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DEVELOPMENT AND CLIMATE CHANGE IN EGYPT: FOCUS ON COASTAL RESOURCES AND THE NILE

by

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FOREWORD

This document is an output from the OECD Development and Climate Change project, an activity being jointly overseen by the Working Party on Global and Structural Policies (WPGSP) of the Environment Directorate, and the Network on Environment and Development Co-operation (Environet) of the Development Co-operation Directorate. The overall objective of the project is to provide guidance on how to mainstream responses to climate change within economic development planning and assistance policies, with natural resource management as an overarching theme. Insights from the work are therefore expected to have implications for the development assistance community in OECD countries, and national and regional planners in developing countries.

This document has been authored by Shardul Agrawala and Annett Moehner, drawing upon four primary consultant inputs that were commissioned for this country study: "Vulnerability and Adaptation of Egypt to Global Climate Change" by Mohamed El Raey (University of Alexandria, Egypt); "Climate Change and the River Nile" by Declan Conway (University of East Anglia, Norwich); "Review of Development Plans, Strategies, Assistance Portfolios, and Select Projects Potentially Relevant to Climate Change in Egypt" by Maarten van Aalst of Utrecht University, The Netherlands; and "Analysis of GCM Scenarios and Ranking of Principal Climate Impacts and Vulnerabilities in Egypt" by Stratus Consulting, Boulder, USA (Marca Hagenstad and Joel Smith).

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EXECUTIVE SUMMARY

This report presents the integrated case study for Egypt carried out under an OECD project on Development and Climate Change. The report is structured around a three-tiered framework. First, recent climate trends and climate change scenarios for Egypt are assessed and key sectoral impacts are identified and ranked along multiple indicators to establish priorities for adaptation. Second, donor portfolios are analyzed to examine the proportion of development assistance activities affected by climate risks. A desk analysis of donor strategies and project documents as well as national plans is conducted to assess the degree of attention to climate change concerns in development planning and assistance. Third, an in-depth analysis is conducted for coastal zones as well as water resource management on the Nile.

Given that Egypt's population, land-use and agriculture, as well as its economic activity are all constrained along a narrow T-shaped strip of land along the Nile and the deltaic coast, it is extremely vulnerable to any adverse impacts on its coastal zones and water availability from the Nile. Climate change poses significant risks through sea level rise on the costal zone, which is already subsiding at approximately 3-5mm/year around the Nile delta. Analyses of current climatic trends reveal a warming trend in recent decades with country averaged mean temperature increases of 1.4°C and 2.5°C projected by 2050 and 2100. Higher temperatures in the semi-arid regions with resulting evaporative losses coupled with increasing water demands will likely result in decreasing water availability from the Nile. There is also some possibility of significant decline in Nile streamflow under climate change as a result of changes in precipitation, although the studies reviewed in this report offer conflicting results. Coastal zone and water resource impacts have also serious implications for agriculture: sea level rise will adversely impact prime agricultural land in the Nile delta through inundation and salinization, while the intensive irrigated agriculture upstream would suffer from any reductions in Nile water availability. Therefore, climate change is a serious development concern for Egypt.

Egypt receives around $1.5 billion dollars of Official Development Assistance (ODA) annually. Analysis of donor portfolios for the country using the OECD-World Bank Creditor Reporting System (CRS) database reveals that roughly 33% of development assistance (by aid amount) or 25% of donor projects (by number) are in sectors potentially affected by climate change risks. These numbers are only indicative, and the reader is referred to the main report for a more nuanced interpretation. In general, donor strategies do not mention climate change – although several stress the concern for water scarcity in Egypt. Some donor strategies and projects explicitly cater to improved water management and conservation in Egypt. While not explicitly recognizing climate change, any measures to promote efficiency of water use would be synergistic with adaptation to the additional stresses on water availability posed by climate change. In addition, there are a few donor projects on coastal zones. The absence of climate change concerns in these projects however could be a significant omission, given the local subsidence at several locations on Egypt's coast, which would exacerbate the impacts of climate change induced sea level rise and saline intrusion. Regarding climate change concerns in national planning, despite existing institutions and assessments, actual implementation of adaptation measures is faced with several obstacles, including other pressing development priorities such as increasing costs of living, loss of land productivity, as well as inefficient economic policies such as the heavy subsidies for water, which make its conservation difficult.

The in-depth analysis in this report, which focuses on Egypt's coastal zones and the Nile water resources, show that Egypt has already conducted fairly rigorous coastal zones vulnerability and impact

assessments and has already started several coastal protection activities to improve the resilience to sea-level rise. However, such actions are largely restricted to "hard" adaptation, and – relative to the magnitude of the problem – are still fairly limited in their coverage of vulnerable areas. Thus, there is both a need for greater coverage of vulnerability assessment and coastal protection activities, as well as to broaden the portfolio of responses beyond hard adaptation. In particular, there is a need to directly address several development and demographic pressures that exacerbate coastal vulnerability – particularly coastal pollution. There is also a need to better implement existing laws that reduce coastal vulnerability and the formulation of new regulations that correct distortions and other activities which might exacerbate coastal vulnerability to sea level rise.

Adaptation options for Egypt's water resources meanwhile are closely intertwined with Egypt's development choices and pathways. Any changes in water supply due to climate change over the medium term will occur alongside the certainty of increased demographic pressures (the national population is growing by 1 million every nine months) as well as the potential increases in Nile water abstractions by the upstream riparian countries. Adapting to climate change will have close resonance with adapting to water scarcity and is likely to require implementation of water demand management strategies which may require capacity building and awareness raising across institutions and society. Adaptation measures on the supply-side include ways to improve rain-harvesting techniques, increasing extraction of ground water, water recycling, desalination, and improving water transportation. In addition, regular reviewing and updating of drought responses and research into improved long-term forecasting is essential to enhance Egypt's ability to cope with prolonged drought.

This case study also highlights the importance of the trans-boundary dimension in addressing climate change adaptation, given the need for dialog and cooperation among the Nile Basin states to address both technical issues such as sharing of data, as well as more political and sensitive ones such as water allocation. The recently established Nile Basin Initiative (NBI) is a first step. If successfully implemented, such an initiative can help reconcile the water use and development priorities of all riparian countries, including their capacity to adapt to any reductions or other changes in Nile flows from climate change. However, it is too early to assess the effectiveness of the NBI, given that it has been in existence for only a few years. Nevertheless, it marks an important beginning in terms of providing a cooperative forum to reconcile the water needs, development aspirations, and climate change concerns, not only of Egypt but of all the Nile Basin countries.

LIST OF ACRONYMS

AfDB	African Development Bank
ADM	Adaptation Decision Matrix
ASE	Adaptation Strategy Evaluation
BCM	Billion Cubic Meters
CIDA	The Canadian International Development Agency
CAS	World Bank's Country Assistance Strategy
CRS	Creditor Reporting System
DAC	Development Assistance Committee
DFID	Department for International Development, UK
EEAA	Egyptian Environmental Affairs Agency
ENSO	El Niño/Southern Oscillation
EU	European Union
GCM	General Circulation Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gases
GIS	Geographic Information System
GNI	Gross National Income
GNP	Gross National Product
GOE	Government of Egypt
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
HAD	High Aswan Dam
ICZM	Integrated Coastal Zone Management
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
MoWRI	Ministry of Water Resources and Irrigation
MW	Mega Watt
NBI	Nile Basin Initiative
NGO	Non-Governmental Organization
OA	Official Aid
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
PRSP	Poverty Reduction Strategy Papers
SLR	Sea Level Rise
UN	United Nations
UNCBD	United Nations Convention on Biodiversity
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

1. Introduction

This report presents the integrated case study for Egypt for the OECD Development and Climate Change Project, an activity jointly overseen by the Working Party on Global and Structural Policies (WPGSP), and the DAC Network on Environment and Development Co-operation (Environet). The overall objective of the project is to provide guidance on how to mainstream responses to climate change within economic development planning and assistance policies, with natural resource management as an overarching theme. The Egypt case study was conducted in parallel with five other country case studies[1] in Africa, Latin America, and Asia and the Pacific.

Each case study is based upon a three-tiered framework (Agrawala and Berg 2002):

1. Review of climate trends and scenarios at the country level based upon an examination of results from seventeen recent general circulation models, as well as empirical observations and results published as part of national communications, country studies, and scientific literature. These projections are then used in conjunction with knowledge of socio-economic and sectoral variables to rank key sectoral and regional impacts on the basis of a number of parameters. The goal of this tier is to present a framework to establish priorities for adaptation.

2. Review of economic, environmental, and social plans and projects of both the government and international donors that bear upon the sectors and regions identified as being particularly vulnerable to climate change. The purpose of this analysis is to assess the degree of exposure of current development activities and projects to climate risks, as well as the degree of current attention by the government and donors to incorporating such risks in their planning. This section will review donor portfolios and projects, as well as development priorities of the Government of Egypt (GOE) to determine the degree of attention to potential risks posed by climate change on relevant sectors.

3. In-depth analyses at a thematic, sectoral, regional or project level on how to incorporate climate responses within economic development plans and projects, again with a particular focus on natural resource management. This case study focuses on the impacts of climate change and the opportunities and challenges in mainstreaming adaptation responses in the coastal zones and along the Nile – both of which are critical for natural resource management and socio-economic development for Egypt.

2. Country background

Egypt is located between 22^o to 32^o North and 24^o to 37^o East. It is bordered on the west by Libya, on the north by the Mediterranean Sea, on the south by Sudan, and on the east by the Gaza Strip, Israel and the Red Sea (Figure 1). Its coastline extends for more than 3,500 km along the Mediterranean Sea and the Red Sea coasts. The Nile delta coast, which constitutes about 300 km, hosts a number of highly populated cities such as Alexandria, Port-Said, Rosetta, and Damietta.

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[1] Bangladesh, Tanzania, Uruguay, Fiji, and Nepal

Figure 1. Map of Egypt

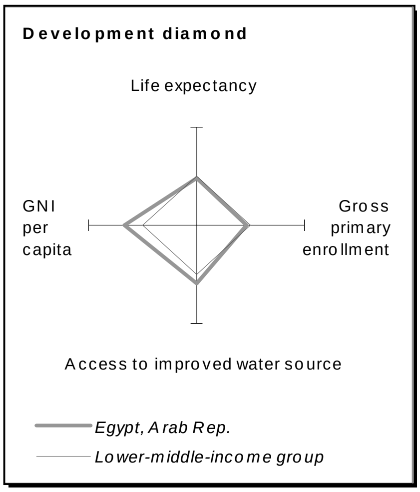
Egypt is the second most populous country in Africa. Its population is over 64 million and is growing at 1.66% per year. Cairo, the capital, has become a mega-city, with a population of 15 million (World Bank 2003). Access to clean water and sanitation appears to be good: the World Bank reports that 95% of the population has access to "improved water resources," and 98% of urban population has access to sanitation (World Bank, 2003). The per capita water availability is about 1,000 m^3 of water per year – countries are sometimes described as water stressed if per capita water availability is less than 1000 m^3.

The per capita income of Egypt is about US$1,500 (World Bank 2003)[2] and GDP is growing at about 5% per year. This ranks below average per capita income for Middle Eastern and North African countries but slightly higher than per capita income for low and middle income countries (World Bank 2002). The poorest quintile can lay claim to only 9.8% of national income while the richest quintile garners nearly 40%. Consequently, almost one-quarter of the population lives in poverty (World Bank 2002). Agriculture contributes 17% of the country's GDP and is the largest source of employment, constituting 30% of the labor force. About three-fifths of the country's agricultural production is in the low-lying delta (Strzepek et al., 1995). Changes in the flow of the Nile, which supplies irrigation water for agriculture, can have large impacts on the country's economy.

