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

Egypt
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

BFT	Benefits Function Transfer
BOD	Biological Oxygen Demand
CDM	Clean Development Mechanism
CH4	Methane
CO	Carbon Monoxide
CO2	Carbon Dioxide
COD	Chemical Oxygen Dissolved
DALYs	Disability Adjusted Life Years
DHS	Demographic and Health Survey
DO	Dissolved oxygen
DRF	Dose Response Function
E. coli	Escherichia Coli
EEAA	Egyptian Environmental Affairs Agency
ENP	European Neighbourhood Policy
ENPI	European Neighbourhood and Partnership Instrument
EPA	United States Environmental Protection Agency
EU	European Union
GAR	Ground Water Recharge
GDP	Gross Domestic Product
GEF	Global Environment Facility
GES	Good Ecological Status
GHG	Green House Gases
GLASOD	Global Assessment of Soil Deterioration
HC	Hydrocarbons
Hg	Mercury
HH	Households
HRC	Human Right Council
IBA	Important Bird Areas
IUCN	International Union for Conservation of Nature
JMP	Joint Monitoring Program MDG Millennium Development Goals
JMP	Joint Monitoring Programme for Drinking Water and Sanitation
LE	Livre Égyptienne (Egyptian Pound)
MENA	Middle East and Northern Africa
MICS	Multiple Indicator Cluster Survey
MPA	Marine Protected Area
MSA	Mean Species Abundance
MSW	Municipal Solid Waste
NGO	Non Governmental Organisation
NH3	Ammonia
NMVOCs	Non-Methane Volatile Organic Compounds
NOx	Nitrogen Oxides
O3	Ozone
PA	Protected Areas
PAH	Polycyclic-Aromatic-Hydrocarbons
Pb	Lead

PM	Particulate Matter
PPP	Purchasing Power Parity
RES	Renewable Energy Source
SEBI	Streamlining European Biodiversity Indicators
SO2	Sulphur Dioxide
SOX	Sulphur Oxides
SWAR	Surface Water Runoff
SWQS	Surface Water Quality Standards
TARWR	Total Actual Renewable Water Resource
TDS	Total Dissolved Solids
TEEB	The Economics of Ecosystems and Biodiversity
TFC	Total Final Consumption
TOE	Tonnes of Oil Equivalent
TPES	Total Primary Energy Supply
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children’s Fund
VIP	Ventilated improved pit toilet
VOCs	Volatile Organic Compounds
VSL	Value of Statistical Life
WDPA	World Database of Protected Areas
WEI	Water Exploitation Index
WFD	Water Framework Directive
WHO	World Health Organisation
WTP	Willingness To Pay
WWT	Waste Water Treatment

EXECUTIVE SUMMARY: ENGLISH / ARABIC

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. 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 Egypt that has been prepared by a team consisting of an EU expert and a national expert, using a Benefit Assessment Manual 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.

Egypt faces several challenges in all its environmental sectors: air, water, waste and nature. These issues are mostly a result of human activities and will be intensified by climate change.

There are considerable benefits from taking immediate action to address the environmental problems facing Egypt. 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 numbers cited in this report are indicative only, based on a rapid assessment often using limited data and many assumptions. While more detailed assessments should be encouraged to be carried out in the future, it is expected that this report can already help to support sound decision-making on environmental issues.

Benefit Assessment

Air pollution is considered one of most serious environmental issues in Egypt. Air quality is particularly poor in the major cities and in Greater Cairo in particular, due to heavy traffic and industrial activities. Cairo is further affected, once a year, by a phenomenon called 'black cloud', a thick cloud of smoke mostly attributed to the open burning of solid waste and agriculture residues.

Despite some improvement in the past decade, poor air quality is still a significant source of pulmonary and cardiovascular illness and early mortality in Egypt. Air pollution can also damage buildings and vegetation, contribute to acidification and eutrophication of ecosystems and affect economically important resources such as fisheries. Improvements in **air quality** are expected to lead to major benefits especially in terms of reduced respiratory diseases and mortality. Benefits to the natural environment and to the cultural heritage of the country are also expected, e.g. through reduced damages to plant species and buildings. Key potential benefits from air quality improvements that will arise by 2020 (the study 'target' year) are as follows:

	Qualitative benefits	Quantitative benefits	Monetary benefits
Air	Health: Reduced respiratory diseases Environment: Reduced damage to ecosystems and crops Economic: improved agriculture output, jobs in green technology Social: reduced damage to buildings/cultural heritage	24,000 fewer cases of death, 46,000 fewer cases of morbidity,	Total domestic benefits (health, crops, materials): € 12,360 million (PPP) per year, i.e. 2.7% GDP

Connection to **drinking water** of sufficient quality is close to 100 per cent in urban areas, and to 87 per cent in rural areas. However, the network in some places suffers from leakages and contamination, and piped connections do not necessarily produce good quality water. The drinking water quality is worse in rural areas and in some places in the delta region.

Sewage connection ranges between 74 and 87 per cent in urban areas, and between 18 and 32 per cent in rural areas. Less than 70 per cent of the collected sewage is treated in **waste water treatment** plants, and it mostly receives only primary treatment. Secondary treatment is currently carried out only in one plant in Cairo.

Improving **water quality and infrastructures** can bring significant health benefits, especially in terms of reduced water borne diseases. The quality of ecosystems will also improve (e.g. reduced eutrophication) and further economic and social benefits will follow, e.g. in terms of tourism and recreational benefits.

Inland and coastal water is exposed to several sources of contamination, especially from industrial and agricultural processes and waste water discharges. Nevertheless the **water quality** of the river Nile is considered mostly good for national standards, despite some hotpots of pollution especially in the delta area. Agricultural canal and drainages experience more severe pollution, and some lakes show signs of eutrophication. Coastal water contamination from waste water is an issue where tourism activity is more intense.

Water scarcity is a key issue, given Egypt's arid climate and limited water resources. The water share for Egypt is 55.5 billion m3 per year, according to the 1959 'Convention of the full exploitation of Nile Water' with Sudan. Ground water provides an additional 6.1 billion m3/year. Aquifer resources are about 11,565 billion m3/year, but these are typically located deep underground and not used due to the high costs of extraction. Overall, water availability per person is on average about 860 m3/ year, which is below the international water poverty line of 1,000 m3/capita.

Improving water quality and infrastructures are expected to lead to significant health benefits, especially in terms of reduced water borne diseases. The quality of ecosystems will also be improved (e.g. reduced eutrophication) and further economic and social benefits will follow, e.g. in terms of tourism and recreational benefits. These benefits, up to 2020, are summarised below.

	Qualitative benefits	Quantitative benefits	Monetary benefits
Water	Health: reduced water borne diseases Environment: improved river/costal water quality, reduced eutrophication Economic: reduced cost of clean water for industry, opportunities for water reuse in agriculture, increased tourists satisfaction Social: improved living conditions especially of the poor	Average reduction in diarrheal disease and mortality between 26-29% where hygiene conditions already good, 57-60% where scope for hygiene improvements	Between €1.2-2.8 million for reduced cases of water borne diseases/death, i.e. 0.3 – 0.6% GDP. Between €2.2-12 million for WTP for improved surface water, i.e. 0.1 - 0.8% GDP (some overlaps with the above).

Waste is a major issue in Egypt, particularly in urban areas. Egypt generates 20 million tonnes of municipal solid waste per year. Waste generation has increased by more than 36 per cent since 2000 (SWEEP-Net, 2010). Of this, only 64 per cent is collected, while the remainder accumulates on city streets and at illegal dumping sites.

Only about 2.5 per cent of the waste collected is **recycled**, 9 per cent is composted and 5 per cent is landfilled in sanitary landfill sites, while the rest (83.5 per cent) is deposited in open dumps. Incineration is undertaken primarily for clinical waste.

In 2000 the contribution of the solid waste disposal sector to greenhouse gases (GHG) emission was about 11,694 million tonnes of CO_2 equivalent. These were mostly from **methane emissions**, which are currently not captured in any of the Egyptian landfills.

Our assessment indicates that, given an expected doubling of the amount of municipal solid waste generated by 2020, improvements in the waste collection, treatment and recycling systems will prevent about 16 million tonnes of waste to be illegally dumped every year – see table below.

	Qualitative benefits	Quantitative benefits	Monetary benefits
Waste	Health: reduced water-borne disease related to waste discharges near waterways and poor hygiene conditions Environment: reduced pollution to soil, surface and ground water and improved air quality, reduced GHG Economic: local employment in waste sector, increased tourists satisfaction, potential for energy production from waste Social: improved living conditions especially of the poor	7,700 km^2polluted land avoided 5,651 work years for waste collection jobs 3,828 additional jobs for waste treatment , recycling & composting 2.3 billion m^3 (about 1.6 million tonnes) avoided methane emissions	€11.3 million total salary for waste collection jobs €2.1 billion WTP for improved waste collection €1.55-2.23 billion for reduced methane emissions in 2020

In terms of **biodiversity**, the country is home to a wide diversity of habitats, including coral reefs, deserts, dunes, freshwater channels and mangrove areas. About 7.7 per cent of the terrestrial environment and 9.91 per cent of the marine areas are protected. Management plans are gradually being drafted but there is an enforcement issue due to a shortage of human resources and infrastructures. Overall, Egyptian ecosystems are threatened by population pressures (including pollution from waste water), hunting, and pollution from industrial and agriculture activities.

Forests cover about 70,000 ha, i.e. approximately 0.07 per cent of the Egyptian territory (FAO, 2011a). Deforestation is currently not an issue. However, all the forested area is planted forest. There are no natural forests and the native forest tree species are limited in number. Mangrove forests are particularly important for biodiversity, and their total area increased from 525 ha in 2002 to 700 ha in 2007 (SOER 2007 & 2008).

About 38 per cent of the land area in Egypt suffers from human induced degradation (FAO, 2000). The main source of human induced **land degradation** is chemical deterioration of the soil, largely caused by agricultural activities. Poor soil quality leads to reduced crop yields and soil erosion, which in turn leads to soil run-offs and sedimentation of rivers and lakes.

Improving the natural environment will have significant benefits for the Egyptian ecosystems. A healthier and well managed environment will in turn offer additional opportunities for eco-tourism and improve the well being of the Egyptian population. Notably, Egypt hosts very rich **coral reef** areas, which are threatened by several anthropogenic activities like unsustainable tourism, over-fishing and uncontrolled building activities. These ecosystems are not only of high biodiversity value, but are also key economic resources given their attractiveness for tourism and recreational activities, and an important part of the country's natural heritage. The appropriate management and conservation of these habitats therefore will have extremely high benefits, both for the environment, the economy and society at large.

	Qualitative benefits	Quantitative benefits	Monetary benefits
Nature	Health: opportunities for recreation and relaxation, contribution to reduction in water-borne disease Environment: ecosystem services - such as water purification, carbon storage, food provision, reduced soil erosion etc. Economic: eco-tourism, improved crop yields Social: opportunities for education and research, sense of identity	Carbon currently stored in forests: 26 million tonnes CO_2 Current jobs related to forests: 13,000 Crop yield increase from reduced land degradation: 4-6%	Value of carbon stored in existing forest in 2010: €435-810 million; stock value in 2020: €990-1,400 million. Value of increased crop yield from reduced land degradation: €2.2- 3.5 billion (PPP), i.e. 0.5-0.8% GDP

With regard to **climate change mitigation**, Egypt's greenhouse gas emissions have gradually increased from 117 million tonnes of CO2 equivalent in 1990 to 288 million in 2008, representing 0.98 per cent of global emissions. In 2008 renewable energy sources (RES) represented 4 per cent of the total energy production, with a strong lead of energy from combustible renewables and waste, followed by hydro power. A wider use of renewable sources would lead to multiple benefits, for the environment first, as Egypt is likely to be severely affected by climate change, but also for human health, as the reduction of air pollution from fossil fuels combustion would reduce respiratory diseases. Furthermore, the diversification of energy sources could have positive effects on employment.

Significant benefits could also be brought forward by **adaptation measures**. Key potential climate change impacts in Egypt are related to air temperature increases, sea level rise and water scarcity. These are all interlinked and can affect biodiversity, crop productivity and the rate of desertification. Coastal zones are also significantly threatened by potential sea level rise. Adequate adaptation policies can therefore limit climate change related damage to key economic activities, like tourism and agriculture. They can also prevent or limit the need for population relocation. Key benefits from mitigation and adaptation up to 2020 are outlined below.

	Qualitative benefits	Quantitative benefits	Monetary benefits
Climate Change	Health: contributing to reduction of respiratory diseases Environment: reduced impacts from climate change to the natural environment (e.g. reduced soil/water salinisation, coral reef bleaching, etc.) Economic: reduced damage to agriculture productivity and coastal tourism Social: energy security, provision of energy to isolated areas (though RES), water availability (combining RES to desalination), reduced need for population relocation	Reduced emissions from fossil fuels: 34,540 ktonnes CO_2 eq	Value of reduced CO_2 emissions: €1.35 – 1.93 billion in 2020

Data gaps

The assessment of the benefits from environmental improvements have not always been possible and/or straightforward given a number of information gaps and data inconsistencies.

The following gaps were noted:

- Data on PM 2.5 are not yet reported.
- The level of drinking water quality at tap is not clearly reported, and water–borne diseases related to drinking water (especially for tourists) are likely to be underestimated/
- Data on sewage connection reported by different official national and international sources showed significant differences, with national estimates for rural connection for instance being significantly lower than international estimates.
- Information on waste water treatment type by plant is not available, and discrepancies were found on the amount of secondary treatment carried out.
- Although the monitoring of surface water has clearly improved, a national mapping of water bodies by quality is still lacking.
- Data on water availability per capita show a certain variability.
- Biodiversity data are still relatively patchy. National reports appear to provide a relatively positive overview, while issues and challenges are not adequately reported. Discrepancies between sources on the size of protected areas exist, and the quality and effectiveness of management is not reported. Overall, data on protected areas appear largely out of date.

Overall, several data appeared relatively out of date. The government, however, applied a significant effort in providing annual reports on the state of the Environment which proved a useful source of information for some of the areas analysed.

Recommendations

Improvements are taking place in the fields of air, water, and protected areas. The less advanced areas are climate change (adaptation measures are in need of further development) and waste management (which still requires significant improvements and modernisation). These should be priorities for investments.

Water availability is also a key issue. Opportunities for waste water reuse (provided sufficient treatment) in agriculture should be explored further, as well as the use of RES for desalination.

Waste water is a critical cause of water pollution and a concern for human health and ecosystems. Adequate collection and treatment should be seriously implemented. The rate of secondary treatment is currently very low, and existing and future plants should ensure that this is adequately carried out.

Air pollution from transport is also an important issue, especially in Greater Cairo. Transport modal shift and cleaner vehicles could have significant positive effects on urban air quality. The issue of the black cloud in Greater Cairo should also be tackled in earnest. As this appears to be related to agriculture waste burning, addressing it will likely have a double benefit both in terms of improved air quality and improve waste management.

The natural environment and in particular coastal and marine areas represent a great asset, both in terms of biodiversity and also as eco-tourism opportunities, and should therefore receive adequate protection and effective management. Monitoring activities will be crucial to ensure that protection measures are enforced.

Overall, **future benefit studies** on Egypt could focus on those areas where immediate investment is needed, in order to assess which solutions will have the highest benefits. In the course of the 'ENPI South' workshop , the following priority areas where identified by the Egyptian delegation: waste collection, climate change adaptation, and sustainable management of energy resources,

The direct benefits for the local population (e.g. income and job generation for the poor, effects on education, creation of small and medium enterprises), and the link between environmental improvements and sustainable development should be further stressed, as these are key issues in developing countries. Other economic benefits, such as the establishment of new industries and market creation should also be further emphasised.

Other parameters and/or sub-topics could be included in future assessments for Egypt, such as water use efficiency in agriculture (as part of 'water scarcity'), industrial water pollution and transboundary issues (as part of 'surface water quality'), use of fossil resources, energy efficiency and transport-related GHG emissions (as part of 'climate change mitigation'). Other parameters will benefit from the inclusion of additional indicators, once data become available, such as the inclusion of PM2.5, ammonia (NH_3) and hydrocarbons (HC) in the 'air quality' parameter. The range of impacts and benefits analysed could also be widened, for example by including a more detailed analysis of the effect of climate change on agriculture productivity, immigration and food availability (under the 'adaptation' parameter).

Future studies could also investigate feasible measures to meet the targets, either theoretical or actual national targets. Further analysis will be needed on institutional capacity and on technological, infrastructural and policy options. This could be complemented by capacity building and training workshops to stimulate prioritisation and actual implementation of the measures identified.
Research should be conducted by, or in close collaboration with, national/local experts, given that several problems are particularly localised in nature (e.g. the black cloud). In addition, this would allow social and development issues to be taken more closely into account (e.g. the role of informal collectors in waste management, the implications for the use of fees and other market based instruments).

مصـــر العربية جمهورية

بصفتها ممثلاً عن الاتحاد الأوروبي، تعاقدت المفوضية الاوروبية مع إتحاد شركات (كونسورتيوم) تقوده شركة اركاديس (ARCADIS Belgium N.V.) البلجيكية لإجراء تحليل للفوائد الاجتماعية والاقتصادية التي تعزز حماية البيئة في ست عشرة دولة تشملها سياسة دول الجوار الأوروبية (ENP) والاتحاد الروسي[1]. اما الشركاء الآخرون للكونسورتيوم فهم : معهد السياسات البيئية الأوروبية (IEEP)، المعهد البيئـي (Ecologic Institute) إدارة الموارد البيئة (ERM)، ميتروايكونوميكا (Metroeconomica) وعدة خبراء مستقلين.

هذا هو الملخص التنفيذي للتقرير حول تقييم الفوائد في **مصر**، قام بإعداه فريق خبراء يتكون من خبير الاتحاد الأوروبي وخبير وطني، وذلك باستخدام دليل تقييم الفوائد الذي تم وضعه في إطار المشروع. وقد تحول هذا الدليل، الذي كان في الاصل معداً للاستخدام الداخلي فقط ، الى دليل تقييم الفوائد لواضعي السياسات بغرض نشره على نطاق أوسع، والذي من شأنه المساعدة على فهم المنهجيات المطبقة في مجال تقييم الفوائد.

التحديات البيئية الرئيسية

تواجه مصر تحديات عديدة في جميع قطاعاتها البيئية : الهواء والماء والنفايات والطبيعة. هذه القضايا هي في معظمها ناتجة عن أنشطة الإنسان، والتي تفاقمت بسبب آثار تغّير المناخ.

ثمة فوائد كبيرة للإجراءات الفورية المتخذة لمعالجة المشاكل البيئية التي تواجه مصر. وتشمل هذه التحسينات الصحة وخفض معدل الوفيات، وتحقيق الوفر الاقتصادي، وإمكانات توفر فرص اقتصادية جديدة، وتحقيق مكاسب واسعة على صعيد رفاهية المجتمع. ويقدم هذا التقرير نظرة أولية للقيمة الاجتماعية والاقتصادية المحتملة الناجمة عن هذه التحسينات في مختلف القطاعات البيئية التي تصل إلى 25,6 مليار يورو بسعر الصرف المعدل بالقوة الشرائية (€PPP). إن الأرقام المذكورة في هذا التقرير هي فقط للدلالة، وتستند إلى تقييم سريع غالباً ما تستخدم فيه بيانات محدودة وافتراضات كثيرة. وبانتظار إجراء تقييمات تفصيلية يمكن الاضطلاع بها في المستقبل، من المتوقع أن يوفر هذا التقرير المساعدة المرجوة لدعم رسم السياسات وصنع القرارات السليمة بشأن القضايا البيئية.

يعتبر **تلوث الهواء** احد القضايا البيئية الاكثر خطورة في مصر. إن نوعية الهواء رديئة خاصة في المدن الكبرى، لا سيما في القاهرة الكبرى، نظراً لحركة المرور الكثيفة والأنشطة الصناعية. وتتأثر كذلك القاهرة، مرة في السنة، بما يعرف بـ "السحاب الأسود"، وهي عبارة عن سحابة كثيفة من الدخان يُعزى في معظمه إلى الحرق المكشوف للنفايات الصلبة والنفايات الزراعية.

وعلى الرغم من بعض التحسن الذي شهدته السنوات العشر الماضية، فان رداءة نوعية الهواء لا تزال مصدراً هاما لأمراض القلب والأوعية الدموية الرئوية وللوفيات المبكرة في مصر. كما ان تلوث الهواء يمكن أن يحدث اضراراً بالمباني والنباتات، ويساهم في تحميض وزيادة مغذيات تأجين النظم الايكولوجية فيؤثر اقتصادياً على موارد هامة مثل المسامك. ومن المتوقع أن يؤدي التحسن في **نوعية الهواء** إلى فوائد كبيرة، لا سيما لناحية تقليص الأمراض التنفسية وعدد الوفيات، الى جانب الفوائد التي تعود على البيئة الطبيعية والتراث الثقافي للبلد، كتقليص الأضرار التي تلحق بأنواع النباتات والمباني. إن الفوائد المحتملة الرئيسية من تحسين نوعية الهواء التي ستنشأ بحلول عام 2020 (سنة "الهدف" للدراسة)، هي:

	الفوائد النوعية	الفوائد العددية	الفوائد النقدية
الهواء	**الصحية :** تقليص الأمراض التنفسية **البيئية** : تقليص الضرر الذي يصيب النظم الإيكولوجية والمحاصيل **الاقتصادية** : تحسين الانتاج الزراعي وخلق وظائف في مجال	تقليص عدد الوفيات: 24000 تقليص عدد الأمراض: 46000	إجمالي الفوائد المحلية (الصحة والمحاصيل والبناء): 12,14 مليون€PPP سنوياً أو بنسبة

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

	الفوائد النوعية	الفوائد العددية	الفوائد النقدية
	التكنولوجيا الخضراء **الاجتماعية** : خفض الأضرار التي تلحق بالمباني والتراث		2,7% من الناتج المحلي الإجمالي في سنة 2020 .

تقترب **توصيلات شبكات مياه الشرب** الوافية من التغطية الشاملة (100 %) في المناطق الحضرية وإلى تغطية بنسبة (87 %) في المناطق الريفية. ومع ذلك، تعاني الشبكة في بعض المناطق من التسرب والتلوث، كما ان التوصيلات بالأنابيب لا تنتج بالضرورة نوعية جيدة للمياه، بل ان نوعية مياه الشرب هي أسوأ في المناطق الريفية وفي بعض مواقع منطقة الدلتا.

تتراوح توصيلات شبكات الصرف الصحي بين 74 و 87 % في المناطق الحضرية، وبين 18 و 32 % في المناطق الريفية. يتم معالجة أقل من 70 % من مياه الصرف الصحي المجمّعة في محطات **معالجة مياه الصرف الصحي**، والتي غالباً ما يتم معالجتها بشكل أولي. ويتم حالياً معالجة ثانوية للمياه المبتذلة فقط في مصنع واحد في القاهرة.

إن تحسين **نوعية المياه والبنية التحتية** سوف يجلب فوائد صحية كبيرة، لا سيما لناحية خفض الأمراض المنقولة بالمياه، إضافة الى تحسين نوعية النظم الإيكولوجية أيضاً (كتخفيض التخثث) وما تلاها من فوائد اقتصادية واجتماعية إضافية، كالفوائد السياحية والترفيهية.
تتعرض المياه الداخلية والساحلية للتلوث من مصادرعديدة، لا سيما التلوث الناتج عن الاعمال الصناعية والزراعية ومكبات مياه الصرف الصحي. ومع ذلك تعتبر **نوعية مياه** نهر النيل جيدة بالنسبة للمعايير الوطنية، على الرغم من بعض من التلوث الحاد، خاصة في منطقة الدلتا. وتبقى القنوات الزراعية ومصارف المياه عِرضة أكثر للتلوث الشديد حيث ان بعض البحيرات بدأت تظهر علامات التخثث. إن تلوث المياه الساحلية من مياه الصرف الصحي لهي مسألة هامة حيث يكثر النشاط السياحي.
تشكل **ندرة المياه** قضية أساسية في ضوء المناخ القاحل في مصر والموارد المائية المحدودة. فبحسب "اتفاقية الاستغلال الكامل لمياه النيل" المبرمة مع السودان عام 1959، تبلغ حصة مصر من مياه النيل 55,5 مليار م^3 سنوياً. كما توفر المياه الجوفية 6,1 مليار م^3 سنوياً اضافية. أما الكتلة الصخرية التي تحوي الموارد المائية الجوفية فتوفر حوالي 11.565 مليار م^3 سنوياً، إلا انها تقع في أعماق الأرض ولن يتم استغلالها نظرا لارتفاع تكاليف استخراجها. وبالمجمل، يبلغ متوسط حصة الفرد من المياه حوالي 860 م^3 بالسنة، وهذا أقل من حد الفقر المائي الدولي المعتمد والمحدد بـ 1000 م^3 للفرد الواحد.
ومن المتوقع أن يفضي تحسين نوعية المياه والبنية التحتية إلى فوائد صحية كبيرة، لا سيما لناحية خفض الأمراض المنقولة بالمياه، إضافة الى تحسين نوعية النظم الإيكولوجية أيضاً (كتخفيض التخثث) وما تلاها من فوائد اقتصادية واجتماعية إضافية، كالفوائد السياحية والترفيهية. وتتلخص هذه الفوائد حتى عام 2020 بما يلي:

	الفوائد النوعية	الفوائد الكمية	الفوائد النقدية
المياه	**الصحية** : تقليص الأمراض المنقولة بالمياه **البيئية** : تحسين نوعية المياه في الأنهر والساحل، و تخفيض التخثث **الاقتصادية** : تخفيض تكاليف المياه النظيفة للصناعة، والفرص المتاحة من معالجة المياه المبتذلة واستخدامها في الزراعة، وزيادة رضا السياح **الاجتماعية** : تحسين الظروف المعيشية خصوصا في الحد من معدلات الفقر.	تقليص حالات الإسهال والوفيات بنسبة: -تتراوح بين 26 و 29 % حيث شروط النظافة جيدة - تتراوح بين 57 و 60 % حيث شروط النظافة قابلة للتحسن.	تحسين الصحة: بين 2,1 و 2,8 مليار لخفض الوفيات و حالات الإسهال أو بين 0,3 و 0,6 % من الناتج المحلي الإجمالي في سنة 2020. تحسين المياه السطحية: بين 2,2 و 12 مليار أو بين 0,1 و 0,8 % من الناتج المحلي الإجمالي في سنة 2020. مع بعض التداخل مع ما ورد أعلاه

النفايات هي قضية كبرى في مصر، ولا سيما في المناطق الحضرية حيث يبلغ انتاجها السنوي 20 مليون طن من النفايات البلدية الصلبة. ولقد ازداد انتاج النفايات بنسبة تزيد على (36 %) منذ عام 2000 (Sweep-Net - 2010)، حيث لا يتم جمع سوى 64 % منها، في حين أن الباقي يتراكم في شوارع المدن وفي مطامر غير مشروعة.

يتم تدوير حوالي (2,5 %) فقط من النفايات التي يتم جمعها ، فيحوّل (9 %) إلى سماد، و يطمر (5 %) في

مواقع الطمر الصحي، بينما يودع الباقي (83,5 %) في مكبات مفتوحة. وبالنسبة للنفايات الطبية، يتم حرقها في المقام الأول.

في عام 2000، اسهمت انبعاثات الغازات الدفينة لمكبات النفايات الصلبة في انبعاثات غازات الاحتباس الحراري (GHG) بحوالي 11694 مليون طن مساوٍ لغاز CO_2؛ هذه الانبعاثات هي في معظمها متأتية من **انبعاثات غاز الميثان**، والتي لا يتم حالياً حبسها في أي من المطامر المصرية.

إستناداً الى حجم النفايات البلدية الصلبة المتوقع مضاعفتها بحلول عام 2020، تشير تقديراتنا إلى أن التحسين في جمع النفايات، ومعالجتها وإعادة تدويرها سوف تمنع من طمر حوالي 16 مليون طن من النفايات سنوياً بصورة غير مشروعة. وتتلخص هذه الفوائد حتى عام 2020 بما يلي:

	الفوائد النوعية	الفوائد الكمية	الفوائد النقدية
النفايات	**الصحية**: خفض الأمراض التي تنقلها المياه الملوثة بالنفايات بالقرب من مجاري المياه ورداءة البيئة الصحية **البيئية** : خفض الحد من تلوث التربة والمياه السطحية والجوفية وتحسين نوعية الهواء، وخفض في انبعاث الغازات الدفيئة **الاقتصادية** : زيادة فرص العمل المحلية في قطاع النفايات، زيادة رضى السياح، امكانات جديدة لإنتاج الطاقة من النفايات **الاجتماعية**: تحسين الظروف المعيشية خصوصا بالنسبة للفقراء.	تجنب تلوث الأراضي: 7700 كلم^2 وظائف متعلقة بجمع النفايات: 5651 في السنة وظائف متعلقة بمعالجة النفايات وإعادة التدوير والتسميد: 3828 في السنة تجنب انبعاثات غاز الميثان: 2,3 مليار م^3 أو 1,6 مليون طن	رواتب العاملين بجمع النفايات: 11,3 مليون €PPP. تحسين جمع النفايات: 2,1 مليار €PPP لمعالجة النفايات. خفض انبعاثات غاز الميثان: بين 1,55 و 2,23 مليار €PPP في سنة 2020.

من حيث **التنوع البيولوجي**، تتوفر مجموعة متنوعة واسعة من الموائل في مصر، بما فيها الصخور المرجانية والصحارى والكثبان الرملية وقنوات المياه العذبة وغابات "المانغروف". تشكل المحميات نحو 7,7 % من البيئة البرية و 9,9 % من المناطق البحرية. تم صياغة الخطط لإدارة المحميات وتبقى المشكلة في التنفيذ بسبب نقص الموارد البشرية والبنية التحتية. عموماً، إن النظم الإيكولوجية المصرية مهددة بسبب الضغوط السكانية (بما في ذلك التلوث من مياه الصرف الصحي)، والصيد، والتلوث الناجم عن الأنشطة الصناعية والزراعية.

تغطي **الغابات** حوالي 70000 هكتار، أي بما يمثل 0,07 % تقريباً من الأراضي المصرية (FAO، 2011a)، وان إزالة الغابات ليست بقضية راهنة. غير ان مساحة الغابات الحرجية هي كلها مزروعة، ولا توجد غابات طبيعية، بل تقتصر أشجار الغابات الأصلية على أنواع غابات "المانغروف" ذات أهمية خاصة للتنوع البيولوجي، وقد تم زيادة مساحاتها الإجمالية من 525 هكتار في عام 2002 إلى 700 هكتار في عام 2007 (SOER 2007 و 2008).

بحسب منظمة الزراعة العالمية، حوالي 38 % من مساحة الأراضي في مصر تعاني من تدهور بفعل الإنسان (FAO، 2000). إن المصدر الرئيسي **لتدهور الأراضي** بفعل الإنسان يعود الى التدهور الكيميائي للتربة، والناجم أساساً عن الأنشطة الزراعية. وتؤدي رداءة نوعية التربة إلى انخفاض نسبة المحاصيل وتآكل التربة، والذي بدوره يؤدي إلى تسريب التربة والترسيب في الأنهار والبحيرات.

لتحسين البيئة الطبيعية فوائد كبيرة على النظم البيئية المصرية. إن توفر بيئة سليمة مصحوبة بافضل الاساليب الإدارية سيفضي بدوره الى خلق فرص إضافية للسياحة البيئية، كما والى تحسين الرفاهية للشعب المصري. والجدير بالذكر أن مصر تحوي على مناطق **الصخور المرجانية** الغنية، والتي أصبحت مهددة من قبل العديد من الأنشطة البشرية، مثل السياحة غير المستدامة والإفراط في صيد الأسماك وأنشطة بناء غير مضبوطة. هذه النظم البيئية ليست فقط ذات قيمة عالية للتنوع البيولوجي فحسب، بل توفر ايضاً موارد اقتصادية رئيسية نظرا لقدرتها على جذب السياح وزيادة الأنشطة الترفيهية، إضافة الى كونها جزءاً هاماً من تراث البلد الطبيعية. لذلك، فإن الإدارة الملائمة لهذه الموائل والحفاظ عليها ستفضيان الى فوائد مرتفعة للغاية، بالنسبة للبيئة والاقتصاد والمجتمع ككل على حدٍ سواء. وتتلخص هذه الفوائد حتى عام 2020 بما يلي:

	الفوائد النوعية	الفوائد الكمية	الفوائد النقدية
الطبيعة	**الصحية** : فرص للاستجمام والاسترخاء ، والمساهمة في الحد من الأمراض المنقولة بالمياه	الكربون المخزن حاليا في الغابات : 26 مليون طن من	قيمة الكربون المخزن في الغابات القائمة في عام 2010 : بين 435 و 810

	الفوائد النوعية	الفوائد الكمية	الفوائد النقدية
	البيئية : خدمات النظام الإيكولوجي -- مثل تنقية المياه وتخزين الكربون ، وتوفير الغذاء ، وانخفاض تآكل التربة الخ **الاقتصادية** : السياحة البيئية ، وتحسين المحاصيل الزراعية **الاجتماعية** : فرص للتعليم والبحوث ، والشعور بالانتماء.	ثاني أكسيد الكربون (CO_2) الوظائف المتعلقة بالغابات: 13000 زيادة المحصول من انخفاض تدهور الأراضي : بين 4 و 6 ٪.	مليونPPP €. قيمة المخزون في 2020 : بين 990 و 1400 مليونPPP €. قيمة زيادة المحصول المتعلقة بانخفاض تدهور الأراضي : بين 2,2 و 3,5 مليار PPP € أو بين 0,5 و 0,8 % من الناتج المحلي الإجمالي في سنة 2020.

اما فيما يتعلق **بتخفيف آثار تغير المناخ**، فقد إزدادت انبعاثات غازات الاحتباس الحراري في مصر بشكل تدريجي من 117 مليون طن مساوٍ لـ CO_2 في 1990 الى 288 مليون طن في عام 2008 ، ما يمثل 0,98 % من الانبعاثات العالمية. في عام 2008، مثلت مصادر الطاقة المتجددة 4 % من إجمالي إنتاج الطاقة، تصدرتها مصادر الطاقة المتجددة للنفايات والنفايات القابلة للاحتراق، وتلتها مصادر الطاقة المائية. إن التوسع في استخدام مصادر الطاقة المتجددة من شأنه أن يفضي إلى العديد من الفوائد: أولاً بالنسبة للبيئة، حيث من المرجح أن تتأثر مصر على نحو كبير من تغير المناخ ، ولكن أيضا بالنسبة لصحة الإنسان، ذلك ان الحد من تلوث الهواء الناجم عن احتراق الوقود الأحفوري سيخفف من الأمراض التنفسية. وعلاوة على ذلك ، يمكن لتنويع مصادر الطاقة ان تكون له آثار إيجابية على العمالة.

