of the benefits. As for the quantitative assessment of the benefits of improving surface water quality, it is included in the monetary estimation. The aim of the economic valuation exercise is to estimate the total economic value of all possible uses people in the country would make of surface water that meet the policy target by estimating what local residents would be willing to pay for the changes. The given policy target consists of an improvement from current conditions to the EC Water Framework Directive (WFD) target of "Good Ecological Status". The approach to value improvements in surface water, is following that of a UK study which determined the willingness to pay of households for cleaner water. This study has been adapted and transferred to Israel.

The achievement of "Good Ecological Status" for surface waters in Israel is important due to the current trends in water pollution and availability. In most cases, water pollution and over-abstractions exceed 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 wastewater 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 total economic value of water use. Valuation techniques are based on either 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.

The total economic value of water is a combination of use and non-use type of values. 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 below:

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

- *Direct use values*, 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.

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 total economic value 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.

For this report, the benefit functions from Baker et al. (2007) have been transferred to Israel. 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 BFT method are related with the quantifiable portion of the total economic value 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 4.14 below. Important to note that it is not possible to disaggregate values for the different types of uses outlined below and that other types of water uses are valued and assessed in other sections of this report.

Table 4.14: Types of benefits covered with the method applied

<table>
<tr><td></td><td colspan="3">Types of water uses</td><td>Example</td></tr>
<tr><td rowspan="7">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="3">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>
<tr><td>Bequest</td><td>Enjoyment from knowledge that future generations will be able to make use of the resource in the future</td></tr>
</table>

Source: Authors' own compilation

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 Israel (information collected in-country);
Average income levels per household in Israel (World Bank);
Education levels in Israel (World Bank);
Population number, Household Gender composition and Household occupancy in Israel (World Bank);
Other socio-economic statistics: GDP figures in Euro and local currency, PPP conversion factors and projections in Israel (World Bank).

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

4.4.2 Current state of bathing/coastal water quality

The benefits from improving surface water quality of transboundary water bodies will be discussed in each benefit assessment report for the respective riparian countries. The inclusion of certain water bodies does not signal a political statement on transboundary water issues.

Israel has a coastline of 273 km (CIA, 2010), 20 rivers and two lakes.35 The coastal streams which are typically located in the lowlands are relatively short (< 50km) and are perennial or intermittent. The eastern streams are rather short, mostly intermittent and ephermal (“Wadis”) and are characterised by steep and fast flowing wasters during storm events. The Jordan River, with 172 km, is Israel’s longest perennial river (Avital Gasit).36 Lake Kinneret (Sea of Galilee) is the only freshwater lake in Israel and supplies an estimated 30% of Israel’s drinking water (Mekorot, 2010). Its surface area amounts to 168 km^2, with a maximum volume of 4.3 billion m^3 (MoEP, 2000). The Dead Sea, with a surface area of 265 km^2 and a transboundary body shared with Jordan and the Occupied Territories of Palestine, is hyper saline. The combined coastline of Israel’s lakes add up to 175km (Avital Gasit).

According to the MoEP (2010a), Lake Kinneret’s waters contain a higher than permitted concentration of fecal bacteria. In general, the level of industrialization and urbanization impact the compliance of drinking water wells with drinking water standards. As such, the number of polluted wells is very low in the sparsely populated south. The percentage of drinking water wells which comply with the standards but show traces of pollutants are high in the centre but low in the north of the country (MoEP, 2010a).

The water levels of Lake Kinneret (Sea of Galilee), Israel’s only freshwater reservoir, have been continuously dropping. The dangers associated with this drop include ecosystem instability, deterioration of water quality, damage to nature and landscape assets, receding shorelines and adverse impacts on tourism and recreation (MoEP, 2005b). The consecutive years of drought led to smaller quantities of water recharging the Lake Kinneret and the aquifer systems, which in turn necessitated increased water withdrawals from Lake Kinneret, further decreasing the water level (MoEP, 2010a).

The ILEC (2010) categorises the levels of siltation and toxic contamination as “not serious” and states that there is no acidification. Further, research undertaken by Israel Oceanographic and Limnological Research illustrated that the overall water quality in Lake Kinneret has not deteriorated in the last 30 years, i.e. levels of pathogenic organisms, toxic substances and heavy metals have dropped and that eutrophication has not taken place. Until 1994, the algal population was generally stable, when the stability of annual phytoplankton development patterns shifted, disturbing this previous stability and thus the ecosystem. Particularly conspicuous is the extreme fluctuation of the amount of dinoflagellate blooms and relative increase of the toxic cyanobacteria (blue green algae), which may risk the future water quality (MoEP, 2005b). To improve the water quality and salinity levels of Lake Kinneret, major saline inputs from the northwest shore of the lake as well as treated sewage from Tiberias and other local authorities along the western shoreline were transported via a “salt water canal” to the Lower Jordan River (MoEP, 2005b).

A recent study by FoEME (2010) found that over 98% of the historic flow the lower Jordan River is being diverted, with the remaining flow mainly consisting of sewage, fish pond

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35 Israel’s perennial rivers: Alexander Stream, Amud Stream, Ayalon River, Banias River, Belus River, Dan River, Ga'aton River, Hadera Stream, Harod Stream, Hasbani River, Jordan River, Kishon River, Na’aman Stream, Nahal Mishmar , Taninim Stream, Tze'elim Stream, Yarkon River, Yarmouk River.
Israel’s ephemeral rivers: HaBesor Stream, Lakhish River, Nahal Sorek.
36 Personal communication with Avital Gasit, February 2011.

waters, agricultural run-off and saline waters which are diverted into the lower Jordan River via the “salt water canal” from areas around the lake Kinneret. The severe decline of flow in the Jordan River has a great impact on the water level and quality of the Dead Sea, the Jordan River being the main water body feeding the Dead Sea. As a consequence, the Dead Sea Water level has fallen from 394 metres below sea level in the 1960s to 420 metres below sea level in 2007 and has already resulted in environmental degradation, such as loss of freshwater springs, river bed erosion and occurrence of sinkholes (World Bank, 2010).

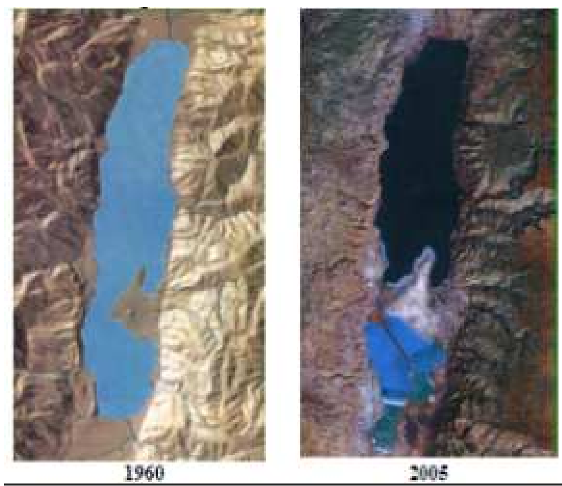


Figure 4.1: Surface Area of the Dead Sea in 1960 and 2005

Source: World Bank, 2010

Measurements of riverine water quality in 2006 revealed that the the biological oxygen demand (BOD) and the total suspended solids (TSS) far exceed the recommended concentrations of 10 mg/l in eleven selected streams (Table 4.14 and Table 4.15). It can be assumed that the high level of pollution reflects the low quality of discharged effluent as wastewater is not treated adequately or not at all (Central Bureau of Statistics, 2006). However, intensive river restoration efforts in the major westbound rivers led to a decrease of pollution levels between 1994 and 2006. Contrary, an increased pollution is observed in the eastbound wadis in the West Bank, which is mainly caused by untreated sewage (MoeP, 2009b).

Table 4.15: Maximum and average values of readily degradable organic matter (mg/l Biochemical Oxygen Demand) in selected streams in Israel, 2000-2004

Stream \ Year	2000		2001		2002		2003		2004	
	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average
Na'aman	135	20	42	18	110	26	28	9	153	17
Qishon	96	39	38	13	34	10	16	12	31	10
Daliyya	15	7	26	13	26	14	11	5	19	7
Taninim	5	3	12	6	8	4	7	3	10	4
Hadera	153	42	45	18	452	82	62	28	297	63
Alexander	84	28	440	66	165	61	433	19	24	8
Yarqon	34	12	114	13	55	16	28	12	84	17
Soreq	353	79	120	36	292	42	42	15	253	40
Lakhish	27	12	136	30	120	32	433	77	380	47
Harod	165	29	370	51	252	42	42	15	39	20
Lower Jordan	13	4	14	6	31	10	180	52	16	8

Source: Central Bureau of Statistics, 2006

Table 4.16: Maximum and average values of Total Suspended Solids (mg/l TSS) in selected streams in Israel, 2000-2004)

Stream \ Year	2000		2001		2002		2003		2004	
	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average
Na'aman	173	92	172	102	844	125	101	61	103	44
Qishon	95	57	454	142	352	81	508	135	177	76
Daliyya	117	41	296	99	1,346	211	95	37	78	35
Taninim	32	16	150	59	130	35	80	36	82	31
Hadera	490	89	86	46	120	64	122	48	429	102
Alexander	111	50	1,500	176	210	62	319	58	120	46
Yarqon	63	24	95	34	112	29	114	29	104	37
Soreq	168	51	160	38	1,013	156	87	27	238	47
Lakhish	1,360	360	68	23	80	39	183	60	310	73
Harod	802	253	272	149	662	206	272	97	186	90
Lower Jordan	269	67	203	51	316	90	276	100	296	71

Source: Central Bureau of Statistics, 2006

In Israel, 111 coastal and inland waters are designated as bathing areas (Israeli Ministry of Health (MoH), 2011). In the annual quality analysis of designated bathing areas in Israel, 2.5% of the tests were found to exceed permitted bacterical concentrations in 2007 (MoH, 2007). From the 20 rivers in Israel, only two rivers are suitable for water activities, with the remaining rivers being closed due to pollution. Swimming is only safe in the Northern Jordan River, while the Yarkon River is open for water sports such as kayaking, rowing and sailing (MoH, 2007).

Following strong rains, there is an acute danger of sewers overflowing and run-off reaching bathing areas, so that bathing is "absolutely not recommended" (MoH, 2011).

With pollutants such as heavy metals, volatile organic compounds, fertilizers and pesticide runoff in surface waters, considerable health risks, including stomach flu, ear infection, upper respiratory infection and major skin rashes, can occur depending on the frequency of exposure and level of pollutants in the water. Frequent exposure to waters containing high concentrations of toxic heavy metals can cause loss of bone calcium, high blood pressure, fertility problems in men and kidney damage (Zalul Environmental Association of Israel, 2011).

A quality assessment of coastal waters identified a number of pollutants. Several coastal rivers show high concentrations of mercury, cadmium and copper. The concentrations of heavy metals in suspended particulate matter are higher in Haifa Bay, near the Qishon estuary, than those outside of the bay. High levels of TBT pollution, i.e. higher than the Israeli water quality standard, were found in the ports of Haifa and Ashdod as well as in Akko, Michmoret, Hertzelia and Tel-Aviv marinas. High concentrations of nitrogen and phosphorous can be found in Haifa Bay and along the coast near the outlet of the rivers Yarkon and Taninim and near the effluent outfall of the Hertzelia sewage treatment plant, decreasing with increasing distance from the shore. In the ports of Haifa, Qishon and Ashod as well as in the Tel-Aviv marina and the cooling basins of Ashdod and Hadera power plants there is a pollution by pesticide residues (DDT). Further, there is a high level of PCBs pollution in the ports of Haifa and Ashdod and the Akko marina, as well as medium pollution of PCBs in the port of Qishon and the Tel-Aviv marina. The ports of Haifa and Ashdod further suffer under a medium level pollution by a few PAHs. Significant TBT pollution can be found in the ports of Haifa, Qishon and Ashdod as well as in the Tel-Aviv and Ashqelon marinas and in the cooling basin of Ashdod power plant (Gasith and Hershkovitz 2010).

4.4.3 Potential environmental improvements

The water quality parameter employed in this valuation exercise measures the water quality of rivers, lakes, reservoirs, transitional and coastal waters (up to three nautical miles) in Israel.

The WFD defines which biological elements must be taken into account when assessing ecological status of a water body and distinguishes five status classes: high, good, moderate, poor and bad. “High status” is defined as the biological, chemical and morphological conditions associated with no or very low human pressure. This is also called the “reference condition” as it is the best status achievable - the benchmark. These reference conditions are type-specific, so they are different for different types of rivers, lakes or coastal waters so as to take into account the broad diversity of ecological regions in Europe. Assessment of quality is based on the extent of deviation from these reference conditions, following the definitions in the Directive. “Good status” means “slight” deviation, ”moderate status” means “moderate” deviation, and so on.

Good ecological status (GES) is defined in Annex V of the WFD, in terms of the quality of the biological community, the hydrological characteristics and the chemical characteristics of a water body. Because of geographical and ecological variability, GES has been generally described as that water quality condition which represents only a slight departure from the biological community, which would be expected in conditions of minimal anthropogenic impact.

The practical definition of ecological status takes into account specific aspects of the biological quality elements, for example “composition and abundance of aquatic flora” or “composition, abundance and age structure of fish fauna”. In addition, The WFD requires that the overall ecological status of a water body is being determined by the lowest scoring biological or physicochemical quality element (i.e. the quality element worst affected by human activity). This is called the “one out - all out” principle. For all specific pollutants (which are a sub-set of the chemical and physicochemical quality elements) with the exception of ammonia, compliance with the environmental quality standards for good status has to be consistent with classification as high or good ecological status. The assignment of high or good can depend on the condition of the other quality elements.

The baseline water quality information used from Israel to feed the benefits transfer model indicates that presently 85% of the catchment area of rivers in the country would not achieve good ecological status according to the WFD. There are a total of 20 rivers in Israel for which an overall assessment of water quality does not exist. The following information collected by the authors has been used to assess river water quality: “Only the Northern Jordan River is currently safe for swimming. The Yarkon River is the only river that is open for water sports such as kayaking, rowing and sailing. All other rivers in Israel are closed due to pollution” (MoH, 2007). Lake Kinneret, Israel’s only freshwater reservoir, has also been considered in the assessment.

The targets used for the assessment are those which have been used by the original valuation study, which are (as a target for their models) compliance with the WFD at national level. WTP values as presented in Baker et al., (2007) relate to a permanent increase in real annual payments (increase in water bills and other expenses) that a household is willing to pay for reaching two alternative scenarios of 75% to 95% of all water bodies in the country reaching Good Ecological Status by certain key dates (2015, 2022, 2027).

In the case of Israel, the quantitative target is the following: 70 % of all surface area of rivers, lakes and reservoirs in the country will be improved to good ecological status by 2020.

4.4.4 Qualitative assessment of the benefits of improving bathing/coastal water quality

Water quality influences human uses of the affected resources, leading to changes in use values and non-use values of the resource. It is difficult however, to quantify the relationship between changes in pollutant discharges and the improvements in societal wellbeing that are not associated with direct use of the affected ecosystem or habitat. That these values exist, however, is indisputable, as evidenced, for example, by society’s willingness to contribute to nature conservation organisations. Therefore, the need in this section is to highlight in qualitative terms all the possible benefits that can be derived from improvements in water quality, including those that cannot be quantified.

An overview of key benefits derived from improved surface water quality in Israel can be found below. The table reflects the range of goods and services that are provided to society by a healthy water environment. Please note that some of these benefits have been covered under other sections of this document.

Table 4.17: Qualitative description of the benefits of improved surface water quality	
Type of Benefit	Description
Health benefits	The key diseases avoided are those of the alimentary system. Microbial (both bacterial and viral) contaminants can cause a range of problems from mild disorders to major diseases such as dysentery. Some disease will occur from infection from regularly occurring intestinal bacteria, while others are diseases passed on from those already infected. Treatment to remove common bacteria (such as faecal coliforms) will also destroy a wide range of more dangerous, if infrequent, bacterial diseases.
Environmental benefits	The presence of pollutants/toxic substances in water (e.g. metals, pesticides), are well known to affect a wide range of species, both freshwater and marine. These may be affected by direct toxic effects on metabolism and the disruption of endocrine functions. Some substance can also be accumulators both within the environment (e.g. sediments) and within animals (bioaccumulation). Therefore they can represent a significant threat even in small concentrations. Excessive nitrates concentrations can also cause extensive harm to the environment through eutrophication, as is happening e.g. in Lake Kinneret. Nitrates greatly stimulate the growth of algae. The decomposition of such algae reduces the water's dissolved oxygen content, adversely affecting fish and other aquatic life forms. Decreases in nutrient loadings thus benefit aquatic habitats. This, accompanied by lower sediment and pesticide loadings, results in increased fish and waterfowl populations. Measures to increase the water levels of Lake Kinneret, the Dead Sea and Jordan River could halt the rapidly processing environmental degradation occurring. Action needs to be taken before irreversible damage occurs.
Economic benefits	Cleaner surface water resources can: • reduce costs to industry (e.g. for pre-treatment) • reduce costs to society (municipalities) by avoiding that the cost of remediation and of drinking water treatment escalates, • stimulate the development of new environmental technologies (e.g. for water treatment), • avoid microbiological contamination of food crops, • increase fish populations and catch, • enhance the potential for tourism, • increase the value of property Water pollution is both a cause and an effect in linkages between agriculture (the single largest user of freshwater on a global basis) and human health: • Agriculture is and is a major cause of degradation of surface and groundwater resources through erosion and chemical runoff. Measures to reduce the negative impact of agriculture can lead to improved farm practices and reduced costs. Such measures may include e.g. stimulating a more efficient use of fertilisers and pesticides. • Avoiding microbiological contamination of food crops, stemming from: use of water polluted by human wastes and runoff from grazing areas and stockyards. Increased fish stocks and harvest: reducing pollution is expected to

Table 4.17: Qualitative description of the benefits of improved surface water quality	
	enhance aquatic life habitat and thus to greatly contribute to increasing freshwater and coastal fish populations. These population increases would positively affect subsistence anglers, commercial anglers and fish sellers, and consumers of fish and fish products. The coastal bathing areas have a strong potential for tourism. An improvement in quality of bathing waters (where this is currently poor or below standards) can ensure that more tourists are attracted to the area and thus revenues for local economy are secured. Aesthetic degradation of land and water resources resulting from pollutant discharges can reduce the market value of property and thus affect the financial status of property owners. Further, improvements to the surface water quality of culturally important water bodies, such as Lake Kinneret, the Dead Sea and Jordan River, can result in increased (spiritual and cultural) tourism. Addressing the water quality and scarcity situation now, can result in high avoided costs stemming from irreversible damages, including ecosystem services.
Social benefits	Water pollution and eutrophication can reduce the amenity value and tourism development benefits to local communities as this restricts the use of waters. Improved surface water quality will favour recreational uses, such as swimming, boating, angling and outings Improved water appearance and odor make it more desirable and visually appealing, for recreation. Further, water pollution affects the quality of living in the areas nearby surface waters. Even if no human activities are affected by water quality degradation, such degradation may still affect social welfare. For a variety of reasons, including bequest, altruism, and existence motivations, individuals may value the knowledge that water quality is being maintained, that ecosystems are being protected, and that populations of individual species are healthy completely independent of their use value. Further, cultural and religious practices related to water, i.e. baptisms, can only be performed in water bodies which are harmless for human's health, resulting in high social benefits.

Source: Authors' own compilation

4.4.5 Quantitative assessment of the benefits of improving bathing/coastal water quality

The quantitative assessment of the benefits of improving bathing/ coastal water quality is included in the monetary assessment in the following section.

4.4.6 Monetary assessment of the benefits of improving bathing/coastal water quality

This section illustrates the range of monetary benefits in Israel from an improvement in water quality from current conditions to "Good Ecological Status", which is the overarching environmental objective of the EC Water Framework Directive (WFD). The monetary benefits are equal to the estimated amount of money that households in Israel would be willing to pay for improved surface water quality by 2020.

The following are important aspects to take into consideration when making use of the results reported below: 1) only people resident in Israel are considered. Any possible value that visitors to the country may have on the overall quality of water resources is not accounted for in this method; 2) values have not been separated by types of uses of water, although the types of values outlined in Table 4.14 are all covered in the analysis; 3) the analysis illustrates a portion of the total economic value of water quality improvements in Israel, only valuation of people's preferences for changes in quality are included here, other chapters illustrate other types of values and 3) it has been assumed that all water bodies in the country have the same value. This assumption becomes important when considering that values for some water bodies may be higher if they are of significant importance (for example for cultural reasons) or if water resources are scarce. Values may also decrease when overall water quality in the country increases as a result of the improvements.

Table 4.18 shows results of the transfer of estimated economic values of water for the UK in Baker et al (2007) to Israel. Mean WTP values for the 85% overall water quality improvement scenario in Israel ranges between EUR 67 and EUR 240 per year per household 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. 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.

Table 4.18: Water quality improvements benefits assessment results for Israel

WTP results (Euro per HH per year) in 2020		WTP results (NIS per HH per year) in 2020		Aggregated benefits WTP in 2020 (Euro/year)		Aggregated benefits WTP in 2020 (NIS/year)		Benefits as a percentage of GDP in 2020	
lower	upper	lower	upper	lower	Upper	lower	upper	lower	upper
67.1	240.0	375.5	1343.0	159.5M	571.1M	893.3M	3.197.5M	0.08%	0.27%

Multiplying WTP values by the number of households projected in 2020, namely 2,379,189, gives a figure for the total benefits for WFD related water quality improvements in Israel by 2020. These range between EUR 159 million and EUR 571 million. In terms of benefits as a percentage share of GDP in 2020, these figures are in the range of 0.08% - 0.27%.

4.5 Benefits from reducing water resource scarcity

Preservation of Israel's water resources is one of the major challenges confronting the country today. Israel entered the 21st century with one of its greatest water overdrafts ever. Today this cumulative deficit stands at some 1.5 billion cubic meters, an amount equal to the annual consumption of the country, in comparison to the average annual replenishment rate of major aquifers. Moreover, water scarcity is exacerbated by the deteriorating quality of water resources due to demographic, industrial and agricultural pressures.

Israel's water sources are limited by the country's climate, geography and hydrology. Seventy-five percent of the annual rainfall is concentrated into four winter months. Rainfall averages up to 950 millimetres per year in some parts of Galilee in the north in contrast to 25 millimetres in the southern tip of the Negev. Variations occur from year to year, with periods of drought or near drought interspersed with periods of heavy rainfall. Global climate change may magnify the pressure on Israel's water system by increasing temperatures and evaporation rates and changing the precipitation regime.

To continue to supply the population with its water needs, under conditions of water scarcity, sustainable water management policies, which relate to both quantity and quality of water, are being introduced. The goal is to utilize Israel's natural water sources in a balanced way and to increase water supply from such sources as desalinated seawater, desalinated brackish water, effluents and more. Furthermore, river restoration action plans have been significantly advanced in recent years and enforcement against polluters of water resources has been stepped up.

4.5.1 Current state of water resource use

Current state of water resource availability and use in 2007

According to Israel's Central Bureau of Statistics, in 2007 water production in Israel accounted for 2,199 million cubic meters (MCM). Natural resources accounted for 1,689 MCM, of which 1,064 MCM was extracted from wells (underground water) and 625 MCM was extracted from surface water, including 224 MCM produced from Israel's national carrier (Lake Kineret). In addition, Israel increases its water supplies by desalination and wastewater reuse. In 2007, the volumes of desalinated water and treated wastewater amounted to 123 MCM and 387 MCM respectively (Table 4.19).

Table 4.19: Water Production in Israel, 2007

Water Sources:	**Water available (10^6 m^3/yr)**
Surface water37	625
Wells38	1,064
Desalinated Water	123
Treated wastewater	387
Total Actual Renewable Water	**2,199**

Source: Israel Bureau of Statistics: http://www.cbs.gov.il/shnaton61/st21_05.pdf

Agriculture is the main total water user, accounting for 57% of the total water used, i.e. 1.185 MCM/year. Municipal and industrial water abstractions account for 37% (768 MCM/year) and 6 % (119 MCM/year) respectively (MOE, 2009). However, when considering that agriculture uses 54% of non-potable (effluents and marginal) water, municipalities are

37 Includes 224 MCM from Israel National Water Carrier, which carries water from Lake Kineret to the rest of the country.
38 Excludes production from well drilling in Dan Region.

the main water user of potable water, accounting for 53% of potable water used, with agriculture accounting for 38% and industry for 8% (Table 4.20).

Table 4.20: Water Usage by Sector in 2007

Sectors	**Total water used (10^6 m^3/yr)**	**Water used (% of total water used)**	**Potable water used**	**Potable water used (% of total potable water used)**
Agriculture	1,185	57	551	38
Municipal	768	37	768	53
Industry	119	6	119	8
Total Water Used	**2,072**		**1,438**	

Source: MoEP, 2009a

In total, Israel uses 2,072 MCM of the 2,199 MCM that are available, leaving a mere 127 MCM/year unused. This is reflected in a water exploitation index (i.e. total freshwater abstracted as a proportion of total renewable water available) of 95% in 2007, indicating severe water stress and unsustainable use of water. 39

With an Israeli population of 7.3 million, 300m³ of water are available per capita/year. Total water use per capita is 280 m³/year, of which 110m³/capita/year are used for municipal water use (see Table 4.21), indicating 'absolute water scarcity' for the Israeli population.40

Table 4.21: Key Indicators on water use and water availability, 2007

Indicator	**Value**	**Units**
Water Available per Capita	300	m3/person/yr
Water Exploitation Index (%)	95	Percentage of water use to water availability
Total Water Use per Capita	280	m3/person/yr
Municipal Water Use per Capita	110	m3/person/yr

Source: Author's calculations

Pressures on water availability include population growth, growth in agricultural and industrial production, as well as general economic development. These pressures continue to put a strain on the limited water resources available, both in terms of water quality and quantity. In recent years, the existing scarcity problem has been further exacerbated by repeated drought cycles, so that natural water resources were overused beyond their natural recharge (MoEP 2008, p. 25).

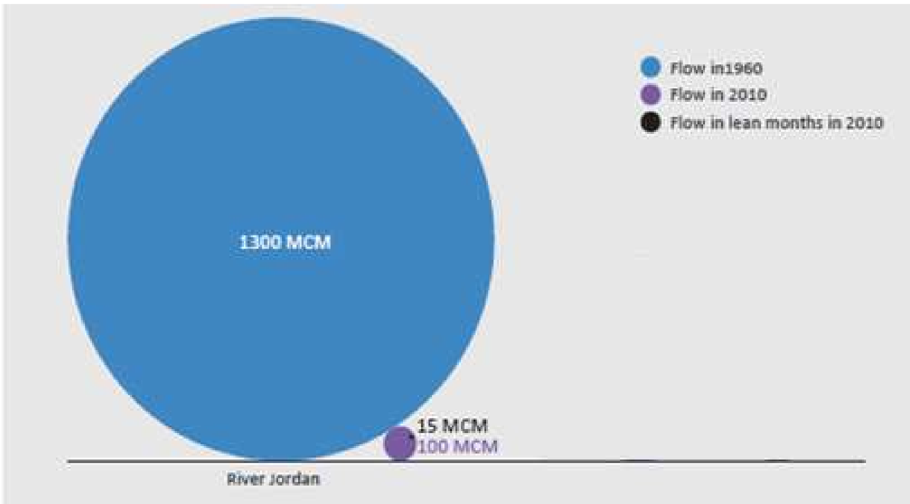
Figure 4.2 provides a visual documentation of the flows of the lower River Jordan, Israel's main river, in 1960 and 2010, including the flows in the dry months of 2010. The annual flow of the lower River Jordan decreased from 1,300 MCM in 1960 to 100 MCM in 2010 annually,

39 Note that a WEI of over 20% implies water resources are under stress, and values above 40% imply severe stress and unsustainable use of water (Raskin et al, 1997)

40 FAO (2007) indicates that regions with water supplies below 1,700 m³ per capita experience water stress, below 1,000 m³ per capita experience water scarcity and below 500 m³ absolute scarcity.

with the average flow in the leanest months decreasing down to 1 MCM per month. Lower Jordan River barely exists for about six months of a year (Strategic Foresight Group, 2011).