Figure 2 provides an indication of how Egypt compares to other lower-middle income countries in terms of four key indices of development.

2 GNI is measured using the Atlas conversion factor, which aims to reduce the impact of exchange rate fluctuations in cross-country comparison of national incomes. The Atlas conversion factor for any year is the average of a country's exchange rate (or alternative conversion factor) for that year and its exchange rates for the two preceding years, adjusted for the difference between the rate of inflation in the country, and through 2000, that in the G-5 countries (France, Germany, Japan, the United Kingdom, and the United States). For 2001 onwards, these countries include the Euro Zone, Japan, the United Kingdom, and the United States. A country's inflation rate is measured by the change in its GDP deflator.

Figure 2. Development diamond for Egypt



Source: World Bank 2002

3. Climate change scenarios and synthesis of key vulnerabilities

Egypt's climate is semi-desert, characterized by hot dry summers, moderate winters, and very little rainfall. The country has areas with strong wind, especially along the Red Sea and Mediterranean coasts. Sites with an annual average wind speed of 8.0-10.0 m/sec have been identified along the Red Sea coast and about 6.0-6.5 m/sec along the Mediterranean coast. Average precipitation in the Ethiopian highlands (where much of the water in the Nile originates) is highest in July, August, and September, at 5.4 mm/day, and almost negligible between January and March.

3.1 Climate change projections

Changes in area averaged temperature and precipitation over Egypt were assessed based upon over a dozen recent GCMs using a new version of MAGICC/SCENGEN. MAGICC/SCENGEN is briefly described in Box 1. First, results for Egypt for 17 GCMs developed since 1995 were examined. Next, 8 of 17 models which best simulate the current climate were selected. The models were run with the IPCC B2 SRES scenario (Nakicenovic and Swart 2000)[3].

[3] The IPCC SRES B2 scenario assumes a world of moderate population growth and intermediate level of economic development and technological change. SCENGEN estimates a global mean temperature increase of 0.8 °C by 2030, 1.2 °C by 2050, and 2 °C by 2100 for the B2 scenario.

Box 1. A brief description of MAGICC/SCENGEN

MAGICC/SCENGEN is a coupled gas-cycle/climate model (MAGICC) that drives a spatial climate-change scenario generator (SCENGEN). MAGICC is a Simple Climate Model that computes the mean global surface air temperature and sea-level rise for particular emissions scenarios for greenhouse gases and sulphur dioxide (Raper et al., 1996). MAGICC has been the primary model used by IPCC to produce projections of future global-mean temperature and sea level rise (see Houghton et al., 2001). SCENGEN is a database that contains the results of a large number of GCM experiments. SCENGEN constructs a range of geographically-explicit climate change scenarios for the world by exploiting the results from MAGICC and a set of GCM experiments, and combining these with observed global and regional climate data sets. SCENGEN uses the scaling method of Santer et al. (1990) to produce spatial pattern of change from an extensive data base of atmosphere ocean GCM – AOGCM (atmosphere ocean general circulation models) data. Spatial patterns are "normalized" and expressed as changes per 1°C change in global-mean temperature. The greenhouse-gas and aerosol components are appropriately weighted, added, and scaled up to the actual global-mean temperature. The user can select from a number of different AOGCMs for the greenhouse-gas component. For the aerosol component there is currently only a single set of model results. This approach assumes that regional patterns of climate change will be consistent at varying levels of atmospheric greenhouse gas concentrations. The MAGICC component employs IPCC Third Assessment Report (TAR) science (Houghton et al., 2001). The SCENGEN component allows users to investigate only changes in the mean climate state in response to external forcing. It relies mainly on climate models run in the latter half of the 1990s.

Source: National Communications Support Program Workbook

The spread in temperature and precipitation projections of these 8 GCMs for various years in the future provides an estimate of the degree of agreement across various models for particular projections. More consistent projections across various models will tend to have lower scores for the standard deviation, relative to the value of the mean. The results of the MAGICC/SCENGEN analysis are shown in Table 1.

Table 1. GCM estimates of temperature and precipitation changes for Egypt[4]

Year	Temperature change (°C) mean (standard deviation)			Precipitation change (%) mean (standard deviation)		
	Annual	**DJF[5]**	**JJA[6]**	**Annual**	**DJF**	**JJA**
2030	1.0 (0.15)	0.8 (0.21)	1.1 (0.18)	-5.2 (7.93)	-8.9 (3.01)	10.7 (26.35)
2050	1.4 (0.22)	1.2 (0.30)	1.7 (0.26)	-7.6 (11.46)	-12.8 (4.35)	15.4 (38.07)
2100	2.4 (0.38)	2.1 (0.52)	2.9 (0.45)	-13.2 (19.95)	-22.3 (7.58)	26.9 (66.28)

The climate models all estimate a steady increase in temperatures for Egypt, with little inter-model variance[7]. Somewhat more warming is estimated for summer than for winter. With regard to precipitation, models tend to estimate the annual precipitation to fall: net decrease of annual precipitation in winter cancels out the net increase in summer. The changes in precipitation are not statistically significant for June, July and August as well as in terms of annual totals. Meanwhile, for December, January, and February statistically significant declines in precipitation are projected. However, since Egypt is mainly a desert and relies primarily on irrigated agriculture, precipitation over the country itself matters very little. Much more important are precipitation changes at the water sources of the Nile, which affect the vulnerability of water resources. Thus, the study also examined the climate models' projections for the source waters of the Nile, in the Ethiopian highlands and equatorial lakes region. Temperature changes there are expected to be similar, yet precipitation changes vary. In general, although the models on average show an increase in precipitation, inter-model variation is so high that it is uncertain as to predict whether annual average precipitation will increase or decrease. On average the models estimate increased precipitation in the winter months and slightly decreased precipitation in the summer months, but there is little confidence in these seasonal projections (see Table 2).

4 This analysis uses a combination of the 8 best SCENGEN models (CSI2TR96, CSM_TR98, ECH3TR95, ECH4TR98, GISSTR95, HAD2TR95, HAD3TR00, PCM_TR00) based on their predictive error for annual precipitation levels. Errors were calculated for each model, and for an average of the 17 models. Each model was ranked by its error score, which was computed using the formula 100*[(MODEL-MEAN BASELINE /OBSERVED) - 1.0]. Error scores closest to zero are optimal. The first eight models had significantly lower error scores than the remaining nine. Therefore, the latter were dropped from the analysis. The error score for an average of the 17 models was 26.7%, the error score for an average of the 8 models was 22%.

5 DJF is December, January, and February.

6 JJA is June, July, and August.

7 Note that each GCM is scaled (i.e., regional changes are expressed relative to each model's estimate of mean global temperature change). Since the GCMs have different estimates of change in global mean temperature, this overstates inter-model agreement.

Table 2. GCM estimates of temperature and precipitation changes around source waters of the Nile [8]

Year	Temperature change (°C) mean (standard deviation)			Precipitation change (%) mean (standard deviation)		
	Annual	DJF[9]	JJA[10]	Annual	DJF	JJA
2030	1.0 (0.19)	1.0 (0.22)	1.0 (0.23)	1.5 (2.37)	16.6 (18.75)	-0.5 (9.47)
2050	1.4 (0.27)	1.5 (0.32)	1.5 (0.33)	2.1 (3.43)	24.0 (27.09)	-0.7 (13.69)
2100	2.5 (0.47)	2.5 (0.56)	2.6 (0.57)	3.7 (5.97)	41.7 (47.17)	-1.2 (23.83)

For the Egypt Country Study, scenarios were examined for changes of 0°C, +2°C, and +4°C and for changes in rainfall of ±10% and ±20%. These scenarios are compatible with the SCENGEN predictions above, and thus the impacts discussed in the Country Study are relevant for the temperature and precipitation changes discussed above.

3.2 Synthesis of key vulnerabilities

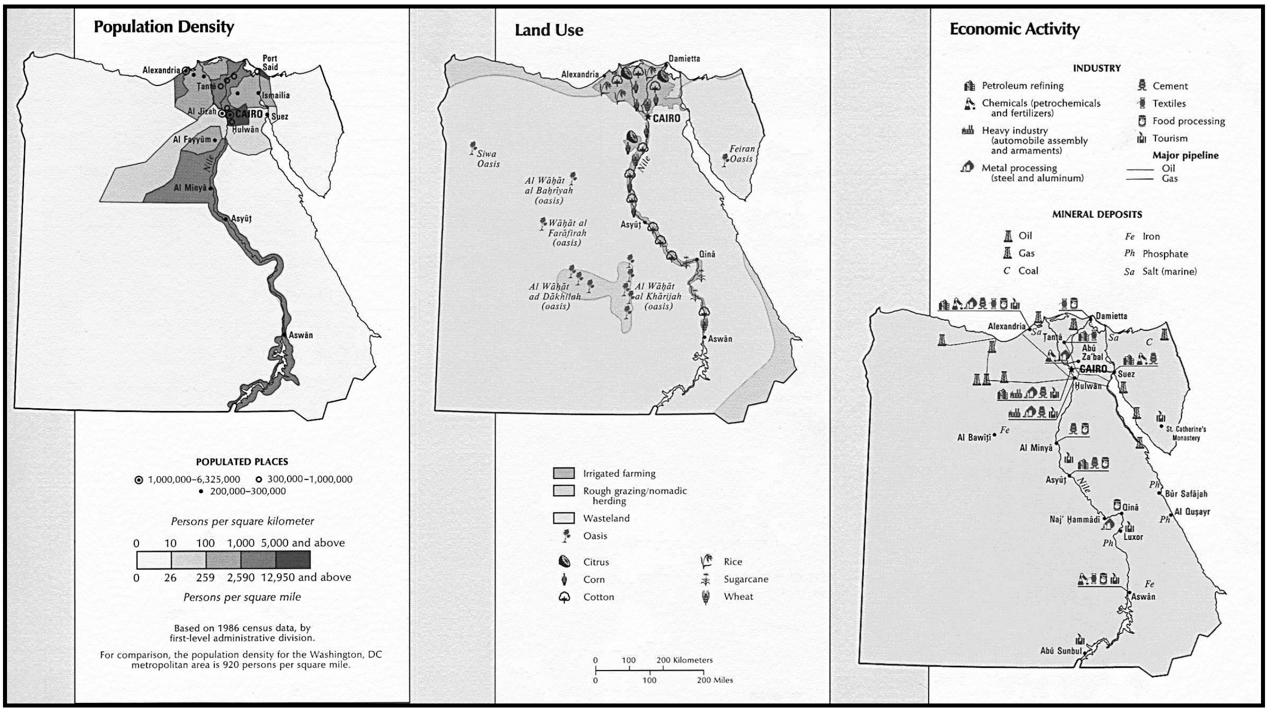
Egypt is fairly unique in the distribution of its population, land-use and agriculture, and economic activity which makes it extremely vulnerable to any potential impacts on its water resources and coastal zone. Despite being a large rectangular shaped country with an area of about a million square kilometers, its lifelines are constrained along a narrow T-shaped strip of land (which constitutes less than 5% of its land area) along the Nile and the coast around the Nile delta. The Nile supplies 95% of the country's total water needs, including water intensive irrigated agriculture along its banks and the delta. Agriculture is quite critical to the national economy as it employs 30% of the work force and contributes 17% to the GNP. Major urban centers, commerce, and industrial activity are also confined to the narrow corridor along the Nile and the coast around its delta. The rest of the country is desert and does not support much population or economic activity. The critical dependence on this narrow lifeline along the Nile and its delta is borne out in Figure 3 which shows the spatial maps of Egypt's population density, land-use, and economic activity respectively.