ثمة فوائد كبيرة يمكن توفيرها من خلال **تدابير التكيّف**. إن الآثار المحتملة لتغير المناخ في مصر مرتبطة بزيادة درجة حرارة الجو وارتفاع مستوى سطح البحر وندرة المياه. كل هذه العوامل مترابطة، ويمكن أن تؤثرعلى التنوع البيولوجي وانتاجية المحاصيل ومعدل التصحر. كما أن المناطق الساحلية مهددة بشكل كبير بسبب ارتفاع مستوى سطح البحر المحتمل. لذا، يمكن لسياسات التكيف الملائمة مع المناخ الحد من الأضرار المتصلة بتغيير الأنشطة الاقتصادية الرئيسية ، مثل السياحة والزراعة. كما أنها قد تمنع أو تحد من الهجرة السكانية. إن الفوائد الرئيسية من التخفيف والتكيف حتى عام 2020 مذكورة في الجدول ادناه:

	الفوائد النوعية	الفوائد الكمية	الفوائد النقدية
تغير المناخ	**الصحية** : المساهمة في الحد من أمراض الجهاز التنفسي **البيئية** : خفض التأثيرات الناجمة عن تغير المناخ على البيئة ، وانخفاض ملوحة التربة و المياه ، الخ.) **الاقتصادية** : خفض الأضرار التي تلحق بالإنتاجية الزراعية والسياحة الساحلية **الاجتماعية** : أمن الطاقة ، وتوفير الطاقة للمناطق المعزولة من خلال الطاقة المتجددة، توافر المياه (مزيج بين الطاقة المتجددة وتحلية المياه) ، وتقليل النزوح السكاني .	خفض الإنبعاثات من الوقود الأحفوري: 34540 كيلو طن من CO_2-equiv.	قيمة خفض انبعاثات CO_2 : بين 1,35 و 1,93 مليار PPP€ في سنة 2020.

ثغرات في المعلومات

إن تقييم الفوائد المرجوة من التحسينات البيئية لم تكن دائما ممكنة و/أو واضحة نظرا لعدد من الثغرات في المعلومات وتناقض في البيانات. وتم رصد الثغرات التالية :

-- عدم توفر اي بيانات تتعلق بـ $PM_{2.5}$ أو الجسيمات (الناعمة).

-- عدم توفر معلومات حول مستوى جودة مياه الشرب في الحنفية؛ وتحجيم التقديرات بشأن الأمراض التي تنقلها مياه الشرب (خاصة بالنسبة للسياح).

-- أظهرت الارقام حول توصيلات شبكات الصرف الصحي تبايناً واضحاً بين المصادر الرسمية الوطنية والدولية : فالتقديرات الوطنية في المناطق الريفية، على سبيل المثال، كانت أقل بكثير من التقديرات الدولية.

-- المعلومات عن معالجة المياه المبتذلة بحسب نوعية المعالجة غير متوفرة؛ اما المعلومات حول معالجة المياه على المستوى الثاني فكانت متباينة.

-- على الرغم من التحسن الواضح الذي طرأ على رصد المياه السطحية، فإن رسم خرائط المسطحات المائية بحسب جودتها من قبل الهيئات المختصة لا تزال غير متوفرة.

-- هناك تفاوت في البيانات حول مدى توافر المياه للفرد الواحد.
-- بيانات التنوع البيولوجي لا تزال غير مكتملة نسبياً؛ ويبدو ان التقارير الوطنية حولها إيجابية الى حد بعيد، في حين لم يتم ذكر القضايا والتحديات على نحو كافٍ. هناك تفاوت في المصادر حول حجم المناطق المحمية الموجودة، ولم يتم التطرق الى جودة وفعالية الإدارة. عموماً، غالبا ما تظهر البيانات عن المناطق المحمية انها قديمة ("عتيقة").

على العموم، ظهر ان العديد من البيانات هي قديمة نسبياً. ومع ذلك ، بذلت الحكومة جهدا كبيرا لتقديم تقارير سنوية عن حالة البيئة التي كانت مصدراً مفيداً للمعلومات فيما يتعلق ببعض المناطق التي تم تحليلها.

التوصيات

إن التحسينات الجارية هي في مجال الهواء، والمياه، والمناطق المحمية. اما المجالات الأقل تقدماً فهي تغيّر المناخ (فتدابير التكيّف بحاجة الى مزيد من التطوير)، وإدارة النفايات (التي تحتاج إلى تحسينات كبيرة والى التحديث)؛ وهي مجالات ينبغي أن تكون على قائمة أولويات الإستثمار.

إن توافر المياه أيضاً قضية رئيسية. وينبغي استكشاف الفرص المتاحة لإعادة استخدام مياه النفايات (توفير المعالجة الكافية) في مجال الزراعة، فضلاً عن استخدام مصادر الطاقة المتجددة لتحلية المياه.

تشكل مياه الصرف الصحي السبب الأساس لتلوث المياه، وهي مصدر قلق على الصحة البشرية والنظم الإيكولوجية. وينبغي العمل بجدية على جمع ومعالجة المياه المبتذلة بشكل ملائم. حالياً، إن معدل المعالجة الثانوية منخفضٌ جداً، والمصانع القائمة والمستقبلية ينبغي أن تضمن معالجة كافية للمياه المبتذلة.

إن تلوث الهواء الناجم عن وسائل النقل هو أيضا مسألة هامة، وخصوصاً في القاهرة الكبرى. كما أن اعتماد وسائط نقل ومركبات أنظف قد يكون لها آثار إيجابية كبيرة على نوعية الهواء في المناطق الحضرية. وعليه، ينبغي التعامل ايضاً بجدية مع مسألة السحاب الأسود في القاهرة الكبرى حيث يظهر ان لحرق النفايات الزراعية صلة كبيرة بهذا السحاب، والتصدي لهذه المسألة سيحقق على الأرجح فائدة مزدوجة، سواء لجهة تحسين نوعية الهواء او لتحسين إدارة النفايات.

إن البيئة الطبيعية، وعلى وجه الخصوص المناطق الساحلية والبحرية، هي مصدر غنى كبير، سواء من حيث التنوع البيولوجي اولناحية توفر فرص السياحة البيئية، ولذا ينبغي أن تحظى بالحماية الكافية والإدارة الفعالة. من هنا ترتدي أنشطة الرصد اهمية خاصة لضمان تطبيق التدابير الخاصة بحمايتها.

عموماً، يمكن للدراسات المستقبلية حول الفوائد في مصر أن تركز على تلك المجالات حيث الحاجة إلى الاستثمار المباشر تبدو ملحة من أجل تقييم الحلول التي سيترتب عليها فوائد أعلى. وفي سياق اعمال ورشة[3] عمل "سياسة الجوار الاوروبي- الجنوب"، قام الوفد المصري بتحديد الاولويات التالية: جمع النفايات، التكيّف مع تغّير المناخ، وإدارة مستدامة لموارد الطاقة.

ينبغي أن نؤكد هنا على الفوائد المباشرة للسكان المحليين (مثل زيادة الدخل وخلق فرص العمل للفقراء، والآثار على التعليم، وإنشاء المؤسسات الصغيرة والمتوسطة) والعلاقة بين التحسينات البيئية والتنمية المستدامة، ذلك انها من القضايا الرئيسية في البلدان النامية. وينبغي أيضا أن نؤكد على غيرها من الفوائد الاقتصادية، مثل إنشاء صناعات جديدة وخلق الأسواق.

يمكن إدراج معطيات أخرى و/أو مواضيع فرعية في المستقبل بالنسبة لمصر، مثل كفاءة استخدام المياه في الزراعة (كجزء من "ندرة المياه")، وتلوث المياه الصناعية والقضايا العابرة للحدود (كجزء من "نوعية المياه السطحية") واستخدام الموارد الأحفورية (المستحاثات)، وكفاءة الطاقة وقضايا النقل المتصلة بانبعاثات الغازات الدفيئة (كجزء من "تخفيف آثار تغير المناخ")؛ إضافة الى معطيات اخرى ستستفيد من إدراج مؤشرات إضافية عندما تصبح البيانات متاحة، مثل إدراج الجسيمات (الناعمة) أو ال$PM_{2.5}$ ، والأمونيا (NH_3) والهيدروكربونات (HC) في إطار "جودة الهواء". ويمكن ايضاً التوسع في تحليل مجموعة الآثار والفوائد، على سبيل المثال، بما

في ذلك إجراء تحليل أكثر تفصيلا لأثر تغيّر المناخ على إنتاجية الزراعة والهجرة وتوافر الأغذية (تحت إطار "التكيّف").

ويمكن للدراسات المستقبلية التطرق إلى تدابير ممكنة من اجل تحقيق الأهداف، سواء أكانت نظرية أو وطنية فعلية. وستكون هناك حاجة إلى إجراء تحليلات إضافية حول القدرات المؤسسية، والخيارات في مجال التقنيات والبنية التحتية والسياسة. على ان تستكمل الجهود من خلال بناء القدرات وحلقات العمل التدريبية لتحفيز تحديد الأولويات والتنفيذ الفعلي للتدابير التي تم تحديدها.

كما يتعين إجراء البحوث من قبل الخبراء المحليين أو بالتعاون الوثيق معهم نظرا لأن العديد من المشاكل متمركزة في الطبيعة (كالسحاب الأسود). بالإضافة إلى ذلك، فإن هذا الإجراء قد يتيح أخذ القضايا الاجتماعية والتنموية على نحو أوثق في الاعتبار (مثل دور مجمّعي النفايات بطريقة غير رسمية في مجال إدارة النفايات، والآثار المترتبة على استخدام الرسوم وغيرها من أدوات السوق القائمة).

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[3] عقدت ورشة العمل في بروكسيل في 28-29 حزيران/يونيو، وحضرها عدد من خبراء الدول المعنية بالدراسة، بما فيها مصر.

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

Country report: Egypt

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 European Neighbourhood Policy (ENP) countries 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 improve awareness of the benefits of enhanced environmental protection within the countries under study and mobilise their capacity to assess these benefits. It is meant to encourage each country to integrate environmental considerations into policy making and to mobilise the necessary financial resources for environmental improvements.

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

This report has been prepared by a Essam Nada (AOYE) and Samuela Bassi (IEEP).

This report has been prepared on the basis of information gathered during a country mission which was undertaken by the authors in the period 17-22 July 2010 and during follow-up meetings with country officials, complemented with a desk review of national and international databases and reports.

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 Egypt involved the following:

- a description of the current status of the environment and how this is expected to change given current projected trends in socio-economic factors (e.g. mainly GDP and population changes);

- an assessment of the potential direction and magnitude of environmental change if specific environmental targets would be 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 is described in a Benefit Assessment Manual for internal use by the project experts that contributed to the country benefit assessments.

The Benefit Assessment Manual for internal use has been developed into a Benefit Assessment Manual for a wider audience of policy makers in the European Neighbourhood and Partnership Instrument (ENPI) countries (Bassi et al, 2011). This Benefit Assessment Manual provides an in-depth understanding of the methodologies applied under the project and can be downloaded from the project's website www.environment-benefits.eu. 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

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, 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 integration .
- 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.

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. Clearly not everything can be covered by the project, and a selection of the key environmental issues on which the analysis should focus on was made.

The aim was to identify issues of importance which are sufficiently representative of the five environmental themes covered by the project, i.e. Air, Water, Waste, Nature and Climate Change (as a horizontal area), which are common across the countries under study and which are sufficiently simple to be assessed rigorously.

To this end, the five themes have been sub-divided into sub-themes and, for each sub-theme, smaller categories called parameters have been identified. The benefit assessments are about assessing the benefits of improvements for each of these parameters.

An overview of the themes, subthemes and parameters is provided in table 1.5 below.

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 in principle be analysed in three ways: qualitatively, quantitatively and monetarily.

- In qualitative terms, providing a description of the nature of the benefit, the people, land areas, sectors and services affected. This the easiest approach 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.

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 a benefit transfer study (i.e. drawing upon valuation study results calculated elsewhere, that value similar changes).

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 between each parameter to be measured and between countries. The purpose of this three-stage approach is to ensure that the full range of benefits arising from 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 national 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 parameter 'biodiversity'.

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 the following table.

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 benefits 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 year 2020 used across the countries 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 Euros are adjusted for Purchasing Power Parity (PPP), except for the carbon prices used as regards climate change mitigation, which are in €. Monetary values calculated for e.g. health benefits associated with avoided impacts of air pollution, or other benefits, 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.
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)[2]. 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 goes up by a factor of 2, the WTP goes up by a factor of two.
LE[3]/Euro, 2008 (PPP adjusted)	2.95 (World Bank, 2010b)
LE/Euro, 2008[4] (Market rate)	8.05 (World Bank, 2010b)

2 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).

3 livre égyptienne, i.e. Egyptian Pound

4 Note: for other years, monetary values converted into EUR at market value using annual average exchange rates as in http://www.oanda.com/

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 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%

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[5].

Full reference to the specific values used for issues 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 that has been developed for the project.

1.9 Structure of this report

Chapter 2 provides an overview of the environment, economy and society of the country. Chapter 3 aims to assess the benefits related to improved air quality, chapter 4 those related to improved water quality and infrastructures, chapter 5 those related to waste management, chapter 6 those related to nature and biodiversity, and chapter 7 those related to climate change measures. The analysis is complemented by a case study on the benefits of improving the conditions of coral reefs in Egypt, presented in chapter 8. Finally, conclusions are provided in chapter 9.

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

2 COUNTRY OVERVIEW: EGYPT

2.1 Environment, economy and society

The Environment

The country faces several challenges in all its environmental sectors: air, water, waste and nature. These issues are mostly a result of human activities and are intensified by climate change.

The air pollution is considered as one of the major problems in Egypt, especially in Cairo due to the heavy traffic and high number of vehicles. Air pollution in Cairo is also worsened by the emissions from the factories surrounding the city, and by solid wastes burning (in particular, the so called 'black cloud' phenomenon).

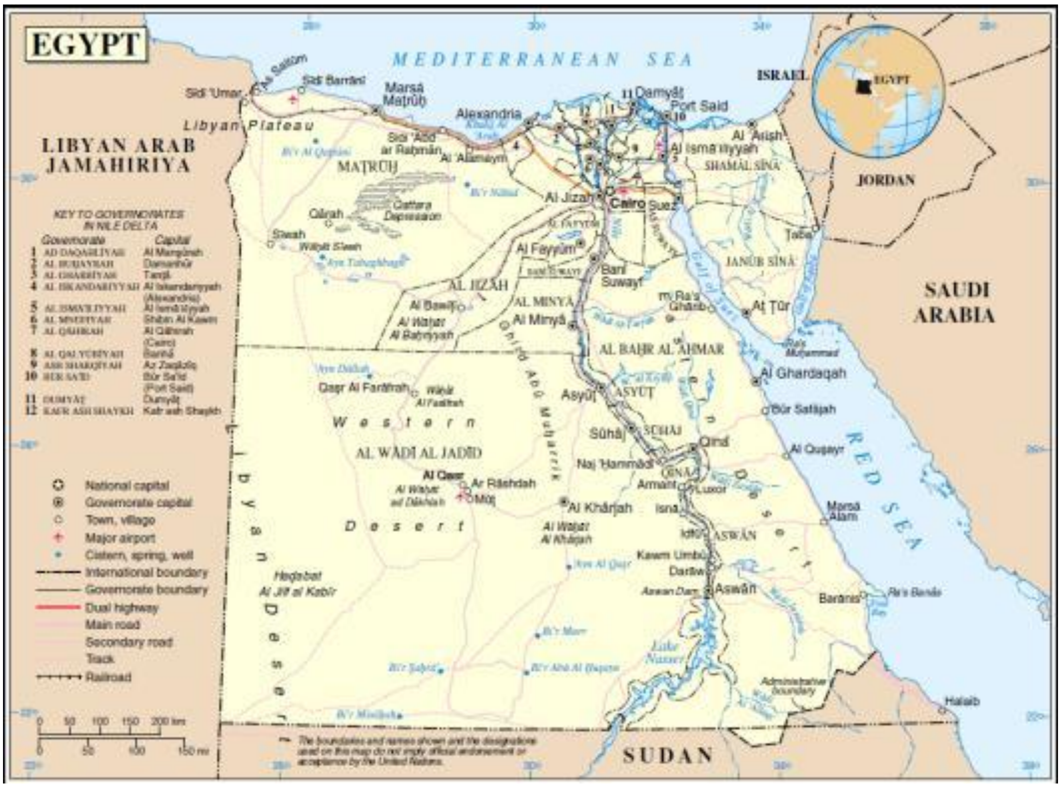
Another major problem is the water quantity and quality. Egypt relies almost entirely on the water resources of the River Nile. The river's water resources are shared among 10 countries. The share for Egypt was agreed in 1959 to be 55.5 billion m3 of water per year. Many Egyptians have been living at the water poverty limit. Water scarcity is a key issue and arguably improved water management and desalination will be needed in the future. Furthermore, there are many sources of contamination of the water resources, including industrial and agricultural processes and waste water discharges, representing a real threat for development and health. Drinking water quality of water in urban areas is mostly at international average. But the network in some places is not intact (due to leakages and contamination) and does not meet hygienic standards. The quality is worse in rural areas and in some hot spots in the delta region. As for waste water, there is almost 100 per cent connection in urban areas, but mostly undergoing primary treatment. Only one plant in Cairo carries out secondary treatment, and a second one is planned.

The waste production per capita was estimated between 0.7-1 kg/day in urban areas, and between 0.4 and 0.5 kg/day in rural areas (SWEEP-Net, 2010). Waste generated was about 19,700 tonnes/day in 2009 (SWEEP-Net, 2010), i.e. about 54 tonnes per day. In Cairo there are two systems of collection and recycling in place, a 'formal' one carried out by multinationals companies officially contracted by the government, and an 'informal' systems of collection carried out by some of the poorest population groups which collect the garbage to resell or reuse. Since 2003 landfills have been built, but these are not considered fully compliant with sanitary standard. There is no leachate collection, and methane is flared instead of captured.

In Egypt there are 27 protected areas. Some management systems are in place in a few protected areas, administrated by the Ministry of the Environment. Some of these areas have a great potential for tourism attraction, but they are not always appropriately protected and promoted.

Egypt is one the countries that could be potentially most affected by climate change. The main problems are related to water scarcity and drought, and sea level rise. Coastal zones in the north-east are starting to experience sea water rise. This is expected to have relevant socio political impacts, and may lead to the need for reallocating part of the population in coastal areas.   As for renewable energy sources (RES), currently solar energy is used for heaters/driers but not for photovoltaic energy. There is potential there, as it is estimated that the volume of solar energy in 1 year in the Arab peninsula could be more than the energy provided by the existing mining resources.

Figure 2-1 Map of Egypt



Source: United Nations, 2004: Egypt, Map No. 3795 Rev. 2, January 2004

Economy and society

Egypt's population is about 80 million and is experiencing rapid growth of about 2 per cent per year (see table below). For the purpose of this study, a more conservative growth rate of about 1.6 per cent a year has been assumed up to 2020.

In the early 2000 the Egypt economy suffered from sluggish growth rates, averaging below 3 per cent a year, high inflation and high unemployment. Gross Domestic product (GDP) started rising more steadily from 2003-2004 and averaged 7 per cent between 2005-2008, thanks to economic reform and strong external demand that pushed up export growth. In 2008 GDP stood at about EUR 110 billion, corresponding to about EUR 1,400 per capita (see table below). During the global economic recession, which began at the end of 2008, real GDP growth slowed to 4.7 per cent level, still well above the 2009 Middle East and Northern Africa (MENA) region average growth rate of 1.4 per cent. Recently the economy has started to revive, with data indicating a real GDP growth of 5.1 per cent in the first thee quarters of 2009-10 (World Bank, 2010a). It should be noted that, for the purpose of this study, a flat

GDP growth rate of 2.03 per cent has been applied to all the Southern ENP regions, which is likely to be an underestimate for Egypt.

Inflation has been relatively volatile in the past decade, ranging from 2.2 in 2001 to a peak of 18.3 in 2008. In 2009 it improved significantly, averaging 11.8 per cent, but remains high. (World Bank, 2010a)

The unemployment rate fell from above 20 per cent in the late 1990s to around 8.8 per cent at the end of 2008-09. This is a relatively good achievement, also considering the rapid population growth and hence the need to absorb about 600-700 thousand new entrants each year. Unemployment has, however, increased again, reaching 9.3 per cent at the end of 2009. Moreover, the official rate of unemployment is likely to conceal considerable hidden unemployment and under employment, as a large share of the population escapes statistics, either by not registering or working in the informal economy. (World Bank, 2010a)

Despite recent successes and sustained reform momentum, Egypt continues to face significant economic and social challenges. Its labour market is a main structural weakness, due to extreme rigidities (e.g. firing and dispute settlements) and an educational system which has yet to reach its full performance potential. Furthermore, public expenditure is high, with a fourth of the work force was employed in the public sector, and large food and fuel subsidies. There appear to be little room for additional spending, e.g. in education and infrastructure. Aware of these constraints, the government started recently to undertake some measures like reducing energy subsidies. High inflation could also pose a renewed challenge, undermining economic activity and leading to regressive effects hurting in particular the poorest. Furthermore, despite economic growth, 20 per cent of the population still remain below the World Bank poverty level. It remains a key challenge to ensure that wider population starts seeing the benefits of an expanding economy. (World Bank, 2010a)

Table 2-1 Key economic indicators for Egypt

Indicator	2008 (unless otherwise specified)
Country surface area	1,001,450 square km[1]
Population size	Current (2008): 81,527,172 Projections (2020): 98,617,000
Population growth rate (annual)	Current actual (2008): 1.82% Assumed for projections to 2020: 1.68% [2]
Number of households	Current (2008): 17,723,298 Projections (2020): 21,438,478[3]
GDP/capita (2008 prices)	Current (2008): €1,360 Projections (2020): €1,730[4]
GDP (2008 prices)	Current (2008): €110,849 million[5] Projections (2020): €170,653 million[4]
GDP in Purchasing Power Parity (2008 Euros, PPP)	Current: € 110,352 million[5] Projections (2020): € 465,527 million[4]
Share (%) of industry in GDP	37.5%
Share (%) of agriculture in GDP	13.2%
Share (%) of services in GDP	49.2 %

Sources: All data from World Bank (converted from US$ to € where applicable) except for:

1 UN Food and Agriculture Organization (FAO)
2Own calculation based on World Bank population projections
3Own calculation assuming an average households size of 4.6 (MICS & DHS surveys)
4Own calculation applying a 2.03% annual growth rate. Note the same rate has been applied to all ENPI south countries
5Own calculation based on World Bank (per capita GDP*population)

3 BENEFITS OF IMPROVING AIR RELATED CONDITIONS

3.1 Introduction to air quality issues

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

The degradation of air pollution is considered one of most serious environmental issues in Egypt. Air quality is particularly poor in the major cities, and in Greater Cairo in particular, due to heavy traffic and industrial activities. Cairo is further affected, once a year, by a phenomenon called 'black cloud', a thick cloud of smoke mostly attributed to the open burning of solid waste and agriculture residues.

Despite some improvement in the past decade, poor air quality is still a significant source of pulmonary and cardiovascular illness and early mortality in Egypt. Air pollution can also damage buildings and vegetation, contribute to acidification and eutrophication of ecosystems and affect economically important resources such as fisheries.

This assessment reveals that halving air pollution by 2020 could lead to saving about 24,000 lives every year, and avoid about 46,000 cases of pulmonary and other diseases. In monetary terms, this will correspond to more than EUR 11 billion each year, equivalent to 2.5 per cent of annual GDP. Improved air quality will also have beneficial effects on crop productivity and on materials (e.g. buildings). Total domestic benefits are estimated at about EUR 12.4 billion, i.e. about 2.7 per cent of GDP. Improving air quality will also have positive effects outside Egypt (trans-boundary benefits). These can be as much as 3 times as high as domestic benefits, depending on local conditions.

3.2 Benefits from improved ambient air quality

3.2.1 Introduction to the issue and approach taken

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, nitrogen oxides (NOx, including NO and NO2 species), sulphur dioxide (SO2), carbon monoxide (CO), ozone (O3), lead (Pb), mercury (Hg), nitrate and sulphate aerosols, 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.

The emissions data used to construct the baseline and policy scenarios for 2020 were taken from the EDGAR Database held by the EC Joint Research Centre (JRC, 2010). This data was used in all the 16 ENPI country-level analysis of air quality benefits under this project. The data is constructed using a modelled approach to national emissions and therefore does not rely on observed data. The use of this data therefore allows comparison between countries since a common approach has been used to estimate the emissions. Similarly, use of this data allows analysis of important components of air pollution where national air monitoring and statistical systems do not allow observations to be made. Clearly, wherever required, further analysis can exploit records of observed emissions where these are judged to be more accurate.

3.2.2 Current state of ambient air quality

The degradation of air pollution is considered one of most serious environmental issues, especially in Cairo and in other major urban areas (World Bank, 2005). Air pollutants result principally from stationary sources and from transport.

Cities having the most significant air pollution problems tend to be those with the highest population totals and heavy road traffic and where there are industrial complexes close by. Substantial national subsidies to all fuels and to certain groups of electricity consumers, especially the residential and agricultural sectors, are considered among the key drivers of emissions (World Bank, 2005). Air pollution in Cairo is also worsened by the emissions from solid wastes burning. Notably, since 1998, every year in autumn the burning of agricultural waste (rice straws) in the countryside surrounding the city creates a thick cloud of smoke, a phenomenon called 'black cloud'.

Inhaled particles are considered a major pollution problem in Egypt, especially in Greater Cairo, due to various sources of pollution.. To date there are 87 monitoring facilities in the major urban and industrial areas, operating since 1998 . Although some improvement has been recorded in the past decade, particularly in PM10, SOx and Lead, pollutants concentrations remain high.

Between 2004 and 2008 sulphur dioxide decreased from about 45 to about 30 µg/m3, remaining below the national permissible limits (60 µg/m3/year), thanks to a more efficient use of fuel in power stations and industrial sectors.

Carbon monoxide (CO) also decreased from about 7 mg/m3in 2004 to 2.5 mg/m3in 2008. Ozone increased between 2004 and 2007, while in 2008 it decreased to 50 µg/m3, slightly below the 2004 values.

Lead concentrations also decreased significantly from 1.2 µg/m3 in 2004 to about 0.3 µg/m3 in 2007, following the transfer of foundries, the cleaning of lead-contaminated sites and the increasing uptake of unleaded gasoline. However, in 2008 concentrations rose again to 0.7 µg/m3, due to the return of non-licensed foundries and the increased consumption of gasoline 80.

Furthermore, an increase in the number of vehicles led to a constant increase of nitrogen dioxide (NO2), rising from about 45 µg/m3 in 2004 to 60 µg/m3in 2008, well above the World Health Organization's (WHO) limit of 40 µg/m3. (EEAA, 2009)

High concentrations of PM10 are not only caused by transport and industrial emissions, but also by natural sources, due to the Egyptian arid climate and dusty desert winds, affecting in particular the air quality in Greater Cairo and in the Delta areas. In 2002, for instance, natural sources were found responsible for 30 to 50 per cent of PM10 in 202 in Greater Cairo. PM10 concentrations witnessed a decrease in recent years, with average yearly concentrations moving from more than 160 µg/m3 in 2004 to 137 µg/m3 in 2008. PM concentrations, however, as still well above the permitted annual average limit of 70µg/m3, and are even higher in some urban areas. In 2008 in Greater Cairo for instance concentrations reached about 160 µg/m3 in several districts (Kolaly, Shoubra El-Khema, El-Sahel and Massara) (EEAA, 2009).

During recent years increased efforts have been made in monitoring concentrations of particulate matter with diameter less than 10µm, which are recognised to constitute an imminent risk to public health. Yearly average concentrations of PM2.5 decreased from 90.2 µg/m3 in 1999 to 72.2 µg/m3 in 20008 in Greater Cairo . Currently there is no legal limit to PM2.5 concentrations, but a limit of 70 µg/m3 is under discussion .

3.2.3 3.2.3 Potential environmental improvements

The 2020 baseline level of emissions for each pollutant is simulated on the basis of the assumption that emissions increase on a linear proportionate basis to the average annual GDP adopted across this ENPI project, such that a 1 per cent increase in GDP leads to a 1 per cent increase in pollutant emission levels. The average annual GDP growth rate for the Egypt is 3.75 per cent.

There exist no published targets for air quality in Egypt that simulate WHO limit values or that attempt to replicate the values implied by conformity to EU Air Quality 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 Air Quality Framework Directive. In the case of air quality, a 50 per cent reduction is assumed to be typical and is utilised. The target is therefore emissions at 50 per cent of their 2020 baseline. The baseline and target data are presented in the table below.

Table 3-1 Air pollution emissions: Baselines and targets – Egypt

Tonne	NH3*	NMVOC*	NOx	PPM2.5	PPMco	PPM10	SO2
Baseline 2008	445,722	1,173,660	497,255	487,775	298,847	786,622	826,352
Baseline 2020	693,301	1,825,574	773,457	758,712	464,842	1,223,554	1,285,352
50% Reduction Target	346,650	912,787	386,729	379,356	232,421	611,777	642,676

Sources for baseline emissions: European Commission, Joint Research Centre (JRC)/Netherlands Environmental Assessment Agency (PBL). Emission Database for Global Atmospheric Research (EDGAR), release version 4.1. http://edgar.jrc.ec.europe.eu, 2010'; Megapoli, contributed by TNO, 2010

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.

3.2.4 Qualitative assessment of the benefits of improving ambient air quality

Environmental benefits

Ecosystems: Damage to forests, lakes and streams from acidification resulting from SO2 and NOx has a major impact on the health of ecosystems and biodiversity in general. In some cases, existing acid deposition may have caused critical loads to be reached in ecosystems and much damage will be irreparable. High concentrations of lead also adversely affected domestic animals, wildlife and aquatic life. More indirectly, the effects of climate change, contributed to by NOx and SO2, are as of yet not fully known, but potentially very damaging to global ecosystems.

Crop damage: Sulphur dioxide and nitrogen oxides, in their gas form, also contribute to crop damage through the degradation of chlorophyll. Reducing the release of these gases in the atmosphere will bring tangible benefits to agriculture, agro-forestry and fisheries industries. In addition, SO2 and NOx are known to corrode building structures at great economic cost. According to experts, this may be one of the key benefits, as improved air quality could lead to better quality crops, including for exports, as products will be more in line with international quality standards .

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 whole 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 the table below.

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

Health benefits

Health benefits are considered the most important benefit from improving air quality in Egypt . The health consequences of exposure to air pollution are considerable and span a wide range of severity from respiratory track sensitisation and irritation, coughing and bronchitis to 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 air pollution's health effects, such as bronchitis, tightness in the chest, and wheezing, are acute, or short term. Other effects appear to be 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) and the costs to national health services. Both acute and chronic effects and can be reversed if air pollution exposures decline as a result of emission reductions.

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.

Social benefits

The social benefits of reduced pollution to air are myriad and relate to improvements to the quality of life (e.g. through reduced health effects), the increased amenity value of improved landscapes, nature and air quality), and reduced damage to cultural heritage such as historic building surfaces in city centres. These benefits are described in the table below:

Social benefits	Description
Improved quality of life	– Reduced health effects – 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 benefits	Description
	social improvement policy.
Increased amenity value of improved landscapes, nature and air quality	– through reduced pollution pressure
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. – Exposure of building materials to SO_2 deposition from acidification results 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.

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.

Economic benefits	Description
'Green technology' industries	– Increase in demand for products and processes that result in lower air pollution emissions, and subsequent employment opportunities, as long as such industries are domestic.
Increased visits to improved landscapes and natural areas	– Increase in tourism and associated expenditures in local areas.
Lower material cleaning costs	– Reductions in expenditures on 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

3.2.5 Quantitative assessment of the benefits of improving ambient air quality

The percentage 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. 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 SO2, NOx, primary particulates, (fine and coarse), NMVOC and NH3.
The air quality model produces an output in terms of Euro per tonne of pollutant. 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 a 50 per cent reduction from projected baseline emissions. The aggregate benefits were than apportioned to the different impact categories, according to the outputs of the air quality model. Typical percentage splits were: mortality (70 per cent); morbidity (20 per cent); crops (6 per cent) and materials (4 per cent).

As a sensitivity exercise, we also provide indicative estimates of potential trans-boundary 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 we are obliged to adopt in estimating trans-boundary effects is somewhat crude. We therefore suggest that the results reported should be considered as indicative, only, and serve principally to draw attention to the fact that these trans-boundary effects exist and may be important in assessments of regional air quality strategies.

Health benefits

The pollutants for which we are able to make quantitative estimates of benefits include: Ammonia (NH3), Particulate matter (coarse and fine) (PM), Nitrogen Oxides (NOx), Sulphur Dioxide (SO2) and Non-Methane Volatile Organic Compounds (NMVOCs).

The mortality and morbidity impacts of the pollution emission reductions assumed above for Egypt are shown in the Table below for 2020 – the year in which it is assumed the 50 per cent reduction from 2008 levels is achieved. The benefits of these reductions in surrounding countries – due to reduction of trans-boundary transport of pollution from Egypt - are also given. Morbidity impacts are of a disparate nature and so cannot be expressed as a common unit. However, for illustration, the morbidity impacts are presented - in the table below - as equivalent number of cases of chronic bronchitis avoided.

Table 3-2 Physical premature mortality and morbidity impacts avoided in year 2020

Total	
Deaths	*Cases*
24,000	46,000

The benefits of these reductions in surrounding countries – due to reduction of trans-boundary transport of pollution from Egypt to neighbouring countries are also derived. They are estimated to result in 2,620 deaths.