Figure 4.2: Depleting River Flows in lower River Jordan, 1960-2010



Source: Strategic Foresight Group (2011)

Water scarcity has been a fact of life ever since the state of Israel was founded; furthermore, the available water resources are distributed unevenly throughout the country. This has resulted in a comprehensive set of advanced regulations, standards, administrative tools and economic incentives that govern the water sector, in order to use the available water resources as efficiently as possible. As a consequence, Israeli technologies for water management and treatment are among the most advanced worldwide, including seawater desalination, wastewater treatment producing recycled water suitable for irrigation, and efficient irrigation techniques in agriculture.

Increased efficiency in water use is a particular challenge for agriculture, which is one of the main water uses. In light of growing domestic and industrial demand, allocations of freshwater to agriculture have been declining. Due to the use of new and efficient irrigation technologies and recycling of wastewater, the falling freshwater allocation has been compensated while maintaining agricultural production at the same level. For instance, only half of the water currently used for irrigation is high quality fresh water, the remainder being recycled water and other sources of lower quality water (MoEP 2008, p. 25).

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.41 This results in a water scarcity index of 482%, i.e. Israel consumes 4.82 times more water than is available in the form of renewable water resources.42 When including alternative water supply options (i.e. desalinated water and treated wastewater) the water

41 Water Footprint of a Nation: total volume of freshwater used to produce the goods and services consumed by its inhabitants (Chapagain et al, 2006)
42 The water scarcity index is the ratio of total water footprint and total renewable water resources (Hoekstra and Chapagain, 2008).

available increases to 2.18 10^9 m³/yr, which translates into a water scarcity index of 191%. 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). In comparison to the remaining ENPI countries, Israel has the highest water import dependency (74%), and consequently the lowest water self-sufficiency.[43]

Table 42 presents a comparison of total renewable water resources, water footprints, water scarcity, water self-sufficiency and water import dependency for all ENP counties, including the Russian Federation, and Spain as a European benchmark with comparable climatic conditions to Israel.

Table 4.22: Water footprint versus water scarcity, self-sufficiency and water import dependency per ENPI country and Spain, 1997-2001

Country	Total renewable water resources (ground and surface water)	Internal water footprint	External water footprint	Total water footprint	Water scarcity (Total WF/Total renewable resources)	Water self-sufficiency (Internal WF/Total WF)	Water import dependency (external WF/Total WF)
	10^9 m^3/yr	10^9 m^3/yr	10^9 m^3/yr	10^9 m^3/yr	%	%	%
Algeria	14.41	24.49	12.21	36.69	255	67	33
Armenia	10.53	2.16	0.66	2.81	27	77	23
Azerbaijan	30.28	6.51	1.32	7.83	26	83	17
Belarus	58.00	9.01	3.73	12.74	22	71	29
Egypt	58.30	56.37	13.13	69.50	119	81	19
Georgia	63.33	3.92	0.25	4.17	7	94	6
Israel	**1.78****	**2.21**	**6.37**	**8.58**	**482**	**26**	**74**
Jordan	0.88	1.70	4.58	6.27	713	27	73
Lebanon	4.41	2.14	4.30	6.44	146	33	67
Libya	0.60	6.77	3.99	10.76	1793	63	37
Moldova	11.65	6.15	0.16	6.31	54	97	3
Morocco	29.00	37.02	6.58	43.60	150	85	15
Russian Federation	4507.25	228.85	42.13	270.98	6	84	16
Syria	26.26	26.24	2.98	29.22	111	90	10
Tunisia	4.56	12.63	2.55	15.18	333	83	17
Ukraine	139.55	62.41	2.99	65.40	47	95	5
Spain	111.50	60.38	33.60	93.98	84	64	36

Source: Hoekstra and Chapagain, 2008. * Adjusted with FAO (2011a) value for 1997-2001.

43 Water import dependency: Ratio of the external water footprint and the total water footprint. Water self-sufficiency: Ratio of the internal water footprint and the total water footprint.

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 4.23) (FAO, 2011b).

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, and is also significantly above the Spanish average water requirement. Potatoes, tomatoes, grapefruit and oranges are produced below global and Spanish average water requirements (Table 4.23).[44]

Table 4.23: 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/ton) (1997-2001)	Water footprint Spain (m^3/ton) (1997-2001)	Water footprint Global Average (m^3/ton) (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, clem,	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

Source: Mekonnen and Hoekstra (2010), FAO (2011b)
Note: Colour Code: Red Field indicate a water footprint in Israel for the listed crop above the global and Spanish average; Yellow fields indicate a water footprint in Israel for the listed crop is below global average; Yellow patterned fields additionally indicate that Israel's water footprint is below Spain's average.

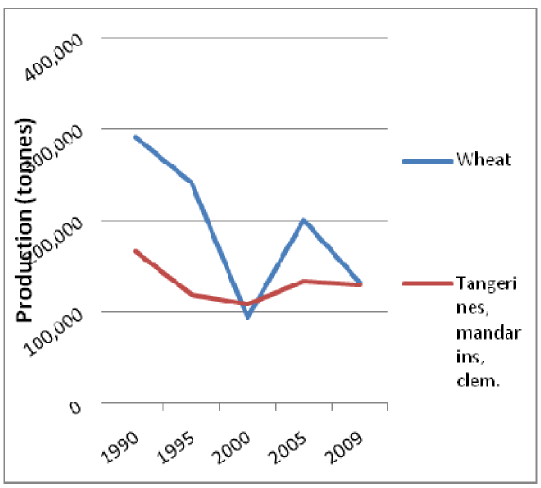
When analysing the trend of agricultural production patterns starting in 1990 up to 2009, a reduction of some water-intensive and increase in water-efficient crops becomes apparent.
The production of wheat has decreased from 291,200 tonnes/year in 1990 to 132,963 tonnes/ year, a production change which reduced annual water consumption by 527 MCM/year, a decrease of 54%.[45] 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

44 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.
45 As the water footprint data was accumulated for the period of 1997-2001, the water savings described do not consider technical efficiency improvements.

internal water use of 74MCM/year, an increase of 185%. 46 In 2008, Further, potatoes were the number one export crop in terms of quantity, with 282,583 tonnes/year (FAO, 2011b).

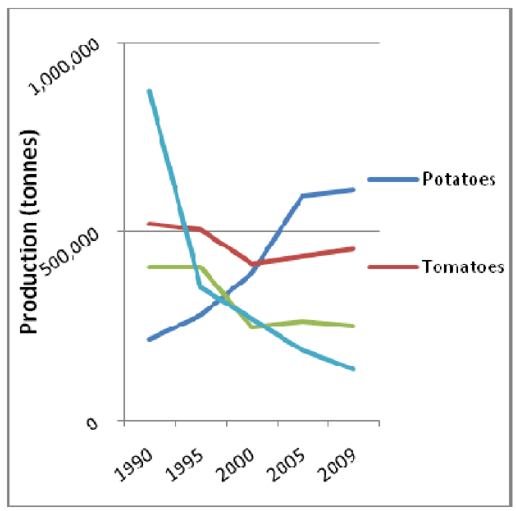
Long-term water insecurity impacts farmers' long-term decisions on investment and cropping patterns. Particularly in the early 2000s, following consecutive dry years with consequent decrease in water ratios by up to 80% for farmers, led to a loss of accumulated agricultural capital (trees and other plants which take considerable time to mature). As a consequence, farmers prefered growing single season crops, despite their lower profitability (Lavee, 2010). The table below shows the decline in orange and grapefruit production, crops requiring high agricultural capital but with low water requirements, starting in 1995. On the other hand, potatoes, a single season crop with low waterfootprint, and wheat, a single season crop with a very high waterfootprint experienced a strong increase in production around 2000.

Figure 4.3 Crops produced in Israel above global average water requirements (tonnes), 1990 - 2009



Source: FAO, 2011b

Figure 4.4 Crops produced in Israel below global average water requirements (tonnes), 1990 - 2009



Source: FAO, 2011b

A downside of the remarkable efficiency in water usage is that Israel manages to use practically all of its renewable water sources (be it for domestic consumption, agriculture or industry). This means that hardly any water is left for environmental uses, with adverse impacts on ecosystems that depend on freshwater such as wetlands, and the flora and fauna that persist in them.

As regards wastewater treatment, high standards have been achieved. From the 500 MCM of wastewater discharged annually, 460 MCM are treated. Of this 31% (155 MCM) were treated to tertiary level and 55% (275 MCM) were treated to secondary level (MoEP, 2010c) 82% of the total municipal wastewater are now reused for irrigation purposes, which is the highest figure anywhere in the world (MoEP, 2010a).

46 Data on the change of production of the top 10 crops, in tonnes and water used, for the period 1990-2009 can be found in the Annex.

Water pricing is an integral part of Israeli water management, with total water supply measured and payments calculated according to consumption and water quality. Water users receive an annual allocation from the Water Commission, for which farmers pay incrementally. Up to 60% of the allocation are priced with 0.14€/m³ (0.20$/m³), 60-80% of the allocation cost 0.17€/m³ (0.25$/m³), and 80-100% cost 0.21€/m³ (0.30$/m³).[47] Urban water consumers pay substantially higher water prices, as a water reclamation levy is incorporated (FAO, 2009). [48]

To close the gap between supply and demand in the future, the Israeli government decided on actions targeting water supply and demand measures to be taken. On the supply side, the production capacity for desalinated water shall be increased to 720 MCM/year by 2020, with an additional 50 MCM/year of brackish water to be desalinated while contaminated wells shall be reclaimed. Further, obstacles to the effluent reuse shall be removed and the water quality of treated effluents shall increase. Demand side measures include an increase in water tariffs, promulgate regulations on water savings in the urban sector and the promotion of public information campaigns on water conservation. 50 MCM of water is earmarked for the conservation of nature (MoEP, 2009a).

4.5.2 Potential environmental improvements

The Baseline 2020

For the purpose of the benefit assessment, the assumptions regarding the state of water resources and water demand in 2020 were partially based on estimates from the Israeli Water Commission (1998) (Ministry of Foreign Affairs (MoFA), 2002). Where appropriate, the estimates where updated by current policy changes.

Table 22 shows the current situation (2007) and the estimates for the 2020 baseline on water use and water sources:

Table 4.24: Water demand and supply in Israel, in 2007 and the baseline 2020 case

	Water Use (Total annual withdrawal (10^9 m³/yr)					Water Sources (Water available - replenishment (10^9 m³/yr)						
Year	Agriculture	Municipal	Industry	Nature	Total	Surface	Groundwater	Reduced water due to Climate	Desalinated	Wastewater reused	Brackish	Total
2007	1.185	0.768	0.119	**/**	**2.072**	0.625	1.064	/	0.12	0.387	N/A	**2.2**
2020	1.185	1.33	0.119	**0.05**	**2.684**	0.640	1.089	(0.2)	0.75	0.618	0.18	**3.08**

Sources: MoEP (2009a), MoFA, 2002
Israel Central Bureau of Statistics: http://www.cbs.gov.il/shnaton61/st21_05.pdf

The baseline estimates for 2020 assume an increase in the population from 7.3 million (2007) to 8.8 million (2020). Municipal water use is the only sector with an expected increase in water withdrawal in these estimates (MoFA, 2002). Water conservation and

47 Using PPP adjusted 2008 market exchange rates
48 http://www.fao.org/nr/water/aquastat/countries/israel/index.stm

water use efficiency measures in the agricultural sector reduce water withdrawals significantly, while increasing output.49

50 MCM/year of water are earmarked for the conservation of nature, following government decisions which were taken between 2000 and 2008 and are thus included as water uses in 2020. 50

According to the Israel Water Commission (1998), availability of surface water and groundwater are expected to increase slightly (by 15 MCM/year and 25MCM/year respectively), mainly due to the rehabilitation of polluted and depleted wells (MoFA, 2002). This is in accordance with Israel's statutory Master Plan.

However, assuming an 1.5°C increase in temperature by 2020, as a consequence of climate change, precipitation is expected to decrease by 10%. 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.

It is current government policy to increase the desalination production capacity to 750 MCM/ year by 2020 (MoEP, 2009a). Further, a programme for desalinating 50 MCM brackish water shall be prepared. These numbers are substituted for the values suggested by the estimates by the Israel Water Commission (1998).

Further, 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, 2005c). When assuming that wastewater volumes increase proportionally with population growth, 618 MCM of wastewater will be treated by 2020 (see section 3.3).51

This data translates into the indicators presented in Table 4.25, to provide clearer insights on the water scarcity situation:

Table 4.25: Key Indicators on water use and water availability

Year	Water Available per Capita (10^3 m3/person/yr)	Water Exploitation Index (%)	Total Water Use per Capita (10^3 m3/person/yr)	Municipal Water Use per Capita (10^3 m3/person/yr)
2007	0.30	95	0.28	0.11
2020	0.35	87	0.30	0.15

Source: Author's calculations

49 The widespread adoption of low volume irrigation systems and automatation decreased the average water requirement per unit of land area from 8,700 m³/ha in 1975 to 5,500 m³/ha in 2002, while agricultural output has increased twelve fold (MoFA, 2002) http://www.mfa.gov.il/MFA/Facts%20About%20Israel/Land/Israel-s%20Chronic%20Water%20Problem
50 MoEP, 2009
51 The target of treating 100% of all wastewater to at least secondary level is not an officially declared target, but serves as a reference to illustrate the benefits of improving wastewater treatment levels. While the target of 100% treatment to at least secondary level is mentioned in official publications as a long-term aspirational objective (with no specific target date), the Israeli water authority has underlined that 90% would be a more realistic target for 2020.

<u>Environmental Improvements and Targets</u>

The EU suggests that countries should, where appropriate, aim to lower their WEI towards 20-40%. A reduced WEI should allow more water to be available to maintain and enhance wetlands and water bodies with improved biodiversity and ecosystem services (e.g. fisheries, recreation and navigation etc).

What is more important is that a sustainable, “demand-led” approach to “integrated water resource management” is adopted, focusing on conserving water and using it more efficiently. In addition, the following Millennium Development Goals should also be targeted:

- Ensure appropriate “environmental” flows are ensured to maintain wetland ecosystem goods and services;
- Change social, economic and regulatory instruments that are inappropriate for water allocations and uses; and
- Mediate water conflicts across the sectors through participation of appropriate stakeholder groups.

Potentially relevant actions to achieve the targets described above, may include actions such as efficiency improvements in agriculture, industry and municipal water use, public awareness campaigns on water conservation and change in cropping patterns.

The baseline 2020 scenario is compared to a policy scenario in which the target of a water exploitation index of 46% has been achieved, and in which an improved management for water supply and demand has been implemented. This assumes that the targets relating to water supply (as described above and incorporated in the baseline 2020) have been achieved, as well as the targets explained in the following:

Municipal and industrial water use will remain constant at their 2007 levels in 2020, due to further efficiency improvements and further improved public awareness in terms of water conservation.

It is assumed that agricultural water use will decrease by 50% of its 2007 levels in 2020, due to efficiency improvements and a change in the crop production and trade structure. The production of crops with high water footprints, such as wheat, tangerines, mandarines and clementines, should be reduced considerably; instead, such crops should be imported. Further, it should 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, mandarines 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.52 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 should be intensified.

Table 4.26 summarized the supply and demand of water in the present (2007), in the baseline 2020 and in the scenario of achieved environmental improvements in 2020.

Table 4.26: Water supply and demand in 2007, the baseline 2020 case and scenario of achieved environmental improvements in 2020

	Water Use (Total withdrawal per annum (10^9 m³/yr)					Water Sources (Water available - replenishment (10^9m³/yr)						
Year	Agriculture	Municipal	Industry	Nature	Total	Surface	Groundwater	Reduced water due to Climate	Desalinated	Wastewater reused	Brackish	Total
2007	1.185	0.768	0.119	***/***	***2.072***	0.625	1.064	/	0.12	0.387	N/A	**2.2**
2020	1.185	1.33	0.119	***0.05***	***2.684***	0.640	1.089	(0.2)	0.75	0.618	0.18	**3.08**
Scenario 2020	0.592	0.768	0.119	***0.05***	***1.529***	0.640	1.089	(0.2)	0.75	0.618	0.18	**3.08**

Sources: FAO (2011a), MoEP (2009a); MoFA, 2002; estimates for scenario 2020

The "environmental improvements" associated with moving from the baseline to the targets described above mainly relate to increased water being available for use during summer months and there being more water in the rivers, lakes and wetlands. In addition, the increased volume of water within surface and ground waters will potentially improve water quality through diluting pollution loads.

The achievement of these targets translates into the following changes to the indicators providing more insight into Israel's water scarcity situation (Table 4.27).

Table 4.27: Key Indicators on water use and water availability for the year 2007, the baseline 2020 and the scenario 2020

Year	Water Available per Capita (10^3 m^3/person/yr)	Water Exploitation Index (%)	Total Water Use per Capita (10^3 m^3/person/yr)	Municipal Water Use per Capita (10^3 m^3/person/yr)
2007	0.30	95	0.28	0.11
2020	0.35	87	0.30	0.15
Scenario 2020	0.35	46	0.17	0.09

Source: Author's calculations

52 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.

4.5.3 Qualitative assessment of the benefits of improving water resource use

Improving water resource use and management will potentially lead to a multitude of benefits. The following benefits, which focus on alleviating water scarcity and optimising overall water use (as opposed to improving water quality), may be gained:

Table 4.28: Qualitative description of the benefits of improving water resource use	
Health benefits	Reduced water scarcity can positively affect the achievements of the targets described in the drinking water, sanitation and hygiene chapter (see section 3.2)
Environmental benefits	Increased environmental flows would provide significant environmental benefits. Achieving the minimal environmental flows in Israel's surface waters can help to improve dependent freshwater ecosystems (wetlands and rivers). Higher river flows would also reduce pollution concentrations and the associated environmental impacts. Decreased groundwater abstractions could reduce the risk of saline intrusion in the coastal aquifer, benefiting humans and the environment alike. Desalination offers potential to increase the supply of available water, however this bears a significant environmental costs related to the energy consumption for desalination (and associated emissions). The consequences of brine disposal into the sea are not fully understood.
Economic benefits	If less water is used due to demand management practices, there is less need to increase the production capacity of desalination plants, freeing up the capital and operating costs. Limiting desalination to brackish water would further restrict expenditures. Besides increased agricultural output through more efficient irrigation and automatisation, less crops and livestock will be lost through droughts. The increased water security can motivate farmers to plant higher value multi-year crops, such as wine, for which water security needs to be guaranteed. This also allows growing crops with higher agricultural capital accumulation (i.e. trees and other plants which take a significant amount to mature), which are more profitable than single season crops (Lavee, 2010) Further, direct and indirect economic benefits could arise from increased opportunities for touristic development due to higher flows in surface water: some of Israel's major surface water bodies, such as River Jordan and the Sea of Galilee (Lake Kinneret), are also important tourist destinations, both for domestic and international tourism.
Social benefits	Enhanced quality of life if living near and using "healthy" rivers and lakes and potential for greater use of water bodies for amenity (sports and leisure), when environmental flows are guaranteed. Considering that surface waters in Israel, such as River Jordan and Sea of Galilee, have immense cultural and spiritual importance for Israelis and for religious practitioners from all over the world, high social benefits can be reaped when allocating sufficient water to nature. This could benefit cultural and religious practices, e.g. maintaining and reviving the tradition of baptism in the River Jordan. For transboundary water bodies, a reduction in water use combined with a greater allocation of water to nature could also improve the conditions

Table 4.28: Qualitative description of the benefits of improving water resource use	
	for alleviating existing conflicts over water use, if such arrangements can be achieved in the frame of an international agreement or treaty.

Source: Authors' own compilation

4.5.4 Quantitative assessment of the benefits of improving water resource use

This study has not attempted to quantify the benefits of reducing water scarcity through improved water resource management due to the complexity of the task and the budgetary constraints of the project.

4.5.5 Monetary assessment of the benefits of improving water resource use

This study has not directly attempted to assess the overall monetary value of reducing water scarcity through improved water resource management due to the complexity of the task, the limited data availability and the budgetary constraints of the project.

It is worth pointing out though that the potential economic losses associated with droughts and reduced crop outputs can be substantial. The reaction of farmers to unreliable water supply, namely that farmers tend to grow less profitable crops which require minimal agricultural capital accumulation (i.e. single-season crops) to limit their losses in the event of water scarcity, can be used as a proxy for assessing the monetary value of improving water resource use.

Lavee (2010) analyzed the cost of water supply uncertainty in agriculture in Israel. Lavee (2010) developed two models to estimate the cost of water supply uncertainty. The first model estimated a risk premium of 0.38 €/m³ (2 NIS/m³) 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 €/m³ (4.03 NIS/m³).53 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 4.29.

Table 4.29: Price of Uncertainty - Sensitivity Analysis (NIS/m³)

Critical water level (as % of mean annual amount)	Interest rate		
	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)

53 Using PPP adjusted 2008 market exchange rates

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%[54] of the wastewater produced shall be reused (MoEP, 2005c).

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 387 MCM to 618 MCM, thus resulting in an increase of 231 MCM. With the cost of uncertainty of 0.38 €/m^3 (2 NIS/m^3), this would deliver benefits of EUR 88 million (NIS 462 million). However, for a more complete assessment, the capital and operating costs of wastewater treatment plants and the necessary infrastructure would need to be included.

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. demand reductions that free up water and thereby increase the available supply.

Further, MoEP (2010d) estimates that the climate-related decrease of renewable water resources by 200 MCM/year can lead to a decline in agricultural income by EUR 70 million yearly and to the loss of thousands of jobs. Achieving the outlined targets could save around 1.155 MCM/year, which could easily be used as a buffer to avoid the decline in incomes and loss of jobs.

Given the significance of water scarcity and water resource management in Israel, it is recommended that the economic benefits of water resource management are further assessed as part of any future integrated water resource management studies within Israel.

4.5.6 Assessment on the benefits of minimizing water produced by desalination

Improving the water resource use, as measured by the water exploitation index, comes with significant benefits. However, some of the options for increasing water supply come with specific consequences, which require a more differentiated benefit assessment. This is the case, for instance, for desalination.

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) (EInav and Lokiec, 2006).

However, the environmental damages can be limited when taking appropriate measures and decisions. For instance, the location of the desalination plant can impact the damage to the marine environment (disposed brine has a more harmful impact on marine life in

54 For a discussion of 100% wastewater treatment target, see Footnote 39.

shallow coastal waters[55]), and the noise pollution impacts are higher in more densely populated areas. The Ashkelon Seawater Reverse Osmosis (SWRO) Plant, which was completed in 2005, took innovative technical measures to dilute the waste product brine with the cooling waters of the adjacent Israel Electrical Company power station, before discharging it back into the sea (EInav and Lokiec, 2006). This practice reduces the adverse impacts on the marine environment. Further, energy recovery centres, which collect pressurized brine from the plant's reverse osmosis banks, can reclaim some of the energy used in the Ashkelon SWRO Plant (Net Resources International, 2011).

Despite the potential for limiting environmental damages, 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 (MoEP, 2009a).

Table 4.30: Costs of methods to augment water supply

Method	Source/ Purpose	Costs (€/m³)	Costs ($/m³)
Desalination	Sea water	0.36-0.48	0.52-0.70
	Saline groundwater (from 50 MCM)	0.24	0.35
Effluent Treatment	Irrigation water	0.12-0.16	0.17-0.23
Water Treatment	Potable water	0.31	0.45

Source: MoEP, 2009a

Going beyond the water exploitation index as a measurable water security target, the targeted reduction in demand could be balanced by a reduction in planned desalinated water. While this approach would increase the water exploitation index, environmental damage is likely to be reduced while financial savings are nearly certain. [56]

55 Qutob (2004)
56 As the water exploitation index is a ratio of water consumed to water available, a decrease of water available (ceteris paribus) results in a higher water exploitation index.

5 BENEFITS OF IMPROVING WASTE RELATED CONDITIONS

5.1 Introduction to waste related issues

Waste disposal and treatment is a particular concern in Israel, for two main reasons: first, some parts of Israel (esp. the coastal plains) feature one of the highest population densities in the world, which means that only very limited land is available for designating sites for landfills or for extending existing sites. Second, the high (and rising) standard of living in Israel and the prevailing consumption patterns are associated with a steady and significant increase in waste generation, an issue that Israel shares with many other developed countries. Over the last decade, the total amount of waste in Israel has grown by 3-5% (Yesha'ayahu & Arne, 2010)

The situation for solid waste management has seen marked improvements in the last two decades. In the early 1990s, 96% of Israel's municipal solid waste was disposed in hundreds of illegal and polluting disposal sites throughout the country. Currently, most of Israel's municipal solid waste is disposed to 14 state-of-the art landfills across the country. In addition, about a 12% of the country's municipal solid waste is recycled (Ministry of Environmental Protection 2010d, p. 9). A separate system deals with construction and demolition waste.

Due to the competition for scarce land resources, a number of alternative options for waste management and disposal are being considered. This starts with source reduction, reuse and recycling, but also includes different disposal methods such as anaerobic digestion, composting and incineration (waste to energy plants).

Waste prevention is a key factor of the EU waste management strategy and should be a key factor in any waste management strategy. However, for methodological reasons, the benefits of waste prevention have not been assessed under this project.

5.2 Waste generation and collection coverage

Israel has achieved the target that was formulated for this sub-theme, i.e. 100% collection coverage of municipal solid waste: in other words, the social and economic benefits of full waste collection coverage are already being enjoyed by the Israeli population. Thus, the following section only describes the state of the environment, but no benefit assessment will be conducted for this sub-theme. Nevertheless, the benefit assessment of the following themes will build on the data provided in this section.

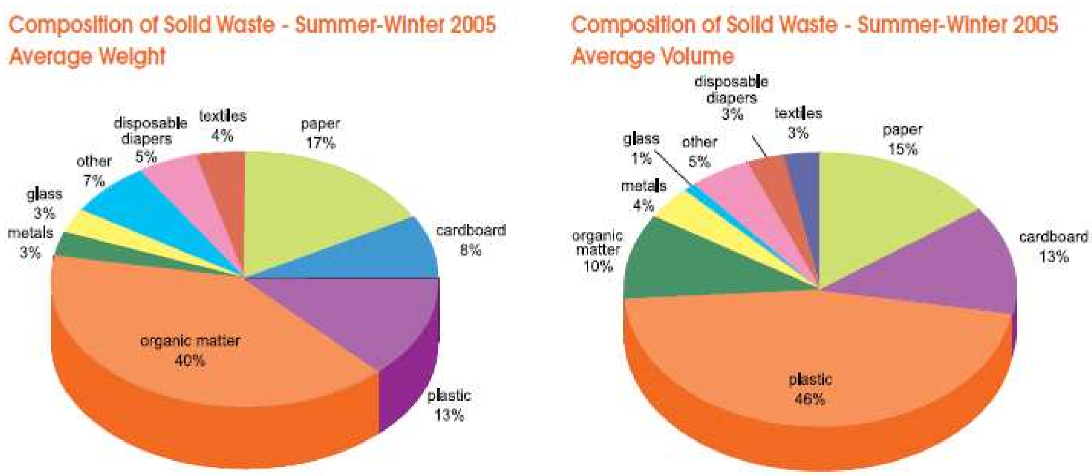
5.2.1 The state of the environment

Waste generation

According to a survey conducted in 2004-2008, the quantity of solid waste in Israel was about 11.3 million tons per year. Of this, about 4.4 million tons per year are municipal waste, some 1.6 million tons per year are industrial waste and about 4 million tons per year are construction and demolition waste. Per capita per year, each person in Israel generated some 577 kilograms of waste in 2007 – well above the EU-27 average of 317 kilograms in the same year (Yesha'ayahu & Arne, 2010, p. 200).