[8] This analysis uses a combination of the 11 best SCENGEN models (CSI2TR96, CCSRTR96, GFDLTR90, CERFTR98, ECH3TR95, HAD3TR00, ECH4TR98, HAD2TR95, BMRCTR98, GISSTR95, IAP_TR97) based on their predictive error for annual precipitation levels. Errors were calculated for each model, and for an average of the 17 models. Each model was ranked by its error score, which was computed using the formula 100*[(MODEL MEAN BASELINE /OBSERVED) - 1.0]. Error scores closest to zero are optimal. The error score for an average of the 17 models was 51%, the error score for an average of the 11 models was 22%.

[9] December, January, and February.

[10] June, July, and August.

Figure 3. Spatial distribution of population, land-use, and economic activity in Egypt



Rainfall variability within Egypt is almost inconsequential, given that the country receives very little rainfall, as well as the fact that its agriculture is irrigated and not rain-fed. Egypt's development has always been fostered by harnessing the Nile waters which originate in upstream riparian countries, although variability in Nile flows have also caused widespread impacts. The annual Blue Nile Flood which resulted from a 4-5 fold increase in Nile flow between July and October has been virtually eliminated with the completion of the High Aswan Dam in 1972. The dam also has one year's worth of storage capacity, to help cope with periodic droughts. Thus, with the completion of the Aswan Dam, Egypt has been reasonably well adapted to current climate variability, though it still remains vulnerable to multi-year droughts.

The current resilience notwithstanding, a key implication of Egypt's contextual dependence on the Nile and the coastal zone corridor around the Nile delta is that *any* medium-term adverse trends with regard to the reliability of water supplies from the Nile or the area under agriculture or human settlements along the coastal zone will have a critical impact not only on particular communities or sectors, but rather on the welfare of the entire country. The rainfall analysis presented in the previous section indicates that there is considerable uncertainty with regard to the projections of rainfall – both over Egypt as well as over the principal headwaters of the Nile. The analysis however is based on the interpretation of country averaged scenarios across various climate models – a more nuanced assessment that focuses on the implications of climate change for the principal sources of the Nile is needed. The MAGICC/SCENGEN results however indicate agreement across climate models that temperatures are projected to increase significantly under climate change. This raises the possibility of enhanced water losses from evapotranspiration – particularly given the arid climates of Egypt and Sudan – which might imply reduction in streamflows. Furthermore, although the MAGICC/SCENGEN analysis does not address sea level rise, there are pre-existing assessments of the vulnerability of the agricultural land and population centers on the Nile delta to sea level rise.

Table 3 ranks risks of climate change to particular sectors in Egypt under climate change, keeping in mind its geographical and contextual characteristics of population density, land-use and economic activity, which play a critical role in conditioning its vulnerability.

Table 3. Ranking of key climate change impacts and vulnerabilities in Egypt

– **Resource/ risk ranking**	– **Certainty of impact**	– **Timing of impact**	– **Severity of impact**	– **Importance of resource**
Coastal resources	High-medium	Medium-low	High	High
Water resources	Medium	Medium	High	High+
Agriculture (indirect impacts - mediated by sea level rise and water resource)	High-medium	Medium-low	High-Medium	High-medium
Agriculture (direct impacts-temperature, rainfall)	Low	Medium-low	Low	High-medium
Energy resources	Medium-low	Medium-low	Medium-low	Medium-low

The potential impacts of climate change on coastal resources are ranked as most serious. Sea-levels are already rising in the Nile delta due to a combination of factors including coastal subduction and reduced sediment loads due to the construction of the High Aswan Dam upstream. Climate change induced sea-level rise only reinforces this trend. In addition to this high biophysical exposure to the risk of sea level rise, Egypt's social sensitivity to sea level rise is particularly high. As discussed earlier in this section much of Egypt's infrastructure and development is along the low coastal lands, and the fertile Nile delta also constitutes the prime agricultural land in Egypt. The loss of this land due to coastal inundation or to saline intrusion will therefore have a direct impact on agriculture, which in turn is critical to Egypt's economy. A more detailed examination of the impact of sea level rise on coastal zones and the mainstreaming of adaptation responses is provided later in Section 6.

The entire country because it provides almost all of the water in the country for drinking, irrigation, and hydro-electric generation. Indeed, a substantial decrease in the flow of the Nile could have a very serious impact on Egypt's well-being. While substantial uncertainties remain about how climate change might affect Nile flow itself through changes in rainfall, there is much more certainty about temperature increases which are likely to enhance evaporative losses from the Nile, and at the same time increase irrigation and other demands for water. A more detailed assessment of the implications of climate change on the demand and supply of water in the Nile, as well as other development trends which might condition per capita availability of Nile waters is provided in Section 7, along with a discussion of the potential for mainstreaming appropriate water management responses.

Agriculture is ranked next as it is a very important sector, employing over 30% of the labor force. In terms of direct impacts of changes in temperature and rainfall, although impacts to most crops are estimated to be significant and negative, impacts on crops such as cotton could increase yields. The key impacts on agriculture will in fact be indirect – mediated by the loss or salinization of prime agricultural land in the coastal zone, and/or reduced irrigation supplies from the Nile, which are already accounted for under coastal zones and water resources.

Energy resources were ranked as least vulnerable because projections of higher temperatures (which have high certainty) in an arid climate are expected to boost energy demands, while any potential reduction in Nile waters would have a direct impact on hydroelectricity generation. However, since hydroelectricity accounts for only about 23% of the energy portfolio, the net impact of climate change on energy is ranked after coastal resources, water resources, and agriculture.

4. Attention to climate concerns in national planning

Egypt has signed or ratified a number of multilateral environmental agreements, and has a number of national level environmental and sectoral plans that intersect with responses that might be required to manage climate variability and long-term climate change.

4.1 Climate policies and national communications to international environmental agreements

Egypt was among the first Arab countries to join the cooperative global efforts to confront climate change. Since the Rio de Janeiro Earth Summit in 1992, it has ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1994 and signed the Kyoto Protocol in 1999. Its First National Communication to the United Nations Framework Convention on Climate Change was published in 1999. The report pays extensive attention to the risks facing the country due to climate change and sea-level rise, mainly in relation to agriculture, water resources, human health, and the coastal zone (particularly the Nile Delta). It also includes economic loss estimates for sea level rise in several coastal cities. Moreover, a large range of adaptation options are identified, most of them “no-regrets”. The report however appears to be weaker in terms of the implementation arrangements for the adaptation options.

Reports and strategies relating to other environmental conventions, such as the Ramsar Convention on Wetlands, the UN Convention on Biodiversity and the UN Convention to Combat Desertification pay very little attention to climate change, even though they nominally mention cooperation between the environmental conventions. At the same time, some of their action plans do contain elements that could also be part of an adaptation strategy for Egypt. For instance, measures to alleviate desertification or conserve coastal ecosystems are likely to make the country more resilient to climate change.

Egypt's Country Profile for the World Summit on Sustainable Development reflects an isolation of climate issues from mainstream development planning: climate change only comes up in a separate section on protection of the atmosphere, and then only in terms of mitigation of greenhouse gas concentrations.

4.2 National policies of relevance to climate change

In 1982 Egypt established the Egyptian Environmental Affairs Agency (EEAA), which subsequently led to the creation of a Ministry of State for Environmental Affairs in 1997. In 1995, the EEAA launched two major programs: Support for the National Action Plan (SNAP), sponsored by the United Sates Country Studies Program (USCSP), and Building Capacity for Egypt to respond to the UNFCCC sponsored by the Global Environment Facility (GEF) and implemented by the United Nations Development Program (UNDP). These two programs facilitated twenty five studies covering various topics such as GHG emissions inventory, GHG mitigation and adaptation technology assessment, climate change adaptation options, and abatement costs. Results and recommendations were disseminated through several conferences, seminars and workshops.

Box 2. Emission scenarios and selected mitigation projects in Egypt

Total CO_2 emissions in Egypt are expected to increase from nearly 75 million tons in 1990/91 to about 261 million tons in 2016/17, with an average annual growth rate of 4.9 percent. Industry is expected to be the major contributor to CO_2 emissions by 2016/17 with a share of about 49 percent, followed by the electricity sector at 29 percent, and the transportation sector contributing 14 percent. Based on a technology assessment study three GHG mitigation scenarios were developed: Fuel Substitution, Renewable Energy and Energy Efficiency. Energy savings for the three scenarios combined are expected to reach about 208 peta joules (PJ) by 2016/17, resulting in a reduction in CO_2 emissions of 18.4 million tons.

A number of mitigation projects have been initiated in Egypt, which include the following:

Technology cooperation agreement pilot project (TCAPP)

Acknowledging technology transfer as one of its highest priorities, Egypt is focusing on initiatives such as the Technology Cooperation Agreement Pilot Project (TCAPP) in cooperation with the U.S. Country Studies Program. The TCAPP is chartered to develop consensus among key Egyptian organizations on a set of high priority, climate-friendly, technology issues aimed at successful commercialization. Results are expected to produce candidate technology transfer areas for consideration under the guidance of the National Climate Change Committee. Market development plans for selected technologies are currently underway.

Promotion of wind energy for electricity generation

This is an active program within the Ministry of Electricity and Energy through the New and Renewable Energy Authority. Supported by many international donors, this project aims at installing 600 MW of wind turbines by the year 2005. 300 MW are already contracted through different donors, and most of them are scheduled to be operating by 2003.

Fuel cell bus demonstration project

Through GEF, UNDP is supporting fuel cell bus demonstration projects in Cairo, Sao Paulo, New Delhi, Beijing, and Mexico City to reduce GHG emissions and other pollutants. The demonstration in Cairo features eight fuel cell buses as well as hydrogen production and supply facilities. The program will run for five years, with three years devoted to driving, monitoring and testing performance. Service was implemented in 2001.

Hybrid electric bus technology

The overall objective of this project is to introduce a viable hybrid-electric bus that will have significant benefits and sustainability in various segments of the country. The project is funded by GEF and implemented by UNDP and the Egyptian Social Development Fund. The project will be applied to high priority historical sites starting with the Giza plateau where the ancient pyramids are located.

Natural gas motorcycles

This is a Canadian technology project developed to reduce the emissions of GHG by converting two-stroke engines used in motorcycles to compressed natural gas (CNG). The project will be implemented in three phases: identification of capabilities and barriers, demonstration of the technology, and finally a hand-over and transition to the local market.

Methane recovery from landfills

This project involves the recovery of methane generated in landfills in cooperation with the Canadian Government and Industry Canada. The proposed work plan involves the design and construction of two bioreactor landfill cells in Cairo. After the completion of the project, the team will hand over the two bio-reactor cells to the Cairo Solid Waste Management Authority. On-site training will be provided to the Egyptian staff for future operation and monitoring. A general policy of encouragement of building up solid waste landfills has been implemented and associated landfills started their operation in Alexandria in October 2001.

Integrated solar thermal/natural gas programs

The New and Renewable Energy Authority (NREA) has prepared a program for implementing a series of solar thermal power plants. This includes an Integrated Solar Combined Cycle System (ISCCS) with a 100-150 MW capacity at Kuraymat. The GEF/World Bank funded project began in 1997 and a second project of likewise capacity is anticipated to go into operation before 2005.

Energy efficiency improvement and emissions reduction project

This four-year UNDP/GEF project was designed to achieve reductions in GHG emissions through policies that promote demand-side management and energy conservation while creating an enabling environment for energy efficiency. The project focuses on the transmission and distribution of electrical systems, co-generation, and market support for emergency energy service companies.