The mortality figures above are not dissimilar to the one assessed by the World Bank (2005), which amounted to about 20,000 cases of premature mortality caused by PM10 and PM 2.5, sulphur oxides and nitrogen oxides. The cases of morbidity estimated by the World Bank are considerably larger, i.e. about 480,000 cases of chronic bronchitis and respiratory symptoms. It should be noted, however, that the present assessment only focuses on chronic bronchitis, i.e. one of the most serious respiratory illnesses related to air quality. Other minor symptoms are expressed in days of chronic bronchitis; therefore the equivalent number of day is necessary small. This should explain the relatively small number of morbidity cases.

Economic benefits

In the case of materials, the impact being quantified is the premature ageing of various building materials exposed to SO2 deposition from acidification. Thus, in our context, the whole exposed material surface area to SO2 will age at a slower rate than if the emission reductions were not made. 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.

The results are reported in the monetary section below.

3.2.6 Monetary assessment of the benefits of improving ambient air quality

Health and Economic benefits

The monetary values of the benefits from reduced air pollution - as assumed above - are presented in summary form in the table belowFout! Verwijzingsbron niet gevonden.. Values presented are in million Euros (2008 prices), and relate to the year 2020, to which the assumed target of a 50 per cent emission reduction applies. Underlying unit values, unadjusted for PPP, are listed in the Benefit Assessment Manual for Policy Makers, which has been prepared under this project.

The benefits are valued at EUR 360,000 or LE 1,800,000 (Egyptian Pounds) per avoided fatality and EUR 60,000 or LE 300,000 per avoided case of chronic bronchitis-equivalent. All figures are in 2008 purchasing power parity (PPP) adjusted Euros and 2008 LE. Table 2.7 shows that the total domestic benefits to Egypt are equal to EUR 12 billion each year, equivalent to 2.7 per cent of annual GDP. These domestic benefits are understood as benefits which accrue to Egypt as a result of its own emission reductions.

Table 3-3 Annual Compliance Benefits – Egypt 2020

	Euro PPP (m)	LE (m)	% of GDP
Mortality	8,656	25,967	1.9
Morbidity	2,597	7,790	0.6
Crop	742	2,226	0.2
Material	371	1,113	0.1
Total Domestic	12,365	37,096	2.7

In additional sensitivity analysis we made initial estimates of the possible extent of the total trans-boundary benefits - the benefits outside Egypt – that may result from the air pollution emission reductions in Egypt. We found that these benefits may be as much as 3 times as high as the domestic benefits, though the specific geographical and social contexts may well mean that the reality differs significantly from these modelled results. These results do, however, serve principally to draw attention to the fact that these trans-boundary effects exist and may be important in assessments of regional air quality strategies.

4 BENEFITS OF IMPROVING WATER RELATED CONDITIONS

4.1 Introduction to water quality issues

This section covers the following aspects of water quality:

- Man-made infrastructures:
  - Connection to safe drinking water
  - Level of sanitation and hygiene, i.e. connection to the sewage network and hygiene conditions
  - Level of waste water treatment
- Natural assets
  - Surface water quality
  - Water resource use

Egypt has made significant progress in improving access to water in recent years. Connection to drinking water quality is close to 100 per cent in urban areas, and to 87 per cent in rural areas. However, critical issues remain. The network in some places suffers from leakages and contamination, and piped connections do not necessarily produce good quality water. The drinking water quality is worse in rural areas and in some hot spots in the delta region.

Egypt is suffering from a gap in the distribution of sewage networks between cities and villages. Official data on sewage connection present different figures, however it can be inferred that connection ranges between 74 and 87 per cent in urban areas, and between 18 and 32 per cent in rural areas. Less than 70 per cent of the collected sewage is treated in waste water treatment plants, and it mostly receives only primary treatment. Secondary treatment is currently carried out only in one plant in Cairo.

Inland and coastal water is exposed to several sources of contamination, especially from industrial and agricultural processes and waste water discharges, representing a serious threat for human health and the environment. Nevertheless the quality of the river Nile is considered mostly good for national standards, despite some hotpots of pollution especially in the delta area. Agricultural canal and drainages experience more severe pollution, and some lakes show signs of eutrophication. Coastal water contamination from waste water is an issue near those areas where tourism activity is more intense.

Water scarcity is a key issue. Egypt’s climate fluctuates between severe arid and semi-arid, and rainfall is on average 158 mm/year. More than 95 per cent of the Egyptian population depend on the water resources of the river Nile. Overall, the Nile crosses 10 countries and is a key water resource for most of them. The water share for Egypt is 55.5 billion m3 per year according to the 1959 ‘Convention of the full exploitation of Nile Water’ with Sudan. Ground water provides an additional 6.1 billion m3/year. Aquifer resources are about 11,565 billion m3/year, but these are typically located deep underground and not used due to the high costs of extraction. Overall, water availability per person is on average about 860 m3/ year, which is below the international water poverty line of 1,000 m3/capita.

4.2 Benefits from improved connection to safe drinking water

4.2.1 Introduction to the issue and approach taken

This section focuses on the benefits of improvements from the connection to a reliable and safe piped drinking water supply on premises. The key benefits are typically related to improved human health. Since such benefits are strictly interlinked with the health benefits from increased connection to a sewage network and improved domestic and personal hygiene practices, they have been assessed jointly for these parameters. The joint health benefits quantification can be found in chapter 4.3 on sewage connection and hygiene, while the qualitative assessment of all benefits are discussed separately in this section (for drinking water) and in chapter 4.3 (for sewage and hygiene).

The following key definitions apply to drinking water:

- Reliable piped water supply: Continuous and plentiful water supply delivered at appropriate and constant pressure to household premises (yard/dwelling) through a piped water distribution network from a central water intake.
- Safe drinking water: Drinking water that does not contain biological, chemical or other agents at concentrations or levels considered detrimental to health according to WHO guidelines for drinking water quality.
- Plentiful water: The amount of water needed to satisfy metabolic, hygienic and domestic requirements. This is usually defined as a minimum of 20 litres of water per person per day (see DESA, 2007).
- Improved water sources: Piped water to premises (dwelling/yard); public standpipes; tube wells/boreholes; protected dug wells and springs; and use of rainwater.
- Unimproved water sources: Unprotected dug wells and springs; tanker trucks/vendors; and open surface water sources (rivers, ponds, etc.).

4.2.2 Current state of drinking water quality

There are 914 drinking-water plants in Egypt with an estimated production capacity of about 25 million m3/day (EEAA, 2009). Continuous population growth and rising of living standard led to increased amounts of water consumed for drinking, domestic and health purposes. In 2008 potable water consumption was about 6.5 billion m2, i.e. 9.4 per cent of the total water usage, serving about 75 million people (EEAA, 2009).

According to the most recent estimate by WHO/UNICEG (2010) over 90 per cent of the population in Egypt have piped water supply on premises, less than 10 per cent use other improved drinking-water sources and only 1 per cent rely on unimproved drinking-water sources (see tables below).

Table 4-1 Drinking water connection and water treatment in 2008 (%)

	Drinking water (% over total consumed)			Household treatment of drinking water (% over total consumed)			
	Piped on premises	Other improved	Unimproved	Boiling	Other	No treatment	Appropriate treatment
Urban	99%	1%	0%				
Rural	87%	11%	2%				
Total	92%	7%	1%	0.4%	4.3%	95.5%	<4%

Source: WHO/UNICEF, 2010a

Table 4-2 Drinking water connection and water treatment in 2008 (million people)

Population (million)		Drinking water (million people)			Household treatment of drinking water (million people)			
		Piped on premises	Other improved	Unimproved	Boiling	Other	No treatment	Appropriate treatment
Urban	34.81	34.46	0.35	0				
Rural	46.71	40.64	5.14	0.93				
Total	81.53	75.01	5.71	0.82	0.33	3.51	77.86	<3.26

*Source: own calculations based on WHO/UNICEF, 2010 except *based on World Bank 2010b*

Egypt has made significant progress in improving access to water in recent years. However, critical issues remain. It is noted that the water service does not keep pace with rapid population growth, hence service coverage is worsening (Min Economic Development, 2008). Furthermore, there are still disparities between urban and rural access, with the worst levels of access reported in the Matrouh and North Sinai governorates, at 73.6 per cent and 80.7 per cent, respectively (Min Economic Development, 2008). Furthermore, the reliability of the service is not measured, and experience in Egypt has shown that piped connections do not necessarily produce good quality water. These challenges are particularly relevant to people living in slums and in rural areas (HRC, 2010)

Key problems of drinking water in Egypt include:

- The deterioration of operation efficiency of water treatment plants (Donia, 2007).
- The ageing of water supply networks which affects the water quality and results in increasing the loss in produced water with percentage 20-50 per cent - on average 30 per cent according to Government reports; leakages have impacts not only on water availability, but also on water pressure and quality (HRC, 2010).
- The weakness of technical experience required for operation and maintenance of water treatment plants (Donia, 2007).
- The increase of organic and chemical pollution of surface water and groundwater (Donia, 2007).
- The use of one fixed system for the water treatment plants all over the country, which is not always compatible with the types of pollution in different places (Donia, 2007).

- The actual low price of water, which is well below the real production cost.
- Water shortages in some communities, which induce the population to purchase water at high cost to meet the daily needs. In some cases people store water in reservoir tanks, use booster pumps or dig their own wells, increasing the risk of water contamination (HRC, 2010).

Drinking water quality is a crucial problem, especially in places at the extremities of the water network and in less affluent areas. According to the National Council for Human Rights (NCHR) 19 per cent of the population still lacks access to pure drinking water, and those who can afford it drink only bottled water (HRC, 2010).

Water tariffs (drinking water and sanitation)

The tariff for drinking water in Egypt is considered one of the lowest tariffs in the world, with over 92 per cent of households spending less than 1 per cent of their household budget on water and sanitation. Domestic rates range between 0.25 and 0.35 Egyptian pounds per m3 (about EUR 0.05 and 0.07) (HRC, 2010).

According to the World Health Organization (WHO) standards, a lifeline level of water service provision would be 100 litres per capita per day. However, people in urban Egypt consume at least twice that amount. Even if the actual consumption rate is lower when leakages are taken into account, it is clear that some people in Egypt consume more than they need, and there could be considerable scope for those who consume more than necessary to pay more for their water and sanitation service. Studies on affordability (Chemonics Egypt, 2009) indicate 'extensive and substantial willingness to pay for improved services'. They further suggest that water and sanitation services should cost between 2 and 5 per cent of the household income. It should be noted, however, that the extreme poor, which are 3.8 per cent of the population (about 3 million people), cannot even afford the small fee currently charged (HRC, 2010). If water fees where to be increased, therefore, issues of affordability should be taken into account.

Many households do not have a water meter and, where installed, there is often only one meter per building. Under this system, the amount to be paid is broken down according to the number of rooms in each apartment, rather than based on how much water is actually consumed by each household. This system therefore does not encourage water conservation (HRC, 2010).

4.2.3 Potential environmental improvements

The environmental improvements are their related benefits are assessed against the flowing target for drinking water:

- Achieving 100 per cent 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.

For the quantification of health benefits, these targets are combined with those for sewage and hygiene, which are listed in chapter 4.3. That section also includes further details on the assumptions used for assessing the baseline for calculations.

The environmental improvements (from drinking water only):

The improvements from reaching the targets by 2020 are the difference between the specified targets and the baseline assumptions. These are summarised in the table below and include:

- An additional 7.9 million people or 1.7 million households would have reliable and safe piped water to premises, and an additional 43.4 million people or 9.4 million households would have connection to a sewage network system
- As some rural communities may be too isolated to be provided these services, an unspecified but relatively small number of these people would be provided plentiful and equally good quality water from other improved water sources

Note for clarity we have also re-stated these benefits under chapter 4.3 to allow for the joint health benefit assessment.

Table 4-3 Number of beneficiaries of reaching the targets, 2020

	Number of people (million)	Number of households (million)
Reliable and safe piped water supply to premises	7.9	1.7
Improvement in reliability and quality of water among those currently with piped water supply	0-90.7	0-19.7

Source: Estimates by the authors – see the methodological approach in the Benefit Assessment Manual (Bassi et al, 2011)

4.2.4 Qualitative assessment of the benefits of improving drinking water quality

Environmental benefits

An improvement of drinking water connection and quality in Egypt does not appear to lead to major direct environmental benefits. Some benefits to habitats and water resources, however, may accrue if water suppliers press for improvements in abstraction sources, especially the river Nile, such as enhanced nature protection, improved wastewater treatment, reduced use of pesticides and fertilisers of and, where necessary, investment in ecological restoration. See also chapters 4.3 and 4.4 for the benefits of increasing sewage connection and improving the treatment of waste water.

Health benefits

The most important benefits related to improved drinking water are related to health. These will accrue particularly in the communities where the current quality of drinking water does impose some health risks, i.e. especially in rural areas and in slums. Links were noted, for instance, between poor water quality and the incidence of kidney diseases (HRC, 2010).

Joint health benefits from good quality piped water supply, hygienic sanitation (flush toilets connected to sewage network) and good hygiene practices include:

- Reduced 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).
- Reduced chemical, heavy metal, and other toxic substances contamination of drinking water reduce the incidence of associated diseases and health disorders.

Social benefits

The provision of safe drinking water in Egypt is strictly linked to basic human rights. The poor provision of good quality drinking water affects particularly the most vulnerable part of the population. Of the poorest 20 per cent of the population, only 60 per cent are connected to taps in their homes, while by contrast 98 per cent of the wealthiest portion of the population is connected. In some slums people have to walk long distances several times a day, in sometimes unsafe conditions, to collect water from public standpipes. This has a particularly detrimental impact on women and girls, who are overwhelmingly tasked with collecting water and must spend a lot of time searching for water (HRC, 2010). An improvement of drinking water provision and quality could therefore improve the health condition of the poorest, and of women in particular.

Also, several complaints were made to public authorities for poor drinking water quality, which in some cases lied unanswered (HRC, 2010). Improving the level of information and assistance in water supply related issues can increase the confidence of people in the public authorities and increase they level of participation in decision making.

Economic benefits

An indication of some of the economic benefits of providing reliable and safe piped water supply to premises is that currently about 4 per cent of the population treats their water prior to drinking with what may be considered appropriate treatment methods (e.g., boiling, filtering, chlorination) according to the Egypt DHS 2008 survey (see also table 4.2 above). Provision of reliable and safe piped water would reduce the need for such household treatment prior to drinking, and also for household water storage tanks and for the purchase of bottled water.

With clean water supplies, the costs for some industries needing clean water, such as food and drink processing companies, can be reduced, and therefore this can improve their competitiveness, especially at international level when international quality standards apply. It can potentially also improve labour productivity and reduce work absenteeism via improvement in human health.

A reduction in the cases of water borne diseases can also help reduce public and private expenditure on health care and treatments, besides saving human lives.

The rehabilitation of existing piped water distribution networks (to improve water quality) can also reduce water losses and thus the costs of providing potable water.

4.2.5 Quantitative assessment of the benefits of improving drinking water quality

The health benefits from improved drinking water quality accrue jointly with improved sanitation. The joint assessment is done under chapter 4.3 below.

4.2.6 Monetary assessment of the benefits of improving drinking water quality

The health benefits from improved drinking water quality accrue jointly with improved sanitation. The joint assessment is done under chapter 4.3 below.

4.3 Benefits from improving the connection to the sewage network and hygiene conditions

4.3.1 Introduction to the issue and approach taken

This section focuses on the benefits from improving the connection to the sewage network and from improved domestic and personal hygiene practices whenever such practices are inadequate for health protection. The key benefits are related to human health, and these are also affected by the connection to a reliable and safe piped drinking water supply on premises. Therefore, while the qualitative benefits are discussed separately in chapter 4.2 (drinking water) and in this chapter (sewage and hygiene), the quantification of the health benefits from all these parameters is presented jointly in this section to avoid repetition. Benefits of improved wastewater treatment and improved surface water quality instead are assessed in sections 4.4 and 4.5.

Definitions of key terms related to sewage and hygiene are as follow:

- Sanitation: Here defined as systems, facilities, and practices for disposal and removal of human excreta (urine and faeces). Sanitation systems include sewage networks, septic tanks and pits, and wastewater treatment. Sanitation facilities include various types of toilets, and sanitation practices include practices such as open defecation.
- Improved sanitation: Flush/pour-flush toilets to sewage networks, septic tanks or pits; ventilated improved pit toilets (VIP); and pit toilets with slab.
- Unimproved sanitation: Pit toilets without slab; hanging toilets over water; bucket toilets; and open defecation (no access to a toilet facility). Households sharing toilets with other households are also classified as having unimproved sanitation, regardless of type of toilet.
- Sewage: Wastewater from households (and industry and other sectors) which is collected and carried off in a sewage network. Sewage generally contains human excreta and water and may also contain other wastes (e.g. kitchen waste).

- Sewage network: A closed system of sewage pipes used to carry off sewage and drainage water. Improved toilets connected to a sewage network are classified as improved sanitation and is often considered as the most developed stage on the sanitation ladder.
- Hygiene: A procedure or system of procedures or activities used to reduce microbial contamination on environmental sites and surfaces and the external body in order to prevent the transmission of infectious disease (see IFH, 2001).

For definitions related to drinking water please refer to chapter 8.2.

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 faeces, before cooking and eating, and before feeding a child), found in many countries to reduce incidence of diarrhoea by as much as 45 per cent (Curtis and Cairncross 2003; Fewtrell et al 2005).

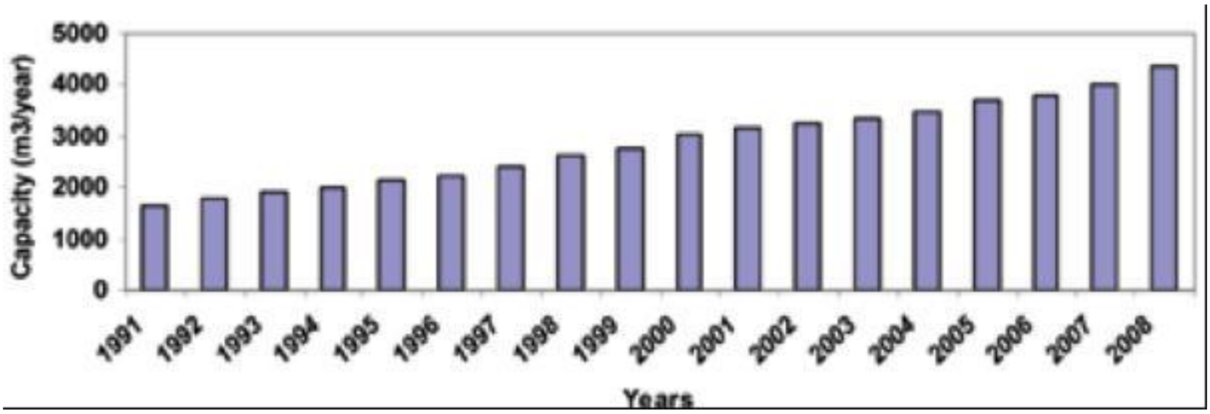
4.3.2 Current state of sewage connection and hygiene

Domestic sewage

The per capita sewage discharge rate is estimated to be about 160 m3/day, corresponding to a total discharge of 12 million m3/day across Egypt. The figure below shows the overall sewage discharge from 1991 till 2008, indicating a constant increase. In 2008 the total wastewater discharge was about 4,380 million m3.

Although a large share of waste water is discharged into sewage networks, part is still discharged directly into agricultural drainages, the Nile, canals, lakes or into the sea. The overall production of treated sewage is 8,123 million m3/ day, i.e. about 2,965 million m3/year.

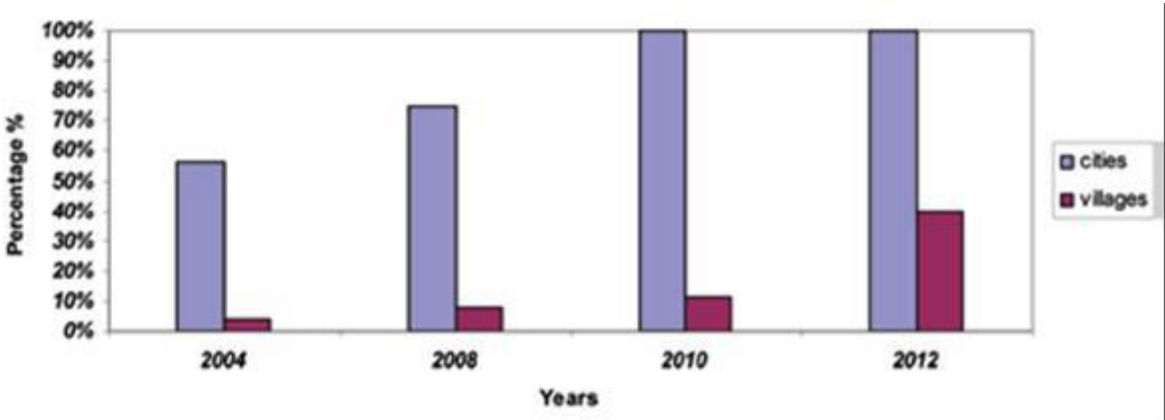
Table 4-4 Total amount of sewage wastewater discharge per year (1991-2008)



Source: EEAA, 2009

According to the Egyptian Environmental Agency (EEAA, 2010), the connection to sewage in 2009 was about 75 per cent in urban areas and 10.5 per cent in rural areas. The government aims to achieve coverage of 100 per cent in cities and 40 per cent in villages by 2012. This is shown in the figure below.

Figure 4-1 Waste water treatment coverage



Source: EEAA, 2009

Data collected through the DHS 2008 survey are relatively higher, indicating a connection level of 87 per cent in urban areas and 32 in rural areas, with an overage connection of 56 per cent in 2008. Data reported by WHO/UNICEF (2010b), although based on the DHS, are slightly lower, indicating a connection of about 74.4 per cent and 18.3 per cent in urban and rural areas respectively, and a total average of 42.2 per cent. See table 4.5 below.

For the purpose of this report, we assessed the health benefits related to both data sets (DHS raw data and WHO/UNICEF) in order to portray sensitivities. We expect results from the latter to be more realistic, as these data appear closer to the national statistics provided by the EEAA.

Table 4-5 Household access to sanitation facilities, percentage of population 2008

Sanitation	Urban	Rural	Total
*Population**	34,812,102	46,715,069	81,527,172
Toilet connected to sewage network (DHS)	87%	32%	56%
Toilet connected to sewage network (WHO/UNICEF)	74%	18%	42%
Other improved sanitation	23%	74%	52%
Unimproved sanitation*	3%	8%	6%
of which: Open defecation	0%	0%	0%

Source: Produced from WHO/UNICEF (2010a,b) except * World Bank 2010b.

It should be noted that even the national statistics are likely to be an overestimate of the actual connection level since, as noted by UNDP (2008), even existing sanitation facilities cannot cope with the increased wastewater flows, and certain sanitation technologies may not be sustainable in Egypt due to the country's very high water tables. Upper Egypt and the frontier governorates are reportedly the areas with the poorest sanitation level.

As for other sanitation practices, we relied on the DHS survey data. It is noted that in rural areas on-site sanitation is the dominant method, but the technology which has been often used, a soak-away system, is no longer sustainable because of population growth, changes in the water flows and rising water tables. As a result, sewage leaks out of the vaults and contaminates the surrounding streets, canals and larger environment (UNDP, 2008). Also in urban slums, many inhabitants cannot afford to connect to the sewage network. Many people who are not connected to the sewage do have septic tanks, but these are reportedly not hygienic and often do not prevent the contents from seeping into the groundwater, thereby contaminating the drinking water (HRC, 2010). In terms of pumping out the septic tanks, the costs of this service can be expensive, thus some people choose to do it only on an infrequent basis, leading to an over-accumulation of waste in the tank and furthering the risk of overflow into the environment. Spillage and leakage also reportedly occur during the process of emptying the tank, especially in the narrow streets of Cairo's slums. Concern was expressed that, when the tanks are pumped out, the pumping trucks dump the waste into the canals rather than taking it to treatment stations. Similarly, concerns were raised by several interlocutors that the Nile river cruises also fail to take their waste to sewage treatment plants, but instead dump it in the Nile (HRC, 2010).

Overall, the lack of access to sanitation has a major impact on water quality, and thus on people's health. Reportedly, 13 per cent of child deaths under the age of five are caused by diarrhoea, which is integrally linked with lack of access to sanitation (NGOs, 2010).

Industrial sewage

Industrial wastewater is one of the main sources of pollution of the River Nile, canals and drainages. Industrial wastewater contains many heavy metals, organic and inorganic components that are harmful to public health and prevents the optimal usage of some water sources. Wastewater resulting from food industries is one of the most important leads to increases in organic matter contents, while chemical industries contribute to pollution with heavy metals, organic and inorganic chemicals.

About 129 industrial facilities are located along Nile River or other water courses. Among these, 102 industrial facilities discharge directly or indirectly about 4 billion m3 /year into the River Nile. Some of these facilities stopped their discharge completely, while others discharge in compliance with the national environmental laws. Violating facilities are committed to implement an environmental compliance plan to adjust their conditions and legal procedures are taken against other violating facilities. Overall, in 2008 27.15 million m3/year or 5.9 per cent of industrial wastewater discharges were not complying with national standards, with some in the process of being improved. (EEAA, 2009)

Other wastewater sources

About 300 Cruisers navigate along the river Nile from Aswan down to Cairo. These Cruisers are usually equipped with storage tank to collect wastewater for at least 6 hours and have their own fixed anchorage through which wastewater is discharged into the sewage network. The efficiency of most of these units, however, is not good as a result of the inappropriate technology as well as the inadequate storage tanks capacity, which lead to inconformity of treated wastewater with national standards. In addition anchorages are insufficient to receive wastewater from the existing Cruisers.

Water tariffs (drinking water and sanitation)

See chapter 4.2.1 above on drinking water.

4.3.3 Potential environmental improvements

The targets:

The environmental improvements and their related benefits have been assessed against the following targets for sewage connection and hygiene.

For sewage connection:

- Achieving 100 per cent 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.

For hygiene:

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

For the quantification of the health benefits, the targets for drinking water listed in chapter 4.2 have also been taken into account.

It should be noted that, 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.

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 Egypt, 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.

The baseline:

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 (see also chapter 4.2), connection to a sewage network system, and good hygiene practices adequate for health protection. As hygiene practices are not well known, a range of 0-100 per cent is applied. Also, as noted above, we looked at two set of data for sewage connection, a higher one (56 per cent total connection) based on DHS raw data, and a lower one (42 per cent) based on WHO/UNICEF. Other baseline data are presented in the table below. These data represent projections or a business-as-usual scenario as if no water, sanitation and hygiene interventions were undertaken to reach the targets. The following baseline assumptions are used:

- Birth rates are projected to decline by 5 per cent.
- 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 1.5 per cent per year.
- Average household size is assumed constant over the period to 2020.

Table 4-6 Baseline assumptions, 2020

	2008 (actual or estimated)	2020 (projected or business-as-usual)
Population (million)	81.5	98.6
Birth rate (births per 1000 population)	24.7	23.5
Mortality rate from diarrhoea among children < 5 years (deaths per 1000 live births)	1.1	1.1
Mortality rate from other infectious diseases among children < 5years (deaths per 1000 live births)	5.8	4.8
Diarrhoea (cases/year, children < 5 years)	2.5	2.5
Diarrhoea (cases/year, population >= 5 years)	0.5	0.5
Household size	4.6	4.6

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

The environmental improvements (from drinking water, sewage connection and hygiene):

The improvements from reaching the targets by 2020 are the difference between the specified targets and the baseline assumptions. The results are summarised in table 4.7 below and include:

- An additional 7.9 million people or 1.7 million households would have reliable and safe piped water to premises, and
- an additional 43.4 million people or 9.4 million households would have connection to a sewage network system (based on DHS raw data) or 56.8 million people or 12.3 million households (based on WHO/UNICEF) (see also chapter 4.2).
- As some rural communities may be too isolated to be provided these services, an unspecified but relatively small number of these people would be provided plentiful and equally good quality water from other improved water sources and improved sanitation facilities if currently without such facilities.
- Potentially a large share of the 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.
- Depending on current hygiene practices, potential beneficiaries of hygiene promotion range from 0 – 98.6 million people or 0 – 21.4 million households.

Table 4-7 Number of beneficiaries of reaching the targets, 2020

	Number of people (million)	Number of households (million)
Reliable and safe piped water supply to premises	7.9	1.7
Improvement in reliability and quality of water among those currently with piped water supply	0-90.7	0-19.7
Connection to sewage network (DHS)	43.4	9.4
Connection to sewage network (WHO/UNICEF)	56.8	12.3
Improved hygiene practices	0 – 98.6	0 – 21.4

Source: Estimates by the authors – *see the methodological approach in the Benefit Assessment Manual (Bassi et al, 2011)*

4.3.4 Qualitative assessment of the benefits of improving 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 below. Some of these benefits (environmental, recreational, improved water resources) are also discussed in the sections on Drinking Water (4.2) Wastewater Treatment (4.4), Surface Water Quality (4.5), and Water Scarcity (4.6).

Environmental benefits

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 waters, and reduced pollution of land resources (see chapters 4.4 on Wastewater Treatment and 4.5 on Surface Water Quality).

Health benefits

Unimproved household sanitation and sewage that is not appropriately collected can cause significant health problems. These are often microbial in character, from light digestive diseases (stomach upsets) going up to fatal cases of dysentery. Overall, improved hygienic sanitation (flush toilets connected to sewage network) and good hygiene practices, together with good quality piped water supply, can lead to:

- reduced presence and transmission of pathogens, which can thus reduce the incidence of diarrhoea and other diseases (Fewtrell et al, 2005).
- Reduced incidence of diarrhoea in early childhood that contributes to improved nutritional status among children (World Bank, 2008). In Egypt, reportedly, 13 per cent of child deaths under the age of five are caused by diarrhoea, which is integrally linked with lack of access to sanitation (NGOs, 2010). An improvement in sewage collection (in combination with improved hygiene practices) can therefore help reducing these cases of illness.
- Good hygiene practices (especially regular hand washing with soap) also reduce transmission of respiratory infections (Rabie and Curtis, 2006; Luby et al, 2005).

Social benefits

The discharge of untreated sewage to local rivers can result in nuisance and odours can lead to a poor quality of life. Investment in collection (and treatment) can enhance quality of life significantly, e.g. by increases household convenience (no needs for emptying and maintaining sewage pits/septic tanks; reduced access time to toilet facility or place of defecation), especially in slum and rural areas where the sewage connection is worse.

Furthermore, the collection of organic waste in tanks under the home can lead to erosion of the soil that the home is built upon, a problem particularly faced in slums. For instance, a lack of sanitation reportedly contributed to the deadly rock slide which killed 98 people in a slum outside Cairo in September 2008. Improving sewage connection can help tackling such type of issues.

Economic benefits

The main economic benefits will derive from appropriate treatment of waste water (e.g., reduced cost of treatment for potable water). These benefits are therefore assessed under the ‘waste water treatment’ parameter and not here, to avoid duplication.

The environmental benefits (see above) of sewage collection and proper treatment of wastewater can provide substantial recreational, tourism, and fishery benefits.

Appropriate sewage connection and good treatment of wastewater can also allow for wastewater reuse in agriculture, and provide substantial cost savings in mobilizing and treating potable water, especially important in water scarce countries (see chapter 4.6 on Water Scarcity). See also chapter 4.4 for benefits more strictly related to waste water treatment.

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

Health benefits

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:

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

Expected reduction in annual incidence of diarrheal disease and diarrheal mortality from reaching the targets is presented in the table below 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.

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 per cent 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 per cent 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 per cent. 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 per cent.

Based on the current distribution of population water and sanitation coverage, reaching the targets is estimated to reduce diarrheal disease and diarrheal mortality nationwide by 26-29 per cent if the entire population has good hygiene practices adequate for health protection, and 57-60 per cent if hygiene practices can generally be substantially improved. In actuality, disease and mortality reduction likely falls somewhere in between these two values, depending on current hygiene practices.

Table 4-8 Expected diarrheal disease and diarrheal mortality reduction from reaching the targets by population group

Group	Current water supply and sanitation coverage	Population distribution 2008	Water and sanitation improvement	Expected average reduction in diarrheal disease and mortality	
				Already good hygiene	**Substantial scope for hygiene improvement**
1	Piped water supply and sewage connection	54% - 40% *	Improvement in reliability and quality of piped water (so as to ensure plentiful and safe water supply) for those of this population currently having water reliability and quality problems	15%	45%
2	Piped water supply but no sewage connection	38% - 52% *	a) Improvement in reliability and quality of piped water (to ensure plentiful and safe water supply) for population currently having water reliability and quality problems. b) Sewage connection (and flush toilet for those with dry toilet or no toilet) for all population.	35%	65%
3	Not piped water supply but sewage connection	2%	Reliable and safe piped water supply to premises for all population	25%	55%
4	Not piped water supply & no sewage connection	6%	Reliable and safe piped water supply and sewage connection (and flush toilet for those with dry toilet or no toilet) for all population	45%	75%
National total		**100%**		**26 -29%***	**57-60%***

Source: Authors (*see the methodological approach in the Benefit Assessment Manual (Bassi et al, 2011)*). Population distribution estimated from WHO/UNICEF (2010a,b) and the Egypt DHS 2008 survey.

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

Health benefits

The annual benefits in year 2020 of achieving the targets amounts to 19-43 million avoided cases of diarrhoea and 1,158-2,644 avoided deaths (see table 4.9). The value to society of these benefits is estimated at EUR 1.2-2.8 billion or LE 3.6-8.3 billion, equivalent to about 0.26-0.60 per cent of GDP in 2020. The benefits are valued at EUR 359,000 or LE 1.06 million per death and EUR 43 or LE 127 per case of diarrhoea. All figures are in 2008 purchasing power parity (PPP) adjusted EUR and 2008 LEs.

Table 4-9 Estimated annual benefits in 2020 of meeting the water, sanitation and hygiene targets (LE is the local currency unit – Egyptian Lira)

	Annual cases avoided			
	Low	High		
Diarrhoea (DHS)	19,006,916	41,644,462		
Diarrhoea (WHO/UNICEF)	20,876,524	43,387,322		
Deaths (DHS)	1,158	2,538		
Deaths (WHO/UNICEF)	1,272	2,644		
	Annual monetized benefits			
	Million (PPP)		Million LE	
	Low	High	Low	High
Morbidity(DHS)	815	1,785	2,405	5,269
Morbidity(WHO/UNICEF)	895	1,860	2,642	5,490
Mortality(DHS)	416	911	1,228	2,691
Mortality(WHO/UNICEF)	457	949	1,349	2,804
Total(DHS)	1,231	2,696	3,633	7,960
Total(WHO/UNICEF)	1,352	2,809	3,991	8,294
Total (% of GDP) (DHS)			0.26%	0.58%
Total (% of GDP)			0.29%	0.60%

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.