According to a 2005 survey, organic materials accounted for 40% of the weight of the total waste, followed by paper and cardboard (25%) and plastic (13%). In terms of volume, plastic contributes to 46% of Israel's waste, followed by paper and cardboard (28%), and organic material (10%) ("Solid Waste Management in Israel: Compendium of Articles from Israel Environmental Bulletin," 2008).

Figure 5.1: Composition of Solid Waste, Summer - Winter 2005



Note: The left figure shows percentages of waste composition by weight, the right figure shows percentages of waste composition by volume. Source: ("Solid Waste Management in Israel: Compendium of Articles from Israel Environmental Bulletin," 2008).

Waste Collection

As noted above, virtually all of Israel's municipal solid waste is collected (Ilan Nissim, Ministry of Environmental Protection, Personal Communication, 2011). Most of this is disposed to 14 state-of-the art landfills across the country (Nissim, Shohat, & Inbar, 2005). A separate system deals with construction and demolition of waste. This category amounts to some 3.5 million tons of waste annually (adding to some 6 million tons of municipal waste). Of these, some 1.4 million tons were treated in authorized landfills, and another 0.7 million tons recycled (double the amount reported in previous years) (Ministry of Environmental Protection, 2008, p. 12). 57

57 The NGO Israel Union for Environmental Defense confirmed impression given by the official data, according to which waste collection coverage is virtually complete for municipal solid waste. Possible exceptions include remote locations, such as unrecognised Beduin villages. No data is available, however, and waste from these settlements would only represent a very small fraction of the overall waste volume. The situation appears to be more problematic with construction and demolition waste, for which it is estimated that about half is not disposed in regular sites, but dumped in unauthorised sites both in Israel and the Palestinian Territory (Gilad Ostrovsky, Israel Union for Environmental Defense, Personal Communication, 2011).

5.2.2 Baseline scenario waste generation

The baseline from now to 2020 is a business-as-usual situation in which the collection coverage does not increase or decline. It is fully defined by demographic evolution and by the evolution of the average generation of waste per capita, in line with augmenting GDP. This leads to the following results:

Table 5.1: Baseline for municipal solid waste generation

	population	GDP	kg/inh.year	tonnes/yea
2008	7.308.800	145	574,6	4.200.000
2009	7.410.516	150	597	4.421.976
2010	7.513.648	156	620	4.655.683
2011	7.618.215	162	643	4.901.742
2012	7.724.237	168	668	5.160.806
2013	7.831.734	174	694	5.433.561
2014	7.940.728	181	720	5.720.732
2015	8.051.239	188	748	6.023.081
2016	8.163.287	195	777	6.341.408
2017	8.276.895	203	807	6.676.560
2018	8.392.084	211	838	7.029.426
2019	8.508.876	219	870	7.400.940
2020	8.627.294	227	903	7.792.090

Source: Authors' own estimation based on Benefit Assessment Manual (Bassi et al. 2011)

When assuming a shift in the composition of the generated municipal waste between now and 2030, in line with shifts in lifestyle, the future generation of different waste fractions can be estimated.

Table 5.2: Baseline shift in waste composition

	Current composition (%)	Future composition 2030 (%)
Organic waste	40,0	44,0
Plastics	13,0	13,0
Paper/cardboard	25,0	16,0
Textiles	4,0	6,0
Metals	3,0	5,0
Glass	3,0	9,0
other	12,0	7,0

Source: Authors' own estimation based on Benefit Assessment Manual (Bassi et al. 2011)

Table 5.3: Baseline municipal solid waste composition

	organic	plastic	paper	Textiles	metals	glass	other
2008	40,0	13,0	25,0	4,0	3,0	3,0	12,0
2009	40,2	13,0	24,5	4,1	3,1	3,2	11,7
2010	40,3	13,0	24,0	4,2	3,1	3,3	11,4
2011	40,5	13,0	23,5	4,2	3,2	3,5	11,1
2012	40,7	13,0	23,1	4,3	3,3	3,7	10,9
2013	40,9	13,0	22,6	4,4	3,4	3,9	10,6
2014	41,1	13,0	22,1	4,5	3,4	4,0	10,4
2015	41,2	13,0	21,7	4,6	3,5	4,3	10,1
2016	41,4	13,0	21,3	4,6	3,6	4,5	9,9
2017	41,6	13,0	20,8	4,7	3,7	4,7	9,6
2018	41,8	13,0	20,4	4,8	3,8	4,9	9,4
2019	42,0	13,0	20,0	4,9	3,9	5,2	9,2
2020	42,1	13,0	19,6	5,0	4,0	5,5	8,9

Source: Authors' own estimation based on Benefit Assessment Manual (Bassi et al. 2011)

Table 5.4: Baseline municipal waste fractions generation

:onnes/year	total	organic	plastic	paper	Textiles	metals	glass	other
2008	4.200.000	1.680.000	546.000	1.050.000	168.000	126.000	126.000	504.000
2009	4.421.976	1.776.470	574.857	1.083.294	180.169	135.776	139.452	517.795
2010	4.655.683	1.878.479	605.239	1.117.644	193.220	146.310	154.340	531.967
2011	4.901.742	1.986.346	637.226	1.153.083	207.216	157.661	170.818	546.527
2012	5.160.806	2.100.407	670.905	1.189.645	222.226	169.893	189.055	561.485
2013	5.433.561	2.221.018	706.363	1.227.367	238.323	183.074	209.239	576.853
2014	5.720.732	2.348.554	743.695	1.266.285	255.586	197.277	231.578	592.641
2015	6.023.081	2.483.414	783.000	1.306.438	274.099	212.583	256.302	608.862
2016	6.341.408	2.626.017	824.383	1.347.863	293.954	229.076	283.665	625.527
2017	6.676.560	2.776.810	867.953	1.390.602	315.246	246.848	313.950	642.647
2018	7.029.426	2.936.261	913.825	1.434.696	338.081	266.000	347.468	660.237
2019	7.400.940	3.104.869	962.122	1.480.188	362.571	286.637	384.564	678.307
2020	7.792.090	3.283.158	1.012.972	1.527.123	388.834	308.876	425.621	696.873

Source: Authors' own estimation based on Benefit Assessment Manual (Bassi et al. 2011)

5.3 Waste treatment

5.3.1 Introduction to benefits of enhanced waste treatment

The primary target is to avoid non-controlled waste dumping, and to replace it by sanitary landfills. Supplementary targets have been defined, based on European Union targets for recycling of specific waste fractions, and for landfill diversion of biodegradable waste. The recycling targets are applicable on the amount of waste being generated in 2030, and the landfill diversion target, to be reached in 2030, is based on a percentage of biodegradable waste being generated in 2010. The target year is set at 2030, because of the ambitious character of the targets. We calculate to which degree these targets will be approached in 2020. The environmental benefit consists of avoided dumping and increased recycling or composting of waste. This leads to societal benefits in the fields of environmental and health impact reduction, resource savings and quantifiable job creation.

5.3.2 The state of the environment

Landfilling

As mentioned above, the situation for solid waste management improved markedly over the last decades. Today, most of Israel's waste for final disposal (about 95%) is disposed to 14 state-of-the art landfills across the country. These landfills are equipped with systems for leachate collection and treatment, and in some cases also with systems for the collection and treatment of gas emissions, including energy recovery (Ministry of Environmental Protection, 2010, p. 9).

Although more than half of the 500 unauthorized dumps have been closed and many others have been substantially upgraded or improved, several large dump sites remain. Most of the dumps were located on or near to groundwater recharge zones, causing a risk to groundwater quality. Over the past five years, criminal charges were filed against about 15 out of the 30 large waste transporters working in the Haifa district alone. Enforcement was targeted at every pile of waste larger than 40 m^3 and criminal investigations were initiated against mayors for illegal waste dumping.[58]

Recycling

Recycling rates for municipal and industrial waste have increased from 3% in 1990 to about 23% in 2005. However, within municipal waste management alone, only 12.5% of waste is being recycled. In addition, 45.5% of the construction waste was recycled and 100% of Israel's coal ash is recycled, mostly for the construction industry (Ministry of Environmental Protection, 2010, p. 9).

The main recycling facilities at the municipal level include paper and plastic collection bins, currently deployed in some 130 local authorities. In addition, other authorities have opened central recycling centers, including 16 centers for electronic waste. Furthermore, in 2001 a deposit scheme on beverage containers came into effect, and collection rates of beverage containers have since increased significantly. In 2005, some 330 million beverages containers have been collected through this scheme ("Solid Waste Management in Israel: Compendium of Articles from Israel Environmental Bulletin," 2008). Table 5.5 below shows estimates of recycling in Israel, by type of raw material.

Composting and Incineration

Currently, treatment of Municipal Organic Waste (MOW) is in its infancy in Israel. A small fraction of Municipal Organic waste is being treated, mostly for composting (about 4.9%). Most of the recycled organic material in Israel is agricultural waste (nearly 90%), and only a small fraction is MOW. Composting of domestic organic materials is limited to some local initiatives, since there is no governmental policy to support scaling up such initiatives.59

58 Source: From Open Dumps to Sanitary Landfills- The Israeli Approach: <http://www.bvsde.paho.org/bvsacd/iswa2005/open.pdf>. 2005.

59 "Eretz Carmel", for example, is a private company which provides composting services for a number of villages which collect domestic organic material, and turns the organic material into compost.

Similarly, there are only few facilities for incineration of organic waste and for energy production from methane, most of them in pilot-assessment stages.60

However, Israel is currently assessing means to increase its capacity for treating MOW, through both composting and incineration. Several studies have looked at the economic viability of composting and incineration, and the MoEP has set a target for diverting nearly all MOW from landfills in the coming decade (Illan Nissim, MoEP, Personal Communication, 2011), as part of the Ministry's policy to reduce MSW by 40% by 2020. In line with this policy, the government has recently approved a support of EUR 40 million to establish facilities for treating municipal organic waste or to upgrade current facilities in order to increase their capacity and adapt them for municipal organic waste.

In addition, in 2010 Israel's Electricity Corporation conducted a hearing for setting a feed-in tariff for electricity production from incineration of organic waste. The proposed feed-in tariff is NIS 0.6 per KWh (0.12 €/kWh), to be implemented by 2017.

Table 5.5: Estimates of recycling in Israel by type of raw material, 2009

Type	Recycled waste, 2009 (tons)	Share of recycling out of total waste
Construction waste	1,809,536	**38%**
Coal ash	1,201,000	**25%**
Metals	497,048	**11%**
Organic material	489,711	**10%**
Paper and newspaper	315,857	**7%**
Yard waste and wood	199,730	**4%**
Sludge	54,500	**1%**
Plastics	47,686	**1%**
Oil	25,898	**1%**
Other	80,313	**2%**
TOTAL	**4,721,279**	**100%**

Source: The Central Bureau of Statistics http://www.cbs.gov.il/shnaton61/st27_15.pdf

5.3.3 Baseline scenario waste treatment

The baseline scenario describes what will happen if waste generation grows in line with GDP and population, as described above, and if there is no change to the waste treatment options.

60 These include the Evron which generates most of its electricity from the nearby Evron Landfill, gas production from the former landfill in Hiria, and others.

Table 5.6: Baseline Scenario for waste treatment

	waste generated	collection coverage	waste collected	waste not collected	dumped (tonnes)	landfilled (tonnes)	incinerated (tonnes)	recycled (tonnes)	composted (tonnes)
2008	4.200.000	100	4.200.000	0	183.277	3.482.258	0	534.465	0
2009	4.421.976	100	4.421.976	0	192.963	3.666.300	0	562.712	0
2010	4.655.683	100	4.655.683	0	203.162	3.860.069	0	592.452	0
2011	4.901.742	100	4.901.742	0	213.899	4.064.079	0	623.764	0
2012	5.160.806	100	5.160.806	0	225.204	4.278.871	0	656.731	0
2013	5.433.561	100	5.433.561	0	237.106	4.505.015	0	691.440	0
2014	5.720.732	100	5.720.732	0	249.637	4.743.111	0	727.984	0
2015	6.023.081	100	6.023.081	0	262.831	4.993.791	0	766.459	0
2016	6.341.408	100	6.341.408	0	276.722	5.257.719	0	806.967	0
2017	6.676.560	100	6.676.560	0	291.347	5.535.597	0	849.616	0
2018	7.029.426	100	7.029.426	0	306.745	5.828.161	0	894.520	0
2019	7.400.940	100	7.400.940	0	322.957	6.136.187	0	941.796	0
2020	7.792.090	100	7.792.090	0	340.026	6.460.493	0	991.571	0

Source: Authors' own estimation based on Benefit Assessment Manual (Bassi et al. 2011)

5.3.4 Targets

Waste prevention policy – targeting the reduction of waste at source – is a new policy field, not only in Israel, but also in the EU. The recently introduced Israeli policy lacks quantified targets, and is too recent to have had a measurable impact. This analysis therefore does not take the effects of waste prevention into account, and the target for waste generation is therefore equal to the baseline. For this reason, benefits like reduction of resource depletion will not be assessed in and of themselves, but in the frame of recycling.

The following targets are assumed:

- 50% recycling of all glass, paper, plastic, metals in municipal waste
- 70% recycling of construction and demolition waste
- 65% of the quantity of biodegradable waste generated in 2010 diverted from landfills

There are two kinds of EU targets :

- The recycling targets really look at an EU target year 2020 and request that 50% of a certain waste material generated in that target year is recycled in that target year.
- However, the EU landfill diversion target is much more permissive. In the EU the total amount of biodegradable waste landfilled in the years 2006, 2009, 2016 (or 2010, 2013, 2020) may not be above 65%, 50%, 35% of the total amount of biodegradable waste generated in 1995. We respected this philosophy and requested in this target that the amounts landfilled in ENPI countries in 2030 would not be higher that 35% of the amount of biodegradable waste generated in 2010. Of course, just as in the EU target, an increase of total waste generation is not taken into account, as the target refers to an absolute, 'historic' value and not to a relative percentage. For this reason the percentage composted can indeed be lower than what would be expected for Israel and still reach the targets.

- For all ENPI countries the basic idea is that the minimum will be done to reach but not to surpass the targets. It is the scope of the whole project to calculate what would be the benefits if targets are reached, and for this reason targets have been set equal for all ENPI countries. In reality the benefits for Israel could indeed be higher when the level of ambition is higher.

The horizon of reaching the targets is set at 2030. The calculated results will show the progress reached in 2020, on which the benefits are calculated.

Table 5.7: Target values in quantitative data for 2030

collection coverage:					
100	% population covered by municipal waste collection in 2008				
100	% population covered by municipal waste collection in 2030			(target year = 2030, year of scope = 2020)	
0,00	% yearly increase				
50% recycling of glass		50% recycling of plastic		minimum quantity for recycling in 2030	
1.173.727	generation in 2030	1.695.383	generation in 2030	2.803.903	tonnes
586.863	recycling target in 2030	847.692	recycling target in 2030		
50% recycling of paper		50% recycling of metals			
2.086.625	generation in 2030	652.070	generation in 2030		
1.043.313	recycling target in 2030	326.035	recycling target in 2030		
70% recycling of C&D waste					
no data	generation in 2030				
no data	recycling target in 2030				
65% landfill diversion of biodegradable waste				maximally allowed on landfills in 2030	
3.189.343	generation in 2010 (previous tab)			10.968.335	tonnes
2.073.073	not allowed on landfills in 2030				

Source: Authors' own estimation based on Benefit Assessment Manual (Bassi et al. 2011)

5.3.5 Environmental improvements

The environmental improvements are

- The amount of waste not being illegally dumped or treated in a substandard way, but being either landfilled, incinerated, composted or recycled.
- the amount of waste not being landfilled but composted or recycled

A scenario is developed in which the targets have been reached in 2030, and in which the appropriate distance to target has been bridged in 2020.

Table 5.8: Minimal percentages for different waste treatment options in a scenario in which target values for 2030 have been reached

		calculated value	target value		distance to target	evaluation
0	% collected waste dumped in uncontrolled dumpsites in 2030					
66	% landfilled in controlled landfills in 2030	8.607.329	10.968.335	(max)	-2.361.006	target reached
4	% incinerated in 2030	521.656				
22	% recycled in 2030	2.869.110	2.803.903	(min)	-65.207	target reached
8	% composted in 2030	1.043.313	1.029.760	(min)	-13.553	target reached

Source: Authors' own estimation based on Benefit Assessment Manual (Bassi et al. 2011)

If 50% of all generated municipal plastic, metal, paper and glass waste would be recycled, this corresponds to the recycling of 22% of all MSW generated in 2030. We can assume, from the described policy initiatives, an intensified composting and anaerobic digestion effort, and increased incineration. The assessment made on incineration is still rather prudent and conservative. 65% of the 2010 generated biodegradable waste needs to be composted or recycled. The target for composting is calculated as the target for landfill diversion of biodegradable waste minus the paper that needs to be recycled. This is a slight over-estimation as it includes eg biodegradable textiles and wood that can be recycled in stead of composted.

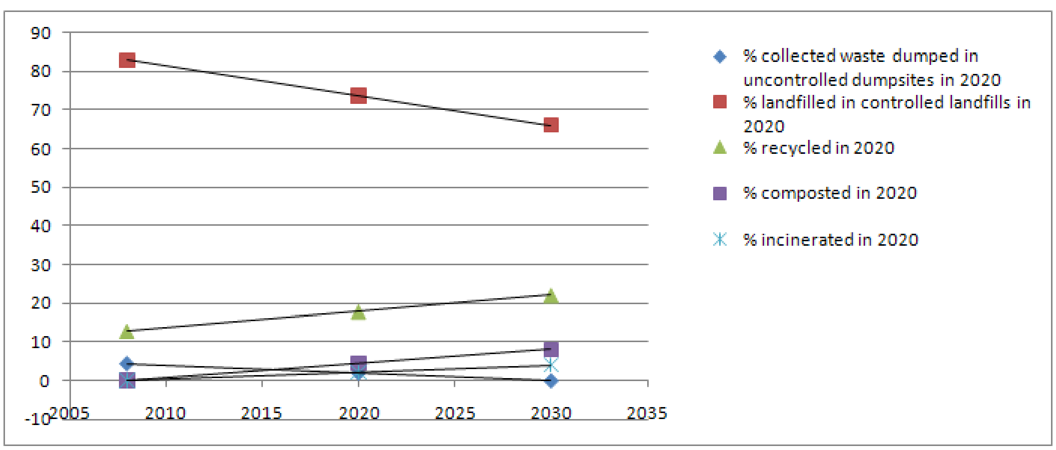
If in 2030, 66% of the generated waste would be landfilled, 22% would be recycled, 4% would be incinerated and 8% would be composted, the targets will have been reached. Assuming a linear progression to these targets, the following waste treatment options have to be reached in 2020 (see Figure 5.2 and Table 5.9):

Table 5.9: Minimal percentages for different waste treatment options in 2020 if targets should be met in 2030

2,0	% collected waste dumped in uncontrolled dumpsites in 2020
73,7	% landfilled in controlled landfills in 2020
2,2	% incinerated in 2020
17,8	% recycled in 2020
4,4	% composted in 2020

Source: Authors' own estimation based on Benefit Assessment Manual (Bassi et al. 2011)

Figure 5.2: Evolution of waste treatment options in order to reach targets



Source: Authors' own estimation based on Benefit Assessment Manual (Bassi et al. 2011)

Table 5.10: Environmental improvements in 2020

the amount of waste not being dumped in uncontrolled dumpsites			
	amount dumped in the baseline scenario :	340.026	tonnes
	amount dumped in the target compliant scenario	154.557	tonnes
	difference = environmental benefit	185.469	tonnes
the amount of waste supplementary composted or recycled			
	amount in the baseline scenario :	991.571	tonnes
	amount in the target compliant scenario	1.725.783	tonnes
	difference = environmental benefit	734.212	tonnes

Source: Authors' own estimation based on Benefit Assessment Manual (Bassi et al. 2011)

5.3.6 Benefits assessment

Qualitative assessment:

Table 5.11: Qualitative description of the benefits of improved waste treatment	
Health benefits	Health benefits can emerge from avoided pollution of soil, ground water and air by wild dumping or burning of waste. Illegal dumps can also attract rodents, which can be vectors for diseases etc. Furthermore, where there are cases of local population involved in informal waste collection, which can lead to contamination due to the handling of waste materials. In addition, one of the main reasons for the closure of the large dumpsite of the Gush-Dan Metropolitan (the "Hiria"), was the large numbers of birds flying over the mountain which posed a large security risk for the airplanes departing from Israel's central airport (Ben Gurion airport). Hence, a sound management of dumpsites has great potential for reducing the risk of human health and human security.
Environmental benefits	Currently, there are several available technologies to capture methane gas from biodegradable waste (biomass) or to produce energy from the incineration of biodegradable waste. This can reduce emissions which otherwise would have been emitted to the atmosphere (such as methane), as well as reduce dependency on fossil fuels for energy production. Several projects are already underway in Israel, and some of them are authorized for use of CDM credits (e.g. energy production from chopped wood in Kibutz Ma'anit or capture of methane emissions for energy production in KIbutz Lahav). One of the main reasons that up to date Israel has not been realizing its potential for energy production from biodegradable, is lack of supply of raw materials for the production process (i.e. low recycling rates of organic waste) (Tzeri, 2008)
Economic benefits	First of all, increasing the recycling rates will increase the availability of secondary raw materials, which can be used in production processes (domestically or exported abroad). Second, organic waste can be used for generating energy (see environmental benefits above), thus reducing costs of energy from fossil fuels. Another related co-benefit is the developing of technology for the production of energy production from biodegradable waste, which can

Table 5.11: Qualitative description of the benefits of improved waste treatment	
	increase Israel's involvement in this uprising global market. Third, due the landfill levy scheme which was implemented in Israel in 2007, Municipalities can gain direct economic benefits from reducing the amount of waste (by weight) which they produce. The landfill rate is determined by the type of waste and type of landfill, and gradually increases over time (expected to reach NIS 50 [about EUR 10] per tonne for Municipal Solid Waste in 2012). Lavee (2007) conducted a cost-benefit analysis, which shows that because of the levy, for most municipalities in Israel a recycling rate of 27.7% would be most efficient economically (see Monetary Assessment below).
Social benefits	The expansion of the recycling industry, including composting and incineration of biodegradable waste, will lead to job creation in this sector. Furthermore, local communities can become more self-sufficient if they make use of recycled waste (e.g. for energy production), which can potentially contribute to an enhanced collective feeling of self-efficacy and self-sufficiency.

Source: Authors' own compilation

Quantitative assessment

The number of employees needed for shifted waste treatment options is assessed as follows:

- An average landfill with a capacity up to 1.000.000 tonnes is 1 chief, 4 porters, 1 compactor driver, 1 bulldozer driver, 1 excavator driver, 1 driver, 1 pump operator, 1 maintenance technician, 1 weighing pond operator = 12 jobs
- The number of employees for a straightforward windrow composting plant of 20.000 tonnes/year = 5 jobs
- Job potential in the recycling industry is very diverse, and an average is not estimated. A conservative assumption is that it will not require less employees to recycle than to landfill.

When applying these assumptions on the amounts of waste treated in a way diverging from the baseline scenario, following amounts of job creation can be assessed:

Table 5.12: Assessment of job creation in 2020 when waste management target should be met in 2030

average number of employees to serve a landfill with 1.000.000 tonnes capacity or 50.000 tonnes yearly capacity		12
	amount landfilled in the baseline scenario :	6.460.493
	amount landfilled in the target compliant scenario :	5.741.740
	supplementary yearly capacity	-718.753
	supplementary jobs	-173
average number of employees to yearly recycle 50,000 tonnes		12
(conservative estimate : recycling generates no less jobs than landfilling)		
	amount recycled in the baseline scenario	991.571
	amount recycled in the target compliant scenario	1.385.765
	supplementary yearly capacity	394.194
	supplementary jobs	95
average number of employees to yearly incinerate 50,000 tonnes		24
(conservative estimate : incineration generates 2* jobs than landfilling)		
	amount incinerated in the baseline scenario	0
	amount incinerated in the target compliant scenario	229.529
	supplementary yearly capacity	229.529
	supplementary jobs	110
average number of employees to yearly compost 20.000 tonnes		5
	amount composted in the baseline scenario	0
	amount composted in the target compliant scenario	340.018
	supplementary yearly capacity	340.018
	supplementary jobs	85
Job balance		
	supplementary jobs	117

Source: Authors' own estimation based on Benefit Assessment Manual (Bassi et al. 2011)

Additional economic benefits for Municipalities from increasing recycling rates

Lavee (2007) conducted a cost-benefits analysis for municipalities, which assumes a reduction of the amount of waste landfilled in order to reduce the landfill levy for households. The reduction in landfilled waste is mainly achieved by increasing the share of recycled waste. The study, which was conducted in Israel in 2000–2004, shows that municipalities can reduce overall waste management costs by 11% on average, if they increase recycling rates and manage their waste more efficiently. The analysis also reveals that recycling is very advantageous for the large municipalities (recycling is efficient for 87% of all such municipalities), but less so for the regional municipalities (recycling efficient for 25%). In addition, the study shows that under the current landfill levy scheme, a recycling share of 27.7% would be optimal from the municipalities' cost optimization perspective (for all municipal solid waste, but excluding organic waste) (Lavee, 2007).

5.4 Benefits of reducing methane emissions from waste

5.4.1 Introduction to benefits of landfill gas capture

When biodegradable waste is landfilled or dumped, anaerobic conditions may occur in which the waste is decomposed by bacterial activity, generating among others emissions of two greenhouse gases, methane (CH_4) and carbon dioxide (CO_2). Reducing these emissions therefore provides socio-economic benefits, by reducing the impact on global warming, reduced environmental and nuisance impact, and the use of landfill gas as an energy source.

The landfill gas emissions in the baseline scenario and in the target compliant scenario in 2020 are derived from an assessment of the total amount of waste landfilled, dumped or not collected. In the target scenario we supplementary assume that 20% of all landfills are equipped with landfill gas collection systems. The difference between both shows the amount of landfill gas emissions that supplementary can be avoided. The socio-economic benefits can be expressed in the marked values of avoided CO_2eq.

5.4.2 The state of the environment

In 2006, Israeli landfills generated about 350,000 tons of methane. Currently, most of the centralized landfills in Israel that treat MSW are equipped with systems for capturing methane emissions. These systems capture about 40% of the Methane emissions from landfills (A. Heifetz & Co. & DHV MED Ltd., 2009, p. 42). Thus, the residual methane emissions from landfills released into the atmosphere amounted to some 210,000 tons in 2006.61

Policies for reducing organic waste in landfills

As stated above, Israel has plans for diverting most of the Municipal Organic Waste (MOW) from landfills, to either composting or incineration, as part of the MoEP policy for reducing MSW by 40% by 2020. Since organic material, together with cardboard and paper, is the main source of methane emissions from MSW, this could lead to a significant reduction in methane emissions. However, it should be noted that even if the above mentioned policy is fully implemented, methane emissions will not be eliminated, for two reasons: 1) MSW dumped in landfills continues to emit methane for about 50 years after disposal (depending on the capacity and lifetime of the landfill); 2) treatment of organic waste reduces methane emissions significantly, but does not eliminate them altogether, and different treatment systems have different abilities for capturing methane emissions (e.g. closed vs. open air composting facilities).