Fuel switching

Current Egyptian energy policy calls for shifting the demand from liquid fuel oil to natural gas given the abundance of natural gas supply, which is estimated at 43 trillion cubic feet (CF). Fuel switching is currently undertaken in electricity generation, industry, and residential sectors. USAID assisted Cairo Air Improvement Program (CAIP) furnished Cairo's municipal bus companies with fifty CNG-powered rolling bus chassis, while the Government of Egypt is contributing the bus bodies. CAIP helped also in equipping the CNG bus maintenance garages required for these fleets, and introduced CNG-related safety standards for fuel tanks, fueling stations, and fuel systems. Serving as an example for public private sector partnerships, since 1996 the private sector has been building and operating 27 CNG fueling stations and converting over 27 vehicles including taxis to CNG. The USAID Commodity Import Program helped in purchasing fueling equipment for many of these CNG filling stations.

In 1997 Egypt formed an inter-ministerial National Climate Change Committee. This committee represents a wide range of governmental and non-governmental stake holders under the leadership of the Chief Executive Officer of the EEAA. Recent Egyptian policy efforts such as the development of Egypt's Climate Change Action Plan (1999), the National Communication on Climate Change (1999), the National Energy Efficiency Strategy and the National Strategy for Solid Waste Management demonstrate the country's national commitment to face threats from climate change impacts. While in the beginning the emphasis was laid on mitigation measures (see Box 2), it was recently realized that the contribution of Egypt to the overall emissions of greenhouse gases is considered minute compared to the high potential impacts on all sectors and that several sectors are highly vulnerable to the impacts of climate change in spite of all possible mitigation measures. It was therefore subsequently decided that it was necessary to consider adaptation measures as an integral part of the policy for climate change.

5. Attention to climate concerns in donor activities

Egypt receives donor aid of the order of US$ 1.5 billion per year, or about 1.5% of GNI. Since the Camp David Accords and the Peace Treaty with Israel, the United States is by far the largest donor, followed at a distance by France, the European Commission, Japan, and Germany. Figure 4 displays the distribution of this aid by development sector and by donor.

Figure 4. Development Aid to Egypt (1998-2000)

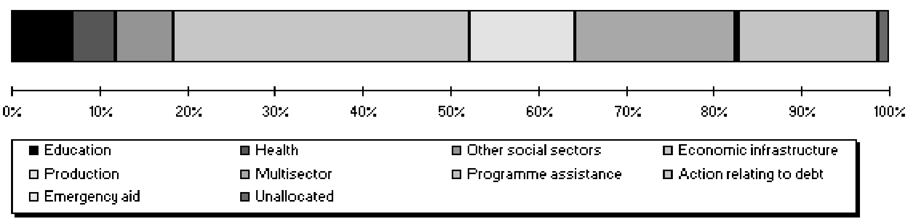
Egypt

Receipts	1998	1999	2000
Net ODA (USD million)	1 955	1 582	1 328
Bilateral share (gross ODA)	75%	81%	83%
Net ODA / GNI	2.3%	1.8%	1.3%
Net Private flows (USD million)	1 851	- 4	1 736

For reference	1998	1999	2000
Population (million)	61.5	62.7	63.8
GNI per capita (Atlas USD)	1 280	1 380	1 490

Top Ten Donors of gross ODA (1999-2000 average)		(USD m)
1	UNITED STATES	799
2	FRANCE	265
3	EC	144
4	JAPAN	129
5	GERMANY	102
6	DENMARK	41
7	IDA	41
8	AUSTRIA	24
9	ITALY	20
10	NETHERLANDS	19

Bilateral ODA by Sector (1999-2000)



Sources: OECD, World Bank.

The following sections highlight the possible extent of climate risks to development investments in Egypt and examine to what extent current and future climate risks are factored in to development strategies and plans, as well as individual development projects[11]. Given the large quantity of strategies and

[11] The phrase "climate risk" or "climate-related risk" is used here for all risks that are related to climatic circumstances, including weather phenomena and climate variability on various timescales. In the case of Egypt, these risks include the effects of seasonal climate anomalies, including droughts, as well as trends

projects, this analysis is limited to a selection. This selection was made in three ways (i) a direct request to all OECD DAC members to submit documentation of relevant national and sectoral strategies, as well as individual projects; (ii) a direct search for some of the most important documents (including for instance national development plan/PRSP, submissions to the various UN conventions, country and sector strategies from multilateral donors like the World Bank and UNDP, and some of the larger projects in climate-sensitive sectors), and (iii) a pragmatic search (by availability) for further documentation that would be of interest to the analysis (mainly in development databases and on donors' external websites). Hence, the analysis is not comprehensive, and its conclusions are not necessarily valid for a wider array of development strategies and activities. Nevertheless, there is reasonable confidence that this limited set allows an identification of some common patterns and questions that might be relevant for development planning.

5.1 Donor activities affected by climate risks

This section explores the extent to which development activities in Egypt are affected by climate risks, which gives an indication of the importance of climate considerations in development planning. The extent to which climate risks affect development activities in Egypt can be gauged by examining the sectoral composition of the total aid portfolio, which is analyzed here using the World Bank/OECD Creditor Reporting System (CRS) database (Box 3). Development activities in sectors such as agriculture, infectious diseases, or water resources could clearly be affected by current climate variability and weather extremes, and consequently also by changing climatic conditions. At the other end of the spectrum, development activities relating to education, gender equality, and governance reform are much less directly affected by climatic circumstances.

Box 3. Creditor Reporting System (CRS) Database

The Creditor Reporting System (CRS) is comprised of data on individual aid activities on Official Development Assistance (ODA) and official aid (OA). The system has been in existence since 1967 and is sponsored and operated jointly by the OECD and the World Bank. A subset of the CRS consists of individual grant and loan commitments (from 6000 to 35000 transactions a year) submitted by DAC donors (23 members) on a regular basis. Reporters are asked to supply (in their national currency), detailed financial information on the commitment to the developing country such as: terms of repayment (for loans), tying status and sector allocation. The secretariat converts the amounts of the projects into US dollars using the annual average exchange rates.

In principle, the sectoral selection should include all development activities that may be designed differently depending on whether or not climate risks are taken into account. In that sense, the label "affected by climate risks" has two dimensions. It includes projects that are at risk themselves, such as an investment that could be destroyed by flooding. But it also includes projects that affect the vulnerability of other natural or human systems. For instance, new roads might be fully weatherproof from an engineering standpoint (even for climatic conditions in the far future), but they may also trigger new settlements in high-risk areas, or it may have a negative effect on the resilience of the natural environment, thus exposing the area to increased climate risks. These considerations should be taken into account in project design and implementation. Hence, these projects are also affected by climate risks. A comprehensive evaluation of the extent to which development activities are affected by climate change would require detailed assessments of all relevant development projects as well as analysis of site specific climate change impacts, which was beyond the scope of this analysis. This study instead assesses activities affected by

therein due to climate change, and risks due to sea level rise. "Current climate risks" refer to climate risks under current climatic conditions, and "future climate risks" to climate risks under future climatic conditions, including climate change and sea level rise.

climate risks on the basis of CRS purpose codes (see Appendix B, which identifies "the specific area of the recipient's economic or social structure which the transfer is intended to foster")[12, 13].

Clearly, any classification that is based solely on sectors suffers from oversimplification. In reality, there is a wide spectrum of exposure to climate risks even within particular sectors. For instance, rain-fed agriculture projects might be much more vulnerable than projects in areas with reliable irrigation. At the same time, the irrigation systems themselves may also be at risk, further complicating the picture. Similarly, most education projects would hardly be affected by climatic circumstances, but school buildings in flood-prone areas might well be at risk. Without an in-depth examination of risks to individual projects, it is impossible to capture such differences. Hence, the sectoral classification only provides a rough first sense about the share of development activities that might be affected by climate risks.

To capture some of the uncertainty inherent in the sectoral classification, the share of development activities affected by climate change was calculated in two ways, a rather broad selection, and a more restrictive one. The first selection ("high estimate") includes projects dealing with infectious diseases, water supply and sanitation, transport infrastructure, agriculture, forestry and fisheries, renewable energy and hydropower[14], tourism, urban and rural development, environmental protection, food security, and emergency assistance. The second selection ("low estimate") is more restricted. First of all, it excludes projects related to transport and storage. In many countries, these projects make up a relatively large share of the development portfolio, simply due to the large size of individual investments (contrary to investments in softer sectors such as environment, education and health). At the same time, infrastructure projects are usually designed on the basis of detailed engineering studies, which should include attention at least to current climate risks to the project.[15] Moreover, the second selection excludes food aid and emergency assistance projects. Except for disaster mitigation components (generally a very minor portion of emergency aid), these activities are generally responsive and planned at short notice. The treatment of risks is thus very different from well-planned projects intended to have long-term development benefits. Together, the first and the second selection give an indication of the range of the share of climate-affected development activities.

In addition, the share of emergency-related activities was calculated. This category includes emergency response and disaster mitigation projects, as well as flood control. The size of this selection gives an indication of the development efforts that are spent on dealing with natural hazards, including, often prominently, climate and weather related disasters.

The implications of this classification should not be overstated. If an activity falls in the "*climate-affected*" basket, it need not to be necessarily redesigned in the light of climate change or even that one would be able to quantify the extent of current and future climate risks. Instead, the only implication is

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12 Each activity can be assigned only one such code; projects spanning several sectors are listed under a multi-sector code, or in the sector corresponding to the largest component.

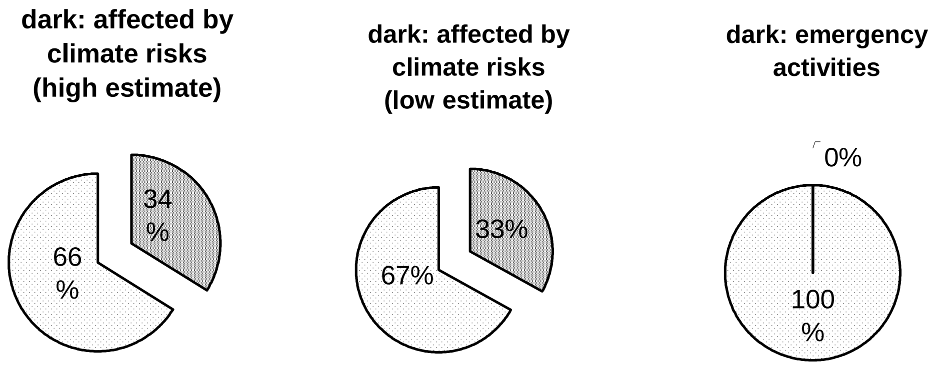
13 The OECD study "Aid Activities Targeting the Objectives of the Rio Conventions, 1998-2000" provides a similar, but much more extensive database analysis. It aimed to identify the commitments of ODA that targeted to objectives of the Rio Conventions. For this purpose, a selection was made of those projects in the CRS database that targeted the Conventions as either their "principal objective", or "significant objective".

14 Traditional power plants are not included. Despite their long lifetime, these facilities are so localized (contrary to, e.g., roads and other transport infrastructure) that climate risks will generally be more limited. Due to the generally large investments involved in such plants, they could have a relatively large influence on the sample, not in proportion with the level of risk involved.

15 Note however, that they often lack attention to trends in climate records, and do not take into account indirect risks of infrastructure projects on the vulnerability of natural and human systems.