4.4 Benefits from improving the level of waste water treatment

4.4.1 Introduction to the issue and the approach taken

Poor waste water treatment leads to damage to the natural environment and substantially affects water quality, which in turn can affect health and ecosystems. It is therefore important to understand the benefits of improving the level of waste water treatment, by increasing connection to and capacities (or number) of waste water treatment plants with at least biological (secondary) grade treatment.

The following definitions apply:

- Urban waste water: domestic waste water or the mixture of domestic waste water with industrial waste water and/or run-off rain water. (CEC, 1991)
- Domestic waste water: waste water from residential settlements and services which originates predominantly from the human metabolism and from household activities. (CEC, 1991)
- Industrial waste water: any waste water which is discharged from premises used for carrying on any trade or industry, other than domestic waste water and run-off rain water. (CEC, 1991)

- Waste water treatment: any process that reduces the amount of the suspended solids, and dissolved compounds and micro-organisms harmful to the environment and/or the human health in waste water. Only treatment in facilities operating with the approval of environmental and/or health authorities should be considered. (WHO 2002)
- 1 Population Equivalent (PE): the organic biodegradable load having a five-day biochemical oxygen demand (BOD5) of 60 g of oxygen per day. (CEC, 1991). For the purpose of this study, if no data on PE is available, just assume that 1 PE= 1 inhabitant.
- Primary treatment: treatment of urban waste water by a physical and/or chemical process involving settlement of suspended solids, or other processes in which the BOD5 of the incoming waste water is reduced by at least 20 per cent before discharge and the total suspended solids of the incoming waste water are reduced by at least 50 per cent. (CEC, 1991)
- Secondary treatment: treatment of urban waste water by a process generally involving biological treatment with a secondary settlement or other process. (CEC, 1991)
- Tertiary treatment: The process which removes pollutants not adequately removed by secondary treatment, particularly nitrogen and phosphorus; accomplished by means of sand filters, microstraining, or other methods. (EEA, undated)
- Eutrophication: the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned. (CEC, 1991)

The approach used is for this report is to assess, qualitatively, the benefits from the additional amount of waste water (expressed in m3 or in people equivalent) that will be treated, assuming that by 2020 all waste water will be collected and treated in plants undertaking at least secondary treatment in the urban areas and in the main rural areas.

4.4.2 Current state of waste water treatment

In Egypt the per capita discharge rate of wastewater is estimated to be about 160 m3 / day, leading to a total discharge of 12 million m3/day in 2008 (EEAA, 2009) – i.e. about 4,380 million m3 per year.

There are 239 domestic wastewater treatment plants all over Egypt, producing about 8,123 million m3 per day of different kinds of treated water (primary – secondary - biological – activated sludge - plant – aerobic and anaerobic oxidation ponds). Of these, 31 plants are still under construction in Monoufia, Behera, Sohag, Assiut and Qena governorates and two plants are expected soon in Fayyoum (EEAA, 2009). Overall, treatment plants are in operation in 23 governorates, serving about 31 million people. The operation and management of these plants is under the responsibility of the Egyptian Holding Company for Drinking Water and Sanitation and its 23 affiliated companies.

An overview of key figures related to waste water treatment (WWT) is provided in the table below.

Table 4-10 . Waste water discharge and treatment [2008]

	Total (2008)	Primary treatment (Mechanical treatment plants)			Secondary treatment	Tertiary treatment (if any)
		Sea outfall	Inland water outfall	Total		
Total waste water discharged (m^3/day)	12,000,000					
# inhabitants connected to WWT plants*	31,153,500	n/a	n/a	n/a	n/a	n/a
Total population	81,527,172					
% connected over population	38.2%	n/a	n/a	n/a	n/a	n/a
Waste water treated (m^3/day)	8,123,000	n/a	n/a		470,000 **	0
% treated over total waste water discharged	67.7%	n/a	n/a	94% (est.)	6% (est.)	0
# WWT plants	239	n/a	n/a	n/a	1	0
WWT plants total actual capacity (m^3/day)	8,279,900	n/a	n/a	n/a	n/a	n/a
WWT plants total design capacity m^3/day)	10,524,000	n/a	n/a	n/a	n/a	n/a
PE treated (if available)	n/a	n/a	n/a	n/a	n/a	n/a
PE total capacity (if available)	n/a	n/a	n/a	n/a	n/a	n/a

Source: All data in the column 'total' are from EEAA (2009 and 2010a) beside 'Total population' from World Bank (2010)

The number and characteristics of WWT plants in each governorate is shown in the table below.

Table 4-11 Domestic wastewater treatment plants in Egypt

No.	Governorate	Plants number	Design capacity (thousand m^3/day)	Actual capacity (thousand m^3 /day)	Population no. (thousand)
1	Cairo	7	4,680	4,630	15,920
2	Alexandria	8	1,191	947	3,888.3
3	Kafr El-Sheikh	4	73.5	31	257.6
4	Sharkeya	12	210.8	143.9	1,120
5	Domiatt	23	167.2	154	
	Dakahleya	25	288.5	231.5	995.1
	Behera	25	361	246.2	1,648.3
	Gharbeya	18	441	289.3	2,183.5
	Monoufia	18	351	218	
	Qalyobia	9	218.5	215.3	
Total Northern Egypt Gov.		149	8,149.7	7,106.2	26,030.8
	Minia	5	94	74.6	583.4
	Bani Suef	4	70.1	46.7	298.8
	Aswan	7	97.4	93.6	382.8

No.	Governorate	Plants number	Design capacity (thousand m^3/day)	Actual capacity (thousand m^3 /day)	Population no. (thousand)
	Fayyoum	22	301.7	138.8	320
	Luxor	5	51.5	44.5	
	Qena	8	369	40	
	Sohag	12	335	66	946
	Assint	5	185	43	1,166.7
Total Upper Egypt Gov.		68	1,503.7	547.2	3,697.7
	Ismailia	7	165	165	
	Port Said	5	234	167.5	475
	Suez	3	144	144	
	New Cities	10	309.6	140	
	The Red Sea	1	18	10	950
Total Gov.			**10,524**	**8,279.9**	**31,153.5**

Source: Based on EEAA, 2009

4.4.3 Potential environmental improvements

For the purpose of estimating the potential future environmental improvement, we first assessed the current level of treatment. As noted above, according to official data (EEAA, 2009), 12,000 million m3 of waste water are discharged per day, of which about 8,123,000 are treated – corresponding to about 67.7 per cent (see table 4.10 above). Data on secondary treatment are quite scarce and not always consistent. For this analysis we have used information from the EEAA (2010a) indicating that about 470,000 m3 of waste water undergo biological treatment at Abu Rawash plant (EEAA 2010). This would suggest that, of total waste water discharged, approximately 64 per cent undergoes primary treatment, 4 per cent undergoes secondary treatment while more than 32 per cent remain untreated. According to the information available, no tertiary treatment in carried out in Egypt. The current situation is summarised in the table below.

Total volume of waste water discharged/day	Amount of WW under primary treatment	Share of primary treat over total	Amount of WW under secondary treatment	Share of secondary treat over total	Amount of WW under tertiary treatment	Share of tertiary treat over total	Amount of WW untreated	Share of untreated WW over total
m3	m3	%	m3	%	m3	%	m3	%
12,000,000	7,653,000	63.8%	470,000	3.9%	0	0.0%	3,877,000	32.3%

To estimate the baseline level in 2020, we assumed that the same share of primary, secondary and tertiary treatment will remain unchanged if no new policy is adopted. This was compared to a target where 100 per cent of at least secondary treatment in urban areas and main rural areas was achieved. The overall improvement was calculated as follow:

Pop. increase rate	Estimated total volume WW in 2020	Estimated primary treat in 2020	Estimated secondary treat in 2020	Estimated tertiary treat in 2020	Estimated volume untreated in 2020	Target	Env improvement [2020 values]	Env improvement (share)	Env improvement [2008 values]
%	m3	m3	m3	m3	m3	100% secondary	m3	%	m3
21%	14,515,200	9,257,069	568,512	0	4,689,619	14,515,200	13,946,688	96.1%	11,530,000

In 2020 the environmental improvement would therefore correspond to about additional 13.9 million m3 of waste water receiving at least secondary treatment, i.e. an increase of about 96 per cent. As a comparison, if the secondary treatment were to be met today, about 11.5 million additional m3 will undergo secondary treatment (in 2008 values).

It should be noted that this is, however, likely an underestimate if we take into account that, by 2020, more households will be connected to the sewage network, and therefore more waste water will be collected. As noted in chapter 4.3, the connection to sewage in 2009 was about 75 per cent in urban areas and 10.5 per cent in rural areas (EEAA, 2010). More benefits will emerge once all sewage water will be collected and appropriately treated.

4.4.4 Qualitative assessment of the benefits of improving waste water treatment

Environmental benefits

In Egypt the pollution of the river Nile is a crucial issue, and waste water is one of the most important sources of pollution. The increased and improved treatment of wastewater is therefore very likely to lead to a reduction in nutrient discharges and, therefore, a reduction in eutrophication in aquatic ecosystems, with due improvements to the eco-systems and associated recovery of fish and other aquatic life.

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 chapter 4.3. on 'sewage connection' and not here, to avoid duplication.

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 chapter 4.3 on 'sewage connection' and not here, to avoid duplication.

Economic benefits

The Nile is the main source for drinking water and irrigation in Egypt, and is therefore of crucial importance for the population and for farming and industrial activities. Therefore a reduction in contaminants in the abstracted waters can bring direct financial benefits in terms of reduced 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 irrigation and other economic uses such as cooling water and industrial water. The option to use treated waste water for irrigation is being explored, and therefore improved treatment can offer significant potential for irrigation purposes.

Wastewater pollution causes significant damages also in terms of fishery losses (close to 0.1 per cent of GDP according to World Bank estimates (World Bank, 2002)). Improving wastewater treatment can therefore also be beneficial for the fishery sector.

Furthermore, the investment in environmental technology and improvement in the skills of those working in the water industry will assist in enhancing the economic base of the country.

4.4.5 Quantitative assessment of the benefits of improving waste water treatment

The health benefits from improved waste water treatment accrue jointly with improved sanitation. The joint assessment is done under chapter 4.3. No additional information was available on quantified benefits.

4.4.6 Monetary assessment of the benefits of improving waste water treatment

The health benefits from improved waste water treatment accrue jointly with improved sanitation. The joint assessment is done under chapter 4.3. No additional information was available on monetised benefits.

4.5 Benefits from improving surface water quality

4.5.1 Introduction to the issue and the approach taken

This section reports on the assessment of the health, social, environmental and economic benefits to society for Egypt 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, 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 meets 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 EU Water Framework Directive (WFD) target of 'Good Ecological Status'.

The achievement of Good Ecological Status for surface waters in Egypt is important because of current trends in water pollution and availability. These are in most cases beyond the assimilative capacity of the aquatic ecosystems, which make freshwater quality a principal limitation for sustainable development. Considering the benefits derived from water quality improvements is essential for making sound decisions regarding the country's aquatic ecosystems and habitats. Decisions could for example relate to efficient and equitable infrastructure investment in the water sector, to the efficient degree of 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. In order to value the improvements in surface water quality, values of a UK study that has determined the willingness to pay of households for cleaner water have been adapted for and transferred to Egypt.

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 Values arise from the actual and/or planned use of the service by an individual, and be direct or indirect:

- Direct, such as when an individual makes actual use of the environmental asset improved - for example, the possibility to undertake fishing activities again in previously degraded/depleted areas, thanks to improved water conditions;
- Indirect, such as 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 Egypt. 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 the table below. It is 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 valuated and assessed in other sections of this report.

Table 4-12 Types of benefits covered with the proposed method

	Types of water uses			Example
Potential Water Quality Benefits	Current use benefits	Direct use	In Stream	Recreational activities: Fishing, swimming, boating
		Indirect use	Near Stream	Recreational activities: Hiking, trekking
				Relaxation, enjoyment of peace and quiet
				Aesthetics, enjoyment of natural beauty
	Non Use		Option	Preferences for future personal use of the resource
			Existence	Maintaining a good environment for all to enjoy
			Bequest	Enjoyment from knowledge that future generations will be able to make use of the resource in the future

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 Egypt (information collected in-country);

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

These parameters are used in the formulas to directly calculate annual WTP for set improvements in freshwater quality per household per year.

4.5.2 Current state of surface water quality

Egypt only has one river, the Nile. The Nile is 6,825 km long, with a total river basin of 3.1 million km2. It crosses 10 countries from south to north, Egypt being the last. The river extends by 1,530 km inside Egypt. It is its main source of fresh water and more than 95 per cent or of the population depends on it (EEAA, 2009). Domestic and industrial wastewater is one of the most important pollution sources of watercourses, due to its high content of biological and chemical pollutants (EEAA, 2009).

In spite of the high organic loads discharged from some of the drains and industrial activities, the water quality of the main part of the Nile River, from Aswan to the Delta barrage is considered good in light of national standards. (Ezzat et al, 2002). In the river Nile in 2009 the concentrations of biological oxygen demand (BOD), nutrient, total dissolved solids (TDS), heavy metal, chlorides and fluorides were mostly within the limits prescribed in the national legislation . Dissolved oxygen (DO) concentrations were above the minimum limits, suggesting relatively clean water. Water quality values in the Damietta and Rosetta branches, however, show less positive results, with values for COD above the national limits. BOD and ammonia were close to the limits in parts of the branches. Phosphate was instead significantly below the limits. Overall, a gradual improvement of water quality was recorded in the past decade (EEAA, 2010). An overview of key national limits for surface water and an outline of the quality of the main water bodies are provided in the table below, on the basis of national monitoring data (EEAA, 2010a)

Table 4-13 Surface water allowable limits in Egypt and quality at key water bodies

	Allowable limit	River Nile	Damietta branch	Rosetta Branch	Lake Nasser
BOD	6mg/L	Below	Below	Above in some parts	Below
COD	10 mg/L	Above in 6 gov	Above	Above	Below
DO	min 5 mg	Above	Above	Above	Above
ammonia	0.5 mg/L	Above in 1 gov	Below	Below	Below
nitrate	45 mg/L	Below	n/a	n/a	Below
phosphate	1 mg/L	Below	Below	Below	Below
Heavy metals	(various)	Below	n/a	n/a	No/traces
TDS	500 mg/L	Below	n/a	n/a	n/a
fluoride	0.5 mg/L	Below	n/a	n/a	n/a
sulphate	200 mg/L	Below	n/a	n/a	n/a
iron	1 mg/L	Below	n/a	n/a	n/a
manganese	0.5 mg/L	No/traces	n/a	n/a	n/a
e.coli	1000 cells/L	n/a	n/a	n/a	n/a
coliform	500 cells/L	n/a	n/a	n/a	n/a

Source: based on EEA, 2010a

In Egypt there are also several canals and drainages. Agricultural drains receive all types of wastewater and experience more severe contamination than the Nile River. The quality of the canals in Upper Egypt was mostly within limits (see table above), except for DO in one canal and BOD in some periods of the year. Agricultural drains receive all types of wastewater and experience more severe pollution. The Fayoum canals are of worse quality, with all canals exceeding Escherichia coli (E. coli) , ammonia and dissolved salts limits, and one canal also exceeding BOD limits. In the Delta, most of the drains receive high loads of pollution exceeding their assimilation capacity. 40 per cent of the Delta canals fall outside the DO limits, and most canals exceed limits for BOD, ammonia and e.coli (EEAA, 2010).

In Egypt there are 12 lakes: Aswan (Nasser) Lake, Manzala Lake, Mariut Lake, Lake Bardawil, Lake Moeris or Qaroun Lake,Wadi Elrayan Lakes, Edko Lake, Toshka Lakes, Great Bitter Lake or al-Buhayrat al-Murrah, Borolus Lake or Paralos lake, Wadi El Natrun Lakes, and Salt lakes of Siwa.

The northern lakes (Bardawil, Manzala, Burullus, Edku and Mariut) are particularly valuable for fish production. Given their importance for fish resources and biodiversity (they are also a refuge for migratory birds), the Egyptian government set a priority to protect them from pollution and depletion. A monitoring programme was started in 2009. Preliminary results indicated that the Bardawil lake is the least polluted. The five lakes showed relatively high concentration of iron, especially in Manzala Lake, while other heavy metals were less than 1mg/l. Average nutrient concentrations (ammonia, nitrate and phosphate) were also less than the allowed 1 mg/l limit, although high ammonia concentration was found in Mariut Lake. Concentrations of total pesticides ranged between 0.018 and 0.158 ng/l, with the highest values recorded in Edku Lake. A particularly high concentration of polychlorinated bipheniyls (a type of pesticide) was found in El-Bardawil Lake (about 0.9 ng/l). Total coliform range d between 32 and 1,293 cells/100ml, with the highest values recorded at El-Burullus Lake. E. coli was below the 1,000cells/100ml limit, with the highest values recorded at l-Burullus Lake. Sediments analysis confirm high concentrations of iron, especially at El Burrullus lake, highest concentrations of nitrogen, phosphate and Poly Chlorinated Biphenyls at Mariut Lake, while the average concentration of total pesticides was highest at Edku Lake (EEAA, 2010).
Eutrophication is an issue. A study by Mahmoud et al (2006) in the Manzala lake revealed that eutrophic conditions covered most of the study area, especially close to water discharges, while more recent studies showed a change from moderate eutrophication to highly eutrophic water (Hra 2011). As a result of the extensive input of nutrients from Alexandria city, the Mariut lake is also affected by eutrophication, especially in its north-western sector (Aboul-Naga, 2001).

Water quality in Lake Nasser has also been monitored (see table above). The lake is a vast artificial reservoir in southern Egypt, shared with Sudan. It was created as a result of the construction of the Aswan High Dam across the waters of the Nile between 1958 and 1970. The lake is considered the reference point for water quality in the Nile, as it is the first recipient of water flowing from Sudan. Monitoring results in 2009 indicated that the water in the lake Nasser is of good quality (EEAA, 2010).
The analysis of groundwater falls outside the scope of this study. However, it is useful to note that some of them showed high concentrations of iron (in Delta, Greater Cairo and Nile

Valley), indicating unsuitability for drinking, and some also show high concentration of salts (Nile Valley) indicating unsuitability also for agriculture use. Aquifers in the Eastern Desert and Sinai Aquifer revealed relatively high concentration of chloride, sulphur, sodium and manganese, as well as an increase in salinity. Aquifers in the Western Desert were instead of relatively good quality, although high concentration of iron and manganese was reported in some wells (EEAA, 2010).

As for coastal water, Egypt's coast extends to about three thousand km (1,150 km on the Mediterranean Sea, 1,200 km in the Red Sea, and 650 km in the Gulfs of Suez and Aqaba). The Mediterranean and Red sea are important waterways and tourist areas, and are characterised by unique marine biodiversity (see chapter 6.1 on biodiversity) . The marine environment receives many pollutants from land-based activities, such as industrial and sewage water through estuaries and banks. Seaports are also important sources of marine pollution, in addition to pollutants from ships such as sewage water, garbage, oil residues and contaminated ballast waster, as well as accidents of oil tankers, leakage of fuel from ships and emission resulting from their operation.

A monitoring programme of costal water quality was started in 1998. Overall, analysis conducted during 1998- 2004 showed that 10 out of 40 monitoring sites in along the Aqaba Gulf, the Suez Gulf and the Red Sea proper were considered polluted - i.e. 20 per cent of their samples exceeded the acceptable levels of bacteriological standards (El-Shenawy et al 2006). More recent results from 20 monitoring stations in the Mediterranean coast revealed that in 2009 there has been an improvement in water quality compared to previous years. However, some sites still record high concentrations of pollutants, in particular some sites substantially exceeded the bacteriological limits due to waste water discharges – in Elborg, Dekhila and Max. Water quality monitoring in the Red Sea, Gulf of Aqaba and Gulf of Suez showed improvements in the concentrations of nitrite and total nitrogen in 2009, although a slight increase was recorded in the northern region of the Gulf of Suez, as well as a relative increase in the amount of outflows reaching all sites. Bacterial count levels improved compared to previous years, although in 4 stations out of 22 bacterial still exceeded the allowable limits. In particular, in the Gulf of Aqaba bacteria were above limits in those areas were tourism activities are most intense (Sharm El Sheikh, Marina Sharm, Na'ama Bay) (EEAA, 2010).

4.5.3 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 Egypt.

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 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, Good Ecological Status (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. Whether high or good is assigned can depend on the condition of the other quality elements.

The baseline water quality information used from Egypt to feed the benefits transfer model indicates that presently 27 per cent of the river Nile length fails to achieve good ecological status according to the WFD. The water quality all over the Nile is in good condition and the major problems are in the upper part downstream nearly in some spots in the first 300-400 km (around 27 per cent of the river total length). The quality of lakes and coastal water was not taken into account in this assessment due to the lack of a national classification of water status.

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 per cent to 95 per cent of all water bodies in the country reaching Good Ecological Status by certain key dates (2015, 2022, 2027).

In the case of Egypt, the quantitative target is the following: 11 per cent (as an average between 75 and 95 per cent) of all surface area of the river Nile in the country will be improved to good ecological status by 2020.

4.5.4 Qualitative assessment of the benefits of improving surface 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 well-being 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, this section highlights in qualitative terms 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 Egypt 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.

Health benefits

Polluted water is a major cause of human disease and death. The key diseases avoided thanks to improvements in water quality are those of the alimentary system. Microbial (both bacterial and viral) contaminants (e.g. E-coli) 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. As the improvement of water quality in Egypt will be closely related to the decrease of the discharge of raw sewage or poorly treated waste water, the health benefits will be similar to those discussed under chapter 4.3 and 4.4

Environmental benefits

Poor water quality can have biological impacts, i.e. eco-system damage and biodiversity loss. The presence of pollutants/toxic substances in water (e.g., metals, pesticides), affect a wide range of animal, fish and vegetation, both freshwater and marine. Species may be affected by direct toxic effects on metabolism and the disruption of endocrine functions, which often impacts on the reproductive system. 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 cause extensive harm to the environment through eutrophication. 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. In Egypt eutrophication is indeed a serious problem in the Mediterranean coast, particularly in both the Nile Delta region and Alexandria coast, resulting in fundamental changes in the structure of the planktonic and benthic communities as well as fish mortality. Eutrophication was accompanied by the appearance of several harmful algal species at several hot spots along the coast (Ansari et al, 2001). Lake Manzala, an important and valuable natural resource area for fish catch, wildlife, hydrologic and biologic regimes, is also increasingly affected by eutrophication (Mahmoud et al, 2006). Improving water quality could hence arguably help tackling these problems.

Economic benefits

Cleaner surface water resources can: reduce costs to industry (e.g. for pre-treatment); reduce costs to society 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 (e.g. eutrophication in Manzala lake can discourage swimming and boating (Mahmoud et al, 2006) – reduced pollution could reverse this trend); and increase the value of property.

Water pollution is both a cause and an effect in linkages between agriculture (the single largest user of freshwater in Egypt) and human health. Agriculture 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. They can also help avoid microbiological contamination of food crops, stemming from: use of water polluted by human wastes and runoff from grazing areas and stockyards. This applies both to use of polluted water for irrigation, and by direct contamination of foods by washing vegetables etc. in polluted water prior to sale. Crops that are most implicated with spread of these diseases are ground crops that are eaten raw.

Reducing pollution is also expected to 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. For instance, lake Manzala produces about 50 per cent of the fish catch of the northern lakes, but is under increasing eutrophication (Mahmoud et al, 2006), therefore improved water quality could reduce the risk of losing valuable resources

The coastal bathing areas are very important for tourism in Egypt. 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. Also, areas currently exposed to heavy tourism activities (e.g. Sharm el Sheikh) are experiencing significant water quality degradation, and could gradually lose their attractiveness – which is mostly based on the quality of landscape and water amenity. Aesthetic degradation of land and water resources resulting from pollutant discharges can also reduce the market value of property and thus affect the financial status of property owners.

Social benefits

Water pollution affects the quality of living in the areas nearby surface waters. It can also reduce the amenity value and tourism development benefits to local communities as this restricts the use of waters. Pollutants can also have effects on health (see above) and therefore can place a strain on social support systems within a community and lead to a feeling of isolation of that community from the social structure of the country as a whole.

Improved surface water quality can therefore favour recreational uses, such as swimming, boating, angling and outings. Improved water appearance and odour make it more desirable and visually appealing for recreation.

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.

4.5.5 Monetary assessment of the benefits of improving surface water quality

This section illustrates the range of monetary benefits in Egypt 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 Jordan 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 Egypt 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 1 are all covered in the analysis;

3) the analysis illustrates a portion of the total economic value of water quality improvements in Egypt, only valuation of people's preferences for changes in quality are included here, other chapters illustrate other types of values and

4) 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.

The table below shows results of the transfer of estimated economic values of water for the UK in Baker et al (2007) to Egypt. Mean WTP values for the 85 per cent overall water quality improvement scenario in Egypt ranges between EUR 31,2 and EUR 173,9 per year per household depending on the two payment mechanism 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 4-14 Water quality improvements benefits assessment results for Egypt

	WTP results (€ per HH year) in 2020		WTP results (LE per HH year) in 2020		Aggregated benefits WTP in 2020 (€/year)		Aggregated benefits WTP in 2020 (LE/year)		Benefits as a percentage of GDP in 2020	
Country	lower	upper	lower	upper	lower	Upper	lower	upper	lower	upper
Egypt	31,2	173,9	100,88	562,07	669.1M	3,728M	2,163M	12,050M	0.14%	0.80%

Multiplying WTP values by 21,438,478 number of households projected in 2020, gives total benefits figure for WFD related water quality improvements in Egypt by 2020 in the range of EUR 669.1M – EUR 3,728M. In terms of GDP share these figures are in the range 0.14 per cent - 0.80 per cent.

4.6 Benefits from reducing water resource scarcity

4.6.1 Introduction to the issue and the approach taken

Management of water requires balancing the needs of people and economic development through agriculture, industry and municipal uses, and environmental requirements so that it continues to sustain the ecosystems on which humans depend. This section provides an assessment of water scarcity and the benefits associated with reducing water scarcity and improving integrated water resource management.

It does this through assessing the level of water availability, threats to water availability and the primary uses of water. It predominantly involves undertaking a qualitative assessment of benefits that include for example, reduced crop loss due to drought, reduced losses through fish kills due to low river flows and improved access to and along waterways.

Where water scarcity is an issue, both a 'demand-led' and ‘supply-led’ approach to ‘integrated water resource management’ should be adopted, focusing on conserving water and using it more efficiently, to complement appropriate capture and storage of water.
Water scarcity is defined as ‘the point at which the aggregate impact of all users impinges on the supply or quality of water under prevailing institutional arrangements to the extent that the demand by all sectors, including the environment, cannot be satisfied fully’. Water scarcity is a relative concept and can occur at any level of supply or demand. Scarcity may be a social construct (a product of affluence, expectations and customary behaviour) or the consequence of altered supply patterns - stemming from climate change for example. In this case, water resource scarcity is taken to cover the availability of renewable freshwater and the extent of its use.

A key parameter to assess water scarcity is the Total Actual Renewable Water Resources (TARWR), used in this section in Table 1. TARWR is the maximum theoretical amount of water actually available for the country, generally calculated from:

(a) Sources of water within a country itself (ground water and surface water, less any overlap effectively shared as it interacts and flows in both the groundwater and surface water systems);
(b) water flowing into a country
(c) water flowing out of a country (treaty commitments).

In this calculation TARWR is added to the water obtained by desalination (potable water obtained from treatment of saltwater) and wastewater re-use (Water obtained from treatment of wastewater available for re-use).
According to the European Environment Agency (2009), one relatively straightforward indicator of the pressure or stress on freshwater resources is the Water Exploitation Index (WEI) (also known as the Water Stress Index and Relative Water Stress Index). This is calculated annually as the ratio of total freshwater abstracted (withdrawal) to the Total Actual Renewable Water Resource (TARWR). A WEI above 20 per cent implies that a water resource is under stress and values above 40 per cent indicate severe water stress (Raskin et al., 1997).

In addition, the UN indicates that hydrologists typically assess water scarcity by looking at the water available per Capita. An area is considered to experience water stress when annual water supplies drop below 1,700 m3 per person. When annual water supplies drop below 1,000 m3 per person, the population faces water scarcity, and below 500 cubic metres 'absolute scarcity'.

In this section, a number of water scarcity indices are covered, as defined below:

- Water Available per Capita = TARWR/population
- Total Water Use per Capita = Total withdrawal per year / population
- Municipal Water Use per Capita = Municipal withdrawal per year / population

The main uses of water covered in this assessment are:

- Agricultural water: Water supplied to crop production, animal husbandry, hunting, fishing, and forestry.
- Municipal water: Water supplied to the community and individuals.
- Industrial water: Water supplied for the production of non-food products.

These uses must be address in the context of environmental requirements, in this document this is quantified by environmental flows which is 'the stream flow required to maintain appropriate environmental conditions in a waterway'.

4.6.2 Current state of water resource use

Water sources and water availability
Overall, national official estimates (EEAA, 2009) of total water resources in Egypt are 70 billion m3/year, as shown in the table below. The river Nile is the main source of freshwater, providing 55.5 billion m3/year, according to the Convention of the Nile Water signed with Sudan in 1959. The lake Nasser, the big artificial lake and created by the High Dam and

shared by Egypt and Sudan, is a key water reservoir, with storage capacity of about 162 billion m3. In addition, there are other 11 smaller lakes in Egypt (see also section 4.5), some of which are shallow salty lakes.

Table 4-15 Water resources in Egypt

Water Sources:	**Water available ($10^9 m^3/yr$) Year 2006/07**
Surface water (SW)	55.5
Ground water (GW) recharge	6.1
Less overlap of GW and SW	0
Desalinated Water	0.06
Wastewater reused (agriculture and sewage)	7
Rainwater	1.3
Total Actual Renewable Water	69.96

All data from EEAA, 2009

Rain water is scarce in Egypt. The climate fluctuates between severe arid, semi-arid and scarce rainfall with average 158 mm/year. Nevertheless rain water is a non negligible water source, providing between 1 and 1.3 billion m3 annually.

Groundwater is an important resource in Egypt. The estimated waste water available is about 11.6 billion m3/year (EEAA, 2010), while the extracted quantity is only about 6.1 million m3/year (EEAA, 2009). Overall reserves are large, but mostly non-renewables and situated at great depth, making extraction costs very high. About 200,000 billion m3 of non-renewable fresh water are stored in the Aquifers of the Western Desert (Nubian Sandstone Aquifers), but little amount can be utilised given the high costs of extraction. There are also some aquifers on the Eastern Desert and Red Sea coast but again, these are deep non-renewable and the possibilities of water extraction are very low. Some aquifers are also present in the Sinai Peninsula, mostly non-renewable, with a total capacity of 0.150 billion m3/year. Most of the extracted water is from the renewable aquifers of Nile River Basin and Delta (EEAA, 2009).

Other non conventional sources of water include the reuse of agricultural drainage water (about 5.7 billion m3 in 2006/07) and of treated municipal and industrial waste water (about 1.3 billion m3). There are also 21 desalination plants, with a production capacity of about 60,380 m3/day. Desalination technology did not receive significant attention until recent years, given its high costs.

Threats to water availability

Threats to water availability in Egypt are represented in particular by population increase, which will add additional pressure to the already limited water resources, and climate change. The vulnerability of Egypt's water resources to climate change entails in particular factors affecting the Nile flows (hypersensitivity to Ethiopian rain; sensitivity to temperature increase in equatorial lakes and Bahr El Ghazal, and uncertainty due to significant differences in the Global Circulation Models output of water flow into the Nile), rainfall (the possibility of a 50 per cent reduction of rainfall on Egypt's Mediterranean coast), and ground water (increased levels and salinity due to sea level rise and consequent sea water intrusion) (Cabinet of Ministries et al, 2002). Existing water losses in the Egyptian distributions system for drinking water also represent an issue, as leakages are around 30 per cent due to the old infrastructures (see also chapter 4.2), increasing water needs by the final consumers.

Water use

The estimated water withdrawal in Egypt between 2002 and 2007 is shown in the table below. Agricultural use dominates significantly (more than 85 per cent in 2006/07), with industry and municipal uses together responsible for just 7 per cent of water use. Other causes of water use are river navigation (0.2 per cent) and evaporation (2.1 per cent)

Table 4-16 Water use (Total withdrawal per annum 109 m3/yr)

	2002/03		2003/04		2004/05		2005/06		2006/07	
Water use	**%**	**Bil m3**	**%**	**Bil m3**	**%**	**Bil m3**	**%**	**Bil m3**	**%**	**Bil m3**
Agriculture	86.8	57.8	86.6	58.1	86.3	58.5	86.1	59.0	86.6	59.3
Evaporation from Nile & Canals	3.1	2.1	3.1	2.1	3.1	2.1	3.0	2.1	3.0	2.1
Drinking & sanitary usage	8.1	5.4	8.4	5.6	8.6	5.8	8.9	6.1	9.4	6.5
Industry	1.7	1.1	1.6	1.1	1.7	1.2	1.7	1.2	1.7	1.2
River navigation	0.3	0.2	0.3	0.2	0.3	0.2	0.3	0.2	0.3	0.2
Total	***100***	66.6	***100***	***67.1***	***100***	***67.8***	***100***	***68.6***	***100***	***69.3***

Source: EEAA, 2009

Water scarcity

This gives an overall water exploitation index (WEI) of 97 per cent (i.e. total freshwater abstracted as a proportion of total renewable water available), which suggests an unsustainable use of water – well above the 40 per cent WEI level indicating severe water stress. Water available per person is on average about 860 m3/ year, which is below the international water poverty line of 1,000 m3/capita.

Table 4-17 Water scarcity indices

Index	**#**	**Unit**
Water Exploitation Index	0.97	% (Percentage water use to availability)
Water Available per Capita	860	m^3/person/yr
Total Water Use per Capita	830	m^3/person/yr
Municipal Water Use per Capita	80	m^3/person/yr

Source: Estimates by the authors - *see the methodological approach in the Benefit Assessment Manual (Bassi et al, 2011)*

Key existing management initiatives

As noted above, currently recycling of some used waters is carried out with the objective of covering the deficit between Egypt's water supply and demand. By the completion of the Al Salam Canal project, an additional 3 billion m3 of water are expected to be recycled per year. Furthermore, several holiday resorts on the Red Sea, Sinai Peninsula and North West Coast are provided with desalination plants of small and moderate size. The overall desalination capacity, however, is still quite limited (see chapter 8.6.2).