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61 Israel Second Communication on Climate Change to the UNFCCC, presents somewhat different figures. The document reports a slightly higher figure for methane emissions from landfilled MSW in 2007, about 250,000 tons - although the quantity of landfilled MSW was reduced between 2006 and 2007. The discrepancy arises since the 2007 estimate assumes a slightly higher emission factor (i.e. tons of methane for each ton of landfilled MSW) Ministry of Environmental Protection 2010g, p. 53). The differences, however, are not very significant for the purposes of this report.

5.4.3 Baseline scenario methane emissions

The baseline scenario assumes that current capacity for capturing methane emissions in landfills will not change by 2020, and that methane emissions will grow in line with the increase in waste generation. Total MSW in 2020 is projected at 7.8 million tons, of which 4.8 million tons belong to waste fractions generating methane (organic - 3.2 million tons, paper and cardboard - 1.5 million). Assuming these 4.8 million tons will be disposed in landfills, they will generate about 550,000 tons of methane. Assuming 40% of this will be captured (as stated above), total methane emissions to the atmosphere would reach 330,000 tons in the baseline scenario for 2020 is (see Table 5.13 below).

Table 5.13: Methane emissions in baseline scenario in 2020

	State of the Environment (2006)	**Baseline 2020**
Total MSW waste	4.700.000	7.792.090
Organic waste	1.880.000	3.280.470
Paper and cardboard	1.175.000	1.527.250
Waste generating methane (organic and paper)	3.055.000	4.807.720
Total methane generated	349.000	549.229
Captured methane emissions	139.600	219.692
Uncaptured methane emissions	**209.400**	**329.537**
Emission factor (tons CH_4/tons of methane-generating waste fractions)	0,11	0,11

Source: State of the Environment: (A. Heifetz & Co. & DHV MED Ltd., 2009, p. 42); Baseline 2020: authors' own estimation based on Benefit Assessment Manual (Bassi et al. 2011)

5.4.4 Targets

The Ministry of Environmental Protection has set a target to divert nearly all organic waste from landfills in the coming years, in line with its policy to reduce the weight of MSW by 40% by 2020. In line with this target, the target compliance scenario will assume a 90% of the organic waste is treated outside of landfills (i.e. composted or incinerated) and only 10% is landfilled.62 In addition, in accordance with the targets of the previous section on waste treatment, 50% of the paper and cardboard waste will be diverted from landfills for recycling. This yields the following results:

a) Total methane-generating waste fractions landfilled: 1.1 million tons. Total non-captured methane emissions from landfilled methane-generating waste fractions 74,827 tons (see Table 5.14 below).
b) In addition, treated organic waste also generates methane emissions, albeit at a much lower level compared to landfilled organic waste. According to expert judgments, when

62 We assume that even under a progressive policy of separation at source of MSW, it will not be possible to divert 100% of the organic waste and collection coverage will not cover 100% of the settlements.

organic waste is being treated (either composted or incinerated), methane generation is reduced approximately by a factor of 10. Assuming no capture for compost facilities or for the residues from incineration, treated organic waste will generate and emit another 33,728 tons of methane emissions (see Table 5.14 below).

In sum, total methane emissions for the target compliance scenario amount to 108,555 tons.

Table 5.14: Methane emissions in target compliance scenario, 2020

Tons	**State of the Env. 2006**	**Target Compliance Scenario 2020**		
		Landfilled	Treated (composted/ incinerated)	**Total**
Total MSW	4.700.000	7.792.090		
Organic waste	1.880.000	328.047	2.952.422	
Paper and cardboard	1.175.000	763.625		
Waste generating methane (organic and paper)	3.055.000	1.091.672	2.952.422	
Total methane generated	349.000	124.711	33.728	
Captured methane	139.600	49.885		
Uncaptured methane emissions	**209.400**	**74.827**	**33.728**	**108.555**
Methane factor (tons CH_4/tons of waste)	0,11	0,11	0,01	

Source: State of the Environment: (A. Heifetz & Co. & DHV MED Ltd., 2009, p. 42)
Target Compliance Scenario 2020: authors' own estimation based on Benefit Assessment Manual (Bassi et al. 2011)

5.4.5 Environmental improvements

The environmental improvement is the amount of methane emitted in the baseline scenario minus the amount of methane emitted in the target compliant scenario:

Methane emissions in Baseline scenario: 329,537 tons
Methane emissions in Target Compliance scenario: 108,555 tons
Environmental improvement: 220,982 tons

5.4.6 Benefits assessment

Qualitative Assessment

Currently, there are several available technologies to capture methane gas from biodegradable waste (biomass) or to produce energy from the incineration of biodegradable waste. This can reduce emissions which otherwise would have been emitted to the atmosphere, and help to reduce dependency on fossil fuels for energy production. Several projects are already underway in Israel, and some of them as CDM projects generating offset credits (CER), e.g. energy production from chopped wood in Kibutz Ma'anit or capture of methane emissions for energy production in Kibutz Lahav. One of the main reasons why, until now, Israel has not been realizing its potential for energy production from biodegradable waste, is the lack of supply of raw materials for the production process (i.e. low recycling rates of organic waste) (Tzeri, 2008).

Quantitative and Monetary Assessments

Environmental benefits

Methane is a greenhouse gas, with a global warming potential 21 times higher than CO_2.63 Thus, the above environmental improvements of 221,000 tons of methane emissions are equivalent to 4,640,628 tons of $CO_{2\text{-eq}}$. According to national assessments, in a business-as-usual scenario total GHG emissions in 2020 are projected to reach 107 million tons of $CO_{2\text{-eq}}$. (A. Heifetz & Co. & DHV MED Ltd., 2009, p. 51). Thus, the above environmental improvements would reduce Israel's greenhouse gas emissions by some 4% below business-as-usual emissions.

Monetary Benefits

The above environmental improvements of 221,000 tons of methane emissions are equivalent to 4,640,628 tons of $CO_{2\text{-eq}}$. The carbon values used is this study for 2020 range from 20€/tCO_2 (lower bound) through 39€/tCO_2 (medium) to 56€/tCO_2 (upper bound) for 2020. Using these values, the possible monetary benefits of the above environmental improvements amount to:

Lower bound:	EUR 93 million
Medium:	EUR 181 million
Upper bound:	EUR 260 million

63 The GWP value of 21 originates from the Second Assessment Report of the Intergovernmental Panel on Climate Change, and is the conversion factor agreed by the Parties to the Kyoto Protocol (IPCC 1995, The Science of Climate Change: Summary for Policymakers and Technical Summary of the Working Group I Report, page 22). Other values are quoted in the science; for instance, the more recent Fourth Assessment Report by the IPCC (2007) mentions a GWP value of 25 for a time horizon of 100 years (2007 IPCC Fourth Assessment Report (AR4), Chapter 2, p. 212)

6 BENEFITS OF IMPROVING NATURE RELATED CONDITIONS

6.1 Introduction to nature protection issues

Despite its small land area, Israel boasts a remarkable biodiversity. Israel has a unique location between different bio-geographic regions (the European, Asian and African continents, the Mediterranean and the Red Sea), its flora and fauna exhibiting influences from all these regions. In addition, Israel has a remarkable diversity of climatic, geographic and physical conditions in a small area, and it serves as a major thoroughfare for migratory birds. Due to all these factors, Israel is endowed with a rich and unique variety of flora and fauna.

However, Israel’s biodiversity is endangered by anthropogenic pressures. Above all, economic development and population growth result in progressive destruction of natural habitats that are converted for human uses: for instance, it is expected that the country’s built-up space will double by 2020. There are ever less contiguous open spaces that give room to nature and provide untouched landscapes, and the remaining ones are subject to major development pressure. This is especially critical since the loss of open space to development is essentially irreversible (Ministry of Environmental Protection 2008, p. 35).

Next to the loss of habitats due to economic development, another major concern is habitat fragmentation. In the past, one effort to counter this has been to designate protected areas. Given Israel’s limited size, it has to be noted that the existing nature reserves are insufficient to protect and sustain many of the endangered populations. Efforts have been made in recent years to introduce a more systematic ecosystem management, for instance linking up reserves through biodiversity corridors. Outside the confines of nature reserves, hundreds of plant and animal species have been declared "protected natural assets."

A further issue are invasive alien species, which threaten to disrupt and disturb the established local ecosystems. A recent survey identified some 200 alien species, 50 of which are aggressive invasive species. There are also many invasive animal species in Israel – both vertebrates and invertebrates. Among vertebrates, the highest numbers of invasive species are among Mediterranean fish and among fowl (Ministry of Environmental Protection 2010a).

This section will cover the following aspects of nature:

- Level of biodiversity protection
- Deforestation levels
- Level of land degradation
- Level of rangeland degradation

6.2 Benefits from improving biodiversity protection

6.2.1 Current state of biodiversity

Israel is a country with a small land area of 21,642 km^2 (slightly larger than Slovenia), and in addition water area of 430 km^2. Despite its small size, it boasts a remarkable biodiversity. This is owed to Israel's location at the junction of three continents, and the variety of different landscapes and climatic conditions found on its territory. Along its length of 470 kilometers, Israel features landscapes that are separated by thousands of kilometers in other regions – from alpine fauna and flora on Mount Hermon in the north, to coral reefs in the Gulf of Eilat in the South. Israel's climate and biota is equally diverse – Mediterranean in the North, and desert in the South, with the central part of Israel as a transition area. Israel is also located at the junction of three phytogeographical regions: Mediterranean, Irano-Turanian and Saharo-Arabian, which is reflected in a diverse collection of herbaceous plants (Ministry of Foreign Affairs 2001).

The unique location is a key reason for the high diversity of species that can be found in Israel. Currently, there are some 2,400 plant species (of which 150 are indigeneous to Israel), 7 amphibian, 100 reptile, 530 bird, over 100 mammal and 32 fish species (CBD 2010).

Depending on the classification applied, some 46 ecosystem types can be discerned in Israel, which can be further grouped into eleven major ecosystem clusters. These include woodlands and shrublands, coastal, desert, freshwater (including swamps / wetlands), marine, agricultural, rangeland and urban ecosystems (Ministry of Environmental Protection 2010e, p. 18).

- Woodland and shrubland ecosystems once used to dominate the part of Israel that enjoys a Mediterranean climate, i.e. the North of Israel. Much of this has since been converted into agricultural land, urban areas, or planted forests (mostly pine).
- Likewise, coastal ecosystems suffer from the fact that most of the land in coastal areas has been converted to agricultural or urban use, with some few relatively rich ecosystems surviving in the remaining areas.
- The Israeli desert, which covers more than half of Israel's territory, harbours a relatively rich biodiversity providing diverse cultural ecosystem services. It encompasses several ecosystem types, differing in their aridity, elevation above sea level and land infrastructure. Pressures on these ecosystems are relatively minor compared to other ecosystems, largely due to the lower pressure from human settlement and other forms of development.
- Freshwater ecosystems comprise a large number of relatively small water bodies, both natural and artificial. There are only few perennial rivers, and only one large lake (Lake Kinneret or Sea of Galilee). As Israel is dominated by dryland climate, the value of these ecosystems and the services they provide is particularly high (including water provision, purification and regulating services, and support of a rich and unique biodiversity). However, freshwater ecosystems are under particular pressure from human uses – competition for scarce water resources, water pollution, and conversion of swamps and wetlands for agricultural and urban uses.

- Marine ecosystems are found in the Mediterranean and the Red Sea. Especially the Red Sea features rich biodiversity. Main ecosystem services include food provision (fishing) and cultural services (angling in the Mediterranean, coral reef tourism in the Red Sea). Ecosystems are impacted by pollution from urban and industrial sources (the latter including power stations and desalination plants). In addition, marine ecosystems in the Mediterranean face the threat of invasive species from the Red Sea.
- A large share of the original woodland, shrubland and coastal ecosystems has been transformed into agricultural areas. These areas also function as ecosystems, however at a net negative effect to the country's biodiversity. Although some 15 % of the original agricultural ecosystems area has been abandoned in recent decades, only a small fraction of this has been returned to its prior state (Ministry of Environmental Protection 2010e, p. 21).
- Rangeland ecosystems are likewise the result of a transformation, typically from woodland and shrubland ecosystems, mainly to be used for cattle grazing, but also from desert ecosystems, mostly used for goat and sheep ranges. However, unlike the transformation to agriculture, the conversion into rangeland ecosystems usually does not involve a trade-off in the provision of ecosystems services: rangeland management usually affects the relations among the different components of natural biodiversity, but maintains most of its components.
- The conversion to urban ecosystems (built-up areas) now covers five percent of the country's area, however at a growing rate (urban sprawl). While urban ecosystems may support some biodiversity (city gardening and adaptation of natural biodiversity to urban conditions), on the whole, transformation to urban areas has a negative effect on biodiversity and ecosystem services.

In 2008, about one fifth (20.7%) of Israel's land area is protected as a nature reserve or national park (Israel Nature and Parks Authority 2009c). Most of this is located in the desert area in the South of Israel. However, it should be noted that these areas were primarily selected due to their low value for development (i.e. the low opportunity cost of awarding them protection status), rather than their high value in terms of biodiversity or ecosystem services provided (Ministry of Environmental Protection 2010e, p. 17).

In 2008 there were 218 nature reserves covering an area of 4,280 km^2, as well as 74 national parks (200.8 km^2). Taken together, these cover 20.7% of Israel's land area. Another 259 nature reserves (2,690 km^2) and 75 national parks (100 km^2) are currently in various stages of the planning process (Israel Nature and Parks Authority 2009c). If all of these were implemented, a total of 6,866 km^2 would be protected, almost a third of Israel's territory. For coastal and marine areas, 14 nature reserves (9.7 km^2) and 23 national parks (18.3 km^2) were designated in 2002, equivalent to about 6.5% of Israel's water area.

6.2.2 Potential environmental improvements

If measured in terms of the protected area, Israel has already achieved a high level of protection: with 20.7%, Israel is for instance already above the 17% target foreseen in the

CBD Strategic Plan for 2011 – 2020.64 However, as the Israeli authorities acknowledge, the current protected areas in Israel were not designated based on the importance of the ecosystems, such as the richness of species found within the perimeter of the protected area or the ecosystem services provided by the protected ecosystem. This implies that the currently designated protected areas are at best a rough proxy for measuring biodiversity.

In order to assess the benefits of improved environmental protection, a hypothetical national target will be assumed to designate protected area status to 35% of Israel's land area. In order to deliver a measurable improvement for biodiversity protection, a significant amount of non-desert areas would need to receive protection status, and the target would need to cover all areas of particular importance for biodiversity preservation. Additional protected areas should be designated so as to limit and, where possible, reverse current trends toward fragmentation, and to counter the pressures on biodiversity from urban development and increasing population.

6.2.3 Qualitative assessment of the benefits of improving biodiversity protection

6.2.3.1 Environmental benefits

The benefits of enhancing biodiversity protection primarily accrue to the environment itself, through improved health and functioning of ecosystems, and the diversity and plentitude of ecosystem services they deliver. Environmental benefits include the following:

- Protection of a unique species diversity of international significance. Israel's location at a biogeographic crossroad, combined with a small, heterogeneous landscape yields very rich biodiversity on the genetic level, on the species level and on the ecosystem level. Within its small area, some 3.5 percent of the globally known species can be found. It is also one of the world's richest areas in progenitors and relatives of major agricultural crops. Beyond the biodiversity that is permanently found in Israel, the country is also a major route for migratory species. During the spring and autumn migration, some 500 million birds cross the country, adding another 280 species to Israel's breeding population of 206 bird species (Ministry of Environmental Protection 2009, p. 6).
- Maintain and enhance ecosystem services (water storage / purification, carbon storage, flood control etc.). Nineteen ecosystem services were found to be provided by these ecosystems. Safriel (2009) identified 19 ecosystem services provided by the ecosystems found in Israel. These include cultural services (which 90% of Israel's ecosystems provide), wild relatives of plant crops (70% of Israel's ecosystems), rich or unique biodiversity (supported by 60% of the ecosystems), water provision (50%) as well as water purification and water quality maintenance (20%). Several other ecosystem services may be relevant (including food provisioning, primary production and recycling of materials, control of climate and air quality, control of diseases or pollination); but these were not covered in this analysis.
- Maintaining and improving biodiversity also strengthens the stability and resilience of ecosystems, i.e. their capacity to adapt to external shocks and pressures. Climate change and the associated impacts (such as changes in precipitation patterns,

64 It should be noted that the CBD target is explicitly formulated as a global target, for which no specific national targets ("effort sharing") have been formulated. The mention of this target therefore does not imply any legal obligation; nonetheless, the target is used as a yardstick reference in this context.

droughts, higher average temperatures etc.) will increase the pressures on Israel's ecosystems. Maintaining healthy ecosystems with a high species diversity increases the capacity of ecosystems to survive these pressures.

6.2.3.2 Health Benefits

Biodiversity and nature protection has several health benefits, most of which are related to some of the ecosystem services listed above. For instance, green public spaces provide opportunities for recreation and relaxation, with associated benefits for mental and physical health. Intact ecosystems also purify air and water, with clear health benefits associated with the clean air and water that ecosystems provide. Other benefits include the diversity of medicinal herbs and other plants used for medical and pharmaceutical purposes. Finally, health risks may be associated with certain invasive species. Examples relevant to Israel include the Asian tiger mosquito, the little fire ant and jellyfish that have occurred in the Mediterranean (Ministry of Environmental Protection 2009, p. 13).

6.2.3.3 Social benefits

The social benefits offered by improved biodiversity are, partly related to the ecosystem services described above. This includes the amenity and recreation services offered by healthy ecosystems through recreation and relaxation, which enhance not only physical and mental health, but also general and spiritual wellbeing.

Maintenance of local biodiversity also has a strong cultural dimension. The preservation of certain iconic species, the preservation of traditional lifestyles and traditional knowledge, the preservation of typical, open landscapes can all contribute to a 'sense of place'. This dimension is of particular relevance in Israel: through its long history of human settlement, Israel boasts an extremely rich heritage in sites of high cultural, spiritual and religious value, including several nature areas of high spiritual and religious importance. By contrast, the loss of open landscapes not only means that these cultural and spiritual services are impaired, but it also increases inequality of access to these services. Due to population density and urbanisation patterns, cultural services are not equally locally available to all citizens: for instance, the central part of the country is inhabited by more than two thirds of Israel's population, but holds only 11% of its open landscape (Ministry of Environmental Protection 2009, p. 29).

6.2.3.4 Economic benefits

Ecosystem services are essentially an anthropocentric concept: humans derive benefits from the goods and services which ecosystems provide. But these goods and services are not always traded on markets: there are markets for the timber provided by a forest or the honey that bees provide, but there is no market for the relaxation and amenity that a forest provides to visitors, or the pollination of plants by bees. Where there is no market, there is also no market value (price) through which the economic value of the ecosystem service can be measured. There are incidences where ecosystem services provide an input to market activities, so that the economic value of these activities can be used to infer the economic value of the underlying ecosystem services. Examples include agriculture (which relies e.g. on pollination), the pharmaceutical industry (which relies on medicinal plants), and tourism (in particular eco-tourism and nature tourism, which relies on intact nature areas). This approximation is only possible where the ecosystem service in question is instrumental to the related market activity, i.e. the market activity would decline significantly if the ecosystem service would cease, or be permanently degraded.

Eco-tourism is of some importance in Israel, although arguably less than tourism related to spiritual and religious motives. Major attractions for environment-related tourism include coral reefs in the Red Sea, birdwatching (esp. in the rift valley and the Upper Galilee), and nature areas of high spiritual or religious value. Through park entrance fees and organised tours, eco-tourism generates revenues and local employment opportunities (paid or voluntary). According to the National Parks Administration, the designated Nature and National Park areas saw 3.1 million visits to historical sites in 2009 (of which 44% from foreign visitors), recreational sites saw another 4.3 million visits (of which 10% foreigners and 90% Israelis). Information on the revenue is not available. However it is estimated that some 700 people are employed in nature protection and conservation in permanent tenure, and another 400 seasonal staff.

6.2.4 Quantitative assessment of the benefits of improving biodiversity protection

As explained above, biodiversity provides a number of benefits, of which many are not amenable to a quantitative assessment. Quantifying the benefits of an improved status of biodiversity is therefore not possible through a top-down, broad-brush assessment as presented here, but would call for a more detailed, spatially explicit analysis at the level of ecosystems. However, as a rough approximation, the following quantification is based on the current and future extent of protected areas in Israel (nature reserves and national parks), making the following assumptions:

- As explained above, the target for protected areas in 2020 is set at 35% of Israel's total land area (up from 20.7% in 2008), and 10% of Israel's total water area (up from 6.5% in 2008). This target was assumed for the subsequent analysis. It is roughly in line with – albeit slightly higher than – official plans for the extension of the existing protected areas. However, these plans are not tied to a specific target date (Ministry of the Environmental Protection 2009, p.17).
- In terms of protected areas, the relative share of nature reserves and national parks remains unchanged (i.e. the same proportions apply in 2020 as in 2008)
- The average size of the additional nature reserves and national parks is the same as the current average (nature reserve on land (water): 19.6 km^2 (0.7 km^2); national park on land (water): 2.7 km^2 (0.8 km^2)). This assumption, however, has no impact on the subsequent estimations.

Table 6.1: Protected areas in Israel, 2008 – 2020

	Status quo (2008)			Target (2020)		
	Number	Area (km^2)	% share	Number	Area (km^2)	% share
Nature reserves land	218	4,280		381	7,231	33.4%
National parks land	74	201		134	344	1.6%
Total protected area land	**292**	**4,481**	**20.7%**	**515**	**7,575**	**35.0%**
Nature reserves water	14	10	2.3%	22	15	3.6%
National parks water	23	18	4.2%	35	28	6.4%
Total protected area water	**37**	**28**	**6.5%**	**57**	**43**	**10.0%**

Source: Ministry of Environmental Protection 2010e; Israel Nature and Parks Authority 2009c.

As noted above, assessing the actual benefits for biodiversity is not possible based on a relatively simple parameter such as the amount of protected land. Clearly, the biodiversity benefits depend not only on the total amount of protected land, but much more on the specific location of additional protected areas: it makes a huge difference for the biodiversity benefits if another square kilometre of desert is protected, or whether protection is awarded to areas of high ecological value (such as wetlands and forests on bird migration routes, or corridors between existing protected areas that connect otherwise separate populations).

However, for some of the ecosystem services provided by protected areas – in particular, recreation and relaxation, but also health benefits – the number of visitors can serve as a first approximation for the population benefiting from nature conservation. According to the National Parks administration, the 292 existing nature reserves and national parks (land only) saw 4.3 million visits in 2009 (figure for recreational sites only, excluding historical sites). This is equivalent to an average of 14,700 visits per site per year, or some 960 visits per km^2 of protected area. For protected areas on water, no figures are available.

In lack of more sophisticated spatial modelling, it is difficult to estimate how an increase of the protected area and the number of designated sites will affect the number of visits. On the one hand, having a greater number of protected areas means that more people will have a nature reserve or a national park in their immediate vicinity. The larger number also offers an increased variety of protected areas. Both these factors suggest an increase in visitor numbers – and they are all the more relevant, as the largest share of the existing protected areas are desert areas in the South of Israel, i.e. remote from the human settlement centres, and offering only limited variety. On the other hand, the number of people that seek recreation in protected areas is not infinite: even if a better, more differentiated supply of protected areas would elicit some additional demand (both from Israelis and international tourists), it is still likely that newly protected areas would divert some visitors from the existing sites. Bearing this in mind, it is assumed that each additional km^2 of protected area would receive between 33% and 100% of the visitors currently tending to the existing areas.

For the additional 3.1 million km^2 of protected areas by 2020 (both nature reserves and national parks), this would suggest an increase of between 1.1 million and 3 million visits per year, bringing the total number of visits for all areas, existing and newly protected, to between 5.4 million and 7.3 million per year.65

6.2.5 Monetary assessment of the benefits of improving biodiversity protection

While a complete monetary assessment of the benefits of improving biodiversity protection is well beyond the scope of this work, some insights can be gained from local case studies (see also the case study on the Mount Carmel Forest in chapter 6.4 below).

65 This rough estimate does not reflect the effect of population growth, a general increase in the level of affluence, and an increase in the number of tourists from abroad, all of which would lead to an increase in the number of visits to protected areas.

One of the better-documented cases is the Hula project in the Upper Galilee. The Hula wetland had been drained in the 1950s to provide land for agriculture and create local employment. However, these expected benefits did not materialise: not only did the soil quality deteriorate, rendering agriculture unprofitable, but the draining also meant that the wetland could no longer provide the nutrient cycling service, resulting in nitrification of the downstream Sea of Galilee (Baron and Zaitsev 2000). Most importantly, though, the drained wetland was reduced to a small remnant, and ceased to function as a habitat for local biodiversity, leading to a notable drop in species observed in the region. In response, the Hula wetland was restored in 1994. It has since again become an important habitat, including for a variety of endemic and migratory bird species including cranes, storks, pelicans, cormorans, herons and almost 300 other species. Since the restoration, the Hula reserve has become a centre of birdwatching in Israel, and attracts some 250,000 visits each year – predominantly Israeli, but increasingly also foreign visitors (Ministry of the Environment 2006).

In 1997, Baron et al. assessed the economic benefits of the Hula reserve by means of a contingent valuation study. Through this study, the authors how much tourists visiting the area would be willing to pay in entrance fees for the Hula reserve. They estimated the mean willingness to pay at NIS_{1997} 30 (EUR 9.46 in 2008 prices). They also estimated an increase in the number of overnight stays in the region by about 35,000 – 40,000, a number that is expected to grow over time and lead to additional revenue for hotels, guesthouses and campsites in the region. The average expenditure for accommodation was estimated at NIS_{1997} 633 per family (EUR 200 in 2008 prices). About a quarter of the surveyed visitors had also visited a restaurant in the region, spending an average of NIS_{1997} 197 per family (EUR 62 in 2008 prices).

A different piece of research has assessed divers' willingness to pay for marine biodiversity (i.e. a greater abundance and variety of species), as well as improved visibility, in the Eilat Coral Beach Nature Reserve in the Red Sea. The study by Wielgus et al. (2003) found that divers were willing to pay an additional NIS_{2003} 11.86 (EUR 2.85 in 2008 prices) per dive, on top of the existing diving fee of NIS 20, for each additional unit in a biological index that measures coral and fish abundance and richness of species. This compares to a willingness to pay of NIS_{2003} 5.46 (EUR 1.30) per dive for each additional meter of visibility. The total value of an overall improvement of environmental quality, which would take the Eilat reef to a level found in the (higher-quality) Sinai reefs, was valued at NIS_{2003} 13.2 million per year (EUR 3.17 million in 2008 prices).

As a crude approximation, the benefits of increasing the protected area in Israel can be estimated in the following way. As described in chapter 6.2.4, achieving the target of designating 35% of Israel's land area as protected area in 2020 can be associated with an increase in the number of visits to these areas by 1.1 – 3 million visits per year. Using Barons 1997 estimate of the willingness to pay of NIS_{1997} 30 per visit – equivalent to NIS 47 or EUR 9.46 at 2008 prices – the annual benefit of additional recreation opportunities could be valued at NIS 53.2 – 139.4 million (EUR 10.7 – 28.1 million) at 2008 prices. As such, this number is likely to both under- and overestimate the actual benefits: it is an overestimate, as the Hula reserve is recognised as an area of particular ecological value, boasting a rich variety of species. It is therefore possible that other areas would elicit a lower willingness to pay. At the same time, the monetary value is a gross underestimate of the economic value, as it only measures the amenity value of the site for visitors seeking recreation and relaxation, but does not include the multitude of other services that the protected areas may deliver.