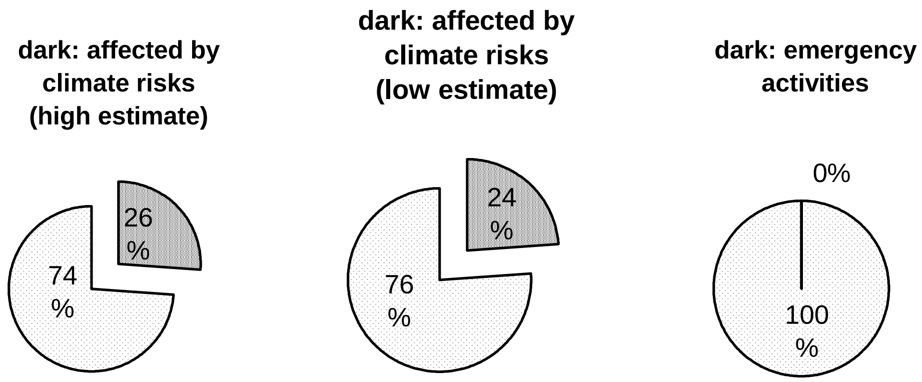
that climate risks could well be a factor to consider among many other factors in the design of development activities. In some cases, this factor could be marginal. In others, it may well be substantial. In any case, these activities would benefit from a consideration of these risks in their design phase. Hence, one would expect to see some attention being paid to them in project documents, and related sector strategies or parts of national development plans. Figures 5 and 6 show the results of these selections, for the three years 1998, 1999, and 2000[16].

Figure 5. Share of aid amounts committed to activities affected by climate risk and to emergency activities in Egypt (1998-2000)



16 The three-year sample is intended to even out year-to-year variability in donor commitments. At the time of writing, 2000 was the most recent year for which final CRS data were available. Note that coverage of the CRS is not yet complete. Overall coverage ratios were 83% in 1998, 90% in 1999, and 95% in 2000. Coverage ratios of less than 100% mean that not all ODA/OA activities have been reported in the CRS. For example, data on technical co-operation are missing for Germany and Portugal (except since 1999), and partly missing for France and Japan. Some aid extending agencies of the United States prior to 1999 do not report their activities to the CRS. Greece, Luxembourg and New Zealand do not report to the CRS. Ireland has started to report in 2000. Data are complete on loans by the World Bank, the regional banks (the Inter-American Development Bank, the Asian Development Bank, the African Development Bank) and the International Fund for Agricultural Development. For the Commission of the European Communities, the data cover grant commitments by the European Development Fund (EDF), but are missing for grants financed from the Commission budget and loans by the European Investment Bank (EIB). In this case Egypt is not included in the EDF scheme but instead it receives its aid mostly through the MEDA program for development cooperation with Mediterranean partner countries and/or from the European Investment Bank. Neither of those is included in the CRS. For the United Nations, the data cover the United Nations Children's Fund (UNICEF) since 2000, and a significant proportion of aid activities of the United Nations Development Programme (UNDP) for 1999. No data are yet available on aid extended through other United Nations agencies. Note also that total aid commitments in the CRS are not directly comparable to the total ODA figures in Figure 4, which exclude most loans.

Figure 6. Share of aid (by number) committed to activities affected by climate risk and to emergency activities in Egypt (1998-2000)



In monetary terms, about one third of all development activities in Egypt could be affected by climate change. By number, the share is about one quarter.[17] Emergency projects make up only a minimal percentage of amount and numbers of development projects. In addition to providing insight in the sensitivity of development activities in Egypt as a whole, the classification also gives a sense of the relative exposure of various donors. These results are listed in Table 4 and 5 (again for the years 1998, 1999, and 2000).

Table 4. Relative shares of CRS activities, by total disbursed aid amounts, for the top-five donors in Egypt (1998-2000)

Amounts of activities (millions US$)			Activities affected by climate risks (high estimate)			Activities affected by climate risks (low estimate)			Emergency activities		
Donor	**Amount**	**%**	**Donor**	**Amount**	**%**	**Donor**	**Amount**	**%**	**Donor**	**Amount**	**%**
Total	*4,823*	*100%*	*Total*	*1,628*	*100%*	*Total*	*1,588*	*100%*	*Total*	*0.063*	*100%*
USA	2,580	53%	USA	630	39%	USA	629	40%	Sweden	0.063	100%
France	752	16%	IBRD	497	31%	IBRD	495	31%			
IBRD	692	14%	Germany	241	15%	Germany	241	15%			
Germany	391	8%	Japan	72	4%	Japan	55	3%			
Japan	74	2%	France	63	4%	France	46	3%			

17 Note that the number of activities gives a less straightforward indication than the dollar amounts. First of all, activities are listed in the CRS in each year when a transfer of aid has occurred. Hence, when a donor disburses a particular project in three instalments, that project counts three times in our three-year sample. If the financing for a similar three-year project is transferred entirely in the first year, it only counts once. Secondly, the CRS contains a lot of non-activities, including items like "administrative costs of donors". Moreover, some bilateral donors list individual consultant assignments as separate development activities. In most cases, such transactions will fall outside of the "climate-affected" category. Hence, the share of climate-affected activities relative to the total number of activities (which is diluted by these non-items) is lower. On the other hand, the shares by total amount tend to be dominated by structural investments (which tend to be more costly than projects in sectors such as health, education, or environmental management).

Table 5. Relative shares (by number) of CRS activities, for the top-five donors in Egypt (1998-2000)

Numbers of activities			Activities affected by climate risks (high estimate)			Activities affected by climate risks (low estimate)			Emergency activities		
Donor	**Number**	**%**	**Donor**	**Number**	**%**	**Donor**	**Number**	**%**	**Donor**	**Number**	**%**
Total	*766*	*100%*	*Total*	*201*	*100%*	*Total*	*184*	*100%*	*Total*	*1*	*100%*
USA	140	18%	Netherlands	32	16%	Netherlands	32	17%	Sweden	1	100%
France	99	13%	USA	27	13%	Germany	25	14%			
Germany	79	10%	Germany	25	12%	USA	24	13%			
Netherlands	74	10%	Italy	22	11%	Italy	22	12%			
Italy	71	9%	France	18	9%	France	13	7%			

Given the high share of development activities in Egypt that could be affected by climate risks, one would assume that these risks are reflected in development plans and a large share of development projects. The following sections will examine to which extent this is the case.

5.2 Climate risks in selected donor strategies

Despite Egypt's vulnerability, donor strategies for Egypt generally do not mention climate change. The main differences between the various strategies are reflected in the way they handle present climate-related development issues, including coastal management, water resources, and land use. Clearly, many activities that address those challenges will also increase resilience to future climate change. All strategies acknowledge the pressing water scarcity in Egypt. Some of them, like CIDA's Country Development Programming Framework and the European Commission's Country Strategy Paper, focus mainly on areas that are insensitive to water issues (such as education and private sector development) and therefore do not go into much detail. The African Development Bank Country Strategy Paper includes dramatic statements such as "*Extremely limited land and water resources constitute the main physical constraints to the development of the Egyptian economy*". The document however does not consider any potential implications of climate change on water scarcity.

Other strategy documents, like IFAD's Country Strategic Opportunities Paper (COSOP) and the World Bank's Country Assistance Strategy (CAS), provide concrete steps towards better water management, which are reflected in their project portfolios. For instance, the World Bank highlights the need for cooperation with other countries in the Nile Basin – which is occurring through the Nile Basin Initiative. In addition, the CAS proposes to address national water consumption, for instance by better operation and maintenance of drainage and irrigation systems, and by rationalizing water allocation. In this light, the World Bank suggests a move out of water-intensive crops like rice and sugarcane. Interestingly, the IFAD COSOP highlights the fact that Egypt still imports 40% of its food supply, while at the same time increasing the proportion of acreage devoted to export crops, which include cotton, rice, fruits, vegetables, and flowers. Contrary to the World Bank CAS the IFAD strategy does not discuss the water implications of this ongoing shift.[18]

In Egypt, land use is intimately coupled to water use, so there is a large overlap between the two development planning domains. In most cases, concerns and responses are fully consistent. In the African Development Bank Strategy however, it is suggested that, in the light of land *and water* scarcity: "the objective of increasing the inhabited area of the country from 5 % to 25% of the total area by 2017 is

18 Another curious element of the IFAD COSOP is in a table on stakeholder involvement, which is filled out for all sectors except water management (probably inadvertently).

therefore very sound". The strategy does not discuss the likely tradeoffs between overall average water supply and the extent of irrigated farming. Coastal and marine management issues receive less attention. The African Development Bank Country Strategy Paper only briefly mentions pollution, IFAD focuses mostly on land-based issues, and even the World Bank, despite having a large project in the Red Sea, only briefly touches upon coastal and marine issues. The Danish strategy contains more detail (partly linked to their ICZM development programme) but still ignores climate change and sea level rise.

5.3 Climate risk in selected development programs and projects

Specific climate change adaptation activities in Egypt have been limited mostly to studies and planning. In particular, the US Country Studies Program has supported impacts and adaptation studies over the course of the 1990s, which fed into Egypt's first National Communication to the UNFCCC. In addition, several donors (in particular the Dutch and the Danish) have supported work in coastal zone management. However, the project documents for the Danish technical assistance do not mention climate change in any way. Nevertheless, these activities clearly enhance Egypt's adaptive capacity.

The German Environment Ministry recently financed a case study on climate change and conflict in Egypt (Brauch, 2002). It concludes that Egypt will face severe environmental security challenges, mainly because of competition for scarce Nile water.

As discussed in Section 5.1, many regular development activities in Egypt may be affected by climate change. A review of a sample of projects showed that in most cases, climate change is not explicitly taken into account. At the same time, many projects do address problems that will be aggravated by climate change, and thus help to increase Egypt's resilience. It is unclear to what extent an explicit consideration of climate change would have changed project design. One example of such a project is the World Bank/GEF Second Matruh Resource Management Project, which addresses rural poverty. Biophysical risks facing the region include problems associated with water scarcity, rainfall variability, strong winds, and agricultural pests, compounded by low crop diversity. The project clearly recognizes the importance of traditional coping mechanisms, which include the use of drought-adapted species, tailoring the timing and area of sowing to the rainfall, low-input farming, and complementing field crops with horticulture, livestock and off-farm economic activities. While effective for survival, some of these coping mechanisms (such as low-input farming) also impede economic progress. Hence, the project both builds on and complements existing coping strategies, by strengthening local capacity for conservation, rehabilitation and sustainable management of natural resources, as well as community development, improved access to services, and new income generating opportunities. All of these elements, particularly when so well tailored to local needs and circumstances, surely contribute to adaptation to climate change. At the same time, it is interesting to note that a project that is submitted under GEF's OP12[19] only recognizes the climate change *mitigation* elements of its objectives and outcomes.

A second example is a planned World Bank Integrated Irrigation Improvement and Management Project, which aims to increase the productivity and sustainability of water use, in the face of growing demand and potentially decreasing supply. By the decreasing supply, the project is referring to competing demands in the upper Nile countries, not to climate change. Nevertheless, the responses remain equally valid: development and implementation of integrated water management plans, rehabilitation and improvement of irrigation and drainage infrastructure, a (GEF-supported) environmental management plan, and on-farm demonstration projects. Yet another example is the World Bank Red Sea Coastal and Marine Resource Management Project, which has assisted in policy and regulatory development and implementation, capacity building in multi-sectoral coastal zone management, development and

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19 A special Operational Program for projects dealing with integrated ecosystems management, providing a comprehensive approach across different conventions.

implementation of public partnerships for sustainable coastal and marine resource management, and the development of databases and inventories. Similar issues are being addressed by the Regional UNDP/GEF Conservation of Wetland and Coastal Ecosystems project, which focuses on coordination, regional strengthening and awareness raising, and a few demonstration projects.