Furthermore, a National Water Resources Plan was issued in 2005 (Ministry of Water Resources and irrigation, 2005). The plan envisaged a number of measures for improved water use, including (EEAA, 2010b):

- Physical improvement of the irrigation system
- More efficient and reliable water delivery
- Redesign of canal cross sections to reduce evaporation losses
- Improvement of drainage systems
- Change of cropping patterns

Additional interventions for adaptation to water scarcity were also taken into account in the Second National Communication under the UNFCCC (EEAA, 2010b). These include the development of new water resources, such as possibilities to increase the Nile flows, the use of deep underground reservoirs, rain harvesting (especially in areas exposed to flash floods), expanding desalination (especially to brackish groundwater), recycling of treated wastewater and increased use reuse of land drainage water. 'Soft interventions' are also considered, such as increasing public awareness campaign on the impact of climate change on water, development of circulation models predicting the impact of climate on local and regional water resources, increasing research and data exchange, enhancing precipitation measurement networks in upstream countries of the Nile Basin, and installing early warning systems.

4.6.3 Potential environmental improvements

Baseline in 2020

Determining a water resource 'no action' baseline for 2020 for any country is extremely difficult due to the multitude of complex factors influencing water supply and demand, requiring a detailed study of its own. There are no readily available data on projected domestic, agriculture and industry water demands. In terms of domestic use, the predicted population change for 2020 is non negligible (1.68 per cent), therefore adding additional pressure to the already scarce water resources available in Egypt.

Assuming a population increase to 97.7 million in 2020, and assuming current resources remain unchanged, the WEI could increase from 97 per cent to x and water availability per capita decrease from 860 to 720 m3/year. This however is likely an optimistic estimate, since water consumption per capita is likely to increase due to future improved living standards, while water availability is expected to decrease. Estimates provided in the National Environmental, Economic and Development Study (NEEDS) for Climate Change foresee the annual per capita share to become 350 m3 in 2040, without considering climate change impacts on Egypt's water resources (Cabinet of Ministries et al, 2002). Using this estimate and assuming a linear change between 2008 and 2040, a possible estimate of water availability in 2020 could be about 669 m3.

In terms of climate change implications, the Second National Communication to the UNFCCC (2010) warns that the Equatorial Nile has a very delicate water balance. Even a slight increase in temperature or slight decrease in precipitation forces its contribution to the main Nile flows to zero. A 15 per cent and 17 per cent increases in precipitation and 2.7°C and 4.8°C warming will cause the equatorial plateau to contribute almost no water to the

Nile flows. The Eastern Nile will continue to be the key to Nile flows under possible climate change. Other basins will also be affected by temperature changes, such as the Bahr El Ghazal Basin, which would have increased water losses rates due to increased temperature. Furthermore, sea level rise will certainly affect groundwater aquifers in the Nile Delta, in particular those close to the northern strip. Increased salinity may cause them to be unusable.

Targets

In terms of establishing targets, due to the complexity of water resource use and management and the considerable contextual variation between and within countries, it is not always that useful to recommend a specific water exploitation index target.

However, the EU does suggest that countries should, where appropriate, aim to lower their WEI towards 20-40 per cent. 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 repairing water distribution networks, drought management plans, changing to low water demanding crops, re-using water, collecting water, charging for water use (including agricultural use) and increase desalination potential.

Potential environmental improvements

The 'environmental improvements' associated with moving from the baseline to the targets described above mainly relate to increased water being available for use throughout the year and their 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.

4.6.4 Qualitative assessment of the benefits of reducing water scarcity

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:

Health benefits

Increased water availability would potentially improve the health of poor agricultural based communities, by increasing the amount of drinking water as well as the water available for crops and livestock. There could also be an improvement in health of local populations through better diets if there is an increase in fish and fishing in rivers and lakes.

Environmental benefits

If environmental flows are maintained within rivers and lakes, there will be more water available to maintain and enhance the broad range of habitats and species that depend upon there being certain water levels within wetlands, rivers and lakes. It may also help avoid issues related to increased salinity in aquifers. Improved water treatment for waste water reuse will also reduce pollution to water bodies, which is currently a significant issue for water quality (see also chapters 4.3, 4.4 and 4.5)

Economic benefits

There could be significant gains in economic productivity of agricultural output if agricultural water use and irrigation were better managed and if other sources developed, such as desalination and improved waste water treatment. This would include increased agricultural output through more efficient irrigation and reduced salinization - e.g. in the northern desert along the Delta fringes, where over-pumping of some wells causes salinization of groundwater (El-Kady and El-Shibini, 2001). In addition, there would be a reduced loss of crops and livestock during periods of drought. There may be additional development benefits from industries that require process water. Commercial fisheries could potentially be developed or enhanced. Furthermore, the development of new desalination plants could stimulate the creation of local small industries, offering new job opportunities for skilled and unskilled workers, and improve tourism services especially those in remote areas (El-Kady and El-Shibini, 2001).

Social benefits

In Egypt the population is on average below the water poverty limit of 1000 m3/year. Increased water availability will therefore arguably improve the life of many citizens, especially those in the most remote/water scarce areas.

Also, importantly, as Egypt depends on water resources which are shared with other countries, improved water availability can potentially improve the relations with neighbours and avoid international tensions (e.g. related to water scarcity caused by other countries filling dams etc.).
Furthermore the environmental integrity of rivers and wetland habitats are maintained, and they do not run dry, they can enhance the quality of life of those people living nearby. This can arise through recreational use of the water bodies. In addition, there may be some cultural and spiritual benefits (non-use benefits) to some people from maintaining nearby water bodies. There will also be significant benefits relating to improving the environment

for tourism, especially along the Red Sea coast, the northwest coast and the Sinai coastal zone.

4.6.5 Quantitative assessment of the benefits of reducing water scarcity

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. Little directly relevant quantitative data was readily available for Egypt.

4.6.6 Monetary assessment of the benefits of reducing water scarcity

This study has not attempted to assess the 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. No relevant Egypt water scarcity valuation studies were identified.

Given the significance of water scarcity and water resource management in Egypt, it is recommended that the economic and social benefits of water resource management are further assessed in future research..

5 BENEFITS OF IMPROVING WASTE RELATED CONDITIONS

5.1 Introduction to waste related issues

This section will cover the following aspects of waste management:

- (Municipal) Waste collection coverage
- Illegal /uncontrolled dumping of waste
- Methane emissions

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.

Waste management is a major issue in Egypt, particularly in urban areas. Egypt generates about 20 million tonnes of municipal solid waste per year. Waste generation increased by more than 36 per cent since 2000 (SWEEP-Net, 2010). Of this, only 64 per cent is collected, while the remainder accumulates on city streets and at illegal dumping sites.

Waste management is undertaken by local Egyptian companies and foreign multinationals (in Alexandria and Cairo), and a parallel informal system of collection and sorting also developed (the so-called 'zabbaleen' or waste-collectors).

Only about 2.5 per cent of the waste collected is recycled, 9 per cent is composted and 5 per cent is landfilled in sanitary landfill sites, while the rest (83.5 per cent) is deposited in open dumps. Incineration is undertaken primarily for clinical waste (SWEEP-Net, 2010). Although the National Waste Management Strategy set several waste treatment targets by 2005 (including 20 per cent recycling of generated waste, 50 per cent composting of organic waste, 80 per cent of disposal to occur in landfills as opposed to dumpsites), none of these has been met yet (CID, 2008).

Methane emissions from landfills are not captured. According to Egypt's Second National Communication under the UNFCCC (EEAA, 2010b), in 2000 the contribution of the solid waste disposal sector to GHG emission was about 11,694 million tonnes of CO2 equivalent. These were mostly methane emissions, which are currently not captured in any of the Egyptian landfills.

The benefits of a sound waste management system expand beyond keeping the day-to-day living environment in the cities clean and tidy. Waste management generates benefits in terms of improved hygiene through the reduction of wild tipping or burning of waste in cities and rural areas. It helps protecting surface and ground water, reduces air pollution, improves the quality of landscape, decreases CO2 emissions responsible for climate change, and contributes to lowering resource depletion, can be a source of energy production and can increase the availability of secondary raw materials from the recycling industry. A sound waste management system can also provide social benefits through job creation in the waste sector. Our assessment indicates that, given an expected doubling of the amount of municipal solid waste generated by 2020, improvements in the waste collection, treatment and recycling systems will prevent about 16 million tonnes of waste to be illegally dumped every year.

5.2 Benefits from improving the waste collection coverage

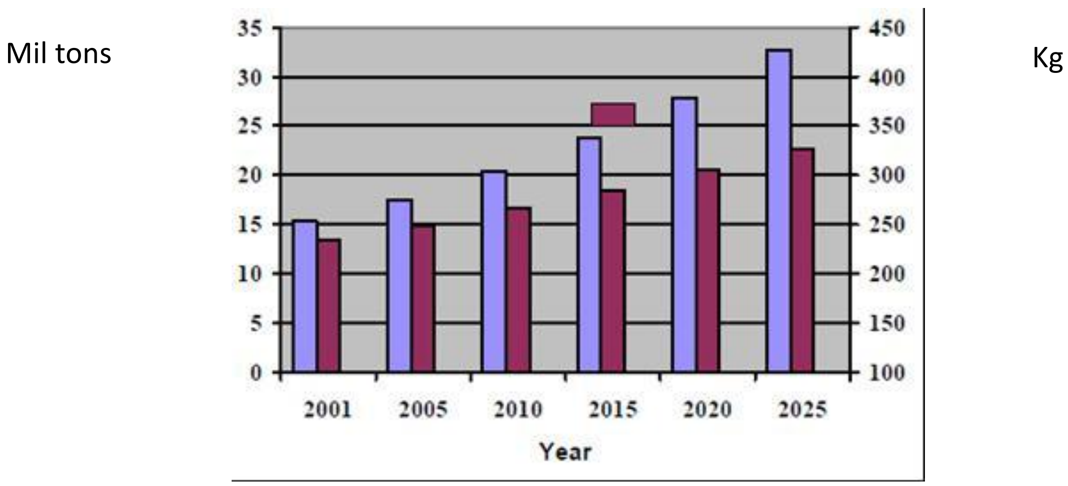
5.2.1 Introduction to the issue and the approach taken

Benefits from enhanced collection of municipal solid waste are calculated by comparing the 2020 situation in case of business-as-usual with the future situation in which a higher level of collection coverage would be reached. As a target we assume 100 per cent collection coverage in 2030. Although the study uses, as a target point of reference, the year 2020, for waste a later target period has been applied, given the relatively longer timeframe required to set up appropriate waste management infrastructures. The benefits are, however, assessed in the year 2020 for comparability with other sections of the report. In the year 2020 collection coverage is assumed to be augmented in such a way that the 2030 target can be reached. Increased collection coverage leads to avoided environmental impact from non collected waste, or to a decrease of dumped waste in non-controlled or illegal dumpsites. Socio-economic benefits are calculated in terms of increased employment and in an improved service - whose value is assessed applying willingness-to-pay figures to the supplementary served population.

5.2.2 Current state of the waste collection system

Egypt counts about 81.5 million inhabitants, and the total municipal solid waste (MSW) generation is about 20 million tonnes/year. The average waste generation is thus 245.3 kg per capita per year. Waste generation has increased more than 36 per cent since 2000 (SWEEP-Net, 2010). The figure below shows the projected waste generation 2001 – 2025, as given in METAP's Egypt's Country Report (2004).

Figure 5-1 Projected MSW generated 2001-2025



Key: Violet: Total waste generation (million tonnes/year
Red: per capita waste generation (kg/person/year)
Source: adapted from METAP, 2004

Although the Egyptian government commenced several initiatives to develop the waste management sector since 2000, such efforts resulted in little improvement (SWEEP-Net, 2010). Only 64 per cent of the waste generated is collected (SWEEP-Net, 2010), i.e. about 13 million tonnes. The remainder accumulates on city streets and at illegal dumping sites. By multiplying the total number inhabitants non-covered by collection with the average municipal waste generation per inhabitant, we can assess the total amount of municipal waste which is dumped or incinerated in a non controlled way, which is about 7.2 million ton/year in Egypt (SWEEP-Net, 2010).

The governorates, municipalities, or waste related authorities in large cities such as Cairo and Giza, are responsible for handling the implementation and operation of the system directly or through contracted international companies (e.g. in Cairo), local private companies, NGOs and informal sector 'zabbaleen' (garbage collectors). (SWEEP-Net, 2010)

Overall, the management waste remains, for the most part, both inefficient and inadequate. This is causing serious environmental and public health problems (SWEEP-Net, 2010).

The most important reasons leading to municipal solid waste problems, according to the Egyptian government, include the absence of integrated sustainable systems for municipal solid wastes management, low environmental awareness and severe deficiency in enforcing legislations related to solid wastes (EEAA, 2009).

5.2.3 Potential environmental improvements

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. To this purposed, Egyptian population growth is assessed at a yearly increase of 1.88 per cent, while GDP growth is assessed at a yearly increase of 4.90 per cent.

It is therefore estimated that the total municipal waste produced in 2020 will be about 44.4 tonnes per year, i.e. more than the double than today's levels. Assuming that the rate of waste collection will not change (i.e. remain at 64 per cent), it is estimated that in 2020 about 16 million tonnes of waste per year will be dumped or burned in a non controlled way,

It is also reasonable to assume a shift in the composition of the generated municipal waste between now and 2030, in line with shifts in lifestyle. The assumption is made that the future municipal waste composition will align with the composition of some EU Member States. Bulgaria is taken as a model. We can assume a shift in the composition of the generated municipal waste between now and the target year 2030 in line with shifts in lifestyle. The future generation of different waste fractions, for the intermediary year 2020 on which we evaluate the benefits, is shown in the table below.

Table 5-1 Municipal solid waste composition – actual (2008) and future (2020)

Municipla solid waste composition	Actual composition 2008 (%)	Actual composition 2008 (M ton/year)	Future composition 2020 (%)	Future composition 2020 (M ton/year)
Organic waste	53,0	10.6	47.9	21.3
Plastics	6,0	1.2	9.1	4.1
Paper/cardboard	15,0	3.0	15.5	6.9
Textiles	4,1	0.8	4.0	1.8
Metals	4,3	0.8	4.6	2.1
Glass	3,0	0.6	5.5	2.4
other	15,0	3.0	11.4	5.0
total	100	20.0	100	44.4

Source: Estimates by the authors - *see the methodological approach in the Benefit Assessment Manual (Bassi et al, 2011)*

The target used to assess the potential environmental improvements is full waste collection coverage of the total population, rural and urban, in 2030. Increased collection leads to less waste sent to wild dumpsites or wild burning, and thus a reduced negative impact on the environment and human health. In order to achieve a 100 per cent target by 2030, an average yearly increase of 2.05 per cent in waste collection has been assumed.

The target horizon is longer than for other parameters assessed in this report (e.g. water, air etc.) given that developing a full functioning infrastructure for was will arguably require more than a decade. Nevertheless, for ease of comparison the benefits have been assessed on the progresses made in 2020, by when it is expected that 80 per cent collection coverage will be reached.

The environmental improvement of reaching the collection targets is based on the amount of waste for which non controlled disposal is avoided. It is the difference between the total amount of dumped waste in the business-as-usual scenario in 2020 and the total amount of dumped waste in the collection-coverage-target compliant scenario in 2020. We are assuming that according to the target-compliant-scenario collection will evolve towards 100 per cent coverage of all waste generated in 2030. The improvement in 2020 will therefore be of 7.8 million tonnes of additional waste collected.

5.2.4 Qualitative assessment of the benefits of improving waste collection

Environmental benefits

The reduction of waste illegally dumped/ not collected will improve the landscape and reduce risk of pollution /contamination, in particular of waterways and drains, which are currently contaminated by the improper disposal of solid waste. Solid waste management projects, including increased recycling (see chapter 5.3), can also help reducing methane emissions from landfills and from illegally dumped waste.

Health benefits

Health benefits can emerge from avoided pollution of soil, ground water and air by wild dumping or burning of waste. The lack of efficient waste collection in fact is causing serious problems in Egypt. The improper disposal of solid waste in waterways and drains has lead to the contamination of water supplies which hinders health and welfare of its people (SWEEP-Net, 2010). Illegal dumps can also attract rodents, which can be vectors for diseases, and have been exposed to arson, leading to pollutant emissions. Furthermore, given the active informal collection sector in Egypt (e.g. scavengers and the Zabbaleen in Cairo) there are cases of contamination and illness due to the unsafe handling of waste material. All these negative effects could be reduced if waste collection was improved.

Social benefits

Improved waste collection can improve the life conditions in cities and rural area, especially those of the poor. An improved environment in the cities can increase sense of community, can be an opportunity to generate jobs locally, and increase the amenity value for locals and visitors. Also, there will be benefits related to the improved sight and odour pollution. Should the informal sector be involved in the future restructuring of the waste management system, better working conditions could be offered to the zabbaleen and scavengers.

Economic benefits

Improving waste collection can help establishing cost recovery mechanisms and generate local employment, stimulate the development of waste technologies, and integrating the informal system into the privatisation of the solid waste sector. A cleaner environment can also stimulate tourism and recreation activities, which can bring additional revenues to cities and coastal areas.

5.2.5 Quantitative assessment of the benefits of improving waste collection

Environmental benefits

The quantitative assessment of environmental benefits focuses on the benefits of reducing the size of land polluted by uncollected waste/dumpsites, thanks to the expansion of the collection coverage (the benefits of improved treatment are discussed in chapter 5.3).
The following assumptions are used:

- Average dumpsite depth of 1 meter
- Average density of dumped waste of 340 kg/m³
- Reduction in volume through uncontrolled fires at the dumpsites with 2/3

The total size of uncontrolled dumpsites avoided by expanding the collection coverage to 100 per cent in 2030 was calculated as follow:
Total non collected municipal waste generated until 2020 (kg) * 1/3 * 1/340 = 7.8 million tonnes * 1/3 * 1/340 = 7,678,698 m² polluted land avoided

Economic benefits

A rough assessment of economic benefits can be done by estimating the impact on job creation of an expanded waste collection system. Based on data for Mascara , the collection efficiency on a waste loader is 90 kg/h. This figure is based upon daily collection, using small recipients and using a modern small compacting truck. For collection in rural areas, not yet covered by collection until now, we could assume a lesser number of loaders, a collection frequency closer to once a week in stead of daily, as a consequence larger volumes per individual collection. This all will lead to higher efficiency. We use a collection efficiency of 900 kg/h, in line with the collection efficiency in Bulgaria . The annual wage is estimated at EUR 11,614 per year.

income per capita	population	total labour force	average wage
GNI per capita, PPP (current international $), 2008 ~ recalculated in euro Source: World Bank 2010. World Development Indicators.	*2008 Source: World Bank 2010. World Development Indicators.*	*2008 Source: World Bank 2010. World Development Indicators.*	*estimate, PPP in euro*
3.749	81.527.172	26.315.732	**11.614**

An average working day for waste collection counts 7 hours, and a work year includes 220 days.
To supplementary collect 7.8 million tons of municipal waste, at the actual efficiency, jobs can be created for 5,651 work years or salaries for a total amount of EUR 65,630,714, plus some supplementary jobs for management and support. More adequate techniques, like bring-in systems and weekly collections can influence the job creation.

5.2.6 Monetary assessment of the benefits of improving waste collection

We assume that any household not receiving waste collection services will be willing to pay 1 per cent of their income for waste management

The monetary value of extended waste collection coverage can thus be calculated using the willingness-to-pay (WTP) value for waste collection:

- The average income of the people supplementary served with waste collection and treatment is assessed at EUR 3,749/year. This is the national average, and may be an exaggeration as most people supplementary served will be rural people with lower average incomes. However this exaggeration can be compensated by applying the average income of 2008 on the year 2020 without taking into account increasing GDP.
- 16 per cent of the total population in 2020 will be supplementary served with municipal waste collection as the collection coverage will have been increased from 64 per cent to 80 per cent. This is translated in 101,945,865 * 16% = 16,311,338 inhabitants supplementary served.
- This population represents an income of 16,311,338 * 3,749 € = € 61,151,206,162
- Willingness to pay would be € 611,512,061 .

5.3 Benefits from improving waste treatment

5.3.1 Introduction to the issue and the approach taken

The primary target used for this part of the assessment is to avoid non-controlled waste dumping and to replace it by sanitary landfills. Supplementary targets have been defined, based on the European Union targets for recycling of specific waste fractions, and for landfill diversion of biodegradable waste. The recycling targets were applied to the estimated amount of waste generated in 2030. The landfill diversion target, to be reached in 2030, was based on a percentage of biodegradable waste generated in 2010.

The target year is set at 2030, because of the ambitious character of these targets. We calculate to which degree these targets will be approached in 2020. The environmental benefit consists of avoided (illegal) dumping and increased recycling or composting of waste. This leads to societal benefits in terms of environmental and health impact reduction, resource savings and job creation.

5.3.2 Current state of waste disposal and treatment

Although the National Waste Management Strategy set several waste treatment targets by 2005 (including 20 per cent recycling of generated waste, 50 per cent composting of organic waste, 80 per cent of disposal to occur in landfills as opposed to dumpsites), none of these has been met yet (CID, 2008).

Collection and treatment is undertaken by both local Egyptian companies and foreign multinationals (in Alexandria and Cairo). There is also a lively informal sector (e.g. the Zabbaleen) which recovers, trades, processes and re-manufacture plastic, scrap metal, paper, cardboard and bones. Waste collectors sort and recycle around 80-85 per cent of the waste they collect, making a living from recovering, recycling and trading recyclable materials (CID, 2008).

Overall, in Egypt only about 2.5 per cent of the waste collected is recycled, 9 per cent is composted and 5 per cent is landfilled in sanitary landfill sites, while the rest (83.5 per cent) is deposited in open dumps (SWEEP-Net, 2010). Different estimates, however, are available on the actual amount of waste recycled, due to the lack of robust official figures and the difficulty to assess the amount of waste managed by the informal sector. A study by CWG and GIZ, (2011) estimated that about 433,200 tonnes are recycled by the formal sector (a figure comparable to the SWEEP-Net estimates), but that additional 979,400 tonnes are also recycled by the informal sector.

For the purpose of this report, and for comparability with other ENPI-MENA reports, we will refer to the SWEEP-Net figures only, but it should be noted that these can be seen as a lower bound estimates, and higher current level of recycling are possible thanks to the informal sector. A future integration of the formal and informal sector would allow having more certain data on total recycling rates in Egypt.

Recycling in Egypt is not undertaken safely and soundly which exposes citizens and workers to several health risks. It is noteworthy that most landfills, where final disposal of such wastes takes place are exposed to intentionally or self burn, which exposes ambient environment to risks and worsen their conditions , in addition that necessary equipment are not available in these sites for wastes’ coverage to prevent such burning (EEAA, 2009).

5.3.3 Potential environmental improvements

The baseline scenario describes what will happen if the average waste generation (all categories) grows in line with GDP and if total waste generation grows in line with demography, as described above, and if the actual waste treatment options remain unchanged. For simplicity, we assume that all collected waste (100 per cent) is dumped in uncontrolled dumpsites.

Table 5-2 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	20.000.000	64	12.800.000	7.200.000	10.688.000	640.000	0	320.000	1.152.000
2009	21.374.424	64	13.679.631	7.694.793	11.422.492	683.982	0	341.991	1.231.167
2010	22.843.300	64	14.619.712	8.223.588	12.207.460	730.986	0	365.493	1.315.774
2011	24.413.119	64	15.624.396	8.788.723	13.046.371	781.220	0	390.610	1.406.196
2012	26.090.818	64	16.698.123	9.392.694	13.942.933	834.906	0	417.453	1.502.831
2013	27.883.810	64	17.845.639	10.038.172	14.901.108	892.282	0	446.141	1.606.107
2014	29.800.019	64	19.072.012	10.728.007	15.925.130	953.601	0	476.800	1.716.481
2015	31.847.912	64	20.382.664	11.465.248	17.019.524	1.019.133	0	509.567	1.834.440
2016	34.036.539	64	21.783.385	12.253.154	18.189.126	1.089.169	0	544.585	1.960.505
2017	36.375.571	64	23.280.365	13.095.205	19.439.105	1.164.018	0	582.009	2.095.233
2018	38.875.344	64	24.880.220	13.995.124	20.774.984	1.244.011	0	622.005	2.239.220
2019	41.546.904	64	26.590.018	14.956.885	22.202.665	1.329.501	0	664.750	2.393.102
2020	44.402.057	64	28.417.316	15.984.741	23.728.459	1.420.866	0	710.433	2.557.558

Source: Estimates by the authors - *see the methodological approach in the Benefit Assessment Manual (Bassi et al, 2011)*

Waste prevention policy is only recently introduced at EU level and in most of its Member States. No quantitative results on this policy can yet be observed on quantities of waste generated. We propose not to take waste prevention effects already in account for the ENPI countries. The target for waste generation is therefore equal to the baseline. For this reason benefits like reduction of resource depletion will not be tackled directly but within the frame of recycling.

- 100 per cent reduction in illegal dumping / disposal to landfills with no environmental control
- 50 per cent recycling of all generated glass, paper, plastic, metals in municipal waste
- 70 per cent recycling of construction and demolition waste
- 65 per cent of the quantity of biodegradable waste generated in 2010 diverted from landfills

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

By 2030:

- 100 per cent collection coverage (i.e. 2.05 per cent increase annually to bridge the gap from current 64 per cent coverage)
- Minimum quantity of waste recycled: 18.56 million tonnes, of which:
    - 50 per cent recycling of glass (assuming 7.78 million ton of glass generated in 2030, 3.88 will be recycled)
    - 50 per cent recycling of plastic (assuming 11.22 million ton of plastic generated in 2030, 5.61 will be recycled)
    - 50 per cent recycling of paper (assuming 13.81 million ton of paper generated in 2030, 6.90 will be recycled)
    - 50 per cent recycling of metal (assuming 4.32 million ton of metal generated in 2030, 2.16 will be recycled)

- o 70 per cent recycling of construction and demolition waste (data not available)
- Furthermore, 65 per cent landfill diversion of biodegradable waste – to be used for composting (assuming 18.62 million ton of organic waste generated in 2030, 12.10 will be diverted from landfills and composted). This will lead to a maximum amount of waste allowed in landfills of 74.20 tonnes

Overall, if the targets are reached, in 2030 69 per cent of the generated waste would be landfilled, 22 per cent would be recycled and 9 per cent would be composted.

The environmental improvements are represented by:

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

A scenario is developed in which the targets are reached in 2030, and in which the appropriate distance to target has been bridged in 2020. Assuming a linear progression to these targets, in 2020 following waste treatment progresses are expected to be reached:

- 39.9 per cent of collected waste disposed in controlled landfills
- 0 per cent incinerated
- 13.1 per cent recycled
- 9 per cent composted
- 38.0 per cent still dumped in uncontrolled dumpsites

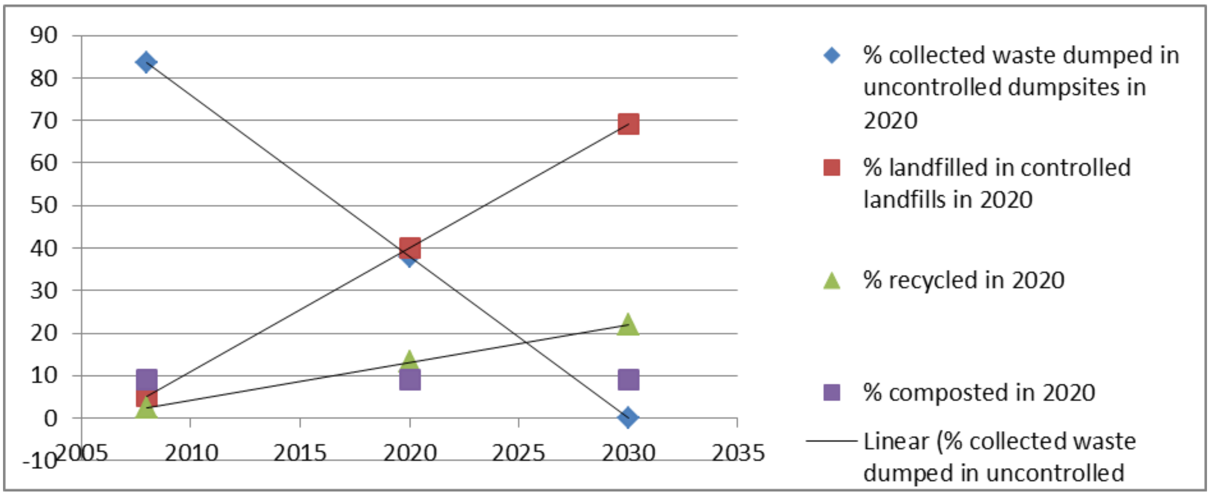
The 'calculated values' below represent the total amount of waste that is landfilled, incinerated, recycled and composted in 2030. No waste will be dumped in uncontrolled dumpsites and all waste will be collected. These values are compared with the target values for recycling and landfill diversion. If the calculated value is equal or higher than the target values we can state that the targets have been reached or surpassed when a certain percentage of the generated waste is landfilled, incinerated, recycled or composted. Within the proposed division composting remains at the actual level of 9 per cent, but will of course augment in absolute values with the increasing amount of waste being generated.

Table 5-3: 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					
69	% landfilled in controlled landfills in 2030	59.552.010	74.203.279	(max)	-14.651.269	target reached
0	% incinerated in 2030	0				
22	% recycled in 2030	18.987.597	18.556.061	(min)	-431.536	target reached
9	% composted in 2030	7.767.653				

Source: Estimates by the authors - *see the methodological approach in the Benefit Assessment Manual (Bassi et al, 2011)*

Figure 5-2: Evolution of waste treatment options in order to reach targets



Source: Estimates by the authors - *see the methodological approach in the Benefit Assessment Manual (Bassi et al, 2011)*

Table 5-4 Environmental improvements in 2020

the amount of waste not being dumped in uncontrolled dumpsites			
	amount dumped in the baseline scenario :	39.713.200	tonnes
	amount dumped in the target compliant scenario	20.924.532	tonnes
	difference = environmental benefit	18.788.668	tonnes
the amount of waste supplementary composted or recycled			
	amount in the baseline scenario :	3.267.991	tonnes
	amount in the target compliant scenario	7.357.579	tonnes
	difference = environmental benefit	4.089.588	tonnes

Source: Estimates by the authors - *see the methodological approach in the Benefit Assessment Manual (Bassi et al, 2011)*

5.3.4 Qualitative assessment of the benefits of improving waste treatment

Environmental benefits

Environmental benefits related to improved waste treatment are closely related to those for waste collection, and consist in particular in improved landscape, avoided pollution to water resources and soil and reduced air emissions (see chapter 5.1). The recycling of waste materials, like plastic and aluminium, can also avoid thee extraction and/or production of new goods, hence reducing the overall emission from production processes.

Health benefits

Health benefits are also related to the benefits from improved waste collection, and include reduced illness cases thanks to avoided pollution of soil, ground water and air by substandard treatment (see also chapter 5.1). Also, currently workers from the informal sector dealing with recycling are subjected to work-related and injuries, and usually do not have access to health care or hygienic facilities (CWG and GIZ, 2011). Improving and formalising the recycling process can therefore lead to significant health benefits for the workers.

Social benefits

Improving waste treatment will improve quality of life in cities and rural areas by reducing the amount of waste dumped or landfilled. Formalising the informal recycling sector can help improving working conditions and guarantee regular wages. It can positively affect in particular employment opportunities and conditions for women, who represent a high proportion of the informal sector (CWG and GIZ, 2010). Other benefits are also strictly related to improved waste collection (see chapter 5.1)

Economic benefits

Improving the waste collection system can generate significant job opportunities in the waste sector, potentially integrating also the workers of the informal waste sector. The recovery of waste material through increased recycling allows to avoid disposal costs. Furthermore, by reducing the extraction of raw materials and returning secondary raw materials to the production cycle, recycling can reduce production costs and energy use. The amount of these benefits will depend on the equipment used for recovery and the materials which are recovered (CWG and GIZ, 2010). In addition, a further involvement of the informal sector in reaching the recycling targets has the potential to increase the revenues of the workers (mostly poor) involved in these operations, and also to reduce the total solid waste system costs. For instance in Cairo the door-to-door recycling carried out by the informal sector is estimated to avoid collection costs of about EUR 12 million (CWG and GIZ, 2010). This could likely be higher if recycling was increased and the informal sector integrated in the waste management system.

5.3.5 Quantitative assessment of the benefits of improving waste treatment

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. An estimate for Egypt indicates that 7 jobs could be created for every tonne of

waste recycled by SMEs (CWG and GIZ, 2011), although this could be a high estimate/suitable to specific areas only.

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

Table 5-5 Assessment of job creation in 2020 when evolving towards target values 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 :	1.420.866
	amount landfilled in the target compliant scenario :	13.264.793
	supplementary yearly capacity	11.843.927
	supplementary jobs	2843
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	710.433
	amount recycled in the target compliant scenario	4.366.202
	supplementary yearly capacity	3.655.769
	supplementary jobs	877
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	0
	supplementary yearly capacity	0
	supplementary jobs	0
average number of employees to yearly compost 20.000 tonnes		5
	amount composted in the baseline scenario	2.557.558
	amount composted in the target compliant scenario	2.991.377
	supplementary yearly capacity	433.819
	supplementary jobs	108
Job balance		
	supplementary jobs	3828

Source: Estimates by the authors - *see the methodological approach in the Benefit Assessment Manual (Bassi et al, 2011)*

It is therefore estimated that about 2,843 new jobs would be generate from additional landfilling in sanitary plants, 877 jobs from increased recycling and 108 from increased composting.

5.4 Benefits from reducing methane emissions from waste

5.4.1 Introduction to the issue and the approach taken

Methane emissions from landfills can be split up over released and captured. Captured landfill gas can be measured or the capacity of the capture installations can be assessed. Released landfill gas has to be assessed from the quantity of waste being landfilled, using general calculation rules. In Egypt, no CO_2 equivalent is reported to be captured in operational landfills.