Table 6.2: Benefits of extending protected areas, 2008 - 2020

Protected area 2008	Protected area 2020	Additional visits 2020		Monetary value 2020 (EUR)	
		Lower bound	Upper bound	Lower bound	Upper Bound
4, 481 km^2	7,575 km^2	1,134,357	2,969,952	10,731,014	28,095,746

Source: Authors' own estimates, valuation based on Baron et al. 1997

6.3 Benefits from reducing deforestation

The benefits assessment on this subtheme on deforestation looks at the benefits of avoided deforestation (where applicable), which have to be seen in the contract of the current forest cover and benefits, and the trend in loss/gain of forest coverage.

This parameter measures the annual change in the area of forested land. Change is measured either as number of hectares (ha) increase or decrease in forested land or as percentage increase or decrease in the area of forested land. The overall assessment of change includes both forest loss due to removal of trees and forest gain due to replanting. It should be noted that a net zero loss in forest cover (replanting the same area as is deforested in a given year) may not necessarily lead to no net loss of value to the country as the stock and flow of products and services from the lost forest and gained forest are often different.

Forests fulfil a number of ecological functions. One of these is their important role in the global carbon cycle for their ability to absorb carbon dioxide and store carbon in biomass. While forests serve as a net carbon sink, deforestation and forest degradation can be a substantial source of greenhouse gas emissions. The issue of carbon storage (stock) and sequestration (flow) is gaining in global prominence which will lead to increasing market/payments for avoided carbon emissions from deforestation and forest degradation. The quantitative and the monetary assessment focus on these benefits, i.e. on the value of carbon stored in forest biomass, as this is perceived as a figure easy to understand and communicate to policy makers/the wider public. The quantitative assessment focuses on benefits in terms of the quantity of carbon captured by the existing forest, as well as the potential avoided loss in case of reduced deforestation. As for the monetary assessment, the value of the benefits related to the carbon captured by existing forest today and in the future (potential for sequestration) has been estimated.

It should be kept in mind, however, that the biodiversity value of forests goes well beyond their capability of storing carbon, and is intrinsically related with to their flora and fauna and the quality of the habitat status – which could not be taken into account in our calculations. Forests in fact provide multiple functions, including goods and services such as timber, food, fodder, medicines, provision of fresh water, soil protection, cultural heritage values and tourism opportunities – leading to significant environmental, health, social and economic benefits. Furthermore, forests are also important for the conservation of species, habitats and genetic diversity, which have a value in their own right ('intrinsic values'), irrespective of the benefits that they provide to human populations. Qualitative insights on the broader set of benefits have been noted to complement the analysis when information was available. The following estimations focus on the value of forests as a carbon sink for the simple reason that this function can be estimated with a reasonable accuracy, based on the available data and using the aggregated methodology of this study. This is not to suggest that the function of forests as a carbon sink is in any respect more important or valuable than the other functions they perform, let alone that the carbon sequestration function through wood should be promoted at the expense of other ecosystem services. Still, in order to gain a more complete picture of the monetary values associated with the ecosystem services that forests provide, a more detailed in-depth analysis would be necessary. More detailed information on the value of forests and the ecosystems services they provide can be found in the case study chapter, which investigates in greater detail the economic benefit of protecting the Carmel forest (see chapter 6.4).

For carbon values, we focus on stock values, and note also the marginal value of avoiding potential losses – especially in those countries were deforestation is not currently an issue, but where it will be important to protect and well manage the existing forest in order not to loose its existing value. Overall, the carbon values are here estimated with a relatively simple procedure applicable to all countries, therefore it has not been possible to take into account local specificities and tailored assumptions. The figures provided should therefore be seen as a general illustration of the potential carbon value of forests, providing an order of magnitude rather than a precise estimate, and hopefully offering a useful starting point for future country-tailored analyses.

The following definitions apply:

Forest: Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use. (FAO, 2010)

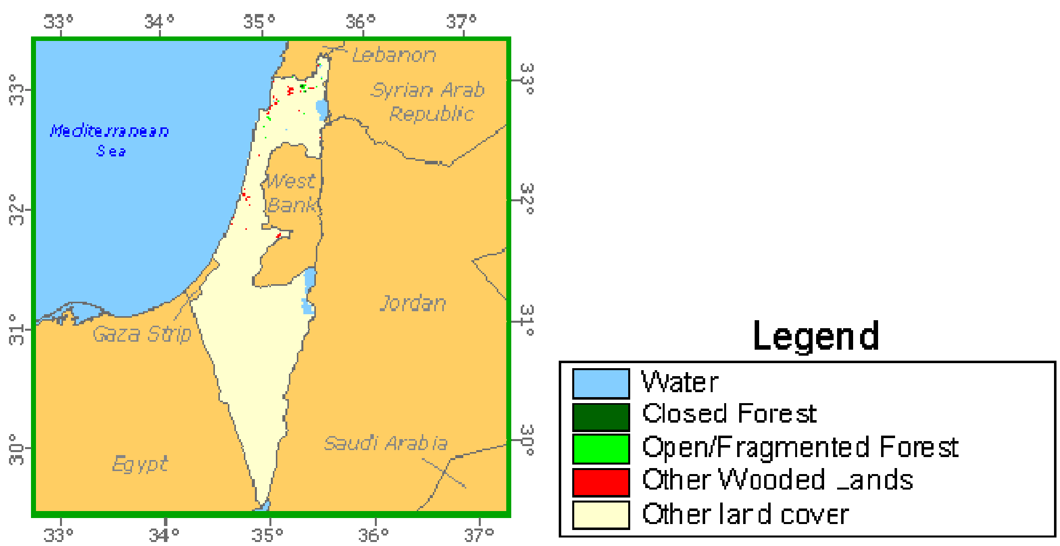
Other Wooded Land: Land not classified as "Forest", spanning more than 0.5 hectares; with trees higher than 5 meters and a canopy cover of 5-10 percent, or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban land use. (FAO, 2010).

Deforestation: includes activities such as conversion of forest to agricultural land, conversion for urbanisation, illegal logging etc. Forest may also be degraded by fire, pests and storms that can lead to their eventual loss. When considering factors driving deforestation, the likelihood of these degradation factors increasing/decreasing should also be considered.

6.3.1 Current level of deforestation

According to FAO data, about 7.12%% of Israel is forested (2010), or about 154,000 ha of a total land area of 2,164,000 ha according to the FAO (FAO, 2011a). National sources point to a larger forest area of 193,100 ha (Eshet et al. 2009). About fifty major forests of different sizes can be distinguished, with the largest forests Biria (2,000 ha), Bar'am (1,000 ha), Carmel (3,000 ha) and Hazorea (3,000 ha) in the North of Israel, Ben-Shemen (2,100 ha) in the central area, and Yatir (3,000 ha), Lahav (3,000 ha), and Be'eri (1,100 ha) in the South of the country.

Figure 6.1 Israel forest cover map (year 2000)



Source: http://www.fao.org/forestry/country/18314/en/isr/

Forests designated functions are mostly for protection of soil and water (79%) and for social services (13%), while 8% is for biodiversity protection, with no designated function to production, multiple use or other services (see table below).

Table 6.3: Forest primary designated functions

Function	Production	Protection of soil and water	Conservation of biodiversity	Social services	Multiple use	Other	None or unknown
Area (%)	0	15	18	3	64	0	0

Source: http://rainforests.mongabay.com/deforestation/2000/Israel.htm based on: http://www.fao.org/docrep/013/al446E/al446E.pdf

Deforestation is currently not an issue in Israel. Between 2005 and 2010, the country gained 0.13% of its forest cover, i.e. around 12,000ha. This was at an average gain of 0.83% per annum, or 1,100ha. Using the total rate of habitat conversion as a different metric (defined as change in forest area plus change in woodland area minus net plantation expansion) for the 1990-2005 intervals, there is a minimal reduction in Israel’s forest cover of 0.2% or 1,100ha (FAO, 2011a).

Israel has been maintaining an extensive afforestation programme, which dates back more than a century. Afforestation efforts are mostly conducted by the Keren Kayemeth LeIsrael-Jewish National Fund (KKL-JNF). As a result, the number of trees in the area increased from less than 5 million trees in 1948 to more than 200 million trees today, adding some 90,000 ha of forest cover. Another 16,000 ha are currently slated for the development and conservation of forests.

Table 6.4: Trend in total net forest cover

Year	1990	2000	2010
Total net forest cover (ha)	132,000	153,000	154,000

Source : http://www.fao.org/docrep/013/i2000e/i2000e.pdf (FAO, 2011a)

Table 6.5: Annual deforestation rate

Year	1990-2000	2000-2005	1990-2010
Annual change rate (%)	1.5	0.1	0.83

Source: own calculations based on: http://www.fao.org/docrep/013/i2000e/i2000e.pdf (FAO, 2011a)

6.3.2 Potential environmental improvements

In order to assess the benefits related to forestry, an ideal 'no net loss by 2020' target was set. This ideal target calls for reducing the annual incremental reduction of the current deforestation rate to 0 per cent by 2020.

Yet, as noted above, deforestation is currently not an issue in Israel as it stands currently at 0.0% per annum (2010 data from (FAO, 2011a)). Implementing the overall target for the NP-wide study would therefore not lead to additional environmental improvements in terms of forest size. The assessment will therefore rather focus on the existing benefits provided by the current forested areas, highlighting the value of avoided deforestation or forest degradation, in order not to loose the current benefits. The benefits in terms of carbon currently stored, and its equivalent monetary value, are assessed in the next chapters.

6.3.3 Qualitative assessment of the benefits of reducing deforestation

Forests provide a wide range of ecosystem services. These include:

- Air quality – forests can filter out airborne pollutants and dust, but also reduce noise pollution e.g. from traffic.
- Climate – forest act as a sink for carbon dioxide: they capture carbon dioxide from the ambient air and, through the process of photosynthesis, bind the CO2 in the form of organic material (wood and leaves).
- Soil – forests conserve soil against wind and water erosion through the fixation by tree roots. Especially on slopes, deforestiaton is therefore often immediately

followed by erosion. Forests can prevent further desertification or even reclaim areas where the process of desertification is underway.

- Water – forests purify rainwater and retain waterborne pollutants. They also act as a buffer, reducing run-off and evaporation of rainwater.
- Landscape – forests provide landscape and amenity values, all the more in an otherwise arid environment.
- Biodiversity – forests are an important habitat not only for trees and other plants, but also for a wide range of birds, mammals and other species.
- Social effects – forests provide important scenic and landscape values, and are often iconic nature areas. Through enjoyment of nature and landscape, they provide amenity and a "sense of place", and give opportunities for relaxation and recreation, including sports and leisure activities.
- Health effects – forests deliver cleaner, oxygen-rich air and a more moderate microclimate.
- Supply of timber and other forest products (including herbs, edible roots, mushrooms, honey etc.).

While all of these ecosystem goods and services are examples of obvious benefits that forests provide, and that are enjoyed by numerous visitors, only few of these goods and services are traded on markets. For instance, there are markets (and hence a price) for the timber provided by a forest or the honey that bees produce, but there is no market (and hence no market price) for the relaxation and amenity that a forest provides to visitors, or the pollination of plants by bees. For this reason, quantification of these benefits can be difficult, and where it is done, it often applies only to specific forest areas. The following sections quantify the carbon sequestration function of forests in Israel, and offer some insights on other benefits delivered by Israel's forests.

6.3.4 Quantitative assessment of the benefits of reducing deforestation

Environmental benefits

Israel's forests contain 5 million metric tons of carbon in living forest biomass, according to 2010 estimates (see tables below). According to 2000 estimates, each hectare of forest stores on average 31 tonnes66 of carbon, i.e. 113.67 tonnes of CO_2 (FAO, 2011a).

Forests, like many other ecosystems are affected by climate change, both negatively and positively. Forests also have the ability to affect global climate and climate change. This effect can be due to increased reflection of heat into the atmosphere in an area heavily forested, than on other land that are more open and soil covered. Another effect can be due to forest's role in the global carbon cycle that affects global climate change. Forests absorb carbon in wood, leaves and soil (carbon sinks) and release it into the atmosphere when burned, during forest fires or the clearing of forest land (Source of Carbon emissions).

66 We assumed that the average per hectare storage capacity has not changed throughout the years, hence assuming the 2000 carbon stock value remains valid today.

According to the FAO 2010 report, the world's forests store more than 650 billion tonnes of carbon, 44 percent in the biomass, 11 percent in dead wood and litter, and 45 percent in the soil. However, for this assessment we limit ourselves to what is stored in biomass.

Further to this The Economics of Ecosystems and Biodiversity (TEEB) shows that to halt forest degradation and deforestation is an integral part of both climate change mitigation and adaption when focusing on 'green carbon'. Forests are further useful to preserve due to their huge range of services and goods they provide to local people and the wider community (TEEB, 2011).

According to 2000 estimates, each hectare of forest stores on average 31 tonnes67 of carbon, i.e. 113.67 tonnes of CO_2 (FAO, 2011a). Accordingly, in 2010 Israel' forests stored about 5 million metric tons of carbon in living forest biomass (see tables below). It will be crucial that no deforestation or degradation takes place in the future in order not to loose the benefits currently provided in terms of carbon storage.

Table 6.6: Per hectare carbon stock in living forest biomass

Year	1990	2000	2005	2010
Carbon stock in living forest biomass (million tonnes C)	5	5	5	5
Carbon stock in living forest biomass (per ha in tons of CO_2)		113.67		
Carbon stock in living forest biomass (per ha in tons of C)	n.d.	31	n.d.	n.d.

n.d. = no data. Source http://rainforests.mongabay.com/deforestation/2000/Israel.htm adapted from (FAO, 2011a)

6.3.5 Monetary assessment of the benefits of reducing deforestation

6.3.5.1 Environmental benefits

By using a monetary (high and low) value for carbon, as identified in recent studies, it is possible to monetise the value of the amount of carbon currently stored in the forests' living biomass, as assessed above.

Assuming a value of CO_2 of 17.2 €/ton (low) and 32 €/ton (high) in 2010, the value of the carbon currently stored by the Israel forests ranges between EUR 300 and 560 million. This is the value of the carbon stored in the living biomass today.

If no deforestation or degradation takes place by 2020, and assuming a range of carbon values from 20€/ton (low) to 39€/ton (medium) and 56€/ton (high), in 2020 the carbon stored will be worth EUR 354 – 990 million. This is summarised in the table below.

67 We assumed that the average per hectare storage capacity has not changed throughout the years, hence assuming the 2000 carbon stock value remains valid today.

Table 6.7: Estimated value of carbon storage in 2010 and 2020 (high and low estimate)

	Value in 2010		**Value in 2020**			
			Unit value (€/ton)	**If deforestation not halted**	**If deforestation halted**	**Difference**
	Unit value (€/ton)	**Total value (m€)**	**Unit value (€/ton)**	**Total Value (m€)**	**Total value (m€)**	**Net value (m€)**
Low estimate	17.2	**300**	20	**NA**	**354**	**NA**
Medium estimate			39	**NA**	**690**	**NA**
High estimate	32	**560**	56	**NA**	**990**	**NA**

Whereas the previous calculations focused on the value of forests as a carbon sink, there is also a relatively rich literature on other services provided by Israel's forests and the associated economic values (see Eshet et al. 2009 for a brief overview). During the last 40 years, about 15 academic studies have assessed the economic value of forests from different angles, focussing e.g. on their value for biodiversity, tourism, recreation, use-value of natural resources, their passive-use value, and on forest policy and management. Many of these studies have focused on two of the largest and most iconic forests in Israel, the Carmel forest (with some 3,000 ha) and the Biria (2,000 ha) (see also the case study in chapter 6.4 for a detailed discussion of the economic values of the Carmel forest).

The earliest forest valuation studies were performed by Shechter et al. in the 1970s, estimating the recreational value of the Carmel and Menashe forests in northern Israel through contingent valuation and the travel cost method. A later study by Shechter et al. (1998) investigated the non-use value of rehabilitating the Carmel forest after a fire (see the following case study for a more detailed description). Zeitouni et al. (2002) undertook an economic valuation of changes in biodiversity in Israeli woodlands and forests, also using Carmel as a test case. In order to arrive at a complete, ecosystem-wide valuation, the authors estimated the values on particular ecosystem components and their main functions and services, associating these with particular species. The functions they valued include forests providing amenity as the main value, and timber as a minor component, pasture serving as grazing land), medical uses of forest plants, pharmaceutical uses, preservation of agro-biodiversity, landscape conservation, and non-use values. Becker and Choresh (2007) applied the travel cost method to assess the recreational value of the Biria forest in the north of Israel, estimating both the total value of the forest and the value of different recreational attributes. They estimated the total recreational value of the Biria forest at between NIS 1.6 and NIS 12.9 million per year (EUR 0.3 – 2.6 million).

In contrast to the previous studies, which assessed the non-market values of forests, Amdur and Zaban (2006) also explored the commercial value of forest plantations in Israel. In addition to the recreational value of forests, they also considered the value delivered in the form of timber and honey (produced from the flowers of trees). For commercial plantations of eucalyptus trees, they derive an economic value of commercial forests ranging from US$ 19 to 190 (EUR 24 to 238) per hectare per year, depending on the local climatic conditions.

6.4 Case Study: Mount Carmel Forest

6.4.1 Overview of current conditions

This case study was chosen to highlight the environmental, health, social and economic benefits provided by forests in Israel within a wider discussion on land use and to show the case of deforestation due to fires. There is pressure to develop more land, for residential, industrial and infrastructure. We aim to show that there are also benefits from protecting the forest and keeping it healthy and intact.

This section provides an overview of the Mount Carmel, a typical Mediterranean forest area near Haifa in north-western Israel. UNESCO has described the mountain as, "rich in its biological, geological and geomorphologic diversity with contrasting landscapes, a mixture of agricultural areas and prehistoric and archaeological sites (The MAB Programme 2002)."From 1978–2006, there were nine large forest fires in the region and more than 350 smaller ones (Tessler 2008). Both the September 1989 fire in the main recreation area of Mount Carmel and a small nearby fire in 2005 have been subject to extensive research. The conclusions of past research are now informing the response to Israel's worst-ever forest fire that raged on Mount Carmel from December 2-5, 2010, burning nearly five million trees on 40 km^2. The tragedy caused 44 deaths and 17,000 evacuations (Environment News Service 2010). As Joel Greenberg of the *Washington Post* observes, "The devastation has raised questions about the place and management of forests in a drought-plagued Middle Eastern country in an age of global warming. And it has forced a reassessment of traditional tree-planting efforts long seen by Israelis and Jewish contributors abroad as part of a national mission to "make the wasteland bloom" (2010)."

The Carmel is one, amongst many, planted forests which are in high risk of forest fires. Perhaps the most notable example is the forests surrounding Jerusalem and its nearby settlement, where forest fires take place in the summer on a yearly basis (sometimes even several times a year). Often, these fires cause severe damage both to human wellbeing and to the fragile ecosystems in the region.

6.4.1.1 Objective

The main objective of the case study is to underscore the importance of forests in Israel. Forests contribute to climate control, soil conservation, biodiversity, related productive industries, tourism and recreation, public health and general wellbeing by providing access to nature. Forestation data in Israel is scant, however, so this case study will complement the country's benefits assessment. In addition, quantifing the impact of the Carmel forest fire provides a practical application of environmental valuation: analysis of the costs and benefits of environmental improvements can guide future forest and fire managment decisions. Ultimately the ecological and economic importance of Mount Carmel, and other forests, should be properly accounted for as Israel debates restoration options.

6.4.1.2 Parameters/issue covered

This case study focuses on deforestation levels, one of the specific parameters within the nature theme. In the overall Benefits Assessment, the assessment of nature focuses on the effect on species populations, the availability of natural resources, ecosystem services, society's natural heritage, and on the benefits that accrue to society of increasing nature protection.

6.4.1.3 Context

Mount Carmel is located at 32°N and 35°E, spanning 266 km^2. The national park covers 84 km^2 rising from the Mediterranean Sea to 546 meters above sea level. One third of the park is protected as a nature reserve. The mean annual precipitation is between 500-750 mm depending on the elevation and falls during the rainy, cool winters. The climate is dry and hot in the summer (Tessler 2008). Carmel National Park is publicly owned and administered by the Nature and National Parks Protection Authority. There is no data about the distribution of specific different forest types at Mount Carmel, but the park roughly aligns with national averages: 43% of Israeli forests are naturally regenerated and the remaining 57% are planted (Butler 2010). Mount Carmel is covered with Mediterranean oak shrub land and some mixed pine forests. According to UNESCO "its batha and garrigue vegetation as well as coastal zones are of special interest from a conservation point of view (The MAB Programme 2002)." The national annual deforestation rate from 2005 to 2010 was 0.13% (Butler 2010). But due to the 2010 fire, Mount Carmel's forests decreased by nearly 16% this past year. The Carmel Hai Bar nature reserve, nestled within the park, is also of special interest; it serves as a breeding core for the reintroduction of animals that were present in historical times but are no longer found within modern Israel.

6.4.1.4 Time frame

The natural ecosystems of Mount Carmenl have been overgrazed, cut and burnt by man for centuries (The MAB Programme 2002). The present forest mantle results from over 150 years of tree planting efforts. The Carmel was declared a national park in 1970, incorporating 31 km^2 of nature reserves and 55 km^2 of densely planted mono-species forests (Naveh 2003).

6.4.2 Potential environmental improvements

As noted, deforestation is currently not problematic in Israel as a whole. However, for Mount Carmel, the propensity of fires needs to be reduced in order to preserve the existing forest. This section explores potential environmental imporvements to reduce fire threats and deforestation in general.

6.4.2.1 Environmental improvements

Israeli foresters must manage the Carmel in order to prevent another large-scale blaze. Suggestions include: creating fire-breaks, thinning out the woodland and forests, using animal grazing to preventing the build-up of shrubs that fuel fires and removing burned vegetation (Greenberg 2010 and Environment News Service 2010). Experts have also called for an early warning fire observation tower and suggest prescribed brush fires to decrease the amount of fuel on the forest floor. Admittedly though, a strategy to avoid fires altogether would not only be unrealistic, but also unnatural. Galan Snatano argues in *Forest Ecology and Management* that, "Fire must be understood as a natural and frequent perturbation of the ecosystem in Mediterranean area, which society must learn to tolerate. Education is a first step towards coexisting with fire, integrating it and not trying, unsuccessfully, to avoid it (2006)." However, the challenge remains to contain fires and limit their effects, not least in order to allow a quick regeneration of the forest to its previous state, and to prevent permanent degradation.

This points to the importance of sustainable forest management in order to support regeneration. Piling scorched tree stumps and branches along contour lines on Mount Carmel forest will prevent erosion, flooding and soil loss by stemming the flow of water. The Carmel fire has also brought traditional planting processes into question. As Joel Greenberg, explains, "The pines, chosen for their ability to grow rapidly and survive in a dry and sunny climate, did indeed spread over the hills, dramatically altering the landscape. But since they were densely planted and all of the same age and type, they were susceptible to the spread of disease, which killed numerous trees in subsequent decades (2010)." The shift in forestry policy, which was adopted by Jewish National Fund in the 1990s, to thinning out the pines to allow for growth under the trees, including native species such as oak and pistacia, should be amplified. It is important to produce a mixed, less-vulnerable forest that is able to survive Israel's dry climate (Greenberg 2010).

Naveh explains that Mount Carmel is threatened presently by, "the mutually amplifying combination of urban-industrial, agricultural, and recreational pressures (2003)." Policy actions must address burning at illegal garbage dumps--which caused the Carmel fire. Other deforestation drivers include road construction, air pollution from industrial and vehicle emissions, groundwater pollution from industrial and domestic waste, chemical fertilizers, and pesticides (Butler 2010). If these drivers were addressed, there would be reduced air pollution in the Haifa region and reduced contamination of valuable groundwater. In general the impact from intense human activities in the region, a major cause of the increasing number and severity of forest fires, deforestation, and ecosystem degradation in the region, must be mitigated to reap crucial environmental improvements (Tessler 2008).

6.4.3 Qualitative assessment

This section describes the current level of environmental, health, social, and economic benefits from Mount Carmel in qualitative terms. The main beneficiaries are Israeli citizens, particularly those who visit the park. The literature also documents the high existence value of the Park; existence value, also known as passive or non-use value, is defined in economic terms as the willingness to pay for nonmarket goods (Schechter 1998). This qualitative assessment can inform policy makers of the expected losses from deforestation and degradation risks if no action is taken to change the status quo.

6.4.3.1 Environmental benefits

The environmental benefits of the Carmel forests include enhanced biodiversity and many ecosystem services. Such benefits justify the expense of sustainable natural resource use. The clearest display of biodiversity on Mount Carmel is Hai Bar Nature Reserve, covering 6 km^2. Hai Bar Carmel works to protect the status quo and reintroduce to the wild species that have become extinct in Israel due to hunting, deforestation and poisoning. These species include: panthers, roe deer, nesting vulture colonies, Egyptian vultures, falcons, and many species of night owl (Israel Nature and Parks Authority 2009a).

The major agro-ecosystems and forestry ecosystems in Mount Carmel are: evergreen sclerophyllous and Pinus halepensis forests, woodlands and Quercus calliprinos shrub-lands

(The MAB Programme 2002). These ecosystems provide the following services: carbon storage, flood control, water storage and purification, soil protection, provision of habitat for animal species, slowing the rate of desertification, and increase resilience to climate change. Eshel makes the additional point that Mount Carmel improves environmental quality because “forests not only reduce the greenhouse effect (gradual global warming) by absorbing carbon dioxide and supplying oxygen but, in Israel, they also act as buffers against congested built-up areas, filter out pollutants, dust and noise, and conserve soil against erosion and depletion (2009).” Sixty-five percent of the Israeli state is desert, but the ecological management of semi-arid lands near Mount Carmel have been shown by long-term research to halt and even reverse the desertification processes of increased soil erosion and reduced productivity.

6.4.3.2 Health benefits

Using forests for recreation and relaxation can promote health and well-being. The wild cliffs and green landscapes of Mount Carmel, along with purified, clean air and peace and quiet, make for a restorative visit. About two million visitors per year enjoy these health and well-being benefits (The MAB Programme 2002).

Conversely, fires damage health especially via air quality disruptions. “In the first days of the fire, the Ministry of Environmental Protection and the Ministry of Health instructed residents in the area not immediately threatened by the flames to stay inside, shut windows and operate air conditions to avoid inhalation of potentially hazardous fumes (Ministry of Environmental Protection 2010f).” Although within a few days the monitoring results in the Carmel region showed satisfactory air quality. Also the forests clean the air, working as a sink for or buffer against air pollution coming from the Haifa region. Deforestation hinders this process and reduces these health benefits.

6.4.3.3 Social benefits

The social benefits provided by Mount Carmel are: recreation, education, and linkages to important cultural and religious heritage.
Mount Carmel forest improves quality of life by providing access to open air activities. Many Israelis echo Technion professor Zev Naveh statement that Mount Carmel is “the largest biologically, and culturally the richest, most attractive open landscape, open-door recreational area in the densely populated coastal zone of Israel (Naveh 2003).” Visitors utilize the roads and hiking trails (including some handicap accessible routes) to view scenic panoramas, Carmel’s highest point at 546 meters, and archaeological sites amid a variety of trees, shrubs, flowers and wildlife (Israel Nature and Parks Authority 2009b).

Another social benefit is education. Several visitor centres offer educational programmes and excursions (The MAB Programme 2002). The Carmel National Park has important ecological, social, psychotherapeutic, educational and scientific functions (Naveh 2003).

The region is also rich in cultural and spiritual heritage. Mount Carmel is part of religious tradition. Elijah is said to have performed one of his best-known miracles, bringing down fire from heaven, at Mount Carmel. Jews, Druze, Muslims and Christians sanctified its sites, and the Carmelite order of Catholic monks bears its name.