While all of these projects' target areas will somehow be affected by climate change, it is unclear how climate change considerations would have altered current project elements. Nevertheless, a good analysis of climate change concerns might have contributed to a better understanding of long-term challenges and needs, and could have triggered additional interventions. A key international program affecting Egypt's future water management is the Nile Basin Initiative, which brings together the twelve countries that are part of the Nile River Basin, all the way from the Ruvyironza River in Burundi and Lake Victoria to the Egyptian Nile Delta, where the water flows into the Mediterranean. This intergovernmental initiative[20] contains two main pillars: a shared vision between all countries, and a program of subsidiary activities at the lowest appropriate level, but with benefits to other partner countries. These activities can include, for instance, watershed management, irrigation, water supply and sanitation, desertification control, hydropower, fisheries management, and flood control, as well as general joint development opportunities not directly related to water management, such as infrastructure, communications, disaster management, and regional tourism development. While climate change is not a primary motivation behind the initiative, this type of regional collaboration is an excellent adaptation strategy, and particularly crucial for downstream countries such as Egypt.

One of the first initiatives under the Nile Basin Initiative (NBI) Shared Vision Program (SVP) is a Worldbank/UNDP/GEF regional Nile Transboundary Environmental Action project. While the project fits the priorities of climate change adaptation, climate change is not mentioned in the main Project Appraisal Document. However, an annex with all basin wide environmental threats contains a separate section on climate change, listing a range of possibly severe implications. Relative to other environmental threats such as soil erosion, riverbank and lakeshore degradation, pollution, mining impacts, eutrophication, water-borne diseases, floods, droughts, and risks to biodiversity and wetlands, climate change is ranked as a “low-to-moderate” risk. In reality, climate change is of course just another risk factor affecting almost all the other threats. The key question would be how to adapt to such shifting risks, an issue which is left open. Two other SVP projects "*Efficient Water for Agricultural Production"* and "*Water Resources Planning and Management"* do not discuss climate change in any way. At the same time, the projects do address the intermediate challenges through which climate change will manifest them, including water scarcity, floods and droughts. Hence, many of the interventions will also affect the vulnerability of the Nile Basin and the most downstream country, Egypt, to climate change. At this point it is too early too evaluate SVP projects, given that the NBI itself has been underway only since mid 1999.

The next two sections will examine in-depth climate change impacts, adaptation options, and mainstreaming challenges and opportunities in two sectors which are most vulnerable to climate change – the coastal zone around the Nile delta, and water availability in the Nile itself.

6. Climate change and coastal zones

The shoreline of Egypt extends for more than 3,500 km along the Mediterranean Sea and the Red Sea. The Nile delta coast stretches about 300 km and hosts a number of highly populated cities such as Alexandria, Port-Said, Rosetta, and Damietta. These cities are also critical centers of industrial and economic activity. In addition, the Nile delta coastal zone includes a large portion of the most fertile low land of Egypt. The coastal zone suffers from a number of major problems including population pressure,

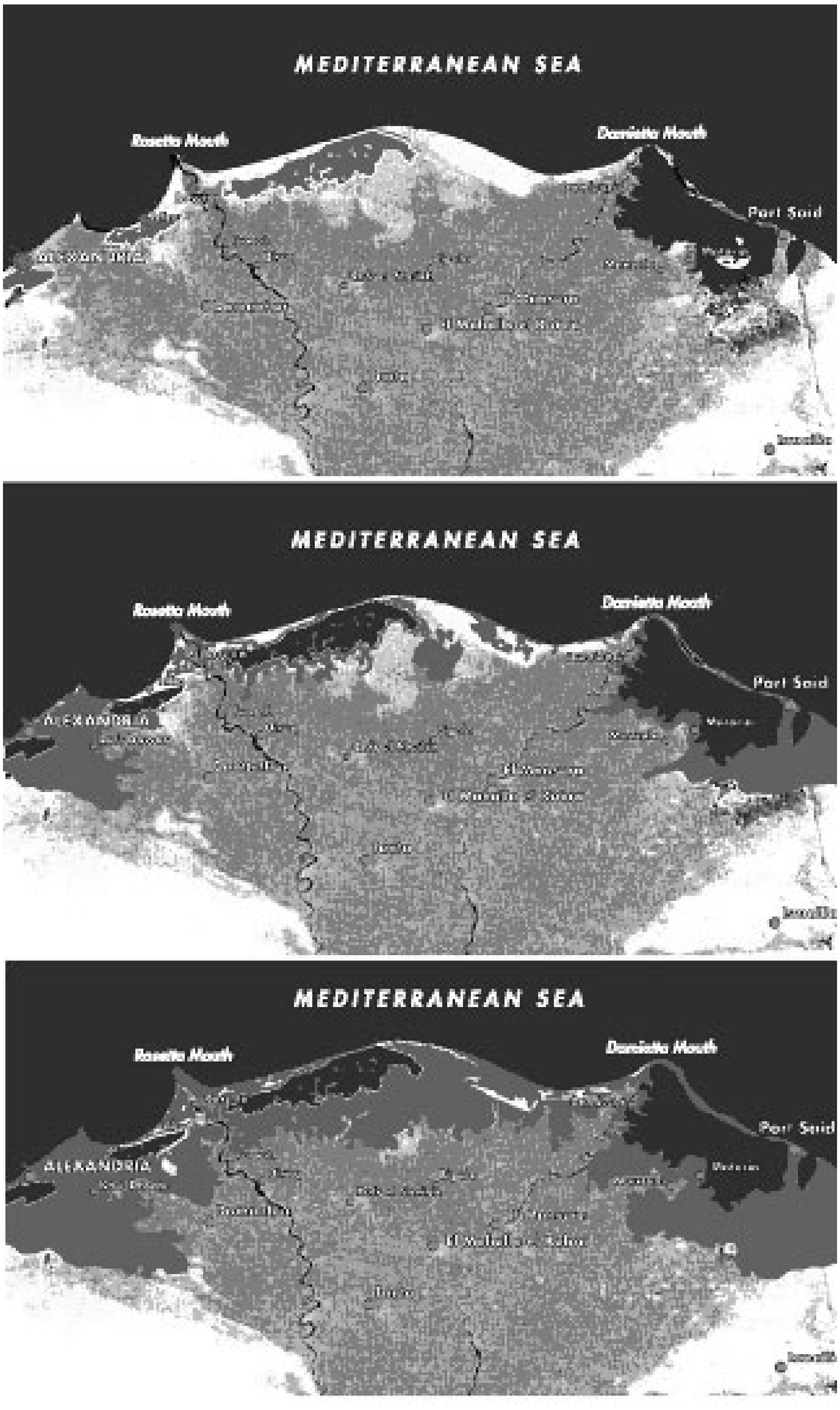
20 Supported by the World Bank

interference of land use, pollution, water logging and lack of institutional capabilities for integrated management.

6.1 Climate change impacts on coastal zones

Egypt's Nile delta with its coastal front on the Mediterranean is considered vulnerable to the impacts of climate change. In addition to expected rise in sea-level, shoreline erosion, stresses on fisheries and saltwater intrusion in groundwater create major challenges. These factors also produce stressful effects on water and agricultural resources, tourism and human settlements. Fragile and unique ecosystems such as the mangrove stands in the Red Sea, which stabilize shorelines and provide a habitat for many species, may also be threatened. The northern Egyptian lakes, which constitute about 25% of the total Mediterranean wet lands and produce about 60% of the fish products, are also highly vulnerable to the impacts of climate change. Since the lakes are relatively shallow, climate change can lead to an increase in water temperature, which could result in changes in the lake ecosystems as well as changes in yield. So far, in-depth studies on potential impacts of climate change on lake ecosystems are not available. The following section provides an in-depth view on the most vulnerable Egyptian cities – Alexandria, Rosetta, and Port Said, shown below in Figure 7 under current conditions, as well as scenarios for 0.5 and 1 meter sea level rise.

Figure 7. Coastal inundation in the Nile delta under sea level rise (current; 0.5m; 1.0m)



Source: Otto Simonett, UNEP/GRID; G. Sestini, Florence; Remote Sensing Center, Cairo; DIERCKE Weltwirtschaftsatlas

6.1.1 Alexandria city

Alexandria city is located to the west of the Rosetta branch of the Nile and is famous for its beaches, historic and archeological sites. It has a population of about four million and hosts the largest harbor in the country as well as roughly 40% of the Egyptian industrial activities. During summer, the city attracts over a million tourists. The extension of the city to the south is impeded by the existence of a large water body: Lake Maryut. Water level in Lake Maryut is kept at 2.8 m below sea level through continuous pumping of water into the Mediterranean. In order to assess the impacts of sea level rise on Alexandria, a Geographic Information System (GIS) was created using the ARC/INFO environment. To assess the impacts from sea level rise (SLR), a number of scenario were assumed over the century (0.25, 0.5 and 1.0 m), taking land subsidence (2.0 mm/a) into consideration. Then, the percentage of the population and land-use areas at risk for each scenario level were identified and quantified by the GIS analysis. The results are shown in Table 6. The first column (current situation) shows the percentage of each sector that is currently located at an elevation below sea level. However, these locations are protected from inundation, either naturally or through hard structures. If sea level rises by 0.25, 0.5, and 1.0 respectively, the other columns of the table show the percentages of sectors that will be inundated, since they cannot be protected by current structures.

Table 6. Percentages of the population and the areas of different land use currently below sea level and at different levels of elevation (m) for the city of Alexandria

Sector	Below sea level	0.25 m asl	0.5 m asl	1.0 m asl
		(% of areas affected)		
Population	45	60	67	76
Beaches	1.3	11	47.8	64
Residential	26.2	27.5	39.3	52
Industrial	53.9	56.1	65.9	72.2
Services	45.1	55.2	75.9	82.2
Tourism	28	31	49	62
Restricted Area	20	21	25	27
Urban	38	44	56	67
Vegetation	55	59	63	75
Wetland	47	49	58	98
Bare Soil	15	24	29	31

The outcomes for each SLR scenario in case of "business as usual" have been extrapolated to assess the potential loss of employment for each sector for the years 2010, 2025 and 2050.[21] Analyses of the results indicate that for a SLR of 0.5m about 30% of the city area will be lost due to inundation. Also, over 1.5 million people will have to be relocated. Other expected losses include 195,000 jobs as well as land, properties and revenues in the range of $30 billion. These are based upon extrapolation of current national statistics, and are only intended as order of magnitude estimates. The results in Table 7 indicate that the most severely affected employment sector will be industry, followed by tourism and agriculture.

Table 7. Area loss, displaced population and loss of employment for each sector under different SLR scenarios in the Alexandria Governorate

	Sea level rise scenarios (m)		
	0.18	0.3	0.5
Area loss (km^2)	11.4	19.0	31.7
Population displaced (x 1000)	252	545	1,512
Loss of employment			
Agriculture	1,370	3,205	8,812
Tourism	5,737	12,323	33,919
Industry	24,400	54,936	151,200
Total loss of employment	32,507	70,465	195,443

21 The underlying analysis was conducted prior to the TAR of the IPCCC, which provides a range of 0.09 to 0.88m sea level rise for the year 2100.

6.1.2 Rosetta City and region

Rosetta city is a well-known Pharaonic and Islamic city located in the Rosetta region near the intersection of the Rosetta branch of the River Nile with the Mediterranean Sea east of Alexandria. Excessive erosion rates have been observed near the Rosetta promontory, due to the cessation of sediments following the building of the High Dam on the River Nile about 1000 km to the south. The region surrounding the city is well known for its water-logging and water-bogging problems.