When biodegradable waste is landfilled or dumped, anaerobic conditions may be generated in which it starts to decompose by bacterial activity, generating among other methane and CO_2 emissions. These greenhouse gasses contribute to the global warming. Socio-economic benefits are to be found in reduced global warming, reduced environmental and nuisance impact and use of the landfill gas as an energy resource.

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, illegally dumped or not collected. In the target scenario we supplementary assume that 20 per cent of all landfills are equipped with landfill gas collection systems. The difference between the baseline and target scenarios reveals the amount of landfill gas emissions that can be avoided up to 2020. The socio-economic benefits are expressed in the marked values of avoided CO_2 equivalent emissions.

5.4.2 Current level of methane emission from waste

According to Egypt's Second National Communication under the UNFCCC (EEAA, 2010b), in 2000 the contribution of the solid waste disposal sector to GHG emission was about 11,694 million tonnes of CO_2 equivalent. These were mostly methane (CH_4) emissions. The recovery of CH_4 was considered to be zero. Incineration is undertaken primarily for clinical waste. Total emission from incineration in 2000 were estimated to e very small, about 0.0032 Million tonnes of CO_2 equivalent.

Since waste generation has increased considerably since 2000 (see chapter 5.1), it is reasonable to consider that CH_4 emissions from waste have increased proportionally.

5.4.3 Potential environmental improvements

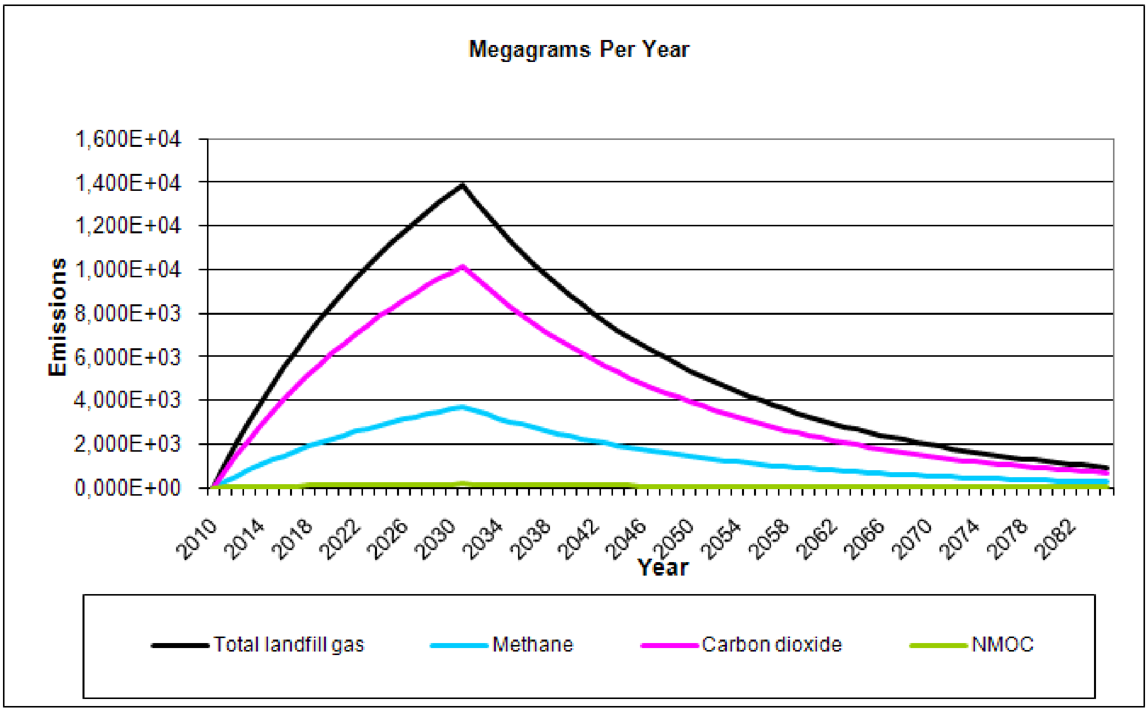
The baseline scenario for waste collection and for waste treatment (landfilling) is used.
The sum is made of all waste that, according to this baseline scenario is either:

- Not collected and presumed illegally dumped, buried or combusted
- Collected and dumped in non-controlled dumpsites
- Collected and landfilled in controlled landfills

The amount of waste treated in these three ways is summed up.

The model of the EPA (United States Environmental Protection Agency) LANDGEM is used to assess the total emissions of landfill gas and of methane from a standardised landfill of 1,000,000 tonnes with a yearly input of 50,000 tonnes and a lifetime of 20 years. This can be a proxy for overall landfill emissions.

Figure 5-3 Methane emissions - projections



Source: Estimates by the authors - *see the methodological approach in the Benefit Assessment Manual (Bassi et al, 2011)*

Total methane emissions are assessed at 170,164,940 m^3 of methane emissions over the whole lifespan of the landfill plus its after-phase. This can be translated in a ratio of 170 m^3/tonne landfilled MSW.

The same ratio is used for dumpsites, although the methano-genesic processes may be different due to different environment conditions and the effect of frequent fire incidents.

The methane generation in the baseline scenario are derived from the amounts of waste being not collected / dumped / landfilled. From this quantity the already collected methane is subtracted, the remainder is the figure for methane emissions through waste disposal.

Table 5-6 Methane emissions in the baseline scenario in m^3

total amount not collected municipal waste in 2020 in the baseline :	15.984.741	tonnes
total amount collected municipal waste in 2020 dumped in the baseline :	23.728.459	tonnes
total amount collected municipal waste in 2020 landfilled in the baseline :	1.420.866	tonnes
sum	41.134.066	tonnes
methane genesis	170	m^3/tonne
methane generation for waste disposed of in 2020 :	6.992.791.144	m^3
methane capture in 2020 :	0	m^3
methane emissions for waste disposed in 2030 :	6.992.791.144	m^3

Source: Estimates by the authors - *see the methodological approach in the Benefit Assessment Manual (Bassi et al, 2011)*

The target scenario assumes that in the year 2020 20 per cent of all landfills are equipped with landfill gas capture installations, except if the actual capture is already higher.

The methane generation in the target compliant scenario are derived from the amounts of waste being not collected / dumped / landfilled. From this quantity the already collected methane is subtracted, the remainder is the figure for methane emissions through waste disposal (see above)

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

Table 5-7 Methane emissions in the target compliant scenario in 2020

total amount not collected municipal waste in 2020 in the baseline :	15.984.741	tonnes
total amount collected municipal waste in 2020 dumped in the baseline :	16.852.599	tonnes
total amount collected municipal waste in 2020 landfilled in the baseline :	17.720.457	tonnes
sum	50.557.797	tonnes
methane genesis	170	m³/tonne
methane generation for waste disposed of in 2030 :	8.594.825.432	m³
18,6% methane capture in 2030 :	1.602.034.288	m³
methane emissions for waste disposed in 2030 :	6.992.791.144	m³

Source: Estimates by the authors - *see the methodological approach in the Benefit Assessment Manual (Bassi et al, 2011)*

In this scenario there is no additional methane emission.
Methane available as an energy resource: 1,602,034,288 m³

5.4.4 Qualitative assessment of the benefits of reducing methane emissions from waste

Environmental benefits

Environmental benefits will be mostly related to reduced climate change impacts (see ‘Climate change’ theme related benefits). Further local benefits are possible.

Health benefits

Health benefits will be mostly related to reduced climate change impacts (see ‘Climate change’ theme related benefits). Further local benefits are possible (e.g. increased level of health and safety in waste treatment plants etc.).

Social benefits

Local improvements related to reduced climate change impacts (see ‘Climate change’ theme related benefits) and improved waste treatment plants (e.g. reduced odours etc.).

Economic benefits

Beside reduced damages due to climate change impacts (see 'Climate change' theme related benefits), economic benefits will also be related to the use of the captured methane as for energy production.

5.4.5 Quantitative and monetary assessment of the benefits of reducing methane emissions from waste

The social and economic benefits are linked with the value of avoided CO2 eq. emissions and the effect of global warming. The carbon values used is this study range between 39 EUR/t to 56 EUR/t for 2020. Methane has a global warming potential (GWP) of 25 for 100 years , which means that one kg methane has the same global warming effect of 25 kg CO2. The density of methane is 0.68 kg/m^3.

An avoided methane emission of 2,343,042,960 m^3 corresponds thus to a benefit between EUR 1,553,437,483 and EUR 2,230,576,898.

6 BENEFITS OF IMPROVING NATURE RELATED CONDITIONS

6.1 Introduction to nature protection issues

This section will cover the following aspects of nature:

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

About 92 per cent of Egypt's terrestrial areas are desert. However, due to its very varied eco-zones, the country is a home to a wide range of habitat diversity, both terrestrial (deserts, dunes and freshwater channels) and marine (coral reefs and mangrove areas). These habitats are home to a diversity of wildlife. The Egyptian ecosystems are threatened by various sources, such as low precipitation, salt water intrusion and soil salinization (especially in the Mediterranean coastal areas), population pressures (including unplanned urbanization and pollution derived by domestic, agricultural and industrial activities), hunting, overgrazing, overcutting and soil erosion (EEAA, 2010b).

About 7.7 per cent of the terrestrial environment and 9.91 per cent of the marine areas are protected. Management plans are gradually being drafted but there is an enforcement issue due to a shortage of human resources and infrastructures.

About 70,000 ha are forested, i.e. approximately 0.07 per cent of the Egyptian territory (FAO, 2011a). Deforestation is currently not an issue in Egypt. Between 1990 and 2010 the forest cover increased by 59.1 per cent. However, all the forested area is planted forest, using the primary treated waste water. There are no natural forests and the native forest tree species are limited in number. Mangrove forests located at the southern part of the Red Sea Coast are particularly important in Egypt. Their total area has increased from 525 ha in 2002 to 700 hectare at the end of 2007 (EEAA, 2008; EEAA, 2009).

About 38 per cent of the land area in Egypt suffers from human induced degradation (FAO, 2000). Poor soil quality leads in turn to reduced crop yields and soil erosion.

6.2 Benefits from improving biodiversity protection

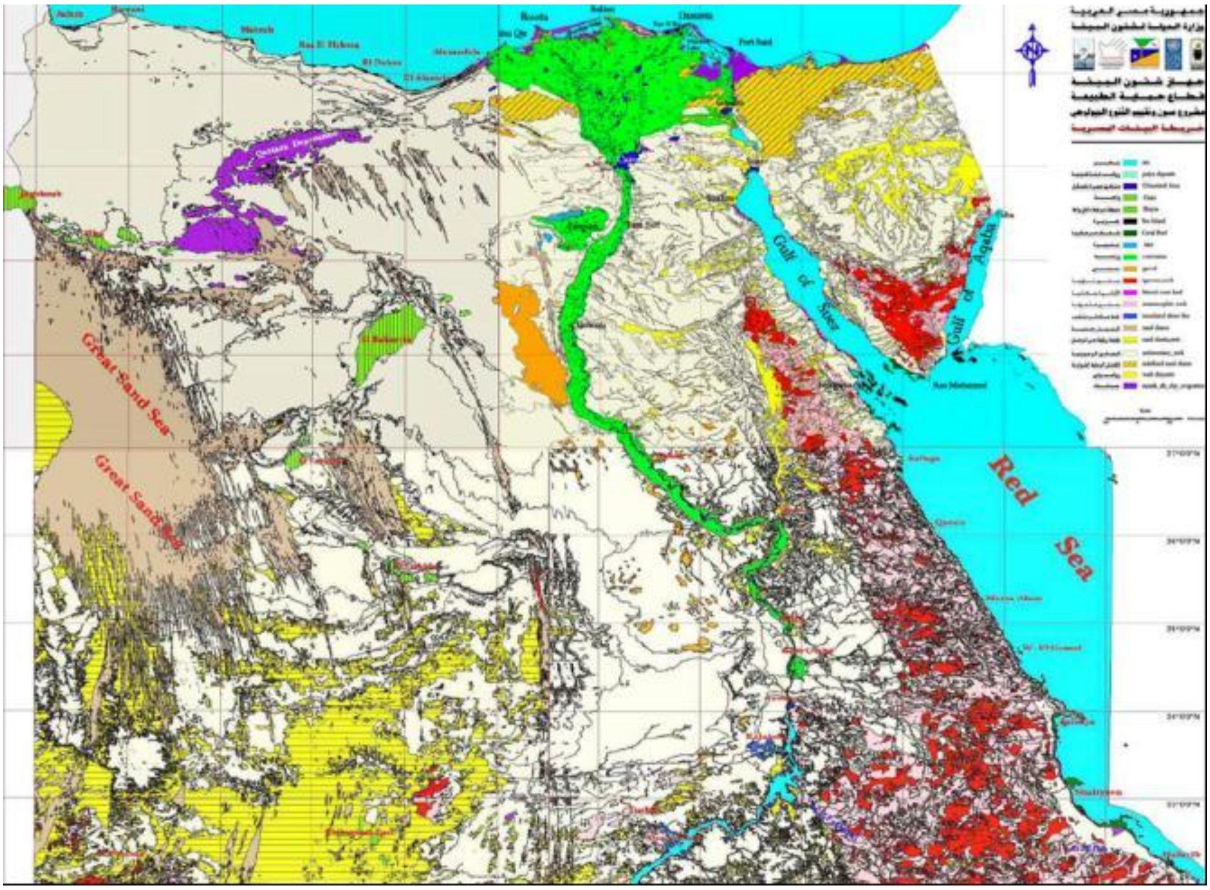
6.2.1 Current state of biodiversity

Egypt covers an area of about one million km2 and can be divided into four physiographic regions: the Nile Valley, Western Desert, Eastern Desert and Sinai. The arid desert covers 92 per cent of the land, the remaining 8 per cent of arable land being restricted to the Nile Valley, the Nile Delta, the Faiyum depression and a few oases scattered in the Western Desert. Most of the population (97 per cent) lives on less than 4 per cent of the land (EEAA, 2010b).

The country can be also divided into 4 bioclimatic zones: the Eastern Desert which is hyper-arid with mild winters, hot summers and extremely rare rainfall; the Southern Sinai region which is also hyper-arid but has cool winters, hot summers, and less than 30mm/year of rainfall; the coastal belt along the Mediterranean Sea; and the sub-coastal belt and the wetlands (Nile Valley and Nile Delta; EEAA, 2009b).

The Egyptian habitats map (EEAA, 2009b) subdivides the territory into 22 main groups, which include: urban areas, islands, oasis's, dunes, metamorphic and sedimentary rocks, open water, fresh water channels, warm springs, coral reefs, deserts, mangrove trees and others (see figure below).

Figure 6-1 Habitat distribution in Egypt



Source: SOER 2007-2008

Habitats

Wetlands are some of Egypt’s most important habitats in terms of biodiversity (second to the Red Sea’s coral reefs), supporting both the greatest diversity and density of bird species. Most Egyptian wetlands have been degraded drastically during the past 50 years: drained, polluted, over-fished and over-hunted. There are six major inland wetland areas in Egypt: the Bitter Lakes, Wadi El Natrun, Lake Qarun, Wadi El Rayan Lakes, Nile River and Lake Nasser. In addition, there are many smaller wetlands dispersed in the Nile delta, Nile valley, and   in the oases of the Western Desert. Of the Mediterranean coastal wetlands, the most important are the six major coastal lagoons on the Mediterranean: Bardawil, Malaha, Manzala, Burullus, Idku and Maryut. The Red Sea coastal habitats and wetlands include mudflats, reefs, mangroves and marine islands. (Baha el Din, undated)

Desert habitats cover over 92 per cent of Egypt's territory. The Mediterranean coastal desert receives the highest rainfall in the country with maximum intensity during the winter, Rainfall does not exceeds 170mm annually, and is the key water source supporting the natural plant cover. In contrast, the desert bordering the Red Sea is very dry. The vegetation is typical of that of the Eastern Desert, being largely restricted to the mouths of larger wadis and along the coast, where saltmarsh vegetation is dominated by halophytic species (Baha el Din, undated)

Several mountain habitats support unique faunal and floral elements, in particular in the South Sinai and the mountains of the Eastern Desert, particularly the Elba mountain complex (Baha el Din, undated).

Open gravel and sand desert occupy the greater part of Egypt's land area. This, however, is the least productive of the country's habitats. Where rain is regular (as in sub-coastal deserts), sparse plant cover is present. In more arid inland regions, vegetation (if present at all) is scant and largely confined to soil depressions where sufficient rainwater accumulates (Baha el Din, undated).

Species

Most of Egypt is either arid or hyper arid, however, due to its habitat diversity, species diversity is significant. The level of endemicity along the river is, however, higher, as the river corridor provides a source of freshwater habitats and wetlands that is extremely important, especially to migrating and overwintering animals (see also 'species' below; EEAA, 2009b)

The Egyptian flora includes 2145 species of native and naturalized vascular plants including 60 endemic species (Boulos, 2009), 10,000 species of insects, 1422 other invertebrates, 755 fish, 470 birds, 126 mammals (Kassas, M., et al., 1995) and 118 reptiles and amphibians (Baha El Din, 2006). Even though country terrestrial species diversity is relatively low due to Egypt's general aridity, many species are very narrowly distributed, making habitat conservation crucial to their survival. Marine biodiversity is also significant, with Egypt's Red Sea coral reefs showing considerable endemism. There is also important genetic diversity, including locally adapted plant varieties in the Western Desert oases and locally adapted plant varieties found in isolated oases, on high altitude mountains and across various bio-geographical barriers (such as the Red Sea and Nile River).

Egypt hosts a sizeable number of endangered species recognized by IUCN as needing conservation management. At least 143 species of threatened animals are to be found in the country (IUCN, 2006), including the highly endangered Slender Horned Gazelle (Gazella leptoceros) and the Egyptian Tortoise (Testudo kleinmanni). The flora includes 82 threatened species (IUCN, 1998). Finally, Egypt represents a vital artery for bird migration, including 39 threatened species, and serves as a major flyway for migrating soaring birds and an important wintering ground for water birds.

Recent data from the IUCN Red List (2010) reveal that animal threatened species were 121 in 2010, see table below. Endemic species includes 5 mammals and one amphibian in Egypt, none of which is endangered.

Table 6-1 Threatened species, IUCN Red List (2010)

Species	Total threatened	Endemic
Mammals	17	5
Birds	10	0
Reptiles	10	0
Amphibians	0	1
Fishes	36	0
Molluscs	0	0
Inverts	46	0
Plants	2	0
Total	121	0

Source: Based on IUCN, 2010

Protected areas

Recent national official data (Ibrahim, 2011) indicate that, to date, 29 protected areas have been declared in Egypt, accounting 15 per cent of the national territory. These include one marine protected area (Sallum, declared in 2010) covering an area 383 km2. Other protected areas both marine and terrestrial sites, namely: Taba, Nabq, Abu-Gallum, Ras Mohammed (S. Sinai), Red Sea Islands, Wadi Gemal and Elba (Red Sea coast) and El-Burullus, El-Omyed, Ashtoum El-Gamel and El Zaraniek (Mediterranean Coast). A summary of key recent data is provided below.

Table 6-2 The area and percentage of each country that falls within terrestrial protected areas, and national targets for protected area coverage

PAs	Number	Total PA area (km2)	PA % of land (including water bodies)	National PA target %
Terrestrial	28	150,000 (approx.)*	15%	-
Marine	1	383	0.04%*	-
Total	29	150,000 (approx.)*	15%	20% by 2017**

Source: Ibrahim (2011) except * own calculations and ** EEAA, 2009

Their extension by IUCN category is available only for the year 2003, when protected areas accounted for only 5.7 per cent of the territory - see table below.

Table 6-3 Extent of Protected areas by IUCN category (2003)

Protected areas	**IUCN category**	**000 ha**
Nature Reserves, Wilderness Areas and National Parks	I and II	313
Natural Monuments, Species Management Areas, Protected Landscapes & Seascapes	III, IV and V	4,223
Areas Managed for Sustainable Use and Unclassified Areas	VI and 'other'	1,062
Total area protected	all	5,598
Marine and Littoral Protected Areas (a)		5,396
Protected areas as a % of total land Area, 2003 (b)		5.7%
Number of protected areas, 2003		26
Number of areas > 100,000ha, 2003		9
Number of areas .1 million ha, 2003		1
Wetlands of International Importance (Ramsar sites), 2002		
Number of Sites		2
Total Areas (000 ha)		106
Biosphere Reserves		
Number of Sites		2
Total Areas (000 ha)		2,456
Total land area (000ha)		100,145

Source: Based on WRI http://earthtrends.wri.org/pdf_library/country_profiles/bio_cou_818.pdf

Thirty four Important Bird Areas (IBAs) have been listed to date by BirdLife International, covering about 35,000 km2. These comprise a wide range of habitats critical for birds, including: wetlands, high altitude mountains, desert wadis, coastal plains and marine islands. Fifteen of these IBAs are in existing Protected Areas. Five further IBAs are under consideration for protection, while others sites, such as Suez and Ain Sukhna, are not protected (EEAA, undated). According to an Egyptian NGO, even in the IBAs that are protected, the law is not enforced .

Management plans have been finalised for 60 per cent of the protected areas, and 3 economic plans were developed for three areas (Wadi el Rayan PA, Wadi Gemal and Ras Mohammed). Some protected areas are still suffering from shortage of human and technical resources as well as infrastructures, such as Abu Galloum, El-Sallum and Gilf-Kabeer (EEAA, 2009a). Some monitoring and research is carried out also outside protected areas, although their overall effectiveness has not been assessed

According to Birdlife, only six of Egypt's IBAs (17 per cent of the total) are located in areas receiving adequate protection. Many protected areas in Egypt are still only 'nominally protected', i.e. have little effective enforcement or management. This is changing though, as the capacity of the country in the field of protected-area management (in terms of both human and financial resources) is increasing, and there is a growing interest in, and effort to, introduce practical and effective protection for these areas (Baha el Din, undated).

A brief overview of some of the main protected areas in Egypt is provided in the box below.

Box 6.1 Overview of some key protected areas in Egypt

Ras Mohamed is the first national park in Egypt, established in south Sinai in 1983. It occupies 480km2 (135 terrestrial land and 345 km2 marine part) in addition to Tieran and Sanafer Islands (370km2). This protected area is very unique and includes coral reefs, Mangrove trees, and marine turtles. It visited by large number of national and international divers (EEAA ,2011)

El-Zaranik is considered one of the most important bird areas in the East Mediterranean region. The end of August and beginning of September is the highest season for bird migration, such as herons, waders, quails, crakes, and storks. It is also one of the most important winter areas for species like sea gulls and greater flamingo. Many predatory and soaring birds also pass during spring time. This area is very important for breeding species like the Kentish plover. In total, 241 species have been recorded, including 8 threatened species like corn crakes (Crex crex), imperial eagles (Aquila heliaca), lesser kestrels (Falco naumanni) and ferruginous ducks (Aythya nyroca) (EEAA, 2009b)

Wadi Al-Hitan (Whale Valley) is a Natural World Heritage Site, and IUCN Strict Nature Reserve (category Ia). It is the only place in the world where the skeletons of families of archaic whales can be seen in their original geological and geographic setting of the shallow bay of a 40 million years old sea. A Management Plan was implemented in the area allowing visitors only on guided tours along a marked trail and proscribing many activities, including the destruction of geological formations, discharging pollutants, hunting and littering. The site is patrolled daily to catch illegal visitors and twice a week a team monitors the condition of the fossils (UNEP/WCMC, 2007).

The Gebel Elba IBA site encompasses a cluster of coastal mountains overlooking the Red Sea, immediately to the north of the border with Sudan, and is part of the Elba National Park. Gebel Elba supports a rich biodiversity unparalleled in any other, similar, desert habitat in Egypt. Some 41 bird species are known or thought to breed in the immediate vicinity of Elba, including species, such as Struthio camelus and Torgos tracheliotos, which have disappeared from most of their former North African/Middle Eastern range, although they have both been greatly reduced in number during the past decade. The area also holds breeding populations of several birds of prey that are rare, or have sharply declined. Hunting is perhaps the most serious threat that birds and other wildlife (in particular gazelle) face in the Gebel Elba region. Increased disturbance by hunters, military personnel and development activities, especially in the coastal zone, is driving wildlife further inland towards more arid and less favourable habitats. Furthermore, green trees are often felled to be turned into charcoal. This, combined with the severe grazing pressure, is working to reduce the vegetation cover, so increasing the aridity of the region. In addition recently, the area between Marsa Alam and Shalateen has been opened to tourists. If large-scale tourism were to take place at Gebel Elba itself, it would be highly detrimental to this relatively untouched wilderness. (Birdlife, 2011a)

El-Burullus Lake is a large, shallow, fresh-to-brackish coastal lagoon located between the two Nile branches forming the delta. It is an IBA protected area and a Ramsar site. It is one of Egypt’s most important wetland for wintering waterfowl, and is one of the most important wintering grounds for Aythya nyroca in the eastern Mediterranean. Because of its relative isolation, Burullus is also an important breeding site for several water birds and wetland species. About 35 species of birds are known to breed. An estimated 37 per cent of the open-water area and 85 per cent of the marsh area have been lost during the past 40 years, largely as a result of ongoing drainage and reclamation of the lake’s margins, and also due to the proliferation of emergent and submerged vegetation. It is anticipated that Burullus, along with other coastal delta wetlands, will be further reduced in area as a result of landward migration of coastal sandbars. This is a consequence of severe coastal erosion, from which the northern coast of the delta has suffered since the closure of the High Dam. Despite being the least polluted of the northern delta lakes, increasing quantities of agricultural drainage-water with heavy fertilizer and pesticide loads are being released into Burullus, contributing significantly to the eutrophication and pollution of the lake, a reduction of the salinity of the lake and the expansion of reed-swamps and reduces fishing opportunities. The large number of fishermen on the lake cause continuous disturbance to biodiversity together with water bird-catching. Furthermore, a coastal highway running through the sandbar north of Lake Burullus has increased coastal development pressures (Birdlife, 2001b).

Threats to biodiversity

In general, threats to Egypt's biodiversity include rainfall shortage along the desert habitats, in addition to demographic pressure, excessive hunting and cutting, resource extraction and pollution (EEAA, 2009a).

In addition, a tenfold increase of fish farms from 86.000 tonnes during 1997 to 595,000 during 2006 led to increasing water pollution and therefore a decrease of water quality. The violation of fishing laws (by increasing the number of motor boats to more than 1000, also by using illegal nets) led to overfishing, with fish landing increasing from 13 million in 1998 to 41 million in 2006. Furthermore, damages to coral reefs by hotels, other tourism establishments, ships and individuals (about 600 violations in the past 10 years) have led to the destruction of coral reefs in many sites (EEAA, 2009b). Coral reefs are also exposed to bleaching due to climate change (EEAA, 2010) – see also case study in chapter 12.

Threats to migratory bird species include: Increasing rates of hunting, whether using nets across the migration route (quails hunting nets) or using weapons for hunting aquatic birds, destruction of natural habitats and bird nests in their original home after harvesting, excessive use of pesticides in agriculture and high rates of pollution in lakes and rivers (EEAA, 2009b).

Wetlands face great threats, mainly in land, land reclamation and construction expansion project. They are also exposed to natural phenomenon like sedimentation, floods and sand storms as well as coastal erosion shrinking the barriers separating the Northern lakes from the sea and seal level rise due to climate change (EEAA, 2009b). The wetlands of the Nile delta constitute about 25 per cent of the fish catch of Egypt. This area is the most vulnerable to sea level rise caused by climatic change (EEAA,2010b). The biodiversity along of the river Nile and the northern lakes is also vulnerable to human induced pollution. Industrial water discharges constitutes 39 per cent of the environmental problems in Egypt (EEAA, 2010b). Fertilizers are also a large source of pollution for soil and water resources (the Egyptian farmers consume more than 1.8 Mt/year fertilizers according to FAO, 2006).

Invasive alien species are also an issue. During 2008 their number reached 110 species; some of which are major threats to the native biodiversity. See an example in the box below. A national action Plan was prepared, but efforts exerted as from 2008 were limited (EEAA, 2009b).

Information on over-grazing in Egypt is very limited, but it is apparent that overgrazing historically contributed to desertification and has more recently co-responsible of the gradual disappearance of species like the Egyptian Tortoise, (Testudo kleinmanni). It is noted that, while in the past traditional pastoralism was relatively limited, the current use of trucks to transport heard from a grazing areas to another has led to the rapid depletion of grazing grounds in large areas, and to graze marginal habitats in distant localities. This has allowed to maintain larger herds, exceeding the carrying capacity of their environment (Baha el Din, 1994).

Box 6.2 Invasive species to Egyptian habitats

The water Hyacinth (Eichhornia crassipes) is a fresh water exotic weed. The plant was exported from South America, and grew uncontrollably over the Nile river and in particular in the Lake Victoria, replacing the local Leminaceae. Among its main negative effects, the water Hyacinth deteriorates water quality and affects biodiversity by replacing local species (such as Leminaceae),causing imbalanced in the aquatic micro-ecosystem, with consequences to the local fauna and fish stock. Furthermore, the plant leads to additional economic and social problems, as it clogs intakes of irrigation, hydropower and water supply systems, creates micro-habitat for a variety of human disease vectors, such as Malaria, Schistosomiasis and lymphatic Filariasis, and increases evapo-transpiration, exacerbating the problem of water losses. In Egypt, the eradication of water hyacinth costs US$150 million every year. (Wafaa, 1995).

Crayfish (Procambarus clarkia) invaded the Nile river in 1980s, and has recently become a serious problem for fishing nets and water channels. Prosopis (Prosopis juliflora) is another potentially serious invasive plant species. It first appeared in the Elba protected area in 2001 and replaced several natural plant species (Wafaa Amer, 2010).

6.2.2 Potential environmental improvements

In order to assess the potential environmental improvement, we will assume a target of 15 per cent of the Egyptian land (the declared 29 protected areas) to be conserved through effective management practices. It should be noted that there is a target to protect 20 per cent of the territory by 2017 (EEAA, 2009).

6.2.3 Qualitative assessment of the benefits of improving biodiversity protection

Environmental benefits

Well managed protected areas are important as they help safeguard species, especially threatened species and species that occur in internationally important numbers. A increased size of protected areas and an improvement in their management can notably help protecting migratory birds, as Egypt host several important bird areas, and coral reefs – an important resource in the Red Sea.

Increased quantity and quality of protected areas will also allow for a more sustainable use of natural resources (vegetation, water, soils etc.) and maintain and enhance ecosystem services (water storage / purification, carbon storage, flood control etc.) – see an example of ecosystem services from wetlands in the box below.

Box 6.3 Ecosystem services provided by wetlands in Egypt

Water purification: wetland ecosystems play a role in removing nitrogen and phosphorus compounds brought by drainage, thus reducing Eutrophication. Reeds and other water plants remove, at least partly, chemical pollutants including heavy metals compounds.
Protection against sea surges: wetlands of northern Delta act as buffer pads between the sea and the low-lying farmlands of the Delta.
Reservoirs of biodiversity: Coastal wetlands are vital to the survival of migratory birds. Wetlands act as refuges for animal species during spells of drought and other environmental adversities.
Wetlands products: wetlands are highly productive ecosystems. The northern lakes, Lake Nasser and near-shore zones of coastal waters are the principal fisheries of Egypt. Mangrove swamps, and tidal wetlands and marine grasslands are breeding and nursery habitats for many fish species. Inhabitants of wetlands areas, mostly fishermen, obtain additional income from catching waterfowl. Wetlands of the Nile delta produce over 60 per cent of the fish catch of Egypt (EEAA, 2010b).
Recreation and eco-tourism: wetlands provide venues for many recreational activities: angling, hunting, boating, bird watching, etc…
Hydrological functions: wetlands could be used for water storage (schemes for using Lake Burullus as a reservoir in years of high flood was considered); they may be sources of replenishment of underground aquifers. In Egypt, the northern lakes act as barriers to the subsurface seawater intrusion to the farmland further south.
Climate change mitigation: some wetland types release methane (one of the principal greenhouse gases); but highly bioproductive wetlands act as carbon sinks, their conservation and restoration increase the potential for sequestration for fending against anticipated rises in sea level.
Education and research: wetlands provide sites for education and public awareness programs. They also provide sites for research studies: water-dependent ecosystems processes, restoration needs, maintenance and conservation methods, etc.
Source: SOER 2007-2008

Some plants provide important regulating services that can be enhanced through better management and increased protection. For instance, the hydrophytes growing naturally around and in the water bodies of the River Nile Islands can be used economically in bioremediation, such as Potamogeton pectinatus (it can be used for remediation of highly polluted water bodies characterized by high temperature, PH, conductivity, sulphates and chloride concentration), Myriophyllum spicatum (it can be used for remediation of water bodies with organic matters, nitrate, nitrite and sulphates) etc. (Wafaa, 1995)

Health benefits

Well managed protected areas can ensure a good status of open spaces, which in turn can be a source of recreation and relaxation (e.g. marine areas), with associated mental and physical health benefits. Health benefits arise also from the provision of clean air and water from intact ecosystems (the overall benefits are assessed under the air and water chapters). Furthermore, improved management can also help reduce invasive alien species, some of which are vectors for human diseases

Social benefits

Protected areas provides amenity and recreation facilities for the local population and for tourists. They also offer opportunities for education and research (see box above on ecosystem services from wetlands), leading to increased public awareness of environmental issues. They can also enhance social values, e.g. by promoting iconic species and encouraging traditional lifestyles, valued landscapes and the maintenance of ‘a sense of place’.

Economic benefits
Well managed protected areas offer opportunities for eco-tourism, including revenue generation from tourism (e.g. entrance fees) and job opportunities (paid or voluntary). They also stimulate income generation from eco-tourism associated businesses – such as hotel, catering, B&B and other recreation activities (e.g. scuba-diving). This is particularly important in Egypt, where tourist activities along the coast are very important. A good preservation of, in particular, the coral reefs will have significant benefits for eco-tourism, while depleting them will involve major economic losses (beside of course the environmental losses) – see the case study on chapter 8. There is potential also for further exploring opportunities for eco-tourism in other protected areas, which will bring additional revenues to local activities (e.g. hotels) and public authorities (e.g. through entrance fees). The public revenues could also be used to cover the cost of managing the protected areas. For instance, visitors in diving areas ranged between 10,000 and 60,000 annually. Ecotourism is estimate to bring about 2.1 million visitors per year, generating about EUR 3.4 million (26.8 million LE) per year, i.e. about 60 per cent of total tourism revenue in Egypt (EEAA, 2009).