6.4.3.4 Economic benefits:

The largest economic benefit of Mount Carmel is tourism. The Hai Bar nature reserve, with several flagship species, is a notable draw. Revenue is also generated from Mount Carmel products. While inadequate rain and soil conditions prevented the production of commercial-grade timber, the mountainside vineyards yield renowned Mt. Carmel wine. There are also olive groves (Columbia Electronic Encyclopedia 2010). Non-use values, such as willingness-to-pay and existence value, can be assumed to be very high. For most of the population at large, Mount Carmel has a high existence value for cultural and religious reason.

6.4.4 Quantitative assessment

6.4.4.1 Environmental benefits

The environmental benefits of Mount Carmel are captured with the national designated function of forests: 15% protection of soil and water, 18% conservation of biodiversity, 3% social services, and 64% multiple use (Forestry Department 2010). Maintaining forests prevents runoff and erosion from forested watersheds. The impact was studied in reverse by testing the effect of fires via a formation of a water repellent layer in affected area. “The results indicate that fire induced water repellence in previously wettable soils (Tessler 2008).” Related studies found a positive correlation between tree cover and stream width/depth in Israel (Malkinson 2007) which subsequently helps ground water recharge.

Mount Carmel is presently comprised of close to 1500 plant species, mostly annual and perennial herbs with “several endemic and rare species as well as a great number of ornamental flowering geophytes. For many of the Europe-Mediterranean species, Mt. Carmel is the southernmost limit of their distribution. The latter include Pinus halepensis, the only natural occurring conifer tree in Israel. The CNP carries its last larger forest remnants, with a dense woody understory, and a well-developed, multi-layered maquis, dominated by Quercus calliprinos […] The great macro- and microsite heterogeneity of Mt. Carmel induced the great floristic diversity both on the interspecies level and the intraspecific level (Naveh 2003).”

6.4.4.2 Health benefits

No quantitative data on health benefits is available.

6.4.4.3 Social benefits

No quantitative data on social benefits is available.

6.4.4.4 Economic benefits

Eshel warns that precisely quantifying economic value is difficult because forests provide positive externalities; not all of the benefits to present and future generations are reflected in the price of market transactions. The economic benefits of Mount Carmel are therefore undervalued (Eshel 2009). But UNESCO has quantified the main direct economic benefit: “The marketing of local products and tourism are major economic activities in the biosphere reserve, providing income for its 200,000 inhabitants (The MAB Programme 2002).” The species at Hai Bar, on Mount Carmel, are associated with high conservation value.

Mount Carmel Forest gives rise to a number of provisioning services that generate wealth. Grazing is the most common use of the 64% of Israeli forests that are multiple-use. Grazing and hunting permits are issued by the Forestry Department. Of the 52 herbaceous species on Mount Carmel, "15 have high pasture values and 25 are valuable for human consumption because of their edible bulbs, shoots, leaves, fruits, or seeds (Naveh 2003)." Citizens are welcome to pick mushrooms and herbs for private use (Forestry Department 2010).

While there is no commercial forestry in Hai Bar, forest management in Mount Carmel produces a limited amount of timber. In Israel timber production is only a by-product of forest management activity. In 2005, 1000 Israelis were employed in the primary production of forestry goods (Forestry Department 2010). Commercial forest plantations, to produce wood, honey, and additional recreation sites, are not pursued near Mount Carmel because the economic feasibility is low (Eshel 2009).

No data is available on poor air quality costs (loss of outputs, cost of hospitalization, damage to buildings).

6.4.5 Monetary assessment

The basis for the monetary assessment comes from a paper by M. Schechter, B. Reiser and N. Zaitsev titled "Measuring Passive Use Value: Pledges, Donations and CV Responses in Connection with an Important Natural Resource" which was published in *Environmental and Resource Economics* in 1998. The study focused on the 1989 Carmel fire, which, albeit smaller, resembled the 2010 fire. The conclusions regarding the willingness-to-pay to rehabilitate the forest and invest in fire prevention measures are applicable today because the two scenarios are quite similar.

The authors estimated passive use by comparing the pledges and actual donations solicited after the 1989 fire to hypothetical, contingent market valuations based on survey responses. The study incorporated both a national control group and real donations, which make its results quite robust. Schechter et. al used estimated the total value of Mount Carmel (including passive use) to be EUR 140 million, in 1993 prices. The value today is probably even higher due to inflation, the large extent of the 2010 fire, and the rise in GDP since 1989. The study also provided a useful comparison: the price per unit of park area was twice as high as some agricultural land in the center of Israel (Schechter 1998).

Israel spends EUR 11.4 million on operational expenditures in the forest sector (Forestry Department 2010). The cost in damages from Mt. Carmel Forest fire was over EUR 40 million. And portions of the burned area will be unusable or have limited public access for years.

No data on the change in risk of forest fire was available.

6.5 Benefits from improved croplands

6.5.1 Introduction

Agricultural cropland degradation is widespread in many countries. This section assesses the benefits of a reversal of cropland degradation or, in other words, an improvement in cropland quality. To do so, the following analysis specifies a target for improvement in cropland quality to be achieved by year 2020, it discusses in qualitative terms the direct and indirect benefits of cropland improvements, and quantifies the direct benefits in terms of increased value of crop production.

Definitions of key terms used in this section are:

- *Cropland:* Land used for cultivation of agricultural crops.
- *Area harvested:* Hectares of cropland multiplied by the number of harvests per year.
- *Crop yields:* Tons of crop harvested per hectare of area harvested.
- *Crop production:* Tons of crop harvested, i.e., area harvested multiplied by crop yield.
- *Cereals:* Mainly wheat, barley, maize, rice, oats, sorghum, rye and millet.
- *Other crops:* Fruits, vegetables, fibre crops, oil crops, pulses, roots and tubers, treenuts and other minor crops.
- *Cropland quality:* Here defined as those characteristics and properties of cropland that affect crop yield. Cropland quality is impaired by cropland degradation and potentially improved by improved cropland management.
- *Cropland degradation:* Inter-temporal changes in properties of cropland such as loss of top soil (from wind and/or water erosion), soil salinity, soil nutrient losses and other degraded physical or chemical properties of the soil.
- *Human induced degradation:* Degradation caused by human activities.
- *Improved cropland management:* Here defined as practices that reduce, prevent, or reverse cropland degradation and preserve or improve cropland quality with positive impacts on crop yield.

6.5.2 Current status

The share of agriculture in Israel's GDP was 1.6 percent in 2008 (World Bank, 2010). The area harvested was 300,000 hectares in 2008. Cereals constituted 90,000 hectares and other crops about 210,000 hectares.68

Much of agricultural cropland in Israel suffers from degradation. But systematic and nationwide data are scarce. One exception is the Global Assessment of Soil Degradation (GLASOD) survey data presented in FAO (2000).69 The national territory is classified into five categories: land that is non-degraded, and land with light, moderate, severe and very severe degradation. According to these data, 43 percent of the land area in Israel suffers from

68 Area harvested is estimated based on linear trends using FAO reported data from 1995-2008 due to annual fluctuations in area harvested (FAO 2011).

69 GLASOD collated expert judgement of soil scientists to produce maps of human induced soil degradation. Using uniform guidelines, data were compiled on the status of soil degradation considering the type, extent, degree, rate and causes of degradation within physiographic units (Sonneveld and Dent, 2007).

human-induced degradation (light or moderate) (Table 6.8). Cases of severe or very severe degradation are not documented for Israel in the GLASOD data. About 99 percent of the population of the country lives on or around degraded land. Main identified types of human induced land degradation are loss of top soil from water erosion and physical and chemical deterioration of the soil, largely caused by deforestation, agricultural activities, and industrialization.

Table 6.8: Extent of human-induced land degradation in Israel

Degradation	Land area degraded (% of national territory)	Population distribution
None	57%	1%
Light	37%	87%
Moderate	6%	12%
Severe	0%	0%
Very Severe	0%	0%
Cause	D, A, I	
Type	W, P, C	

Source: FAO (2000). Note: D=deforestation; A=agriculture; I=industrialization; W=water erosion; P=physical deterioration; C=chemical deterioration.

A disadvantage of the GLASOD data is that they date back more than 20 years. They may therefore misrepresent (and, more likely, underestimate) the actual extent of land degradation today. Advantages of the data are that they provide a basis for multi-country economic assessments, and that economic assessments are simplified by the data providing land categories that reflect an aggregate of various forms of degradation.70 It is therefore not necessary to undertake an economic assessment of each type of soil degradation (erosion, salinity, nutrient losses, loss of soil organic matter, compaction, and other degraded chemical and physical properties of the soil).

6.5.3 Potential environmental improvements

6.5.3.1 **Target to be reached by 2020**

The target for which benefits are assessed in this study is an improvement in cropland quality by year 2020 that results in an increase in crop yields equivalent to half of the crop yield losses from current levels of land degradation. Improvement in land quality also has other benefits that are discussed qualitatively (see below).

It is assumed that the improvement in cropland quality as stipulated by the target is achievable through improved cropland management practices that reduce or halt on-farm loss of top soil from erosion, reduce soil salinity, partially of fully replenish soil nutrients, and improve other physical and chemical soil properties.

70 Sonneveld and Dent (2007) note that the GLASOD data do not necessarily represent consistent classifications of land degradation across countries. Cross-country economic assessments are therefore not necessarily comparable.

The GLASOD data are used here to estimate the increase in crop yields from meeting the target in 2020. Such estimation is, however, not free from problems and necessitates many assumptions:

- First, crop yield reductions resulting from current levels of land degradation must be assumed. Plausible reductions applied here are presented in table 2 using a "low", "medium" and "high" scenario.71
- Second, the GLASOD data do not allow for crop specific yield effects. It is therefore assumed that all crops cultivated in each land category suffer from the same yield reduction.

In light of the need for these assumptions, the benefit assessment in this section should be considered as only indicative.

Table 6.9: Assumptions on current crop yield reductions on degraded land

Land degradation categories	Yield reduction (relative to non-degraded land)		
	Low	Medium	High
Not degraded	0%	0%	0%
Lightly degraded	5%	5%	5%
Moderately degraded	10%	15%	20%
Severely degraded	15%	20%	25%
Very severely degraded	20%	25%	30%

Source: Assumptions by the authors.

Baseline to 2020

Baseline tons of crop production must be projected to the year 2020 from the reference year 2008, assuming business-as-usual (i.e., no change in cropland management practices). Baseline crop production is then compared to the estimated crop production that would result from achieving the 2020 target of improved cropland management. To value the monetary benefit associated with improvements in cropland quality, projections are also needed for the real crop prices to the year 2020.72

Baseline assumptions are presented in Table 6.10:

Table 6.10: Projected baseline crop production and value of production, 2008 - 2020

	Cereals	Other crops
Annual increase in crop production	0%	0%
Annual increase in real crop prices	4.0%	3.0%

Source: Estimates by the authors.

71 The assumed yield reductions for "moderately degraded" land are of similar orders of magnitude as average yield losses reported in Pimentel et al (1995) and a literature review of several regions of the world by Wiebe (2003).
72 Real crop price increase is nominal crop price increase minus the nominal price increase of other goods and services in the economy.

Projected annual crop production from 2008 to 2020 is based on linear trends in production of cereals and other crops in Israel from 1990 to 2008 using data from FAO (FAO 2011). Projected production reflects changes in both areas harvested and crop yields.73

Crop prices may be expected to increase at a faster rate to 2020 than prices of other goods and services in the economy. The FAO world food price index increased by 33 percent and the FAO world cereals price index increased by 31 percent from the 2007-2010 average index value to the January-February 2011 average index value (FAO 2011). However, the large price increases of cereals and foods observed during 2006-2008 and again in 2010 are likely to be offset by future periods of decline in prices as experienced during 1999-2003 and again in 2009. Thus the projected real price of cereals is assumed to increase at a rate of 4 percent per year and the real prices of other crops at a rate of 3 percent per year to 2020. The crop prices in reference year 2008, to which these price increases are applied, are FAO reported international commodity prices for cereals and FAO reported Israeli producer prices for other crops.74 International commodity prices for cereals were applied because they better reflect the real economic value of internationally traded crops, such as cereals, than domestic producer prices of these crops.

Improvements achieved by reaching the targets

The improvements of reaching the target by 2020 are the difference between cropland quality with no change in cropland management practices and cropland quality with improved land management practices. This difference is assumed to result in an increase in crop yields equivalent to half of the crop yield losses from current levels of land degradation (see chapter 6.5.3, Target to be reached by 2020). Improvements in cropland management practices may also be expected to have many other benefits (see below).

The GLASOD data do not map the share of land in the different categories of land degradation that is used for growing crops, let alone the distribution of different crops within the categories. It is therefore necessary to make assumptions about the distribution of crop areas harvested.

Two distribution options are used here:

- Crop areas harvested are distributed in proportion to land area in each land degradation category (e.g., 37 percent of areas harvested in Israel are on lightly degraded land (see Table 6.8)).
- Crop areas harvested are distributed in proportion to population distribution across the land degradation categories (e.g., 87 percent of areas harvested in Israel are on lightly degraded land (see Table 6.8)).

The first option assumes that crop area harvested is uniformly distributed across the country. Clearly this is a special case and unlikely because of forests, mountains and other areas that are not suitable for agriculture.

73 Note that the assumption of linear trends in crop production is a simplification. As argued in chapter 3.5, Israel currently produces a large share of crops with a high water footprint, such as wheat, tangerines, mandarines and clementines. In order to confront the exacerbating water scarcity, one option is to reduce water consumption in agriculture by changing to less water-intensive crops, which would imply a change in the composition of agricultural output. It was not assessed how these changes would affect the estimated benefits of reduced cropland degradation.

74 Reference year cereal prices are averages for 2007-2010 to smooth the price volatility observed in 2008.

The second option assumes that hectares of crop area harvested per population are the same everywhere. This would be a good approximation if the distribution of the population was in line with the distribution of agricultural land in the country, i.e. if the centres of agricultural production were also in the regions with the highest population density.

Using the data in Table 6.8 and Table 6.9, the following Table 6.11 presents estimates of yield increase from meeting the target in 2020 based on the two distributions of crop areas harvested. “Low”, “medium” and “high” refer to the scenarios of yield losses from land degradation in Table 6.11.

Table 6.11: Estimates of yield increase from meeting the target in 2020

	Land area distribution	Population distribution	Mean value
Low	1.3%	2.9%	2.1%
Medium	1.4%	3.3%	2.3%
High	1.6%	3.6%	2.6%

Source: Estimates by the authors.

6.5.4 Qualitative assessment of the benefits of reaching the targets

Improvement in cropland management resulting in improved cropland quality and reversal of cropland degradation has many direct and indirect benefits including health, environmental, economic and social. Direct benefits are those that accrue on-farm, such as increased crop yields and long-term sustainability of land use. Indirect benefits are those that accrue off-farm, such as benefits from reduced soil and agro-chemical run-offs. A generic overview of these benefits is provided in Table 6.12 (e.g., see also CDE 2009).

Table 6.12: Benefits of improved cropland management

Health benefits	• Soil erosion control can reduce agro-chemical run-offs which can help reduce pollution of water bodies, both surface and groundwater, and thus contribute to protection of health. • Improved soil nutrient management can reduce the need for chemical fertilizer applications and thus reduce nitrate pollution of surface and groundwater resources used for drinking.
Environmental benefits	• Soil erosion control can reduce soil run-offs and sedimentation of rivers and lakes. Sediment: o causes turbidity in the water that limits light penetration and prohibits healthy plant growth on the river bed. o can cover much of a river bed with a blanket of silt that suffocates life. o is an important carrier of phosphorus, a critical pollutant which causes eutrophication. • Soil erosion control can reduce run-offs of agro-chemicals and thus reduce water pollution. • Improved land quality can prevent land becoming degraded to the extent that it is abandoned. Thus, improved land quality can help reduce the risk of desertification.
Economic benefits	• Improved land quality enhances agricultural crop yields. • Erosion control reduces sedimentation of reservoirs and dams used for irrigation, municipal water supply, and/or hydropower, and therefore increases their useful lifetime. • Reduced agro-chemical run-offs from erosion control may also reduce the cost of municipal water treatment.
Social benefits	Amenity values associated with the above environmental effects, and employment related to the above economic effects

Source: Produced by the authors.

6.5.5 Quantitative assessment

Many of the benefits of improved cropland management are difficult to quantify, such as health, environmental, and off-farm economic benefits. The quantitative assessment focuses therefore on the on-farm value of increased crop yields from improved cropland management. The economic benefits of reduced dam and reservoir sedimentation are especially important in water scarce counties. The social benefits of improved recreational values from reduced agro-chemical pollution of water resources are reflected in the benefit assessment section on surface water quality.

The benefits of meeting the target of improvement in land quality that reduces current crop yield effects of land degradation by 50 percent by 2020 are estimated based on the yield increases in Table 6.11. The yield increases are multiplied by the estimated value of crop production in 2020 (see below). This gives an estimated value for the extra tons of crop production as a result of reducing land degradation, and the associated annual benefits of meeting the 2020 target.

6.5.6 Monetary assessment of the benefits

The projected real market value of total crop production in year 2020 is NIS 17.8 billion. The annual benefits, i.e., the estimated value of the extra tons of crop production, in year 2020 of achieving the target amount to 2-3 percent of this value, or NIS 371 – 457 million (EUR 71 – 87 million, converted in 2008 PPP Euro). This is equivalent to 0.03-0.04 percent of projected GDP in 2020. All figures are in 2008 PPP EUR and 2008 NIS.

Table 6.13: Estimated annual benefit from avoided cropland degradation in 2020

	Low	Medium	High
Value of increased crop yields (million NIS)	371	414	457
Value of increased crop yields (million PPP EUR)	71	79	87
Value of increased crop yields (% of GDP)	0.03%	0.04%	0.04%

Source: Estimates by the authors. Note: Mean value of estimated yield increases in Table 6.11 is applied.

7 BENEFITS OF IMPROVING CLIMATE CHANGE RELATED CONDITIONS

In the recent past, Israel's greenhouse gas emissions grew in line with population growth and economic development. Between 1996 and 2007, greenhouse gas emissions (carbon dioxide, nitrous oxide and methane) grew by 23% or 14 million tons of $CO_{2\text{-eq}}$, from 62.7 million tons $CO_{2\text{-eq}}$ in 1996 to 76.9 million tons $CO_{2\text{-eq}}$ in 2007. During this period, per-capita emissions rose from 11 tons in 1996, peaked at 11.5 tons in 2000, and have since dropped markedly to 10.7 tons of $CO_{2\text{-eq}}$ in 2007. By comparison, Israel's per capita emissions are thus some 5% above the EU average (10.2 tons in 2007). The main source of greenhouse gas emissions is fuel combustion for electricity production and fuel refining, which account for 55% of Israel's greenhouse gas emissions. The second source is fuel combustion for transportation (20%), and the remainder from fuel combustion for manufacturing and construction and industrial processes. In terms of CO_2 emissions, coal was the dominant fuel, contributing just less than half of Israel's CO_2 emissions. As for non-CO_2 greenhouse gases, the largest contributor is methane emissions from the decomposition of solid waste. Total methane emissions from this source have been estimated at 250,000 tons in 2007. Considering that methane is a significantly more potent greenhouse gas than CO_2, the contribution of this source amounts to 7% of Israel's overall greenhouse gas emissions. By comparison, methane emissions from agriculture are relatively minor.

As regards adaptation to climate change impacts, Israel is expecting to see a marked trend towards a warmer, more arid climate, with a general decrease in average precipitation levels, greater variety in seasonal precipitation patterns, and an overall increase in extreme weather events. Given the already noticeable lack of water resources, these patterns are expected to exacerbate existing problems. In response to this threat, Israel's government has set out to develop a national plan for adaptation, which will cover the sectors water, agriculture, coastal zone, public health, biodiversity, energy and infrastructure and the economy.

7.1 Climate Change Policy and Legislation

Israel is a party to the United Nations Framework Convention on Climate Change (UNFCCC) since May 1996 and in 2004 Israel ratified the Kyoto Protocol. Although Israel is a non-Annex I country under the Climate Convention, the government has resolved to undertake voluntary activities to restrict/reduce emissions of greenhouse gases on the basis of the conclusions of an inter-ministerial committee on climate change. In addition, foreseeing the severe impacts of Climate Change, Israel has set forward to develop an adaptation policy.

Over the last few years, several important governmental decisions were made in the context of Climate Change:

- A decision on a five-year investment program for renewable energy, to increase renewable energy sales and increase R&D investments in this field (08/2008).
- A decision on Energy Efficiency, with the aim of bringing about 20% savings in anticipated electricity consumption by 2020 (09/2008). Among the proposed measures: energy savings in the home and in government buildings, green buildings,

higher energy efficiency standards for electrical appliances, information programs and establishment of an energy efficiency fund.

- Establishment of targets and tools for the promotion of renewable energy including generation of 10% of Israel's electricity from renewable sources by 2020 (01/2009).
- Establishment of a directors-general committee to prepare a climate change policy and to formulate an adaptation action plan (06/2009).
- Establishment of an inter-ministerial committee on formulating a nation action plan for the reduction of GHG emissions (03/2010).

Preparation of Mitigation and Adaptation National Action Plans - In 2007 the Ministry of Environmental Protection commissioned a study on options for mitigating GHG emissions in Israel under different GHG scenarios, accompanied by a cost benefit analysis to the national economy. Furthermore, a study on adaptation assessment was initiated and initial results were published in 2008, to advise the inter-ministerial committee on the formulation of the adaptation national action plan. The study provided interim recommendations on adaptation measures in each of the following sectors: water, agriculture, seas and coasts, public health, biodiversity, energy and the economy.

Cooperation on CDM projects - In 2004, a designated National Authority for authorizing Clean Development Mechanism (CDM) projects in Israel was established and to date, at least 40 projects were submitted for approval of which 13 are registered in the UN. In 2005 and 2008, Israel signed Memorandums of Understandings on cooperation regarding CDM projects with Italy and Germany, respectively.

7.2 Benefits from increasing the uptake of renewable energy sources

7.2.1 Current state of the environment

7.2.1.1 Current level of energy consumed by source

Table 1 (below) shows the primary energy supply and the final consumption of energy in 2006, and their breakdown according to source of energy. In the respective year, final consumption of energy in Israel was 13.386,1 ktoe. The majority of this consumption (12.643,1 ktoe or 94.45%) was based on energy from fossil fuels, mainly petroleum products (for transport) and coal (for electricity generation). Only 743 ktoe (5,55%) of this came from Renewable Energy Sources (RES).

Table 7.1: Current level of energy consumed by source, in thousand tonnes of oil equivalent (ktoe)

	Heat and steam	Electricity	Natural gas	Total petroleum products	Refinery feedstocks	Crude oil	Oil shales	Coal	Total Fossil Fuels	RES[75]	Total
PRIMARY ENERGY SUPPLY - TOTAL	**-**	**-172,8**	**2.090,9**	**-831,0**	**1.614,9**	**10.275,9**	**31,7**	**7.665,0**	**20.674,6**	**743,0**	**21.417,6**
Indigenous production			2.091,1			1,5	31,7			**743,0**	
Imports – Total				4.203,0		10.318		7.721,8			
Imports – Thereof: Refinery feedstocks				-1.611,8	1.611,8						
Exports		-158,4		-3.660,9							
Marine bunkers				-254,8							
Stock changes				167,7		251,2		-152,8			
Statistical differences		-14,4	-0,2	346,9	-18,0	-294,8	-	96,0			
FINAL CONSUMPTION OF ENERGY - TOTAL	**21,1**	**3.923,7**	**5,7**	**8.692,6**	**-**	**-**	**-**	**-**	**12.643,1**	**743**	**13.386,1**
Petroleum refineries			-64,0	11.894	-1.614,9	-10.276					
Electricity generation – Total	21,1	4.455,7	-2.021,2	-1.512,9			-31,7	-7.665,0			
Electricity generation – For public consumption		4.337,5	-2.021,2	-1.265,5			-31,7	-7.665,0			
Electricity generation – For own consumption		118,2	-	-247,5			-	-			
Own use and losses		-359,2		-857,4							

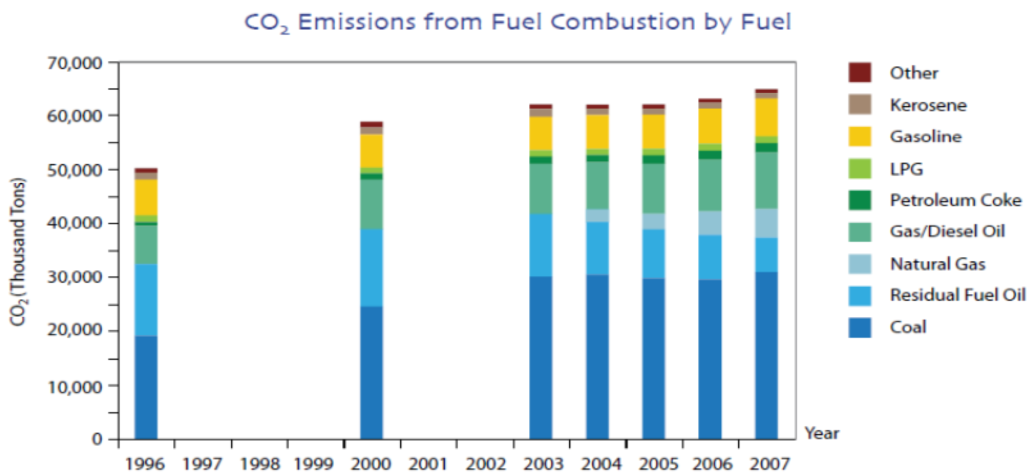
Source: Israel Central Bureau of Statistics, 2006

7.2.1.2 Current level and trends of CO_2 emissions from the energy sector

By far the largest anthropogenic source of CO_2 emissions is the oxidation of carbon when fossil fuels are burned to produce energy. In 2007, about 65 million tons of CO_2 were emitted by this process, which account for about 97% of Israel's total CO_2 emissions. CO_2 emissions from the combustion of fossil fuels have increased by about 15 million tons between 1996-2007 Figure 7.1. The energy industries (power plants and oil refineries) are the largest source of CO_2 emissions (65%), followed by transport (23%). Figure 7.1 shows the breakdown of CO_2 emissions according to source (in 2007): coal contributes 46% of the CO_2 emission in the energy sector, gas and diesel oil contribute 16%, and gasoline, residual oil fuel and natural gas contribute 11%, 10% and 8% respectively (Ministry of Environmental Protection 2010g, p. 48)

75 For RES, we assumed primary energy supply to be equal to final energy supply, and hence to final energy consumption. Since 98% of RES comes from private solar water heating systems, this seems like a reasonable assumption.