Similar to Alexandria, a quantitative vulnerability assessment of the potential impacts of sea level rise has also been carried out for Rosetta (El Raey et al., 1999). For a sea level rise of 0.5m, the study estimated the loss of about one-third of employment as well as the loss of $2.9 billion from land and property. As in the Alexandria study, the loss of historic and archeological sites is unaccounted for. In addition, erosion problems are expected to be exacerbated by sea level rise. So far, the Government has built a massive sea wall near the tip of the promontory as a protective measure against already existing erosion problems. However, recent observations indicate that this massive hard structure is seriously challenged by coastal erosion. Periodic beach nourishment may be a possible solution. However, plans for the development of the area should consider an approach in which decision-making is based on a detailed GIS suitability analysis.

6.1.3 Port-Said

Port-Said is located on the Mediterranean Sea east of the Damietta branch of the River Nile at the entrance/exit of the Suez Canal. In addition to its strategic position, it is the second largest tourist and trade center of Egypt on the Mediterranean. Lake Manzala, the largest of the Nile delta lakes, is located just to the west of the city and receives a sizable amount of effluent pollution from various sources. Port Said Governorate has a total area of 1,851 km^2 and is divided into five districts: El Shark, El Monakh, El Arab, El Dawahi, and Port Fouad. The coastal zone of Port Said is critically important for tourism, which is primarily oriented at beach activities. Most tourism facilities are located within 200-300 meters of the coastline. Besides, there are important archeological sites along the northern part of the Suez Canal.

The vulnerability of Port Said to sea level rise is particularly high given the socio-economic importance of its coastline and the fact that it has one of the highest rates of local land subsidence in the Nile Delta (5 mm/a), which amplifies the effects of climate change induced sea level rise. Sea level rise is expected to cause a landward shift of the salt wedge and increase the rate of saline seepage in the top soil, which may have potentially serious implications for agriculture and drainage conditions as well as available groundwater resources in the upper Nile Delta. Changes in salinity of Lake Manzala may lead to impacts on lake ecology and fisheries. Further, given that the lake is unlikely to migrate inland, sea level rise will lead to a decline in shallow wetland areas and less abundant reed beds. As shown in Table 8 the most severely impacted sectors are expected to be industry (12.5%) and transportation (11.7%). In case of a SLR of 0.5m, a loss of 6,700 jobs (5.3%) is expected. In terms of economic losses, the loss of beaches is likely to outweigh losses in other areas, given their high value for tourism. In addition, there are again no assessments to value the loss of historical sites.

Table 8. Physical and socio-economic losses for a SLR of 0.5m in the Port Said Governorate*

	El Shark	El Arab	El Monakh	Port Fouad	Total	%	Million US$
Beach area (km^2)	0.426	0.377	7.419	13.039	21.26	1.6	2,126
Urban area (km^2)	0.034	0.044	0.339	0.046	0.46	7.8	92
Industry area (km^2)	0.015	0.002	0.018	0.016	0.05	12.5	25
Aquacultural area (km^2)	0	0	0	0.024	0.024	0.12	2.4
Transport Network (km)	10	7	3	3	23	11.7	4.6
Population (affected)	3,968	16,699	6,503	1,021	28,191	5.3	-
Employment	953	4,000	1,558	248	6,759	5.3	-

* No data available for El Dawahi

6.1.4 Other vulnerable areas on the coastal zone

It should be noted here that Alexandria, Rosetta and Port Said are not the only vulnerable areas along the coastal zone of Egypt. Beaches and tourist sites at other cities such as Matruh City to the west of the delta and Arish City to the east are also vulnerable to a rise in to sea level. Water-logging and water-bogging problems in low lying areas close to the coast have already emerged in many localities. Sand dune movement in the coastal zone is also expected to be more severe in the future. So far, declines in land productivity in the Nile delta region resulting from salt water intrusion as well as declines in fish catch resulting from ecosystem changes in the northern lakes have not been accurately accounted for. Besides, the continuous degradation of coral reefs along the coasts of the Red Sea would severely impact biodiversity, fish catch and tourism in that region. The socio-economic impacts associated with these changes are far reaching and include migration, unemployment and possibly political unrest.

6.2 Adaptation options for coastal resources

Several criteria are important for the assessment of various options for adaptation in coastal zones, including: net benefits, environmental impacts, robustness and flexibility, chance of success, feasibility and fairness. Using these criteria the following generic options have been identified as the most promising for coastal zones in Egypt.

6.2.1 Beach nourishment and groins

Beach nourishment includes the deposition of sand onto the open beach as well as the scraping of beach, the building of artificial dunes as storm buffers and sand reservoirs, and the placement of pipes underneath the beach to suck in water and trap sand. Groins, which are hard structures perpendicular to the coastline, are used in conjunction with beach nourishment to trap sand. Costs for this option are low compared to installing breakwaters or to changes in land use. Also, direct or indirect net benefits could be expected since this adaptation option forms new beaches for tourism and thus creates more employment. Environment impact is fair, particularly for the beach. Regarding sea level rise, flexibility and chance of success can be assumed, since the option can be repeated periodically given close proximity to the desert with nearly unlimited supply of sand. Likewise, public acceptance (feasibility and fairness) are judged to be excellent. This adaptation measure would have no negative effect on fishermen. In fact, it may increase fishing yields, since new sand materials could constitute additional nutrient sources for fish. In addition, beach nourishments have no adverse effects on farmers since it protects their land from flooding and saltwater intrusion and no adverse effects on industrial workers, since it protects factories and employees from flooding. The major advantage of this strategy is the preservation of beaches for tourism, the protection of hotels and the possible rise in jobs in the tourism sector. Nevertheless, it must be noted that to pursue this option is to commit to beach nourishment in perpetuity. In the meantime, development would continue along the beach, increasing the “value at risk.” Perhaps a longer time horizon would affect the balance of the effectiveness of this option with ongoing costs.

6.2.2 Breakwaters

Breakwaters are hard structures used to reduce wave energy reaching the shoreline. They can be set up offshore either as submerged breakwaters or as riprap along the shore to absorb wave energy. This strategy however is relatively expensive in comparison to beach nourishment and legal regulation. Likewise, flexibility, chance of success as well as feasibility of implementation are thought to be good. Given that people living in coastal areas need protection from coastal erosion, breakwaters and dikes are sufficient tools to protect agricultural land as well as infrastructure. Breakwaters however have a number of potential disadvantages; they can cause changes in ocean currents, affect fishing processes, and can inhibit the free mixing of coastal pollutants with the open waters leading to enhanced pollution levels at the coast.

6.2.3 Legal development regulation

Legal development regulation involves the taking of legal or regulatory actions to restrict development or prohibit re-development of hazard-prone areas. Regulations may include the adoption of erosion-based setback regulations, restricting post-storm reconstruction, or changing the tax structure to discourage development. Though this strategy can be expensive, proper formulation and implementation of this measure could result in net benefits and no adverse environmental impacts. Effective implementation of regulations however is a major challenge in Egypt. While regulations may influence the behavior of certain formal sectors, they might have only limited impact on stakeholders from the informal sectors such as fishing and farming. Finally, effective implementation of regulations may also require the development of an institutional capacity for monitoring and assessment like a remote sensing system.

6.2.4 Integrated Coastal Zone Management (ICZM)

Resulting from rapid population growth, coastal areas experience increased pollution and the degradation of natural environments, which might necessitate the construction of barriers to protect against erosion or coastal flooding during storm surges. Accelerated sea level rise is another factor stressing the natural ecosystem, which should be taken into account within the planning framework. Directing growth away from sensitive lands and towards less vulnerable areas is one option to reduce the risks associated with sea level rise as well as to reduce vulnerability to other problems of the coastal zone.

Integrated Coastal Zone Management (ICZM) requires the availability of a geographic database, a monitoring system such as remote sensing, and a decision support system, which necessitates advanced training and investment. The objectives of ICZM are to: (1) develop public awareness, build capacity, foster cooperation, and implement issue-driven action plans; (2) provide local and national benefits and improve the quality of life; (3) optimize the use of natural resources by integrating horizontal and vertical institutions in decision-making and development; and (4) minimize the degradation of natural systems and stimulate sustainable development. ICZM embraces the general principles of environmental management adopted by UNCED’s Agenda 21, including the precautionary principle, the use of proper resource accounting, the principle of trans-boundary responsibility, and the principle of intergenerational equity. However, the ICZM approach is somewhat theoretical, in that it lists a number of institutional initiatives but does not explicitly include implementation of actual adaptation measures.

6.2.5 Land use change

The adaptation option to change land use in vulnerable areas is still under consideration. The objective of changing land use is to move to less vulnerable activities or different uses of land, which better utilize lowlands, for example, aquaculture. A slight or moderate rise in sea level might be quite beneficial for the development of aquaculture in coastal areas.

6.3 Ranking of adaptation options in Alexandria and Port Said

Evaluating adaptation strategies is an increasingly urgent task for the economic sectors of vulnerable regions such as Alexandria and Port Said. A multi-criteria approach may be more effective for anticipatory adaptation evaluation than single-measurement approaches such as cost-benefit analysis and multi-attribute utility analysis because social decisions regarding climate change impacts are better considered within a broader development context and by taking a range of attributes that often go beyond those of cost-benefit analysis in its pure form into account (Smith and Chu 1994).

Thus, the Adaptation Decision Matrix (ADM) was used to evaluate the selected adaptation measures in Alexandria and Port Said. The ADM analyses cost-effectiveness of adaptation measures by comparing costs of adaptation measures with benefits measured in a common measurement, but not necessarily dollars. Such measurements can be added up across the different policy objectives, which are weighted according to their relative importance, and compared regarding their costs. Thus, the most efficient adaptation measure will be the one that produces one unit of benefit at the lowest cost.

6.3.1 Alexandria case study

A questionnaire was prepared and administered by personal interviewers using a random sample of 100 persons representing fishermen, industry workers, businessmen, farmers and others who were part of the main stakeholders in the Alexandria Governorate. Although this sample is not statistically significant, it is considered sufficient to provide broad indications of major directions. A supplement to the questionnaire was supplied explaining the problem in order to upgrade awareness among vulnerable groups. Results of the questionnaire indicated: (1) A clear agreement of almost all stakeholders of the need to protect the area. (2) A strong feeling among most stakeholders that cost is the main obstacle. (3) A weak tendency among stakeholders to change jobs in response to the effects of climate change. (4) A wide variation of opinions concerning barriers, responses, and recommended actions. This may reflect the various interests of stakeholders and their flexibility to respond to coastal problems. (5) A low percentage of stakeholders not interested in the subject.

The Adaptation Decision Matrix for coastal resources in Alexandria, shown in Table 9, is based on four relevant objectives: protection of property, avoidance of floods, development of the coast, and the preservation of wetlands. Each considered objectives was weighted on the basis of its relative importance, rather than its absolute value. Weights range from one (low importance) to five (high importance). While the protection of property, the avidance of floods, and the development of the coast are equally valued (3), wetland preservation is ranked least important (1). To enhance the analysis, the ADM uses a rise and a no-rise in sea level scenario to consider the benefits from each measure in different impact situations. In addition, scores were assigned for each measure ranging from one (poor) to ten (excellent) reflecting how well they perform in achieving each relevant objective. These values were then multiplied with the corresponding weights. Thus, the quantified benefits of each measure (total score) are the sum of the partial scores for each objective and each sea level rise scenario. The last column of the matrix (cost-effectiveness) is the incremental benefit of each measure compared to the current policy.[22]

[22] For example, for beach nourishment and groins the incremental benefit compared to the current policy is 55 (150-95). Thus the marginal benefit (cost-effectiveness) of this adaptation measure is 0.98, which is derived by dividing its costs (54 million USD) by its incremental benefit (55).