Ecosystems also can offer significant provisioning services, in terms of agriculture and fishery products. In some areas of Egypt, e.g. near the River Nile Islands, biodiversity is also a source of raw material used daily by the local inhabitants. Some edible plants secure food in rural areas (e.g. leaves or fruits like figs and dates). Tree leaves and twigs, young branches and fruits are also used as high nutritional fodder for livestock. Some plant species are used for fibre production, while some species have medicinal values. More than 20 plant species have been used for medicinal purposes in rural areas (e.g. Citrullus colocynthis, Hyoscyamus muticus, etc.) (Wafaa, 1995).

6.3 Benefits from forests and reducing deforestation

6.3.1 Introduction to the approach taken

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 as number of hectares (ha) increase or decrease in forested land and 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 play an 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 focuses 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 using a high and low EUR value for carbon, based on recent literature.

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 (TEEB, 2010, 2011). 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.

For carbon values, we focus on stock values, and note also the 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. A range of carbon values, based on well recognised studies , have been used – as shown in the table below.

Table 6-4 Carbon value used in this study (EUR/t)

GHG	Range	2010	2020
Carbon dioxide (CO_2) or CO_2 equivalent	Low	17.2	39
	High	32	56

Source: based on data from EC (2008; DECC (2009); and Centre d'analyse stratégique (2009)

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 per cent, 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 per cent, or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees above 10 per cent. 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 which can lead to their eventual loss. When considering factors driving deforestation, the likelihood of these degradation factors increasing/decreasing should also be considered.

6.3.2 Current level of deforestation

In 2010 about 0.07 per cent of Egypt was forested, i.e. about 70,000 ha over a total area of 99.5 million ha (FAO, 2011a). Half of it the forested areas are privately owned, and the other half is owned and managed by public administrations . A map of the Egyptian forest cover is shown in the figure below.

Figure 6-2 Egypt forest cover map (year 2000)

Source: Global Forest Resources Assessment 2000, base map: ESRI http://www.fao.org/forestry/country/18314/en/egy/

Deforestation is currently not an issue in Egypt. Between 1990 and 2010, the country gained 59.1 per cent of its forest cover, i.e. around 26,000 ha. Most of the increase happened between 1990 and 2000, when Egypt gained 52.3 per cent of its forest cover, or around 23,000 hectares, at an average annual reforestation rate of 3.5 per cent. Between 2005 and 2010 the rate of forest change decreased to 0.9 per cent per annum .

Table 6-5 Trend in total net forest cover

Year	1990	2000	2010	*Projection: 2020*
Total net forest cover (ha)	44,000	59,000	70,000	*88,292*

Table 6-6 Annual change rate

Year	1990-2000	1990-2010
Annual change rate (%)	2.98%	2.35%

Source: own calculations based on http://www.fao.org/docrep/013/i2000e/i2000e.pdf

Measuring the total rate of habitat conversion (defined as change in forest area plus change in woodland area minus net plantation expansion) for the 1990-2005 interval, Egypt gained 0.0 per cent of its forest and woodland habitat, indicating that the area increase is due only to plantation (FAO, 2011a). The most commonly grown species were introduced from Australia (Min of agriculture, 1999). Forest plantation started in the nineteenth century when Casuarina and Eucalyptus seeds were introduced and planted around fields and along roads, canals and drainage ditches .

A small share of mangrove forests, however, are present in Egypt are particularly important for biodiversity (see box 6.4 below). The total area covered by mangrove trees has increased to 700 hectare by the end of 2007, compared with 525 hectare in 2002. This is because of limiting animal grazing, increased protection of the sites, as well as the implementation of transplantation program for mangrove trees. (SOER, 2007 & 2008).

Forests designated functions are mostly for protection of soil and water (49 per cent) and for multiple uses (46 per cent), while only 2 per cent is for production and 3 per cent for biodiversity conservation (see table below) . One major (known) source of disturbance to forests is represented by insects, which affect about 1 per cent of the total forest cover .

Table 6-7 Forests primary designated functions

Function	Production	Protection of soil and water	Conservation of biodiversity	Social services	Multiple use	Other	None or unknown
Area (%)	2	49	3	0	46	0	0

Source: http://rainforests.mongabay.com/deforestation/2000/Egypt.htm#01-cover

6.3.3 Potential environmental improvements

In order to assess the benefits related to forestry, an ENP study wide 'no net loss by 2020' target was set, to allow comparability across nations. This ENP wide target calls for reducing the annual incremental reduction of the current deforestation rate to 0 per cent by 2020. The analysis therefore aims to identify the benefits that achieving this reduction can bring.

Deforestation, however, is not currently an issue in Egypt as it stands currently at 0.0 per cent per annum (2010 data from(FAO, 2011a)). Implementing the study target therefore will not lead to additional environmental improvements in terms of forest size. The assessment will therefore rather focus on the existing benefits provided by forested areas. What the analysis aims to highlight is that it will be important not to degrade or reduce the size of the existing forest in order not to loose the current benefits. It should also be noted that, where natural afforestation is not possible, planted forests can be beneficial in terms of carbon sequestration and also for some other ecosystem services such as soil and water retention, to the extent their management is done in a sustainable way. This inter alia means taking into account implications for other neighbouring habitats (e.g. avoiding the introduction of invasive alien species), using native rather than exotic tree species, limiting the use of fertilisers and pest control, and reducing the impact from harvesting methods.
The benefits in terms of carbon currently stored, and its equivalent monetary value, are assessed in the next chapters.

The baseline for 2010 sets a rate of current deforestation per annum is at 0.0 per cent in 2010. The 'BAU baseline' to 2020 would therefore see a further loss of 0.0 per cent of 2010 forest cover. Reaching the target of halting deforestation by 2020 requires no reduction per annum to 2020 (own calculations based on (FAO, 2011a)). Continuing the historic trend would see an increase of forested area of nearly 20,000 hectares or around 26%.

6.3.4 Qualitative assessment of the benefits of reducing deforestation

Environmental benefits

Environmental benefits provided by forests in Egypt include the provision of habitat for animal species diversity and ecosystem regulating services such as carbon storage, soil and water conservation, flood control, slowing the rate of desertification and coastal protection.

An example of the provision for habitat species by the Egyptian mangrove forests is provided in the box below. The benefits from carbon storage are highlighted in the quantitative and monetary sections.

Box 6.4 Benefits of Egyptian mangrove habitats for local biodiversity

In Egypt, studies proved that mangrove habitats are characterized by high biodiversity, including algae (36 species), insects (40 species), crustacean (65 species), echinoderms (17 species), and fish (22 species). Mangrove habitats are considered of particular economic importance, as they work as incubators that provide food and protection for small fish. (SOER 2007 & 2008)
As an order of magnitude, studies in Thailand, for instance, showed that the estimated benefits of retaining the mangroves are around $584/ha for collected wood and non-wood forest products, $987/ha* for fishery nursery and $10,821/ha for coastal protection against storms (Barbier, 2007). The total value of the mangrove is therefore around $12,392/ha .

Health benefits

Forests can promote health and well-being through their use for recreation and relaxation. No specific evidence on health effects was found in recent literature. Overall, the health effects can be considered to be relatively small/negligible compared to the other benefits provided by forests.

Social benefits

Benefits here include provision of amenity for recreation, education, tourism, cultural and spiritual heritage.

Economic benefits

Forests provides economic benefits in Egypt by providing job opportunities (see quantitative benefits below) and revenues from trading forest related goods, especially wood (see monetary benefits).

The benefits from carbon sequestration are presented in the monetary section.

Forests may also attract tourists and therefore generate additional revenues and stimulate rural development. However, no specific evidence on tourism revenues related to forests was found in the available literature and this may deserve further attention in future studies.

6.3.5 Quantitative assessment of the benefits of reducing deforestation

Environmental benefits

Egypt's forests contain 7 million metric tons of carbon in living forest biomass (see tables below). Each hectare of forest stores on average 99 tonnes of carbon, i.e. 363 tonnes of CO_2. It should be noted that significant levels of carbon is also found in the soil and litter, so the carbon values used here should be seen as a conservative figure. In the event of deforestation or degradation it is not only the living carbon that can be released but also the 'dead carbon' (MA 2005, TEEB 2011, Keith et al 2009).

Further to this The Economics of Ecosystems and Biodiversity (TEEB) shows that halting 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 the huge range of services and goods they provide to local people and the wider community (TEEB, 2009; TEEB 2010; TEEB 2011; MA 2005).

According to 2000 estimates, each hectare of forest stores on average 99 tonnes of carbon, i.e. 363 tonnes of CO_2 per hectare (FAO, 2011a). Accordingly, in 2010 Egypt's forests stored about 7 million metric tons of carbon in living forest biomass, equivalent to around 26 million tonnes of CO_2 (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.
Should the historic trend continue, there would be a gain of around 6.6 million tonnes of CO2.

Table 6-8 Comparative assessment for million tonnes of CO2 stored under BAU and target scenarios.

Year	2010	BaU: 2020 continued trend	Target 2020: halting deforestation trend in 2020	Net saving from halting deforestation	Net gains relative to baseline in 2020	Net saving relative to 2010 reference point
CO_2 stored (million tonnes)	25	32	27	n.a.	5.1	6.6

Source: http://rainforests.mongabay.com/deforestation/2000/Egypt.htm adapted from (FAO, 2011a).

Table 6-9 Per hectare carbon stock in living forest biomass – total and per hectare

Year	1990	2000	2005	2010
Carbon stock in living forest biomass (million tonnes C)	4	6	7	7
Carbon stock in living forest biomass (million tonnes CO_2)	15	22	26	26
Carbon stock in living forest biomass (per hectare in tonnes)	99	99	99	99
CO_2 stock equivalent in living forest biomass (per hectare in tonnes)	363	363	363	363

Source: FAO, 2011a and http://rainforests.mongabay.com/deforestation/2000/Egypt.htm

Economic benefits

Forests are also a source of employment in Egypt. About 13,000 people were employed in forestry activities in 2005 (i.e. about 0.06 per cent over a total labour force of 20.7 million in 2005). 12,000 of them were involved in primary production, and 1,000 in protected areas conservation.

6.3.6 Monetary assessment of the benefits of reducing deforestation

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 CO2 of 17.2 EUR/ton (low) and 32 EUR/ton (high) in 2010, the value of the carbon currently stored by the Egypt forests ranges between EUR 435 and 810 million. This is the value of the carbon stored in the living biomass today and hence should be seen as an underestimate.

If no deforestation or degradation takes place by 2020, and assuming a carbon value of 39 EUR/ton (low) and 56 EUR/ton (high), in 2020 the carbon stored will be worth between EUR990 million and EUR 1,420 million. This is summarised in the table below. Were the forest carbon stock to increase at the rate seen over the past twenty years the value would increase by between EUR 260 and EUR 370 million.

Table 6-10 Estimated value of carbon storage in 2010 and 2020 (high and low estimate)

	Value in 2010		Value in 2020					
			Unit value (€/tC02)	Baseline: if trend continues (If deforestation not halted / if afforestation continues)	Target: If deforestation halted by 2020	Value of avoided emissions	If forest carbon stays at 2010 levels	Value of stock gain 2010 to 2020
	Unit value (€/tC02)	Total value (m€)	Unit value	Total Value (m€)	Total value (m€)	Net value (m€)	Total value (m€)	Net value (m€)
Low estimate	17.2	**437**	39	**1250**	**N.A.**	**N.A.**	**991**	**259**
High estimate	32	**813**	56	**1795**	**N.A.**	**N.A.**	**1,423**	**372**

Note that this is a stock value and not an annual value of carbon sequestered , so care is needed when looking at carbon savings from renewable energy technologies, which offer savings every year (See later section). Note also that these values are total values; strictly speaking the carbon values applied are more suited to marginal changes than total stock values (as if all stock were to be lost, the marginal value itself would change); nevertheless the calculated values are important as indicators of the climatic importance of not losing the forest cover.

As noted earlier, there is a wide set of other ecosystems services taken into account besides carbons storage, but only the assessment of carbon storage has been possible within the context of this study. The benefits of preserving and well managing the existing Egyptian forest are clearly already significant in terms of carbon storage; all the more so, were the other services to be taken into account.

6.4 Benefits from reducing cropland degradation

6.4.1 Introduction to the approach taken

Agricultural crop land degradation is widespread in many countries. This section assesses the benefits of a reversal of crop land degradation or, in other words, an improvement in cropland quality. A target for improvement in cropland quality to be achieved by year 2020 is specified, direct and indirect benefits of crop land improvements are discussed qualitatively, and direct benefits in terms of increased value of crop production are quantitatively assessed.

Definitions of key terms used in this section are:

- Crop land: Land used for cultivation of agricultural crops.
- Area harvested: Hectares of crop land 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, tree nuts and other minor crops.
- Crop land quality: Here defined as those characteristics and properties of crop land that affect crop yield. Crop land quality is impaired by crop land degradation and potentially improved by improved crop land management.
- Crop land degradation: Inter-temporal changes in properties of crop land 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 crop land management: Here defined as practices that reduce, prevent, or reverse crop land degradation and preserve or improve crop land quality with positive impacts on crop yield.

6.4.2 Current level of cropland degradation

Agriculture share of GDP in Egypt was 13 per cent in 2008 (World Bank, 2010). Area harvested was 5.8 million hectares in 2008. Cereals constituted 3.0 million hectares and other crops about 2.8 million hectares.

In Egypt agriculture production is expected to be confronted by several threats during the 21st century. The main challenges would be the harmful effects on agricultural land and fresh water quality due to the projected decrease in the Nile flow, the rise in sea level and the projected flooding of the Nile delta due to climate change (Hegazy et al. 2008).
The projected changes in crop production (compared to the current status) of some major crops in Egypt in 2050 under a temperature increase of 2 °C will be: change in rice production by -11 per cent, maize by -19 per cent , soybeans by -28 per cent , Barley by -20 per cent and cotton will increase by +17 per cent (Abou-Hadid, 2008).

Moreover, pests and disease remain important factors negatively affecting crop productivity and diversity. Their effect on crop productivity is projected to worsen with climate change. For example, currently parts of Egypt are suffering from severe epidemics of tomato late blight (Phytophthra infestans), wheat’s leaf rust disease caused by Puccinia triticina and stripe rust disease caused by Puccinia striiformis (Abolmaaty, 2006).

About 84 per cent of the population of the country lives on or around degraded land, mainly in Nile valley and delta. The main identified type of human induced land degradation is chemical deterioration of the soil, largely caused by agricultural activities (Egyptian farmers consumes 1.8Mt fertilizers annually). The cost of the environmental degradation resulting from wastewater was estimated as 1.0 per cent and for the solid wastes was 0.25 per cent of Egypt's GDP for 2001 (EEAA, 2010b).

6.4.3 Potential environmental improvements

The target for which benefits are assessed in this study is an improvement in crop land 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.

It is assumed that the improvement in crop land quality as stipulated by the target is achievable through improved crop land 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.

Simulation studies in Egypt (Abou-Hadid, 2006) showed that 10 days delay in wheat sowing date at the north Nile delta might mitigate the negative impacts on crop productivity by 10 per cent. Also, Medany et al. (2009) recommend that the change of agriculture practices and crop patterns are the most promising adaptation measures that could be applied at national level to overcome the harmful impacts of climate change on crop production, in addition to the use of disease-tolerant crops and the monitoring of plant pests and diseases. The Egyptian Strategic Development Plan (Ministry of Agriculture, 2009) outlined that by 2030 the area of wheat cultivation could increase by 1.54 times over the 2007 levels, while maize cultivation could double.

Table 6-11 The national assumptions for the agriculture production to 2030

Crop	2007		2017		2030	
	Area / 1000 Feddan	Production Feddan/Ton	Area / 1000 Feddan	Production Feddan/Ton	Area / 1000 Feddan	Production Feddan/Ton
Wheat	2716	2.72	3750	3.50	4200	4.3
Rice	1673	4.11	1250	5.11	1300	1.6
Maize	1843	3.45	3150	4.00	3700	5.0
Sugarcane	355	49.0	340	56.6	350	65.4
Sugar beet	248	22.0	500	28.0	800	35.0
Pea nut	155	1.4	230	2.0	350	2.50
Horse bean	212	1.42	300	1.6	400	1.8
Cotton	575	1.3	750	1.6	1000	1.8
Citrus group	395	9.1	450	12.0	500	15.0
Grape	170	9.9	200	12.0	250	14.0
Mango	184	4.6	160	6.0	180	10.0
Tomato	537	14.5	580	20.0	620	30.0
Potato	257	10.7	300	12.0	350	14.0

1 Feddan = 4200 m^2= 1.038 acres

Source: based on Ministry of Agriculture, 2009

For the purpose of this study, the GLASOD (Global Assessment of Soil Deterioration) 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.

- 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 6-12 Assumptions of 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 – *see the methodological approach in the Benefit Assessment Manual (Bassi et al, 2011)*

Baseline tons of crop production must be projected to year 2020 from reference year 2008, assuming business-as-usual (i.e., no change in crop land management practices). Baseline crop production is then compared against estimated crop production resulting from achieving the target in year 2020 (see above) through better crop land management.

Projections in real crop prices to year 2020 must also be made in order to estimate the monetary benefit of improvement in crop land quality.

Baseline assumptions are presented in Table 3:

Table 6-13 Projected baseline crop production and value of production, 2008-2020

	Cereals	Other crops
Annual increase in crop production	2.2%	2.4%
Annual increase in real crop prices	4.0%	3.0%

Source: Estimates by the authors - *see the methodological approach in the Benefit Assessment Manual (Bassi et al, 2011)*

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

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 per cent and the FAO world cereals price index increased by 31 per cent 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 off-set 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 per cent per year and the real prices of other crops at a rate of 3 per cent 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 Egypt producer prices for other crops. 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.

The improvements of reaching the target by 2020 are the difference between crop land quality with no change in crop land management practices and crop land 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 Target to be reached by 2020). Improvements in crop land management practices may also be expected to have many other benefits (see below).

The GLASOD data do not map crop areas harvested by the categories of land degradation in table 1. Assumptions about distribution of crop areas harvested must therefore be made. Two distribution options are used here:

1. Crop areas harvested are distributed in proportion to land area in each land degradation category (e.g., 7 per cent of areas harvested in Egypt are on severely degraded land (see table 1)).
2. Crop areas harvested are distributed in proportion to population distribution across the land degradation categories (e.g., 52 per cent of areas harvested in Egypt are on severely degraded land (see table 1)).

The first option assumes that crop area harvested is uniformly distributed across the country. Clearly this is a special case and highly unlikely because of forests, mountains and uncultivable desert/arid areas.

The second option assumes that hectares of crop area harvested per population are the same everywhere. This may be close to the case if the whole population were rural and employed in agriculture.

Using the data in tables 1-2, table 4 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 2.

Table 6-14 Estimates of yield increase from meeting the target in 2020

	Land area distribution	Population distribution	Mean value
Low	1.6%	6%	4%
Medium	1.9%	9%	5%
High	2.2%	11%	6%

Source: Estimates by the authors.

6.4.4 Qualitative assessment of the benefits of reaching the targets

Improvement in crop land management resulting in improved crop land quality and reversal of crop land 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 5 (e.g., see also CDE 2009).

Environmental benefits

Improved land quality crop land management can prevent land becoming degraded to the extent that it is abandoned (e.g., severe erosion or salinity, physical or chemical soil degradation). Thus, in Egypt, improved land quality can contribute to reduced desertification.

Health benefits

Soil erosion control can reduce agro-chemical run-offs which can help reduce pollution of water sources used for drinking and bathing, and thus contribute to protection of health. Improved soil nutrient management can also reduce the need for chemical fertilizer applications and thus reduce nitrate pollution of surface and groundwater resources used for drinking.

Economic benefits

Improved crop land management land quality enhances agricultural crop yields through improved physical and chemical soil properties and reduced salinity and erosion. This is a key issue in Egypt as crop production is also expected to be negatively affected by climate change (see also chapter 11.3). 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. Increases in agricultural production can lead to an increase of national income through the reduction of importations, the increase of exports and job creation through agro-industrial activities.

Social benefits

Erosion control reduces agro-chemical run-offs and therefore improves quality of water bodies used for recreation. Land productivity is also important to protect/create new jobs, as agriculture is estimated to employ 55 per cent of the labour force in Egypt (EEAA, 2010b).

6.4.5 Quantitative assessment

Many of the benefits of improved crop land 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 crop land 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 per cent by 2020 are estimated based on the yield increases in table 4. The yield increases are multiplied by the estimated value of crop production in 2020 (see below). This provide the estimated value of the extra tons of crop production as a result of reducing land degradation and are the annual benefits in 2020 of meeting the target.

6.4.6 Monetary assessment of the benefits

The projected real market value of total crop production in year 2020 is LE 166 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 4-6 per cent of this value, or LE 6.5-10.4 billion (PPP EUR 2.2-3.5 billion). This is equivalent to 0.47-0.76 per cent of projected GDP in 2020. All figures are in 2008 PPP Euros and 2008 LEs.

Table 6-15 Estimated annual benefits in 2020 of meeting the target

	Low	Medium	High
Value of increased crop yields (LE billion)	6.5	8.4	10.4
Value of increased crop yields (PPP Euros million)	2,191	2,846	3,529
Value of increased crop yields (% of GDP)	0.47%	0.61%	0.76%

Source: Estimates by the authors. – *see the methodological approach in the Benefit Assessment Manual (Bassi et al, 2011).*
Note: Mean value of estimated yield increases in table 4 is applied.

7 BENEFITS OF IMPROVING CLIMATE CHANGE RELATED CONDITIONS

7.1 Introduction to climate change related issues

This section will cover the following aspects of climate change:

- Uptake of renewable energy sources
- Analysis of 2-3 impacts among:
    - Sea level rise
    - Sea temperature rise
    - Desertification (covered under nature/water)
    - Water resource use (covered under water)
    - Increased risk of pest or disease outbreaks
    - Risk of forest fire
    - Risk of flood
    - Other effects
- Insights on deforestation in relation to climate change
- Insights on methane emission from waste in relation to climate change

Egypt's GHG's emissions have gradually increased from 117 million tonnes of CO2 equivalent in 1990 to 288 million in 2008, representing 0.98 per cent of global emissions. The main contributors to emissions are the energy sector, followed by agriculture, industry and waste.

Egypt is not committed to any emission target under the UNFCC or the Kyoto Protocol. However, some mitigation measures have been taken, in particular the development of renewable energy sources. In 2008, renewable energies represented 4 per cent of the total energy production, with a strong lead of energy from combustible renewables and waste, followed by hydro power.

A wider use of renewable sources would lead to multiple benefits, for the environment first, as Egypt is likely to be severely affected by climate change, but also for human health, as the reduction of air pollution from fossil fuels combustion would reduce respiratory diseases. Furthermore, the diversification of energy sources could have positive effects on employment.

Significant benefits could also be brought forward by adaptation measures. Key potential climate change impacts in Egypt are related to air temperature increases, sea level rise and water scarcity. These are all interlinked and can affect biodiversity, productivity of crops and accelerate the rate of desertification. Coastal zones are also significantly threatened by potential sea level. Adequate adaptation policies can therefore limit climate change related damage to key economic activities, like tourism and agriculture. They can also prevent or limit the need for population relocation.

7.2 Benefits from increasing the uptake of renewable energy sources

7.2.1 Introduction to the approach taken

This section focuses on the benefits of increasing the use of renewable energy sources (RES), as these can reduce the amount greenhouse gases (GHG) thanks to the reduction in the consumption of fossil fuels. Whilst the resulting air quality improvements are primarily local and national in scale, the reductions in climate change impacts are assumed to be spread globally. The following definitions apply:

- Energy from renewable sources: energy from renewable non-fossil sources, namely: Wind, Solar, Aerothermal (i.e., energy stored in the form of heat in the ambient air), Geothermal (i.e., energy stored in the form of heat beneath the surface of solid earth), Hydrothermal (energy stored in the form of heat in surface water) and ocean energy, Hydropower, Biomass (i.e., biodegradable fraction of products, waste and residues from biological origin from agriculture - including vegetal and animal substances- , forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste), Landfill gas, Sewage treatment plant gas, and Biogases. (EC, 2009)

- Gross final consumption of energy: the energy commodities delivered for energy purposes to industry, transport, households, services including public services, agriculture, forestry and fisheries, including the consumption of electricity and heat by the energy branch for electricity and heat production and including losses of electricity and heat in distribution and transmission. (EC, 2009) In this report it is calculated as: total final consumption + distribution losses + own use

The quantification assessment will focus on the environmental benefits related to increased substitution of fossil fuels with RES, resulting in a decrease in CO2 emissions, if a hypothetical target of 20 per cent RES uptake were to be reached by 2020 (based on EU targets). While this target is currently ambitious, there is potential for a much higher level of RES contribution to domestic energy demand in Egypt (and indeed for export) given the insolation levels in Egypt and the area available for solar plant.

To assess the monetary value of reduced CO2 emissions due to the RES uptake, a range of carbon values, based on well recognised studies , have been used – as shown in the table below.

Table 7-1 Carbon value used in this study (€/t)

GHG	Range	2010	2020
Carbon dioxide (CO_2) or CO_2 equivalent	Low	17.2	39
	High	32	56

Source: based on data from EC (2008; DECC (2009); and Centre d’analyse stratégique (2009)

7.2.2 Current uptake and potential for renewable energy sources[6]

Egypt's GHG emissions have increased steadily with economic development. Total emissions increased from 117 Million tonnes of CO2 equivalent in 1990 to 288 million in 2008, moving from a contribution to global yearly emissions of 0.35 per cent to 0.98 per cent. The energy sector is the primary contributor to emissions of GHGs in Egypt, followed by agriculture, industrial processes and then the waste sector. Energy intensity in the transport sector in Egypt is particularly high due to the low efficient-engines using hydrocarbons fuels, and the fact that it relies heavily on road transport as the main means of transportation in Egypt (EEAA, 2010b). Emissions per capita also increased, from 1.9 tonnes of CO2 per year in 1990 to 2.93 tonnes in 2008 (EEAA, 2009).

As a non-annex I country, Egypt is not required to meet any specific emission reduction or limitation targets in terms of its commitments under the UNFCCC or the Kyoto protocol. However, some mitigation measures based on national plans are in progress, including for the introduction of renewable sources of energy (EEAA, 2010b).

The main barriers that currently prevent the industrial sector from achieving full energy conservation and considerable GHG emissions reduction include a lack of information about GHG emissions reduction opportunities in the sector, long payback periods on some GHG emissions reduction investments, and financial barriers such as the lack of access to investment capital and/ or high interest rate on investments (EEAA, 2010b).

According to EIA data for 2008 (EIA, 2010), the RES contribution to overall gross final energy is currently about 4 per cent – see table below. Renewable energy share includes both combustible renewable and waste and the 'clean' RES such as solar, wind and geothermal energy.

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[6] 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 [2]than 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.

Table 7-2 Energy by source in Egypt (2008)

2008 gross final energy	[ktoe]	Share over total [%]	share over total fossil fuels [%]
Total	51,424	100.00	
Total without RES	49,871	96.98	
Coal and Peat	400	0.78	1
Oil (crude + products)	38,474	74.82	78
Gas	10,437	20.30	21
Nuclear	0	0.00	
RES: Hydro	560	1.09	
RES: Combustible Renewables and Waste	1,518	2.95	
RES: Geothermal, Solar, et al	35	0.07	
RES total	**2,114**	**4.11**	

7.2.3 Potential environmental improvements

In order to calculate the baseline situation in 2020 it is assumed that energy consumption will change proportionally with the change in population (i.e., more people, more energy consumed), and that the share of fossil fuels and RES over total final consumption will remain as the actual levels, i.e. 4.11 per cent. It is also assumed that by 2020 the same amount (in kilo tonnes of oil equivalent - ktoe) of combustible renewable and waste will remain the same as today.

In our baseline, the gross final energy consumption from fossil fuels in 2020 if no additional investments in RES are made will be of about 59,000 ktoe. The gross final energy from RES will be about 2,500 ktoe.

Table 7-3 Baseline in 2020 for energy consumption

Total Current gross final energy consumption	Current population	Current gross final energy consumption per capita	Population in 2020	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	*million*	*ktoe/ million*	*million*	*ktoe*	*ktoe*	*%*	*ktoe*
51,424	81.53	0.001	97.67	61,603	**2,532**	4.11	**59,071**

To assess the potential environmental improvements, this ‘business as usual’ baseline scenario is compared to a theoretical target of at least 20 per cent of gross final consumption of energy obtained from RES by 2020. This target is inspired by EU Directive 2009/28/EC requiring mandatory national targets for the overall share of RES in gross final consumption of energy of 20 per cent by 2020. It is understood that this can be an ambitious target to reach by 2020 in Egypt, but it is useful to provide an estimate of the benefits to be gained from an ideal improvement.

The environmental improvement consists on the increase in the uptake of renewable energy if the 20 per cent target is reached by 2020. In Egypt the amount of gross final energy consumption from RES if the target is met is estimated at 12,321 ktoe, of which 10,803 ktoe from 'clean' RES. This represents an increase of about 9,790 ktoe from the baseline scenario, and leading to an equivalent reduction of fossil fuel consumption.

Table 7-4 Reduced amount of fossil fuel use

Gross final energy consumption in 2020	target	Target gross final energy consumption from RES	Target gross final energy consumption from 'clean' RES	Target gross final energy consumption from 'combustion' RES	Target fossil fuel consumption	**Reduced amount of fossil fuels /increased RES**
ktoe	*%*	*ktoe*	*ktoe*	*ktoe*	*ktoe*	ktoe
61,603	20%	12,321	10,803	1,518	49,283	**9,789**

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

Environmental benefits

Increasing the amount of energy produced from RES, and hence reducing GHG national emissions will help tackling climate change. Since official reports stress that Egypt is one of the countries most hit my climate change, especially the river Delta, Egypt is also arguably one that can most benefit from climate change reduction.
In Egypt there is also the possibility to associate RES to desalination (see also chapter 8.6) – hence improving water availability without increasing fossil fuel consumption. It is of course crucial to make sure that possible impacts from RES to the local environment are minimised (e.g., no deforestation caused by biomass, no/limited land use change, etc.)

Health benefits

A reduced consumption of fossil fuels can help improving air quality by reducing emissions related to fossil fuel combustion that can lead to pulmonary diseases. The benefits of improved air quality are discussed in section 7.1.

Economic benefits

An increased uptake of RES can increase energy security, thanks to increased diversification of sources and increased national production. Employment opportunities can also be created in the RES sector (e.g. for production, installation and maintenance), and lead to possible cost savings in energy production (on a case by case level – e.g., wind energy in some areas may result cheaper than renovating/building new power plants).

Social benefits

The use of RES is helpful to provide energy to isolate locations not connected to the electricity grid. Furthermore, contributing to mitigating climate change will be beneficial for the wellbeing of citizens living in cities more exposed to sea level rise, like Alexandria, and will help avoiding relocations.

Combining RES with water desalination can also increase water availability in coastal areas, improving wellbeing and amenity value (the latter is especially important in tourism areas) – see also section 8.6 on water scarcity.

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

An increase of the RES share of gross energy consumption from 4.11 to 20 per cent is estimated to reduce CO2 emissions by about 34.5 million tonnes by 2020 – see table below. In particular, the reduction of emission is achieved through a reduction of the amount of oil and gas consumed.

Table 7-5 Amount of CO2 emissions reduced through increased RES uptake

	Quantitative benefits: reduced fossil fuels and CO_2	Reduction in the consumption of coal/peat in 2020	Reduction in the consumption of gas in 2020	Reduction in the consumption of oil in 2020
Energy *(ktoe)*	9,789	79	2,072	7,637
CO_2 eq. *(Ktonnes)*	**34,540.62**	596	15,682	18,263

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

Assuming a CO2 value ranging from EUR 39 and EUR 56 per tonne in 2020, the reduced emission from CO2 estimated above will represent a saving of between EUR 1.3 and 1.9 billion.

For the purpose of comparing the results to current money values, if the RES target were to be met today the benefits from reduced emissions will correspond to EUR 0.6 to 1.1 billion in 2010 values.

Table 7-6 Value of CO2 reduced emissions – avoided emission in 2020 and carbon values for 2010 and 2020

Reduced amount of CO_2 emissions if target met in 2020	CO_2 value in 2010	**CO_2 value in 2020**	Monetary benefit (2010 values)	**Monetary benefit (2020 values)**
Tonnes CO_2	€/tonne CO_2	**€/tonne CO_2**	€	**€**
34,540,620	17.2	**39**	594,098,662	**1,347,084,175**
34,540,620	32	**56**	1,105,299,836	**1,934,274,713**

7.3 Benefits from adapting to climate change

7.3.1 Introduction to the approach taken

This section identifies benefits from adapting to climate change. This section primarily synthesises existing research, but has supplemented this material where data availability allows.

The overall objective is to identify potential impacts from climate change, before identifying measures – known as adaptation – that may be expected to reduce these impacts, and so provide benefits. The emphasis is on climate change impacts that are likely to be detrimental – rather than beneficial - to human well-being.

It should be noted that many of the benefits identified and assessed in this report for other parameters, are common to this section. For example, water resources may be further threatened under climate change futures. In this case, measures that alleviate pressure on water resources are also likely to reduce climate change-induced water resource pressure. However, since climate change exacerbates the pressure, it is implied that to fully respond to the pressure, additional economic resources will be needed.
Adaptation can be defined as adjustment in natural or human systems in response to actual or expected climatic change or its effects. The purpose of the adjustment is to reduce harm- or risk of harm- or to exploit beneficial opportunities associated with climate change. Various types of adaptation can be distinguished, including anticipatory (before impacts are observed) and reactive (after impacts have been felt) adaptation, private and public adaptation, and autonomous (action from individuals, households, businesses and communities) and planned (the result of deliberate policy decisions) adaptation. In most circumstances, anticipatory planned adaptations will incur lower long-term costs and be more effective than reactive adaptations.

Adaptation measures are practical initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects, such as raising river or coastal dikes moving human settlements out of flood plains, the substitution of more temperature-shock resistant plants for sensitive ones, etc.

Adaptation benefits are the avoided damage costs or the accrued benefits following the adoption and implementation of adaptation measures. One can distinguish between potential impacts and residual impacts. Potential impacts are all impacts that may occur given a projected change in climate, without considering adaptation. Residual impacts are the impacts of climate change that would occur after adaptation.