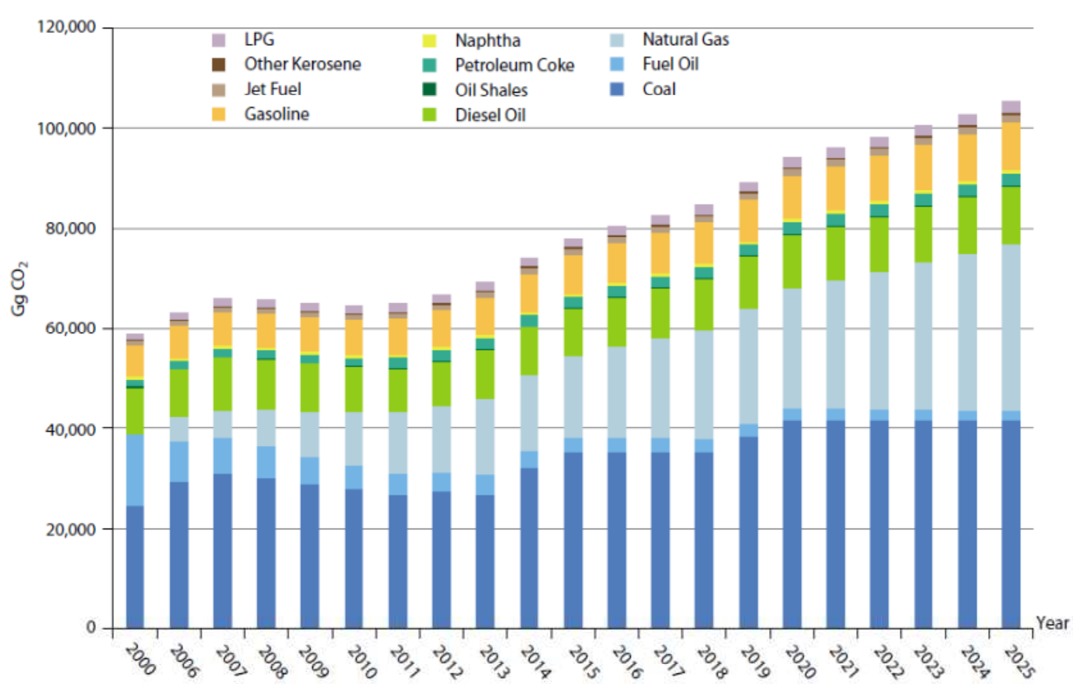
Figure 7.1: CO2 emissions from the energy sector, by fuel type, 1996 – 2007



Source: Ministry of Environmental Protection 2010g, 48.

Future forecasts estimate a 67% increase in CO_2 emissions from the energy sector between 2006-2025. The increase mostly stems from increases within the three major subsectors: energy industries, transport and manufacturing and construction. The contribution of the different fuel types to the total emissions is presented in Figure 7.2 below. As can be seen in the Figure, the contribution of fuel oil to CO_2 emissions is projected to decrease, whereas the contribution of natural gas is projected to increase. This trend is mostly due to the transformation of heavy fuel oil power plants to natural gas." (Ministry of Environmental Protection 2010g, p. 108).

Figure 7.2: Evolution of CO2 emissions by fuel in the energy sector, 2000 – 2025



Source: Ministry of Environmental Protection 2010g, p. 109.

7.2.1.3 The current situation of RES in the country[76]

In 2006, final energy consumption from RES was about 743 thousand tonnes of oil equivalent, which accounted for about 5.5% of final energy consumption in Israel (see Table 6.1 above). The primary source of RES in Israel is private solar water heating, which in 2006 accounted for about 98% of final energy consumption from RES in Israel (see Table 7.2 below).

Table 7.2: Breakdown of RES in Israel by source / type

Source	year	toe/year
Private Solar Water Heating	2006	724,315.2
Solar energy water heating (others)	2001	190.08
PV cells	2001	0.048
Geothermal	1999	2,400
Biomass	1999	8,400
Total		735,305.328

Source: Central Bureau of Statistics Israel. Data for 2006 could not be retrieved for all RES sources. However, correspondence with CBS officials has confirmed that there have not been major fluctuations in supply from RES sources over the last decade, aside from several decreases in supply from PV cells, geothermal and biomass, which are insignificant for the purpose of this analysis (Rachel Klein, Central Bureau of Statistics Israel, personal communication, December 2010).

However, the share of RES in electricity generation in Israel has remained rather insignificant. "Israel's statistics on primary energy supply include no mention of renewable, indicating that renewables' share of primary energy supply is less than 0.1%, far less than the 2% to which the Government has committed since 2003."[77]

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76 The analysis of the benefits of avoided CO_2 emissions from increasing the share of RES of the partner countries energy mix, focuses on total final energy consumption and builds on IEA data for these countries. Some assumptions as regards conversion losses in the electricity, heat and CHP (combined heat and power) were necessary in the calculations to allocate outputs to fuel inputs. The use of common assumptions for the countries has led to the renewable share of the total energy consumption being somewhat lower in the final RES figures ²than would be the case in practice, though not to the extent of changing the overall CO_2 savings significantly (the savings of meeting the ENPI wide target should arguably be a few percent lower on averages). This slight overestimate is thought to be more than offset by the arguably more conservative assumption that energy consumption per capita over the period 2010 to 2020 remains constant, as in reality future increase in demand can be expected to be more than offset by efficiency gains (hence the share of renewables over may be higher). Note that the Benefits Assessment Manual and the supporting spreadsheet tool available to countries have instead been revised using an adjustable set of conversion rates, to offer countries a tool that allows for using more country specific assumptions. Slightly revised values, taking into account some of these country-specific assumptions, have been included in the two regional ENPI synthesis reports, but not in the single country reports as these were already concluded before this additional finalisation of the method (conducted beyond the end of the project). Countries wishing to do their own analysis can explore the issue further by adapting their assumptions in light of fuller nuanced country-specific information on the electricity, heat and CHP stock (performance efficiency, losses, age), exports and imports of fuels, energy efficiency and demand changes.

77 Amit Mor und Shimon Seroussi, "Mediterranean and National Strategies for Sustainable Development Energy Efficiency and Renewable Energy - Israel National Study," 2007, 16, www.planbleu.org.

7.2.1.4 Potential for further uptake of RES and major challenges and barriers

“Since its pioneering efforts to develop rooftop solar water heating, Israel has done little to develop a renewable energy industry that can substantially reduce its energy dependency."(Mor & Seroussi, 2007, p. 15) Like many of its eastern Mediterranean neighbors, Israel has among the highest solar radiation rates in the world, yet its solar industry has largely consisted of developing technologies for export, rather than employing it for domestic use. Furthermore, the Ministry of National Infrastructures (MNI) estimates that without further government involvement solar penetration will continue to lag behind most European countries through 2025. If the initial government incentives will not be provided, “it is unlikely that solar PV and thermal systems, with facilities costs exceeding $4,000 per peak kW and few suppliers, will reach the necessary scale to be competitive with fossil fuels.”(Mor & Seroussi, 2007, p. 15)

It is important to mention, that aside from solar energy, Israel’s renewable potential is considered quite limited. Mor and Seroussi (2007) estimate biomass potential to be about 8.6 Mtoe, primarily from municipal waste. They also estimate Israel’s wind potential to be rather low, with a maximum capacity of about 600 MW (or about 1.75 billion kWh).

In 2003, the government of Israel announced a strategic plan for sustainable development, which included target of 2% of electricity production from renewable energy sources by 2007. To date, Israel has failed to comply with this target, and renewable energy still accounts for less than 0.1% of primary energy supply for electricity production. In 2004, the Ministry of National Infrastructures (MNI) has published several policies and procedures to promote renewable development, including tariffs, licensing procedures, and codes of conduct for renewable electricity generators. However, renewable developers’ response to these government initiatives has been rather slow, and currently less than 100 MW of renewable generators have received conditional licenses (Mor & Seroussi, 2007, p. 15).

Mor and Seroussi (2007) assess the following factors as the most significant barriers to the limited uptake of renewable energy in Israel:

1. Insufficient action by the Ministry of National Infrastructure, such as the absence of a comprehensive implementation plan for renewable energy.
2. The dominant role of the Israel Electric Corporation (IEC) in electricity production and fuel acquisition. The IEC, which has a strong interest in maintaining the status quo (i.e. dependency on coal for electricity production), is impeding the implementation of renewable energy policies (such as licensing of PV systems).
3. Low renewable tariff incentives, which do not internalize the full externality costs of fossil fuels.
4. Low levels of public investment in research and development. Currently, most of the research and development in RE is either funded by universities (e.g. Ben-Gurion University in the Negev) or self-financed by the private sector. Only a small number of projects are being partially financed by public money.
5. Lack of public awareness of climate change issues in Israel, which lags behind that of many European countries. For example, nearly two-thirds (65%) of Israelis identify global warming as a serious environmental issue, but less than 50% have taken steps to reduce their energy consumption, believing that the Government should take the initiative to developing the necessary action plans.

These factors explain why Israel's uptake of RES has been rather slow and ineffective. It also explains the rather small share of RES in Israel technology exports (about 0.001%), despite Israel's proven capability in RES research and development.

7.2.2 Potential environmental improvements

7.2.2.1 Baseline in 2020

Table 7.3 below shows the baseline for gross final energy consumption in 2020. Official estimations assess that total final consumption of energy in Israel is expected to reach 16,123 ktoe by 2020 (Mor & Seroussi, 2007).[78] In a baseline scenario, we assumed the share of RES in total final consumption to remain constant (5.5%).[79] Thus, we projected that in 2020 final consumption of fossil fuels will reach 15,228 ktoe and final consumption of RES will reach 895 ktoe.

Table 7.3: Baseline for gross final energy consumption by 2020

Total Current gross final energy consumption	Estimated gross final energy consumption in 2020	Baseline Gross final energy consumption from RES in 2020	Share of RES over total in 2020	Baseline Gross final energy consumption from fossil fuels in 2020
ktoe	ktoe	ktoe	%	ktoe
13,386	16,123	895	5,55%	15,228

Source: authors' own estimation based on Benefit Assessment Manual (Bassi et al. 2011)

7.2.2.2 Target in 2020

At least 20% of gross final consumption of energy from RES by 2020.

7.2.2.3 Assessing the environmental Improvements

Table 7.4 shows the environmental improvements that will be achieved if a 20% RES target is met. For Israel, based on the assumed energy consumption, this would mean reducing energy consumption from fossil fuels by 2,330 ktoe (to be replaced by energy consumption from RES), which would result in a decrease of 7.7 million tons of CO_2.

Forecasts for CO_2 emissions from the energy sector in 2020 estimate CO_2 emissions will reach 94.2 million tons (Ministry of Environmental Protection 2010g, p. 108). Thus, the above environmental improvement will decrease BAU CO_2 emissions from the energy sector by about 8,1%.

78 This estimation is based on a population projection of 9.266 million in 2020, i.e. some 5% higher than the projected 8.8 million that are used in this study.

79 Israel Energy Policy includes increasing the share of RES in electricity production to 5% by 2016, and 10% by 2020. This means RES share in final consumption will be even higher than 10%, since this targets excludes solar boilers which already account for about 5% of final consumption. However, we decided to set the baseline as no-progress scenario, in case Israel fails to implement its Energy Policy, and RES shares in final consumption continues to rely on its current sources, thus maintaining a level of 5.5% (in the same way it has failed to implement its 2% renewable target from 2003).

Table 7.4: Environmental improvements from 20% RES target

Estimated gross final energy consumption in 2020	Target share of gross final energy consumption from RES	Target gross final energy consumption from RES	Target gross final energy consumption from fossil fuels	Reduced fossil fuel consumption if target met	Average CO_2 intensity (2006)[80]	Reduced CO_2 emissions if target met
ktoe	%	ktoe	ktoe	ktoe	1.000 tCO_2/ktoe	1.000 tCO_2
16,123	20%	3,225	12,898	2,330	3.33	7,757

Source: Authors' own estimation based on Benefit Assessment Manual (Bassi et al. 2011)

7.2.3 Qualitative assessment of the benefits of increasing the uptake of renewable energy sources

Table 7.5 presents a summary the benefits of increasing the uptake of RES in Israel by 20% by 2020, according to four main criteria: health benefits, environmental benefits, economic benefits and social benefits.

Table 7.5: Qualitative description of the benefits of increasing the uptake of RES

Health benefits	Covered under the 'Ambient air quality' parameter.
Environmental benefits	Reduced contribution to climate change. Although there are potential adverse environmental effects of uptake of RES, namely conversion of open spaces and protected areas for construction of solar PV systems and wind farms, these adverse effects can be tackled through several land-use planning measures. These include creating regulatory and economic incentives for installation of RES facilities on private and public buildings, unused or converted land and unprofitable agricultural land; identifying open spaces with low environmental sensitivity in the Negev which can be used for RES facilities; incorporating environmental considerations (open spaces, biodiversity) when in RES land-use planning practices (Amit, Seroussi, & Lester, 2008).
Economic benefits	Creation of jobs in the RES sector, avoided fossil fuel costs, stable and known energy prices (security of supply), reducing transmission and distribution costs, increasing foreign investments in RES technology, decreasing income tax by introducing carbon tax or carbon permits (double dividend). For more details, see following section.
Social benefits	Possibility to provide energy to isolated locations (not connected to the electricity grid), job creation, reducing taxes on fossil fuels which are considered regressive, decentralising energy supply.

Source: Authors' own compilation

80 Source: World Bank Development Indicators: http://www.tradingeconomics.com/israel/co2-intensity-kg-per-kg-of-oil-equivalent-energy-use-wb-data.html; http://www.nationsencyclopedia.com/WorldStats/WDI-environment-emissions-co2-intensity.html.

7.2.4 Quantitative assessment of the benefits of increasing the uptake of renewable energy sources

(Already covered under the previous section 7.2.2, Potential environmental improvements).

7.2.5 Monetary assessment of the benefits of increasing the uptake of renewable energy sources

Table 7.6 presents the monetary benefits resulting from the environmental improvements, hence from the reduction of 7.7 million tons of CO_2. The carbon values used is this study for 2020 range from 20€/tCO_2 (lower bound) through 39€/tCO_2 (medium) to 56€/tCO_2 (upper bound) for 2020. According to these carbon values, **the monetary benefits from the environmental improvements mentioned above are in the range of EUR 155 to 434 million** (Table 6.6).

Table 7.6: Monetary benefits of reducing CO2 emissions in 2020

	Reduced amount of CO_2 emissions if target met	CO_2 value	Monetary benefit
Unit	tCO_2	€/tonne CO2	EUR
Lower bound	7,757,731	20	155,154,620
Medium	7,757,731	39	302,551,516
Upper bound	7,757,731	56	434,432,947

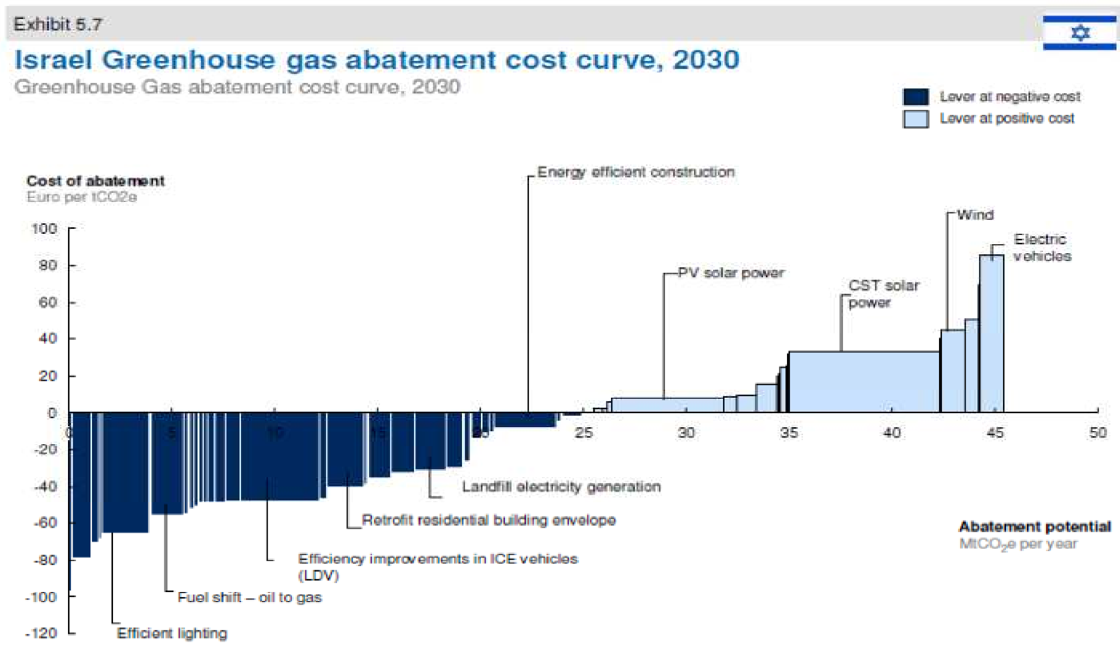
Source: Authors' own estimation based on Benefit Assessment Manual (Bassi et al. 2011)

7.2.5.1 Additional monetary benefits

Increasing the share of RES in Israel's energy primary supply has several additional economic benefits, aside from realizing the potential value of reduced carbon emissions. These economic benefits have been studied in several economic feasibility studies for increasing the share of RES in Israel's energy supply, and they include creation of jobs in the RES sector, avoided fossil fuel costs, stable and known energy prices (security of supply), technology development, and so on. A summary of selected studies is presented below:

- The McKinsey Report: In 2007 the Ministry of Environmental protection commissioned McKinsey & Company to estimate the potential GHG abatement in Israel and evaluate the sectoral costs involved in realizing this potential. The study examined a set of technical measures for abating CO_2 emissions, and concluded that "**many of the abatement measures examined are net profit positive to the economy,** i.e., they are beneficial to the economy as a whole". The analysis shows that "some 60 percent of the measures, accounting for more than 50 percent of the abatement potential, are net profit positive to the economy. An example of a net profit positive measure is energy-efficient lighting, for which the increased upfront cost of the light bulbs is more than compensated for by the savings in power consumption costs." Finally, the study concludes that should all measures be implemented, savings from the net profit positive abatement measures would cancel out the costs of the others – hence, total net cost to the economy of implementing all abatement measures is approximately zero in 2030. The study included an 25% share of RES in the electricity sector, which will bring about an abatement potential of 14 MtCO2eq. (McKinsey&Company, 2009).

Figure 7.3: Israel greenhouse gas abatement cost curve in 2030



Source: McKinsey&Company, "Greenhouse gas abatement potential in Israel: Israel''s greenhouse gas abatement cost curve," November 2009.

- Benefits from uptake of solar energy:
  An evaluation of the economic impact of the rapid development of solar energy sources in Israel, concludes that the net benefit for the country from a large-scale solar energy deployment is evaluated conservatively at $1.8 to $2.7 billion by 2025. This would include the installation of some 2000 MW of central-station solar thermal electricity generation, at least 500 MW of distributed photovoltaic and solar thermal systems, and additional penetration of "passive solar" technology (e.g., solar water heating). The annual net benefits for reaching a 2,500MW solar generation capacity will amount to some $125-$150 million per year (see graph below). These benefits include: avoided environmental costs, stable and known energy prices, avoided transmission & distribution (T&D) costs, avoided fuel costs, real options value for T&D investments. Indirect benefits (income multiplier and avoided unemployment compensation) were also included in the analysis (Mor, Seroussi, & Ainspan, 2005).

- Benefits from energy efficiency
  Studies show that significant benefits can be obtained from increasing Energy Efficiency in Israel, and that reducing energy consumption will offset initial investment costs. For example, estimates of the potential energy savings in buildings range from 25-40%, by applying the following measures: improved insulation, more

efficient heating/air-conditioning, maintaining year-round temperatures between 17.5 and 25.5 degrees Celsius and passive solar energy. At current rates, such energy saving will reduces expenses on electricity by EUR 0.7-1.1 billion annually (Mor & Seroussi, 2007, p. 35).

- Employment benefits – assessing the double divident of carbon tax
  Platanik and Shechter (2008) evaluated the potential employment double dividend from introducing carbon tax/emission permits to achieve the 7% Kyoto target, using a Computable General Equilibrium of the Israeli economy. They concluded that under a rather standard set of assumptions, a double dividend can be obtained by reducing employment (income) taxes which are relatively high in Israel, consequently leading to a decrease in unemployment levels and increased economic and social welfare (Palatnik & Shechter, 2008).

7.3 Benefits of reducing methane emissions from landfills

(refer to chapter 5.4, Benefits of reducing methane emissions from waste)

7.4 Benefits of reducing deforestation

(refer to chapter 6.3, Benefits from reducing deforestation)

7.5 Benefits of adapting to climate change

In 2008 the Chief Scientist at the Ministry of Environmental Protection published a report on Israel's Adaptation to Climate Change. This report was the first comprehensive study covering the impacts from and vulnerabilities to climate change, as well as potential adaptation policies for Israel. The contents of this theme is based primarily on this report, since it is the single most advanced study which was conducted in this field.

7.5.1 Current state of the environment

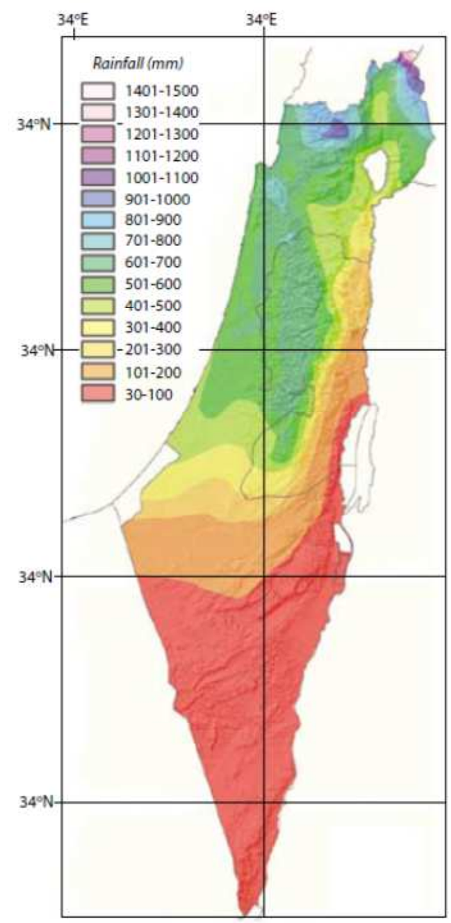
7.5.1.1 Current climatic conditions[81]

81 This section was retrieved from: Ministry of Environmental Protection 2010g (Israel's Second National Communication on Climate Change: Submitted under the United Nations Framework Convention on Climate Change), p. 36-38.

Israel lies in a transition zone between the hot and arid southern part of West Asia and the relatively cooler and wet northern Mediterranean region. As a result, there is a wide range of spatial variation in temperature and rainfall. The climate of much of the north-western part of the area is typically Mediterranean, with mild rainy winters, hot, dry summers and short transitional seasons. The southern and eastern parts are much drier, with semi-arid to arid climate. Throughout the area, summers are completely dry, requiring irrigation for crop production. Average annual rainfall varies from less than 30 millimetres (mm) in the southern part of Israel to as much as 1000 mm in the north. Rainfall along the Mediterranean coast ranges from 300 mm in the south to 600 mm in the north. More than 60% of the area receives less than 250 mm annually. As is typical of arid and semi-arid climates, there is considerable inter-annual variability in rainfall. Precipitation in wet years may be almost three times that of dry years (see figure 6).

The annual mean of rainy days is 50-70 in the northern and central parts of Israel, going down to less than 30 in the southern region. These winter precipitations largely result from the relatively cold air masses passing over the warm Mediterranean Sea.

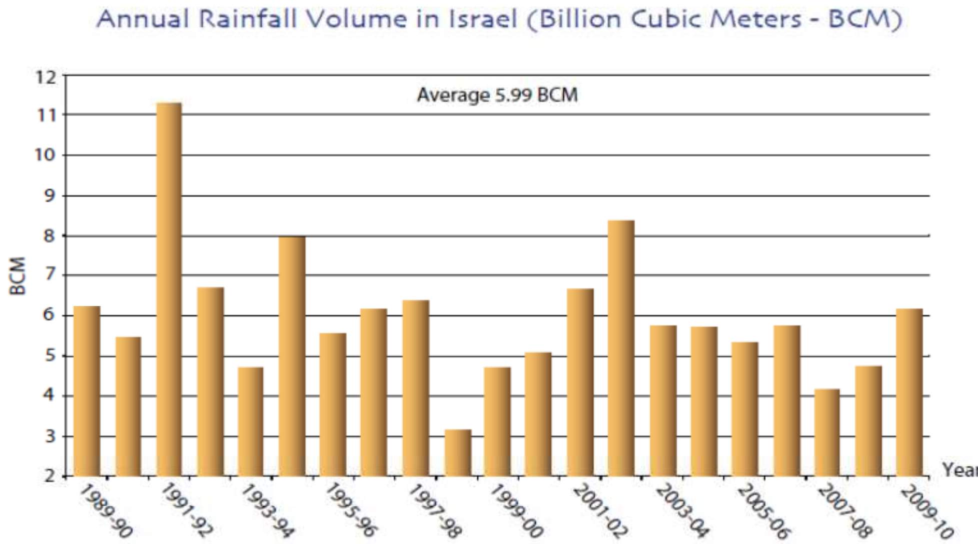
The coastal area belongs to the dry summer subtropical (Mediterranean) climate, although its southern continuation belongs to the semi-arid climate, characterized by potential evaporation and transpiration exceeding precipitation. This marked transition between two climatic types along the coast may serve as an important indicator of the sensitivity of the Eastern Mediterranean Basin to regional climate change.



Summer temperatures are generally high, with the average maximum ranging between 29°C to 33°C in the coastal plain and the mountains and around 40°C in the Jordan Valley and Arava. In the winter, maximum temperatures average about 17°C along the Mediterranean coast and about 10°C at higher altitudes. In the Jordan Valley and Arava, winter temperatures may exceed 25°C during the day and could drop to 7°C or lower at night.

Solar radiation is very high in the summer causing high evaporation, accounting for more than 40% of the annual total evaporation.

Figure 7.4: Annual rainfall volume in Israel (Billion Cubic Metres)



Source: Ministry of Environmental Protection 2008

7.5.1.2 Brief overview of vulnerable sectors

Israel adaptation report identifies seven sectors which are vulnerable to climate change impacts: the water sector, agricultural sector, coastal zone, human health, ecosystems and biodiversity, energy and infrastructure and the economy as a whole. The first five sectors were also identified as the most vulnerable sectors in the Nairobi work programme on impacts, vulnerability and adaptation to climate change (reference). Overall, the Israeli adaptation report's identification of vulnerable sectors is much in line with the common approach of the Nairobi work programme (see Annex 1).

The seven sectors in the Israel adaptation report are briefly presented below, and a more detailed overview of projected climate change impacts in each of these sectors is presented in the next section – Baseline for 2020.

The first and probably the most important sector in this regard is the water sector. The water sector is already under severe stress due to different factors, such as population growth, economic development and the high rainfall variability in Israel's arid and semi-arid climate (this is thoroughly discussed in chapter 4.5, water scarcity). Hence, climate change will exacerbate existing stress on this vulnerable sector, but policies to address this vulnerability are already in place.

Related to the vulnerability of the water sector is the vulnerability of the agricultural sector, where decreased water availability, increased evaporation and increasing temperatures will create stress on both crop yield and livestock. The MoEP (2010) assumes that by 2020, the available water may drop by 200 MCM/year; a drastic cut in this magnitude in agricultural water is a realistic option. Agriculture currently contributes some 1.6% to Israel's GDP (World Bank, 2010): EUR 4,7 billion per year for agricultural produce, EUR 818 million for agricultural products for exports, and EUR 613 million for processed food. In addition to agricultural output, agriculture is also a public commodity which provides external benefits, such as preservation of open spaces and scenic views. The high value of this sector on the one hand, and the high probability it will realize impacts of climate change on the other hand (partially due to the close linkage to the vulnerability of the water sector), make this sector a particular concern for policymakers in Israel.

The third sector, coastal zone, is vulnerable due to the risk of sea level rise. However, although there is quite a high probability that sea level in the region will rise due to global warming, there is high uncertainty regarding the extent of this rise. Under different scenarios of sea level rise, a broad range of potential impacts and risks could be introduced in this sector, some which will induce high economic costs.

The fourth sector, human health, is addressed in Israel's adaptation report, albeit receiving somewhat less attention, partially due to the *assumed* low risk of disease spread and relatively high adaptive capacity of the public health sector, and partially due to the limited research which was conducted on the potential impacts of climate change on human health in Israel. This stands in contrast, for example, with the high attention given to heat-wave preparedness in some of the EU Mediterranean countries. Uncertainty also lies with regard to the vulnerability of the fifth sector, ecosystems and biodiversity. A particular concern regards the increased risk of forest fires, which has got even stronger due to the last large forest in the Carmel in December 2010.