Different countries and systems have different adaptive capacity, i.e. a different ability to adjust to climate change or to cope with the consequences. Adaptive capacity is often assumed to relate closely with: level of economic development (GDP/capita); availability of technologies, infrastructure, institutions and education.

Vulnerability depends on climate change exposure, sensitivity, and adaptive capacity.

7.3.2 Overview of key climate change impacts that are expected to affect the country

Egypt is considered one of the most vulnerable countries to the potential impacts and risks of climate change, with a vulnerability of all sectors of development and a low resilience of the majority of stakeholders. The sectors of water resources, agricultural resources and food security, coastal resources, tourism, and health are all highly vulnerable with serious socioeconomic implications (EEAA, 2010b).

The general climate of Egypt is dry, hot, and desert, with a mild winter season with rain over the coastal areas, and a hot and dry summer season. Data collected by the Egyptian Meteorological Authority and local universities for the period 1961- 2000 indicate that there is a general trend towards warming of the air temperature, with increases in the number of hazy days, the misty days, turbidity of the atmosphere, frequency of sand storms and hot days. (EEAA, 2010b)

Observed changes in climate parameters for the period 1961-2000 includes the following: the mean atmospheric pressure is increasing by + 0.026 hPa/year; the mean air temperature has a positive trend of + 0.017°C /decade, with mean maximum and minimum temperature increasing by + 0.34°C /decade and + 0.31°C /decade respectively; the mean annual relative humidity of air is increasing by + 0.18% /year (El-Shahawy, 2007).

The main climate change challenges facing Egypt, which can affect energy, industry, security and the national economy, as well as the national environment and the well being of the population, are related to the effects of sea-level rise, lack of water resources, decrease of agricultural productivity and other effects on tourism, health and infrastructure (EEAA< 2010b). These effects are closely interrelated. For the purpose of this report, we clustered them into 3 main issues which appeared particularly relevant in Egypt: temperature rise, sea level rise and water scarcity. There are clearly several overlaps between them in term of impacts and adaptation options.

Temperature rise

Temperature increases can have damaging effects to human health and biodiversity, and affect economic activities, particularly those related to agriculture. Climate change studies predict a reduction in the productivity of two major crops in Egypt: wheat and maize, by 15 per cent and 19 per cent respectively by 2050. It should be noted this would be due not only to temperature rise, but also to the combined effect of crop-water stress, pests and disease, and the inundation and salinisation of 12-15 per cent of fertile land in the Nile Delta as a result of seal level rise and salt water intrusion (see above). Moreover, projected temperature rises are likely to increase crop-water requirements thereby directly decreasing crop water use efficiency and increase irrigation demands of the agriculture sector (Cabinet of Ministries et al, 2010). Crop water requirements of the important strategic crops in Egypt are expected to increase by a range of 6 to 16 per cent by 2100 (EEAA, 2010b). Temperature rise will also have negative impacts on the marginal agriculture and increased desertification rates. Additionally, temperature increases are expected to have adverse effects on livestock and fish production and lead to bleach coral reefs (EEAA, 2009). In general, increasing frequencies and severity of extreme events are also expected to negatively impact the archaeological heritage in Egypt.

Sea level rise

The coastal zones in Egypt extend for over 3,500 km in length along the Mediterranean and Red Sea shore. The Mediterranean shoreline is the most vulnerable to sea level rise due to its relative low elevation compared to the land around it. The Delta and its north coast hosts several main towns and cities such as Alexandria, Port Said, Damietta and Rosetta, hosting several million of population, and large investment in industrial, touristic and agricultural activities as well as infrastructures. Coastal resources are expected to suffer direct impacts through sea level rise and inundation of low elevation areas, as well as indirect impacts such as salt water intrusion and contamination of ground water resources. These impacts are expected to lead to the immigration of 6 to 7 million people from the Nile Delta. In addition, sea level rise on the low elevation Mediterranean coast will lead to increased coastal erosion, leading to losses of beaches, including important areas for tourism and recreation.

Water Resource Availability/ Scarcity

As noted in chapter 8.6 total water resources in Egypt amount to about 70 billion m3/year,. The river Nile is the main source of freshwater in Egypt, providing 55.5 billion m3/year, while other sources include groundwater aquifers and rainfall. Furthermore, in order to cover the deficit with water demand, recycling of some waste water is carried out, especially for agriculture purpose, and a limited amount of desalination is also taking place in coastal areas. The 2008 Egypt State of the Environment (EEAA, 2009) point out the following threats to water resources related to climate change:

- Change in amounts, places and patterns of rainfall; some studies indicate a divergence in periods of rainfall with increase in precipitation rate, leading to increase floods and droughts (EEAA, 2009); the possibility of a 50 per cent reduction of rainfall on Egypt's Mediterranean coast is envisaged (EEAA, 2010b)
- Vulnerability of the river Nile, e.g. to hypersensitivity to Ethiopian rain, sensitivity to temperature increase in equatorial lakes and Bahr El Ghazal, etc. (EEAA, 2010b). Some studies show that Nile flow may decrease by approximately 60% (EEAA, 2009);
- Saltiness of coastal aquifers due to the increase in seawater intrusion.

Furthermore, these effects would be further exacerbated by population growth. It is estimated that, even without considering climate change impacts, the annual per capita share of water demand could decrease to 350m3 by 2040 (EEAA, 2010b).
The issues, potential improvements and benefits related to decreased water scarcity are described in more detail in chapter 8.6 above.

7.3.3 Potential environmental improvements

No assessment has been conducted so far on the potential improvements and benefits associated to adaptation to climate change. The Egyptian government, however, identified a number of adaptation initiatives that can help reducing the impacts of climate change (Cabinet of Ministries et al, 2010).

For agriculture, the most important adaptation measures being considered include changing sowing dates and cultivars; improving surface irrigation system efficiencies and applying deficit irrigation; and improving the current low productivity cattle and buffalo's breeds. Further studies on the impacts, vulnerability, and adaptation to climate change are still needed in the agriculture sector in order to be able to develop an effective adaptation strategy for the sector.

For coastal zones, necessary adaptation policies entail changes in land use; integrated coastal zones management, and proactive planning for protecting coastal zones.

For water scarcity, different ideas considered for adaptation fall within the management of water storage capacities; improving irrigation and draining systems; developing new water resources; as well as a number of soft interventions.

7.3.4 Qualitative assessment of the benefits of reducing the impacts of climate change

Environmental benefits

Climate change can have several negative impacts on biodiversity. Most notably, coral reefs are among the most sensitive ecosystems to climate change. 15 per cent of the Egyptian coral reefs in the Red Sea have been lost due to the warming of the ocean surface, and it is expected that climate change will further contribute to coral reef degradation, along with current damaging human activities (such as over-fishing, pollution, development in coastal areas). Adaptation measures, such as the expansion and improved management of protected marine areas and integrated coastal zone management can help reducing the loss of this important ecosystem. For further biodiversity benefits see chapter 6.2. Additional information on coral reefs are provided in the dedicated case study in chapter 8.

Health benefits

Adaptation to climate change can help reduce the negative effects of temperature rise and water scarcity on health, which in Egypt can be substantial, and include: spread of common vector, borne diseases such as malaria and dengue; as well as other major killers such as malnutrition, diarrhoea, cardiovascular diseases, respiratory diseases, and cancers; health effects resulting from water shortage, high temperature, humidity and the increasing intensity of heat and cold waves; and increasing in mortality rate among children and the old due to high temperature (EEAA, 2009).

Economic benefits

Adaptation to the effects of increased temperature, sea level rise and water scarcity can help reduce significant economic losses related to climate change, which are likely to affect in particular the poor. These include in particular losses in the agriculture sector, due to the decrease in the productivity of agricultural crops and livestock and fishery, soil erosion and water scarcity. The tourism sectors is also very likely to benefit from adaptation, as otherwise significant losses can be incurred due to the bleaching of coral reefs (an important tourism attraction), deterioration of the cultural monuments at the high temperature and variable weather conditions, decreased numbers of safe beaches (due to coastal erosion) and increase water scarcity. These effects will lead not only to economic losses, but likely also to increased unemployment on the sectors most hit by climate change.

Furthermore, economic opportunities from adaptation (and also mitigation) can be offered by investment in Clean Development Mechanism (CDM), aiming at implement projects reducing GHG emissions from different sectors such as industry, waste recycling, transport, and afforestation to absorb GHG. These projects can contribute to achieving sustainable development goals, create job opportunities, and produce addition al financial return from selling carbon reduction certificates (EEAA, 2010b).

Social benefits

Adaptation to climate change can bring significant benefits to the population, especially to the poor. The quality of life can be generally improved thanks to reduced environmental, economic and health impacts mentioned above. Adaptation measures can also help maintaining important public infrastructures in better status. Furthermore, adaptation can help reducing the displacement of several people, as climate change is expected to cause the immigration of 6 to 7 million people from the Nile Delta.

8 CASE STUDY: CORAL REEFS IN EGYPT

8.1 Overview of current conditions

In Egypt, coral reefs extend along most of the entire shoreline of the southern part of Sinai, particularly at Ras Antur and the area between Ras Nasrani and Ras Mohamed. In the Red Sea area, important reefs are around Hurghada and near Gebal Elba at the extreme southern border of Egypt (EEAA, 2010b). There is no official estimate of the area of coral reefs in Egypt, but it is estimated that they cover an area of over 4,000 km2 (Cesar, 2003)

Coral reefs represent some of the most biologically diverse ecosystems in Egypt, providing critical habitat to approximately 25 per cent of marine species. A total of 209 hard coral species and approximately 120-125 soft coral species have been recorded (Cesar, 2003). The Egyptian red Sea also hosts a total of 325 fish reef fish, of which 17 per cent are endemic. In addition, these ecosystems provide economic benefits through tourism and fisheries. However, human activities, including development in coastal areas, over-fishing, and pollution have contributed to a global loss of over 10 per cent of these valuable ecosystems. An additional 15 per cent have been lost due to warming of the surface ocean, and it is expected that climate change will further contribute to coral reef degradation in the decades ahead (EEAA, 2010b).

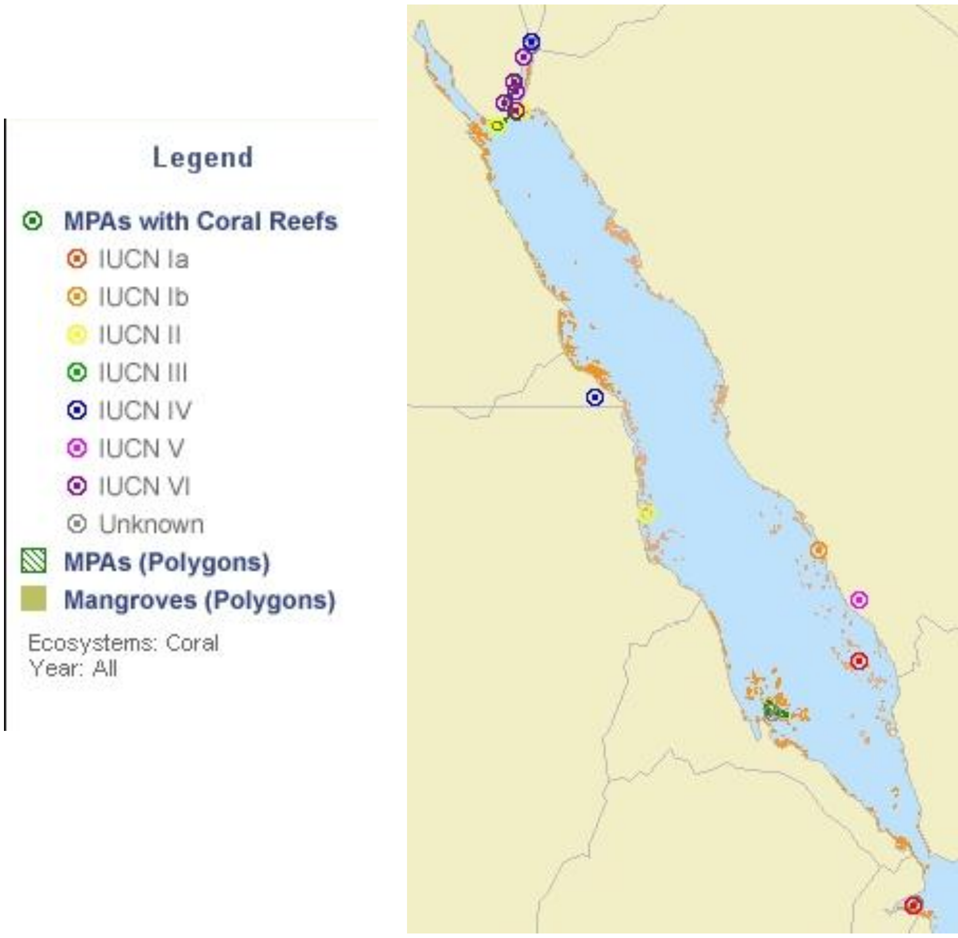
In the Middle East over 60 per cent of reefs are considered threatened, although the percentage under pressure is lower in the Red Sea than in other areas (e.g. the Persian Gulf) (WRI, 2011).

Coral reefs status in Egypt has been monitored since 2001 in more than 120 sites in the Red Sea and Gulf of Aqba. The studies indicated that coral reefs status inside protected areas is better than elsewhere. In addition, sites, which are far away from human activities, have witnessed increase in coral reefs (14 per cent) compared with areas with human activities (5-7 per cent). In some of the northern areas that attract considerable number of divers, coral coverage showed a decrease (4– 5 per cent). (EEAA, 2009)

Protected areas

About 50 per cent of Egypt's reefs are inside Marine protected Areas (MPAs). These MPAs are considered at least partially effective in protecting the reefs, and have likely played an important role in reducing the impact of the burgeoning tourism industry over extensive areas of the Egyptian coast (WRI, 2011). A map of the location of the reefs and of the MPAs along the Red Sea is provided below.

Figure 8-1 Egypt coral reefs and protected areas



Source: Reefbase at http://reefgis.reefbase.org/

An overview of key protected areas (up to 2003) including coral reefs is shown in the table below, and the box underneath provides a brief description. These areas include major tourist destination and encompass extensive and diverse coral reefs and associated fauna. They are also important sea turtle and seabird nesting or foraging habitats. Most of them surround the Sinai Peninsula and the Gabel Elba conservation area between Egypt and Sudan. Several smaller protected areas which include coral reefs have also been proposed to the government.

Table 8-1 Protected areas including coral reefs (up to 2003)

NAME	YEAR	TYPE	IUCN CAT	AREA SIZE (km^2)
Abu Galum	1992	Managed Resource Protected Area	VI	500
Dahab	1992	Protected Coastline	VI	75
Gabel Elba	1986	Conservation Area	IV	4800
Nabq	1992	Managed Resource Protected Area	VI	600
Ras Mohammed	1983	National Park	II	460
Sharm-el Sheikh	1992	Protected Coastline	VI	75
Taba Coast	1996	Protected Coastline	VI	735
Tiran-Senafir	1983	National Park	II	371
Wadi El Gamal	2003	n/a	n/a	4,000

Source: Based on Spalding et al, 2001,and Pilcher and Abou Zaid, 2000

Box 8.1 Coral reefs and key protected areas

Examples of key MPAs including coral reefs:

- Ras Mohammed National Park: Established in 1983, the Park occupies part of the southern portion of the Sinai Peninsula.
- Naqb: established in 1992, it occupies about 600 km² of the southern Sinai Peninsula, encompassing a number of marine and terrestrial ecosystems. Threats include recreational diving-related damage and uncontrolled output from a shrimp farm.
- Abu Galum: Established in 1992, the site occupies part of the Sinai Peninsula extending into the Gulf of Aqaba, and covers an area of roughly 500 km ². The coral reefs form one of the main diving attractions in the region.
- Elba: The Elba protectorate is the largest in Egypt, encompassing 35,000 km² of the Doaib, Gabel Elba and Abraq regions. It is home to an extensive fringing reefs along the mainland and offshore islands. The main threats are extensive fishing activities.

De facto and planned MPAs (as of 2000):

- Giftun Islands and Straits of Gubal: This MPA has been proposed to the Egyptian government based on the well-developed and diverse coral reefs and rich reef-associated fauna. Current threats are recreation pressure, anchor damage and fishing.
- Safaga Island: Small patches of coral reef surround the mangrove-lined island, which is also a seabird nesting site. Current threats are shipping and a small-scale fishery.
- Sharm al-Lulu: This is a small bay lined with coral on both sides. Threats to the area include tourism.
- Dedalus Island: The island lies some 40 km from shore, and is mostly impacted through recreational diving and anchor damage.
- Zabareged Island: This is a small sea turtle nesting island surrounded by coral reefs, threatened by recreational diving and anchor damage.
- Brother Islands: The coralline islands support extensive and well-developed coral reefs, on which extensive diving takes place.
- Al-Qusair Reef Complex: The site includes an extensive and complex submerged offshore reef with diverse reef-associate fauna. Threats have been identified as anchor damage, coral collection and diving-related damage.

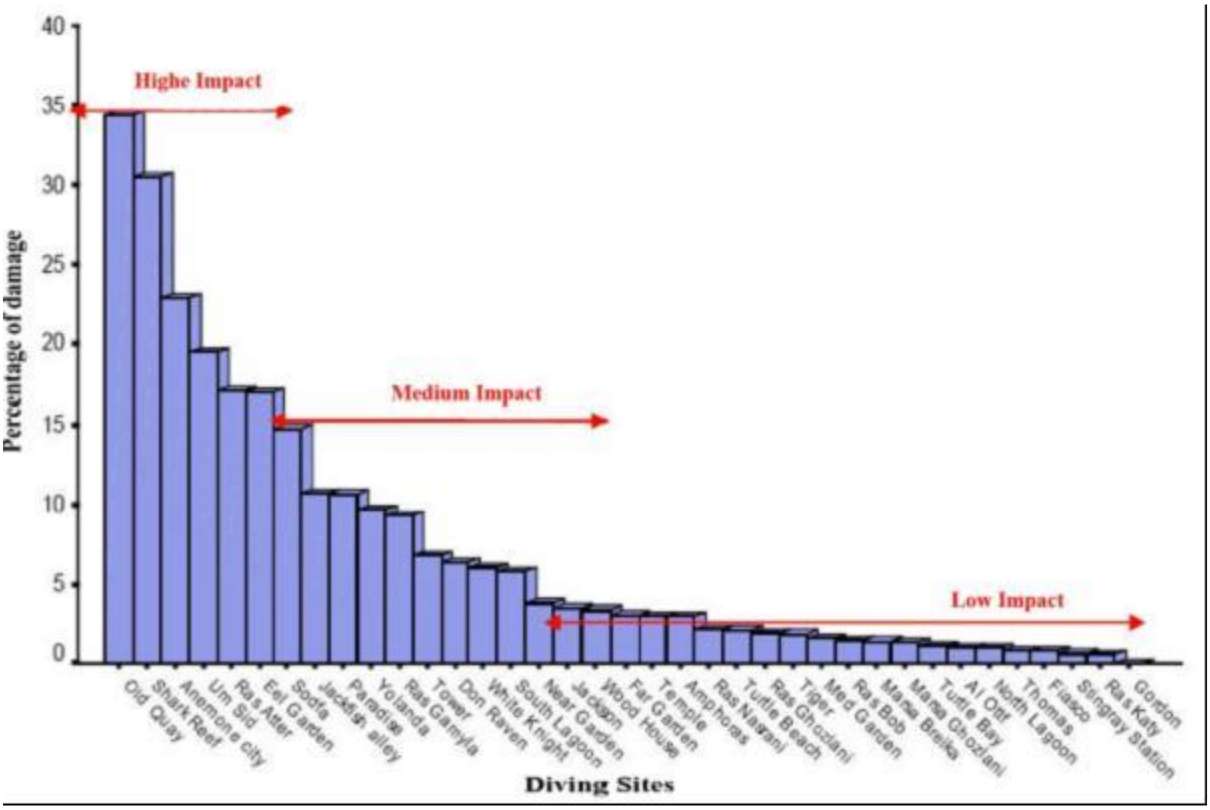
Source: Pilcher and Abou Zaid, 2000

Threats

A global survey by the World Resource Institute estimated that 61 per cent of the coral reefs of Egypt were seriously at risk from human impacts (Bryant et al, 2008)

Tourism: Tourism is both an opportunity and a threat to coral reef. Visitor numbers in diving areas have ranged from 10,000 to 60,000 divers annually. Abou Zaid (2002) suggests a number of 10,000 dives per year as carrying capacity. This is higher than the number of 4-6,000 that Dixon et al. (1993) established for Bonaire in the Caribbean but lower than the 10-15,000 dives per site established under the Coral Monitoring Program of the PSU in Hurghada (IRG, 2003), which is used by EEAA as a guideline if coral health and sustainability. The table below illustrate the EEAAA estimate of the impact of tourism in various diving areas (EEAA 2010a). Direct damage is caused by tourist use of the reefs (trampling and divers breaking corals), damage from recreational boat anchoring and boat grounding, and through tourism facilities (sewage run-off, sedimentation, and coastal alteration). A variety of smaller threats occur from other anthropogenic impacts, such as over-fishing and destructive fishing, ship groundings, and pollution (Cesar, 2003).

Figure 8-2 Tourism impact on diving sites



Source: EEAA, 2010a

Shipping: The Suez Canal brings with it a large amount of international trade to be transported through the Red Sea. As a consequence, important coral reef ecosystems are under threat from ship groundings. Also, cruise ships and dive boats in reef areas have caused major damage (Cesar, 2003).

Overfishing: There are reports of some unsustainable fishing practices along the Egyptian Red Sea coastline, including the use of closed mesh nets and even blast fishing. Shark finning and sea cucumber collection have appeared as major additional threats to Egyptian reefs. Removal of sea cucumbers could lead to increases in algae and bacteria in coral reef ecosystems with possibly disastrous consequences (Cesar, 2003).

Development: Coral reefs in Egypt are under threat from high siltation and sedimentation rates due to poorly planned and implemented construction of buildings, especially hotels and resorts facilities associated with the tourism industry. Though this seems particularly a problem of past construction, the impacts of these activities still continue (Cesar, 2003). In the port of Jeddah, for instance, extensive areas of shallow water have been filled in for industrial, urban, and tourism infrastructure, resulting in direct impacts (such as loss of habitat and ecosystems) as well as indirect impacts (such as alteration to sediment transport and current patterns) over wide areas (WRI, 2011).

Untreated sewage: Sewage and phosphate ore washing are the main sources of nutrient enrichment in the Egyptian Red Sea (Pilcher and Abou Zaid 2000). Sewage, high in nitrogen and phosphorous causes primary production in the marine environment. Algal blooms then subsequently die off, reducing the amount of oxygen in the water causing eutrophication and threatening marine organisms.

Climate change: Corals are particularly sensitive to elevated sea surface temperatures, which can lead to coral bleaching The Red Sea appears to have suffered less from coral bleaching than other major reef region. However, thermal stress and ocean acidification in the Middle-East region are projected to increase threat levels to nearly 90 per cent by 2030, while by 2050 these climate change impacts, combined with current local impacts, will push all reefs to threatened status, with 65 per cent at high, very high, or critical risk (WRI, 2011).

8.2 Potential environmental improvements

A possible target for coral reefs in Egypt is that no further degradation takes place in the future, and coral reefs area are managed in a sustainable way.

Most of the quantitative and monetary estimates provided below build on the study by Cesar (2003) for USAID. The study assessed a baseline for the value of coral reefs in 2000, and assessed the potential benefits from sustainable management by 2050. The benefits stemming from improved environmental improvement where therefore calculated across 50 years, by comparing a 'business as usual' scenario to a 'towards sustainability scenario'. The approach is not dissimilar to the one used in the present study, although using a longer timeline. This, however, is reasonable for some ecosystems like coral reefs, as the improvements will require a relatively long time to become visible (e.g. avoided reduction in the size of the reefs, avoided bleaching) and the benefits will be significant for future generations. The results therefore appear relevant for this study, and the key findings have been noted in the following chapters.

The baseline recreational value added of coral reefs in Egypt in 2000 was estimated at about EUR 121 million (US$ 11.6 million). This reflected the actual expenditure related to snorkelling and diving experiences, indirect expenditures such as hotel and travel costs, and used a multiplier effect of 1.4 for the Egyptian economy. It also included the welfare gain of visitors (consumer surplus) from data available from one single site (Marsa Alam). No data were calculated for bequest values, nor for existence values for non consumer surplus beside Marsa Alam, therefore this estimate should be seen as a severe underestimation.

Table 8-2 Recreational value added of coral reefs in Egypt in 2000 (in million €)

Recreational value (2000)	Consumer surplus (CS)	Value Added (VA) of direct expenditure	VA of indirect expenditure	Multiplier effect*	Total VA with CS	Total VA without CS
Egyptians	0.0	0.9	0.4	0.5	1.8	1.8
Foreigners	23.2	26.2	32.5	23.4	105.1	81.9
Live abroad	2.2	4.6	4.0	3.5	14.1	11.9
Subtotal	25.4	31.7	36.7	27.3	**121.0**	**95.7**

Source: Based on Cesar, 2003

Beside tourism revenues, the value of other reef-related goods and services were estimated for the 2000 baseline year. These included the value of fishery, research, bioprospecting and biodiversity.

Table 8-3 Value added of reef-related goods/services in baseline 2000 (in million EUR)

	Sharm el Sheikh	Hurghada	Marsa Alam	Egypt-overall
Fisheries	0.0	2.2	4.6	15.4
Coastal protection	unknown	unknown	unknown	unknown
Research	0.2	0.1	0.02	0.3
Bioprospecting	0.8	0.8	0.8	3.8
Biodiversity	1.1	0.3	0.1	1.5

Source: Based on Cesar, 2003

The value of coastal protection was not calculated, given lack of data availability. As a reference point, it should be noted that the cost of building an artificial barrier replacing a damaged reefs has been estimated at about EUR 9.1 million per kilometre (Barrania, 2007) - see below.

8.3 Qualitative, quantitative and monetary assessment

Environmental benefits

Coral reefs provide a large number of ecosystem services. These include: shoreline protection, build-up of land, promoting growth of mangroves and seaweed and the generation of coral sand; biotic services (within ecosystem) like the maintenance of habitats, biodiversity and a genetic library, the regulation of ecosystem processes and functions, biological maintenance of resilience; biotic services (between ecosystems) like biological support through 'mobile links', and the export of organic production etc. to pelagic food webs; and bio-geo-chemical services like nitrogen fixation, CO_2/Ca budget control, waste assimilation

Coral reefs play major role in protecting shoreline from erosion. Even though the average tidal in Egypt is only 25 cm, coral reefs can protect Egypt's Red sea shore from erosive powers of storms and wave action. Under normal conditions reefs are self-repairing, natural breakwaters. However, if reefs become severely degraded, their ability to recover is markedly reduced and may have to be replaced using expensive engineering projects (Barrania, 2007). It has been estimated that it costs about EUR 9.1 million per kilometre (US$ 12.5 million) to build an artificial barrier replacing a damaged reefs (Barrania, 2007).

According to the World Resource Institute's estimates (WWF, undated) the costs of destroying 1 km of coral reefs ranges between US$137,000-1,200,000 over a 25-year period. As a simple estimate, and assuming that the costs are identical across time (no discounting), we could consider that the cost of destroying 1km of coral reef could be about EUR 4,000-36,000 per year (US$5,500-48,000) . The Institute also estimated that a properly managed coral reef can yield an average of 15 tonnes of fish and other seafood per square kilometre each year. Applying this figure to the 4,000 km2 (estimated) Egyptian coral reef will suggest that the reef could yield about 60,000 tonnes of fish and other seafood.

Health benefits

Natural substances produced by coral reefs are used in treating many diseases such as cancer (EEAA, 2009)

Economic and social benefits

More than 2 million tourists visited the Egyptian Red Sea, many of them to the Sharm el-Sheikh and Hurghada area. The percentage of direct users of the reef (divers and snorkelers) varies from 30 to 100 per cent depending on the location. The portion of the economic value of the reef related to divers and snorkelers is around 85 per cent, while fisheries contributes to about 11 per cent and the rest is related to the other coral reef functions (Cesar, 2003). According to the Egyptian Environmental Agency (EEAA, 2009), incomes generated from coral reefs and mangroves are estimated at about EUR 10 million per km2 (80 million LE).

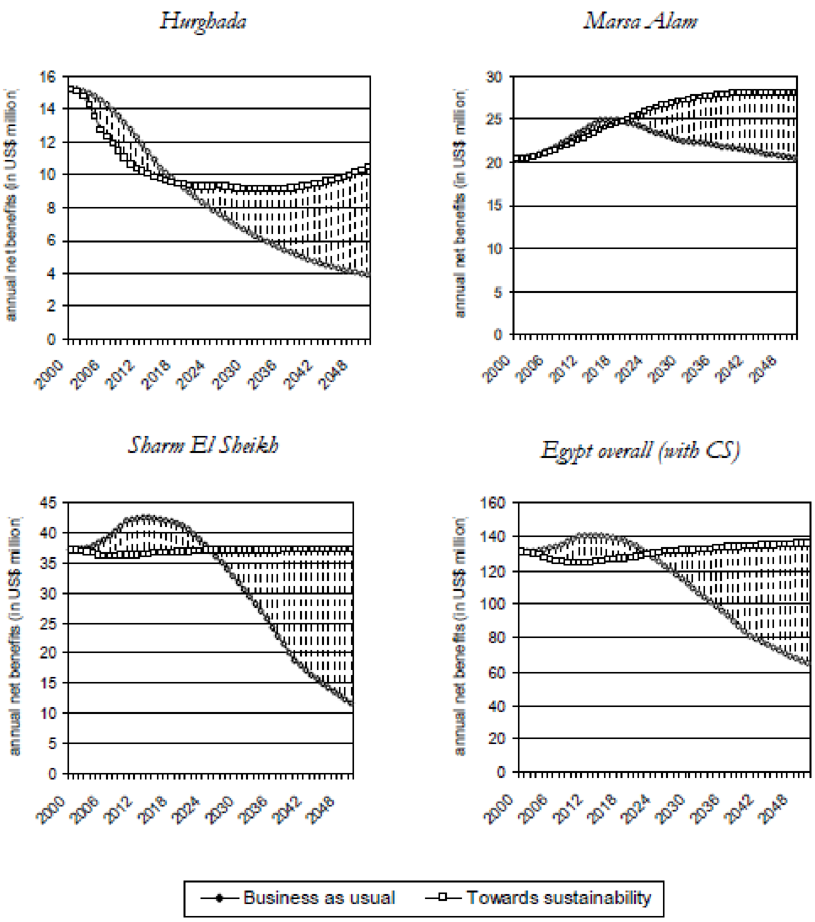
World Bank estimates (2002) based on a study by Huybers and Bennet (2000) on WTP for environmental quality indicate that tourism losses due to environmental degradation at the Red Sea are of the order of 0.2-0.3 per cent of GDP.

The above mentioned study by Cesar (2003) estimated the economic value of a well preserved coral reef, by comparing a business as usual scenario (the baseline described above) with a 'sustainable' scenario up to 2050 in three important marine sites and in the overall country. The assessment took into account benefits for tourism, fisheries, research, biodiversity and bio-prospecting, on the basis of available market-based data.

The analysis reveals that, in the long run, the baseline scenario would lead to high numbers of reef-related tourists, but low value added per tourist. The sustainability scenario instead is geared towards increasing the value added per person while reducing the overall size of the reef-related tourist population in line with carrying capacity constraints. The value added change over time in line with changes in coral cover and the overall states of the reefs. With higher number of tourists the state of the reefs deteriorates.

The change in annual total benefits over time for the two scenarios is shown in the figure below. It is apparent that the benefits of continuing with the 'business as usual' practices will be higher in the short term, but will decrease steeply in the long run – due to the deterioration of the reefs. In the year 2050 this will cause the benefits of the reef to decrease to half of its current value. Sustainable management will instead allow the current benefits provided by the reefs to remain constant, or even slightly increase, in the long term. Results are shown for the three study areas and for the overall country.

Figure 8-3 Changes in annual benefits over time



Source: Cesar, 2003

The annual benefits were calculated as net present values (NPV), using different discount rates (0, 5, 10 and 15 per cent). The results are presented in the table below.

Table 8-4 Net present value for baseline and sustainability scenario (million EUR)

	Hurghada	**Marsa Alam**	**Sharm el Sheikh**	**Egypt-overall**
	million €	million €	million €	million €
	Business as usual (baseline) scenario			
discount rate 0%	477	1,247	1,746	6,226
discount rate 5%	293	651	1,020	3,536
discount rate 10%	152	260	456	1,562
discount rate 15%	108	184	325	1,106
	Sustainability scenario			
discount rate 0%	564	1,410	1,378	7,235
discount rate 5%	315	705	1,074	3,753
discount rate 10%	152	260	434	1,519
discount rate 15%	108	184	304	1,063
	Net benefit of management			

	Hurghada	Marsa Alam	Sharm el Sheikh	Egypt-overall
	million €	million €	million €	million €
discount rate 0%	65	163	206	**1,009**
discount rate 5%	22	54	54	**217**
discount rate 10%	0	0	-22	**-43**
discount rate 15%	0	0	-22	**-43**

Source: Based on Cesar, 2003. Exchange rate US$/€ = 1.08 (year 2000)

Notably, the net benefit of sustainable management with no discounting is estimated at about EUR 1 billion (US$930 million). Using a 5 per cent discount rate, the net benefits would be about EUR 217 million. For increasing levels of time preference, the difference between the two scenarios becomes smaller and eventually negative. These results are strictly related to the nature of sustainability: the shorter is the time horizon and the more the discounting (i.e. the less the value attached to future benefits), the larger the incentive for unsustainability. A 5 per cent discount rate would arguably be a more reasonable assumption.

The study notes that the net benefits of sustainability are likely much higher in reality, as the approach used very conservative estimates. For instance, additional negative impacts of the baseline scenario, such as rehabilitation costs needed to mitigate the consequence of unsustainable exploitation of the reef, have not been taken into account, as these are very difficult to predict. These additional costs could significantly increase the difference between the two scenarios. Furthermore, as noted above, the length of the time horizon has also an effect on the net present value of the benefits. This study looked at a time horizon of about 2 generations (40 years). If the benefits of three or more generations were taken into account, the net benefits would have been even larger.

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