The sixth sector, energy and infrastructure, is mentioned in the Israeli adaptation report, due to the high stress which already exists in the energy sector in meeting demand, particularly during heat waves, and in light of Israel low energy security. Addressing this sector in the adaptation report creates an important link between mitigation and adaptation policies in Israel.

Finally, the economic sector is presented as a cross-cutting sector. Much in line with this benefit assessment, it is incorporated in the adaptation report to enhance buy-in of key politicians and policymakers.

7.5.1.3 Adaptive capacity

In 2008, the Chief Scientist at the Ministry of Environmental Protection issued a report on Israel's Adaption to Climate Change. The report presents climate change trends and forecasts for Israel, anticipated impacts on the most vulnerable sectors (mentioned above) and interim recommendations on requisite steps for adaptation and preparedness in all these sectors. These recommendations related to enhancing climate monitoring and building a database for improving the capacity to model and assess impacts of climate change (under different scenarios); as well as specific policy measures which can be taken to adapt to climate change, which serve as an initial step in the formulation of a national adaptation plan.82

In 2010, the government of Israel has called for a preparation of an adaptation plan, to enhance "decision maker's ability to assess the consequences and risks of climate change and to use existing knowledge in the best possible way" (2nd report, pp90). The aim of this

82http://www.sviva.gov.il/bin/en.jsp?enPage=e_BlankPage&enDisplay=view&enDispWhat=Zone&enDispWho=adaptation_climate_c&enZone=adaptation_climate_c

plan is to integrate preparations for climate change in the strategic planning systems of the various economic, social and environmental sectors. In order to prepare this plan, working groups have been appointed for addressing adaptation policies in each of the following sectors: urban sector, agriculture, biodiversity, public health, drainage and runoff, water resources, as well as economic and insurance aspects. The working groups attempt to bridge the knowledge gap on the impacts of Climate Change in Israel with regard to different potential scenarios, searching for available means for minimizing damage and vulnerability and the identification of local technologies which could facilitate their application (Ministry of Environmental Protection 2010g, p. 90).

Israel is already making efforts to position itself as frontrunner in developing cutting-edge technologies and effective management systems in climate-vulnerable sectors, such as water management, recycling and reuse of treated wastewater, seawater desalination, desert agriculture and afforestation. Israel further wishes to position itself as a regional and global centre of knowledge for climate change adaptation, based on existing research capacity, know-how and technological investment in the areas such as effluent reuse, irrigation with marginal water, development of drought-resistant crop, desert afforestation and soil preservation, and others.

Israel is currently examining the feasibility of establishing an information and knowledge centre for adaptation to climate change, which will facilitate regional scientific collaboration in monitoring and forecasting climate change impacts, facilitate technology and information between the different countries in the (Mediterranean) region (Ministry of Environmental Protection 2010g, p. 98).

7.5.2 Potential environmental improvements

7.5.2.1 Baseline in 2020 (and beyond): projected impacts of Climate Change

The baseline is defined as the potential impacts of climate change under a synthesis of different IPCC scenarios, as they are described in a study issued by the Chief Scientist of the Ministry of Environmental Protection in Israel (cited).

According to A1B scenario of the IPCC, the average temperature in Israel is expected to rise by 1.5°C by 2020, compared to 1960-1990 levels. IPCC scenarios further predict a 3.5-5°C increase in average temperature by the end of the century. In addition, a 10% decrease in precipitation is predicted by 2020, and by 2050 precipitation is projected to decrease by 20%.

Another expected change in Israel's climate is an increase in the number of extreme rainfall events, along with a decrease in the amount of seasonal rain. According to IPCC scenarios, extreme rainfall events will take place either during the autumn or during the spring (depending on the scenario type), thus shifting current precipitation patterns. In addition, the seasonal intervals between wet and dry spells will increase, and the variance between wet years and dry years is also predicted to increase, leading to more severe droughts. All of these changes indicate a tendency towards a more arid climate in Israel (Golan-Engelko & Bar-Or, 2008, p. 4).

The following section will present the main impacts more in detail, in the six vulnerable sectors mentioned earlier: water, agriculture, coastal zone, human health, ecosystems and biodiversity, and energy and infrastructure.

Impacts on the water sector

Climate change will introduce a number of stressors on the water sector, including: reduced precipitation and change in precipitation patterns, sea level rise and retreat of the coastal aquifer and increase in the frequency and severity of floods.

Overall, the above stressors are expected to **reduce water availability by 25% in 2070-2099**, in comparison with 1961-1990 levels. Water availability depends on two main sources, both which will be significantly affected: groundwater and surface water.

Groundwater recharge is expected to decrease, due to: a) decreased precipitation; b) increased probability of intense and short rainy events leading to floods, soil erosion and decreased filtration; and c) changes in the upper layers of soil, which will decrease filtration (e.g. plant cover, increased salinity, etc.). In addition, sea level intrusion into the coastal aquifer is expected to lead to a retreat of this vulnerable aquifer. Estimations predict a loss **of 16.3 MCM of water of each kilometre along the coastal plain,** as a result of a potential rise in sea level of 50 centimetres (Ebid).

The largest body of surface water in Israel is the Sea of Galilee. According to a study which investigated the implications of 20% decrease in precipitation and 20% increase in evaporation in the upper Jordan River basin area, **a reduction of 110 MCM per year is expected, nearly 43% of the annual recharge of the major springs of the upper Jordan River**, the main tributary of the Sea of Galilee. Due to the decrease amount of water of the Sea of Galilee, its salinity is expected to rise significantly, which according to the Kinneret Limnological Laboratory could reach 470 mg of chlorine by 2040.

Overall, average annual flow of rivers in Israel is expected to decrease significantly. Even under the moderate climate change scenarios, such as an increase of 1-2°C and a decrease of 10% in precipitation, **the annual flow of rivers in Israel is expected to decrease by 40-70%.** In addition, an increase in the frequency and severity of floods may cause major damage to property and to people (Golan-Engelko & Bar-Or, 2008, p. 10).

Impacts on the agricultural sector

Climate change will introduce a number of stressors on this sector, including: change in precipitation patterns (short heavy rainfall, instead of a prolonged seasonal rain), extreme weather events and change in temperature trends. These changes will impact two important sub-sectors: crop production and animal farm, both which will now be discussed.

Overall, reduced precipitation and reduced water availability in the soil is expected to **increase water demand for crop irrigation by 20%.** In fact, many crops which are currently rain-dependent will become irrigation-dependent (such as cotton), making some of them economically non-profitable (e.g. wheat, under certain climate change scenarios). Despite growing demand for irrigation, the increased water stress will lead to sharp cutbacks in the allocation of freshwater resources for agricultural irrigation, challenging even more the ability of this sector to adapt to decreased water availability. Overall, climate change is expected to have the following impacts on crop production: reduction in fruit and vegetable yields, shortening of the productivity season of pastureland, damage to the nutritional value and shelf life of agriculture produce, and emergence of new pests and pathogens.

It should be mentioned, that temperature increase is not expected to create additional stress on crop production, and might even have potential benefits for certain crops (prolonging growth season, etc). However, temperature increase is expected to have negative impacts on the productivity of animal farm. Although Israel has the ability to adapt to these changes (e.g. through improved infrastructure, air conditioning systems, etc.), these adaptation measures will increase costs of production and energy demand in this sub-sector. Another important stress on animal farm production is shortages (and increased costs) of animal feed, due to reduced productivity of crops mentioned above.

In addition, a recent increase has been observed in farm animal diseases, which originate from mosquitoes and pests. This increase can partially be attributed to climate change (higher temperatures lead to an increased growth rate of pathogen), and might be worsened due to projected temperature increases, especially in arid areas (e.g. Arava desert) (Ministry of Environmental Protection 2010g, p. 78-80).

Impacts on the coastal zone

According to different studies, in the Eastern Mediterranean area sea level is expected to rise by 0.5-1 meter by 2100. Sea level in the Israeli coast is expected to rise by around 0.5 meter by 2050 and by approximately a meter by the year 2100. A 10 cm increase in sea level, will lead to a 2-10 meter retreat of the coastline and to the loss of 0.4-2 square kilometres of coast every ten years. **A one meter increase in sea level will flood 50-100 meter wide belt on sandy beaches, flooding more than half of the length of the Israeli coastline.** A one meter rise will also shift the storm line some 100 meters eastward (inland) on sandy beaches. The effects of sea level rise will further be exacerbated by the projected intensification of extreme weather events, causing an increase in the height and intensity of waves which penetrate inland and increasing the penetration of sea water. The effects of sea level could also be exacerbated by human intervention activity along the shoreline, such as sand mining and removal of sand for construction.

Sea level rise poses significant risk to infrastructure positioned along the shore, such as sewage and fuel pipes, marinas, harbours, and the coastal power plants. A retreat of the coastal cliff will cause an expansion of the risk zone of the infrastructure constructed on the coastal cliff **by 40-50 meters eastward.** Furthermore, sea level rise also put at risk coastal archaeological sites, as well as ecosystems of the coastal environment, particularly in the event of flooding of river deltas.

Finally, increased water temperatures in the Mediterranean Sea will increase the ability of alien species from the Red Sea to become established in the Mediterranean Sea (migrating through the Suez Canal). This could have a negative impact on fisheries in the Mediterranean, and in some cases create nuisance to humans (one observable example is the large intrusion of jelly fish over the last several decades).

Impacts on Human Health

One of the highest concern regarding impacts of Climate Change in human health is with regard the projected increase in heat burdens, which may particularly harm the elderly, the ill and workers exposed to heat (see Box 1 below). This will particularly affect the coastal zone, where the largest portion of the population is concentrated, and where humidity levels are already high. High humidity levels, which are expected to increase even further due to climate change, have a greater impact than temperature on mortality and morbidity related to heat burdens (Ministry of Environmental Protection 2010g, p. 85).

Box 1: Assessing how the summers will be in Israel

The Israel Electric Corporation is currently preparing for increased energy demand, according to several climatic scenarios. The statistical analysis indicates four possible scenarios for heat intensity in the summer: average, harsh, extreme, and exceptional. The results of this analysis are as follows:

Average summer: Probability 53.5%.

Represented by the year 2001, in which a heat wave lasting 5 days was recorded, with the heat burden peaking at 28.71°C on a national average.

Harsh summer: Probability 27.9%

Represented by the year 2005, in which a heat wave lasting 2 days was recorded, in which the heat burden peaked at 29.55°C on a national average.

Extreme summer: Probability 16.3%

Represented by the year 1999, in which a heat wave lasting 11 days was recorded, with a peak heat burden of 29.7°C on a national average.

Exceptional summer: Probability 2.3%

Represented by the year 1998, in which a heat wave lasting 13 days was recorded, with a peak heat burden of 31.36°C on a national average."

Source: Irit Golan-Engelko und Yeshayahu Bar-Or, 2008

Other impacts are projected with some uncertainty. It is assessed, that a rise in extreme weather events along with higher temperatures may increase the mosquito population and change its distribution, however, with low probability risk of renewed outbreak of malaria. In addition, there is some concern that higher temperatures in the beginning of the spring may bring forward West Nile Fever.

However, the Israel report on adaptation emphasizes that that further research is needed to explore the effect of climate change on human health in general, and on mortality and morbidity due to heat burdens in particular, in order to institute effective public health intervention. Furthermore, it noted that further research is necessary in order to understand the impacts of climate change on food-borne and waterborne diseases (Golan-Engelko & Bar-Or, 2008, p. 22).

Energy sector

The benefits from reducing the share of fossil fuels and increasing the share of RES in electricity production have been covered in the previous section. In addition to these above mentioned benefits, there are additional benefits from adapting the energy sector to the impacts of climate change. The Israel Electric Corporation (IEC) projects, that increased temperatures, coupled with population growth and economic growth (leading to improved living conditions), will increase electricity demand by 3.2% per year, in a long-term average. In addition, an increase in peak demand for electricity is expected during heat and cold burdens (Golan-Engelko & Bar-Or, 2008, p. 26). This will exacerbate the current difficulties of IEC to meet energy demand, especially during heat waves, which have led to a recent proposal to build an additional (third) coal power plant near Ashkelon (currently being debated). Although it will decrease the energy sector's vulnerability to climate change, increasing Israel's coal-based energy production will have adverse environmental and economic effects. It highlights the need to address the vulnerability of the energy sector, in a comprehensive and sustainable way.

Impacts on biodiversity in Israel

Israel contains a number of rich ecosystems, some of them particularly sensitive to changing climatic conditions. One of the first concerns in the event of regional warming, is a spatial movement northward in the distribution of Mediterranean species and their replacement by desert ecosystems, which will migrate from the Negev. For example, a rise of 1.5°C is expected to lead to a spatial shift northward of 300-500 km in the distribution of Mediterranean organisms and the occupation of the area by desert ecosystems. Overall, the desert line will shift northward, causing a desertification of Mediterranean systems currently on the edge of the desert. There is still some uncertainty regarding the impact of these changes on specific species, but it can be assessed that prolonged intra-seasonal periods of dryness will have an adverse impact plant life and wildlife in the area.

Another important impact is the warming of water bodies. A particular concern is the appearance of blue-green algae in the Sea of Galilee, which produce toxins, and may adversely impact the quality of potable water and reduce biodiversity in the lake.

Finally, a concern which has recently received heightened attention is the increased risks of forest fires, due to increased dry conditions and a lengthening of the dry season. This seriously challenges current forest management practices in Israel (see box 2) (Golan-Engelko & Bar-Or, 2008, p. 23-24).

Box 2: The 2010 Forest fire in the Carmel - first Climate Change disaster?

In December 2010, Israel experienced the largest forest fire in its history, which created extensive damage to one of the most significant forests in Israel – the Carmel. The fire caused the death of 42 people and over 17,000 people had to be evacuated from their homes. Nearly 5 million trees covering over 40 square km of forest where burned, decreasing about 16% of the forest.

“The fire disaster in the Carmel Mountains near Haifa is a typical example of climate change effect and a taste of the future, says Dr. Guy Pe'er, one of the authors of Israel's first report to the UN on climate change.”[1] In a report written by for the Ministry of Environmental Protection in 2000, Dr. Pe'er and other Israeli scientists warned that expected climatic fluctuations, heat events, decreased rainfall and delayed late winter rainfall, could lead to increased risk of intense forest fires. Although the single occurrence of a fire such as this is not in itself evidence of climate change, this fire and the fires in Russia in the summer of 2010, add to the growing body of evidence that climate change is already occurring. Both fires were preceded by drought and higher than normal temperatures and are consistent with the types of events expected under climate change scenarios.[2]

[1] *Source: http://www.physorg.com/news/2010-12-scientist-israel-typical-climate-effects.html*

7.5.2.2 Target in 2020

The target for adaption is to climate-proof the six sectors that are deemed most vulnerable to the impacts of climate change: water sector, agriculture, coastal zone, human health, ecosystems and biodiversity, and energy and infrastructure.

Climate-proofing refers to decreasing the risk of realizing the above mentioned impacts in each of the six vulnerable sectors, to a reasonable degree. The decision to what extent should the risk be reduced and the impact avoided, depends on a variety of factors:

1. The amplitude of the impact, in terms of social, economic, environmental or health related costs. For example, the amplitude of impacts on the water sector in Israel is considered quite high (as in many other national adaptation policies, according to the Nairobi work programme), and thus extensive efforts are given to climate-proofing this sector.
2. The degree of certainty with which the impact will be realized. For example, there is a high variance in the potential impacts of sea level rise, including its temporal and spatial characteristics, under a broad range of different scenarios. Thus, climate proofing this sector demands considering a variety of scenarios and their respective uncertainties, when assessing the viability of different climate-proofing measures.
3. The available resources (e.g. financial resources, technology, know-how, etc.) to reduce the risk, as well as the efficiency and effectiveness of these resources, with respect to the amplitude and certainty of impacts mentioned earlier.

This target cannot be defined in absolute terms, and needs to be tailored to the specific characteristics, needs and capacities of the country. For Israel, the national adaptation report can provide a first point of reference regarding the appropriate adaptation policy which needs to be taken, in order to climate-proof each of the vulnerable sectors. Table 7.7 below presents a summary of these adaptation policy measures.

Table 7.7: Summary of adaptation measures for the six vulnerable sectors	
Vulnerable sector	Adaptation measures
Water Resources	• Incorporating the impacts of climate change (such as decreased water availability, sea level rise, etc.) into water policy making in Israel. • Increasing water supply (re-use, desalination, etc.) • Increasing water efficiency (promoting water saving technologies, dry gardening practices, household conservation schemes, water conservation campaigns, etc). • Improving modelling capacity: o Modelling climate change impacts, with regard to flood control, aquatic system protection and water infrastructure planning. o Integrating ecological and hydrological models o Increased biological monitoring in order to evaluate health of aquatic water systems. o Incorporating a range of different climate change scenarios • Improving the management of water economy – assessing the price of water, so that it internalizes externalities of water supply. • Improving infrastructure resilience to floods. • Moderation of floods – diverting urban runoff to infiltration areas, maintaining flood plains along rivers, capturing floodwater for agricultural use, etc.
Agriculture	• Improving modelling capacity: o Assessing crop growth, crop productivity, water and fertilizer consumption, and the spread of pests, insect and plants diseases. o Assessing the frequency and strength of severe heat stress periods and freeze events, frequency of dry spells and other events which affect plant physiology. • Improved irrigation efficiency: o Maximizing the use of effluents as a substitute for freshwater in Israel, o Promoting use of more efficient irrigation techniques and technologies. . • Improved crop management: o Promoting the use of water efficient crops, whose added value per cubic meter of water is higher (such as wheat, chickpeas, sunflower, cauliflower, lettuce and garlic). o Diversifying to winter crops, as well as spring/autumn crops which have a short growth period, and avoiding summer crops. o Changing planting and harvesting dates to cope with change in climatic conditions. • Farm animals: o Selection of cattle species which are more resistant to heath conditions and pests. o Timing breeding according to changes in seasonal climatic conditions.

Table 7.7: Summary of adaptation measures for the six vulnerable sectors	
	o Improved management of animal feeds (efficiency). o Improving climate control systems for relieving climatic stress (mainly heat).
Coastal Zone	• Incorporation of Climate Change implications in land-use planning of the coastal area. • Improving monitoring capacity, including o Sea level rise. o Retreat of the coastal cliff. • Protection of the coastal cliff (e.g. detached brake-waters, sand nourishment). • Enforcing measures to prevent transfer of alien marine species, as well as in-land sources of marine pollution.
Public Health	• Enhancing education and awareness raising on the potential health impacts from climate change. • Applying means to reduce heat stress in urban areas (shading, tree planting, etc). • Improving monitoring capacity of disease carrying vectors. • Reducing the risk of water borne diseases: o Reassessing clean water criteria, and risks of water-borne diseases or disease vectors related to water. o Limiting the habitat of disease carrying vectors (e.g. mosquitoes). • Improving adaptive capacity in the public health systems: o Identifying vulnerabilities (e.g. vulnerable populations). o Training of health experts in the relevant areas. o Introducing vaccination schemes for re-emerging diseases.
Ecosystems and biodiversity	• Incorporating climate change in the management of natural protected areas. • Enhancing species migration, ecological corridors between ecosystems. • Identifying vulnerable species and enhancing protection measures. • Preventing the spread of invasive species • Enhanced monitoring capacity: sensitivity of plants and animals to endemic and exotic pests, pathogens and parasites, as well as modelling the iteration of these hazards under changing climatic conditions. • Forest management: o Adapting forest planning to forecasted changes in climatic conditions (temperatures, precipitation). o Planting trees which are more resistant to dry conditions. o Thinning forests to increase their resilience to droughts. o Incorporating forest health knowledge in forest management. o Applying measures to prevent soil erosion and enhance water conservation in forests. o Applying fire prevention measures – improvement of grazing management, treatment of forests bordering built areas, maintenance of forest paths, upgrading fire engine systems, cleaning forests of potential fire hazards or execution of controlled fires.
Energy and	• Reducing reliance on fossil fuels.

Table 7.7: Summary of adaptation measures for the six vulnerable sectors	
infrastructure	• Increasing energy efficiency, particularly in urban areas (to reduce the stress of urban heat). • Adapt planning and building regulations to impacts of climate change: preparing risk assessments for vulnerable infrastructure (e.g. floods), strengthening and protecting vulnerable infrastructure, etc.

Source: Ministry of Environmental Protection 2010g, 91-97.

7.5.2.3 Assessing the environmental improvements

The environmental improvements will stem from implementing the measures mentioned in the target above, and making the best effort to climate-proof the vulnerable sectors. These improvements cannot be quantified in absolute terms (for the same reason the target could not be quantified in absolute terms). However, the section below illustrates some of the benefits which will be realized from climate-proofing (to some extent) the vulnerable sectors.

7.5.3 Qualitative assessment of the benefits of reducing climate change impacts

Table 7.8: Qualitative description of the benefits of adapting to climate change	
Health benefits	Health benefits include the reduced morbidity and mortality from heat waves, in case of improved adaptive capacity, including cardio-vascular and respiratory illnesses. Other health benefits include reduced exposure to climate-related illnesses and disease, such as vector-borne disease, water-borne disease (although there projected intensification of these diseases in Israel due to climate change is still uncertain).
Environmental benefits	Climate change adaptation through conservation efforts will ensure that species, habitats and ecosystems are maintained. Flood and coastal management practices introduced in response to climate change will also help protect vulnerable habitats. This is especially significant for vulnerable ecosystems and species, which are in danger due to both changing climatic conditions and a variety of anthropogenic stressors. Some of these species have a particular high value since they belong to the Mediterranean biodiversity hotspot. In addition, preventing the intrusion of alien species, pests and animal diseases, will enhance conservation of valuable ecosystems (e.g. coral reefs in Eilat), will help in protecting crops and livestock and can also benefit human health. Another important environmental benefit is the prevention of forest fires, which will contribute both to the preservation of ecosystems and to reducing risk to human wellbeing.
Economic benefits	Adapting the agriculture sector to climate change impacts will prevent economic losses from crop or livestock loss, and might even introduce potential gains from enhancing compatibility of livestock and crops to local climatic conditions. In addition, great benefits could be obtained from preventing damage to infrastructure in the coastal zone, especially if future land-use planning takes into account modelling of sea level rise. Moreover, adaptation through flood management and generic design specification will limit damages to economic assets such as property and the wider infrastructure (e.g. transport, water distribution and energy transmission networks) and so limit wider economic disruption. Finally, investment in adaptation related technologies and know-how may also provide an engine for economic growth. This is especially significant with regard to

Table 7.8: Qualitative description of the benefits of adapting to climate change	
	areas such as water management and desertification, where Israel already benefits from exporting knowledge and technologies to other countries, and where it has a potential to increase its role as a regional and global player in developing cutting-edge adaptation technologies and management systems.
Social benefits	The process of identifying and implementing adaptation at a community or wider level may serve to generate greater social cohesion, and adaptive capacity per se. Socially disadvantaged groups are often most vulnerable to climate change impacts. Hence, adaptation measures can help to address social inequalities and improve the wellbeing of disadvantaged groups. For example, cooperating with the Bedouin population for spreading solar panels in the Negev, can provide both socio-economic benefits and solve problems related to land-use rights in the Bedouin population, and at the same time increase energy supply from renewable energy in Israel. Moreover, introducing a differential water price which takes into account the externalities of water management (re-use, desalination, etc) and reduces economic burden on low-income households (which typically have lower consumption), can provide both economic, environmental and social benefits.

Source: Authors' own compilation, based on Ministry of Environmental Protection 2010g, 91-95.

7.5.4 Monetary assessment of the benefits of reducing climate change impacts

The following section presents a collection of studies which were conducted on the potential (monetary) costs which will be borne on the different vulnerable sectors from realizing the impacts of climate change. These costs can be regarded as potential benefits if these vulnerable sectors are climate-proofed, to the extent which the climate-proofing takes place. It is important to mention that in most cases adaptation policies do not aim for 100% climate-proofing, either due of efficiency considerations (i.e. the trade off between costs of adaptation and potential costs of realizing climate change impacts, according to the applied risk premium); or due the uncertainties regarding the amplitude and/or timing of climate change impacts, and the development of corresponding adaptive capacities (e.g. technological development).

Nevertheless, the studies below provide an important set of indications for the potential monetary benefits which can be realized, if adaptation measures are taken to climate-proof the vulnerable sectors.

Water sector
Intensification of floods: In a Cost benefit analysis for floods in the Ayalon basin, damages for rain events at a probability of 1 in 50 years were estimated at NIS 89 million, and for rain events at a probability of 1 in 100 years, at NIS 338 million (in 1987 prices). The direct damage from the floods of the severe winter of 1991/2 was estimated at over NIS 200 million. In addition, indirect damages were caused due to road blockages, loss of work days, and loss of income, estimated at tens of millions of NIS. A trend of more extreme rain events and greater severity of extreme precipitation events will lead to the increased frequency and severity of floods and concomitantly to severe damages to property and humans" (Golan-Engelko & Bar-Or, 2008, p. 9).

Agricultural sector83

- A rise in the incidence, intensity and frequency of extreme weather events will damage crops and will cause severe economic damages. For instance, in 2008, the damage from freeze wave was estimated at more than EUR 95 million. 84
- A cut of 50% or more in freshwater quantities for agriculture is very realistic according to the climatic scenarios expected in Israel, and the economic damage is estimated at billions of NIS. Under a business as usual scenario, reducing agricultural water consumption by 200 MCM per year (as expected according to several forecasts for 2020) could lead to reduced income of approximately EUR 70 million a year and a loss of thousands of jobs. However, it should be noted that increased water scarcity will eventually demand reducing water supply for the agricultural sector, and the costs above can be avoided by applying means to adapt this sector to the decrease in water availability (e.g. converting to low water-intensive crops, winter crops, etc.), rather than by maintaining water availability at current levels.
- A decrease in the feed quality for livestock and an increase in its prices will lead to reduced profits. The shortening of the production season of grazing areas will lead to increased usage of more expensive feed substitutes. For instance, grazing lands in humid Mediterranean climate areas currently save cattle growers EUR 56 per hectare a year and EUR 79 per hectare a year for sheep growers.

Coastal zone

One study assessed the economic costs in case of a 1 meter sea level rise scenario. It concluded that at least 8.4 km of coast will be lost by 2060, leading to economic damages of 4-5 billion NIS, an equivalent of EUR 762-952 million (Golan-Engelko & Bar-Or, 2008, p. 16).[85]

In addition, sea level rise may cause a retreat in the coastal cliff, which may cause extensive economic damage. Estimates of the damages due to cliff retreat have been undertaken according to an estimate of alternative building costs for existing buildings and for properties which could be damaged. The damage to existing buildings has been estimated at between EUR 12-17 million, if the retreat rate is accelerated to an average of some 0.5 meters per year, reaching up to EUR 52,5 million if the retreat rate reaches a one meter per year average. The market value of the properties which could be damaged has been estimated at between EUR 37-50 million if the rate of annual retreat increases to approximately 0.5 meters per year. If retreat rates will increase to about one meter per year, the damages are estimated at EUR 152 million (Golan-Engelko & Bar-Or, 2008, p. 20).

The economic loss due to coastal recession (diminishment of coastal areas) of some 10 meters in 20 years is estimated at EUR 34 million. On the other hand, activities to protect the coast, which will extend its area by one meter, will lead to an economic value of the same amount. The cost estimate per meter of cliff length is between EUR 2,400 and 6,600, based on the means of protection.

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83 This section is taken from: (Golan-Engelko & Bar-Or, 2008, p. 14).
84 All EUR Prices in this chapter were converted from NIS or from USD, using 2008 conversion rates.
85 Prices converted from NIS (2008), Bank of Israel database.

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