Table 9. Coastal resources Adaptation Decision Matrix (ADM) for Alexandria

Measure	Scenario	Weighted Objectives				Score	Total score	Cost of Measure (million US $)	Cost – effectiveness (cost/incre-mental unit of benefit)
		Property Protection (3)	Flood Avoidance (3)	Coastal Development (3)	Wetland preservation (1)				
Current policy	Rise No rise	6 5	5 3	4 7	2 3	47 48	95	Na	Na
Beach nourishment and groins	Rise No rise	7 9	6 7	8 9	6 6	69 81	150	54	0.98
Breakwaters	Rise No rise	8 9	8 8	5 7	7 8	70 80	150	468	8.5
Legal Regulation	Rise No rise	2 8	2 8	3 7	4 7	25 76	101	20	3.3
ICZM	Rise No rise	8 9	7 8	7 9	7 7	73 85	158	550	8.7
Land use Change	Rise No rise	3 8	2 7	3 6	6 7	30 70	100	900	180.0

Source: El Raey et al. 1999

The analysis of the ADM indicates that current policy (hard protection measures in some vulnerable areas) has the lowest score. Measures involving beach nourishment, breakwaters and ICZM have the highest scores with beach nourishment having by far the lowest costs.

6.3.2 Port Said case study

The ranking of adaptation options in Port Said followed a similar approach. A random sample of 100 individuals from key stakeholder groups (fishermen, industry workers, businessmen and others) was selected for personal discussions and participation in a questionnaire. The results of the analysis showed that about 86% of the interviewees were aware of the problem of sea level rise, 74% indicated that they are unwilling to move as part of any adaptation strategy, and 32% believe that decision-makers are not serious about coastal protection against sea level rise. The ADM for Port Said is shown in Table 10.

Table 10. Coastal resources Adaptation Decision Matrix (ADM) for Port Said

Measure	Scenario	Weighted Objectives				Score	Total score	Cost of Measure (million US $)	Cost – effectiveness (cost/incre-mental unit of benefit)
		Property Protection (3)	Flood Avoidance (3)	Coastal Development (3)	Wetland preservation (1)				
Current policy	Rise No rise	4 5	2 3	6 7	2 3	38 48	86	Na	Na
Beach nourishment and groins	Rise No rise	7 9	6 7	8 9	6 6	69 81	150	81	1.29
Breakwaters	Rise No rise	8 9	8 8	5 7	7 8	70 80	150	702	10.64
Legal Regulation	Rise No rise	2 8	2 8	3 7	4 7	25 76	101	20	1.3
ICZM	Rise No rise	8 9	7 8	7 9	7 7	73 85	158	200	2.63
Land use Change	Rise No rise	3 8	2 7	3 6	5 7	30 70	100	684	58.9

Source: El Raey et al. 1999

The results indicate that current policy again has a low score. Meanwhile, ICZM, installation of breakwaters as well as beach nourishment and groins are ranked higher among the stakeholders. In terms of cost-effectiveness beach nourishment, legal regulation and ICZM are particularly attractive.

6.4 Towards mainstreaming of coastal adaptation options in Egypt

The vulnerability of Egypt's Nile Delta to sea level rise is particularly critical, given the concentration of population, agriculture and economic activity, coupled with significant rates of natural land subsidence. However, Egypt is also at the forefront in the developing world in terms of rigorous coastal zones vulnerability and impact assessments – which have been conducted largely by its own experts. Further, there are a number of coastal protection activities already underway to improve resilience to sea-level rise. Fanos et al. (1995) review several such projects including the construction of a new drain at the western Nobariya drain outlet west of Alexandria; construction of a 180m extension of a breakwater in Alexandria's eastern harbor that would reduce wave heights at critical locations of the coast; beach nourishment projects undertaken in five beaches in Alexandria; the reinforcement of the Abu Quir Sea wall that was originally constructed in 1780; construction of four breakwaters west of El Gamil; construction of two jetties on the western and eastern sides of the El Gamil outlet to protect it from siltation and migration; and the construction of a small bituminous dyke to protect a low lying coastal road to the airport from flooding.

All the measures outlined above were undertaken largely in response to current development and environmental priorities, but are synergistic with adaptation to sea level rise from climate change. Nevertheless, such measures are largely restricted to "hard" adaptations, and – relative to the magnitude of the problem – are still fairly limited in their coverage of vulnerable areas. Further, while detailed vulnerability analyses have been conducted for key urban areas such as Alexandria, Rosetta, and Port-Said, there is also an urgent need to assess the vulnerability of several other economic centers in the Nile delta, coastal agriculture, lakes and wetlands, and Egypt's key coastal archeological sites to sea level rise.

Successful mainstreaming also requires an increased emphasis on "softer" adaptations – which include the implementation of existing laws that reduce coastal vulnerability and the formulation of new regulations that correct distortions and other activities which might exacerbate coastal vulnerability to sea level rise. Environmental Law 4/1994 for example requires Environmental Impact Assessment (EIA) prior to the implementation of any coastal project in vulnerable areas. While this has encouraged several projects to conduct EIAs, there are many others which have not done so. Proper enforcement of this law is therefore critical to manage costal vulnerability. There is also a need to monitor land use, erosion patterns in coral reef and mangrove areas, and pollution from oil spills and from land-based sources. Further, given the high ranking of Integrated Coastal Zone Management (ICZM) as an adaptation response by stakeholders in the studies reviewed earlier, there is a need to reconsider land-use planning in the coastal zone. While a committee for ICZM has been established, it has not been very active. Activation of the committee by involving NGO and academic experts could help energize ICZM efforts. Implementation of ICZM might also be facilitated by the establishment of local ICZM networks, as well as proper monitoring of land use and environmental practices in partnership with relevant authorities. For example sea level rise and coastal inundation in Alexandria only exacerbate the effects of increasing pollution as a result of increasing population and industrial development, untreated sewage and industrial waste, and shipping industry and agricultural runoff (Frihy et al. 1996). Implementation of aggressive pollution control measures should therefore be a critical component to reducing the vulnerability of Egypt's coastal areas to sea level rise. There is also a need to reorient economic policies that help shape the behavior of private agents. For example, water is subsidized, encouraging overuse, and discouraging conservation, which could be critical to adaptation to the impacts of climate change.

Given the inevitability of coastal subduction and sea level rise there is also a need for research and development of suitable adaptation technologies. The development of salt tolerant species through research in biotechnology could be an effective adaptation to the impacts of saline intrusion on the coastal zone which is projected to have significant impacts on coastal agriculture. Technologies for water desalinization and treatment and re-use would also help reduce the impacts of sea level rise, while also promoting water availability and contributing to pollution control.

Finally, yet another set of adaptation strategies closely tied to development objectives could revolve around the promotion of alternate, "win-win" land use practices. Aquaculture or rice cultivation on vulnerable land on the Nile delta could, for example, harness available workforce, help to improve food security, and have beneficial impacts on the soil. Meanwhile, the establishment of greenbelts on coastal hinterland based on the use of treated wastewater from tourist resorts could help stabilize soil and dune movement and reduce dust impact on the Nile delta, promote carbon sequestration, reduce the impact of saline intrusion, harness rainwater, and provide employment to the local population.

7. Climate change and Nile water availability in Egypt

Egypt is almost wholly dependent upon water that originates from the upstream Nile basin countries; Uganda, Ethiopia, Tanzania, Kenya, Rwanda, Burundi, Congo, and Eritrea and Sudan. The Nile is comprised of tributaries draining the Ethiopian highlands which contribute around 70% of overall Nile flow, with 50% from the Blue Nile, and 10% from the Atbara and 10% from the Sobat rivers. Most of the remaining 30% of Nile flow originates from Lake Victoria with additional contributions and losses from lakes in Uganda and wetland systems in Southern Sudan, hereafter referred to as the White Nile system. Because of Egypt's almost complete reliance on the Nile for freshwater it is essential for any analysis of climate change and Egypt to consider the possibility of climatically-induced changes in Nile flows. To do this it is necessary to understand the generic linkages between water and climate change and the specific characteristics of the Nile basin which determine how climate interacts with other factors to produce Nile flows.

This analysis is divided into five sections; the first contains a review of previous research on climate change and Nile flows. The second presents an analysis of climate and water resources variability in the two main source areas of the Nile and its relevance to contextualising climate change impacts and adaptation. The third section contains a qualitative analysis of the significance of warming trends for increasing evaporative losses in the Nile basin. The final section discusses adaptation to climate variability and change in Egypt in the context of existing policies for water resources management and broader political and socioeconomic policies.

7.1 Review of previous work on climate change and its impacts on Nile flows

A number of papers have looked at the implications of fluctuations in Nile flows for water resources in Egypt, particularly since a prolonged period of low flows during the 1970s and 1980s. Abu-Zied and Biswas (1991) and Conway and Hulme (1993) considered the implications of climate fluctuations for water management with emphasis on the Nile. They stressed the uncertainties involved in predicting future climate change and that existing planning processes and hydrologic methodologies need to be improved to deal with such challenges. They also emphasised the importance of fluctuations in river flow over the historical period for managing water resources.

Hulme (1990) reviewed the factors affecting precipitation over the Nile basin at different temporal and spatial scales. He presented future changes in temperature and precipitation, based on the results of a number of global climate model (GCM) experiments for the Nile basin, with a discussion of their implications for Nile flows. Conway and Hulme (1996) used hydrologic models of the Blue Nile and Lake Victoria to assess the magnitude of potential impacts of future climate change on Nile flows. The impacts were largely dependent on the wide range of inter-model differences in future climate, particularly associated with the direction and magnitude of rainfall change. A Lake Victoria water balance model similar to one first developed by the UK Institute of Hydrology (Piper et al., 1986) was driven with three climate change scenarios from three GCMs and produced changes in Lake Victoria outflows ranging from -9.2% to +11.8%. Sensitivity analysis showed that a 10% increase in Lake Victoria rainfall caused a 31% increase in runoff and a 4% increase in evaporation caused an 11% decrease in runoff. By combining changes in Lake Victoria outflows with changes in runoff in the other Nile sub-basins Conway and Hulme (1996) obtained a range of –9% to +12% change in mean annual Nile flows for 2025.

Strzepek et al. (1996) used a spatially aggregated monthly water balance model to explore the sensitivity of Nile flows to climate change. Like Conway and Hulme (1996) they found that there was divergence between climate model results for the Nile basin; from a sample of four models two produced increases and two produced decreases in flows, with one producing a decrease of over 70% of annual flow. In a later study Yates and Strzepek (1998) found that five out of six climate models with a doubling of CO_2 produced an increase in Nile flows at Aswan, with only one showing a small decrease (-15%).

Strzepek and colleagues have produced two recent updated studies with greater emphasis on developing methodologies for designing what they term as ‘not implausible’ climate and economic scenarios and for assessing and evaluating adaptation strategies. Strzepek et al. (2001) use a purpose-designed software system to produce a sample population of climate change scenarios for the basin that incorporate uncertainties due to differences between climate models, a range of climate sensitivity estimates, emission pathways for greenhouse gases and sulphate aerosols and the effects of sulphate aerosols. They selected nine representative scenarios from the full range which were translated into future Nile flow scenarios using a suite of water balance models. The results showed a propensity for lower Nile flows (in eight out of nine scenarios), in contrast to their earlier study, in which five out of six scenarios produced an increase in Nile flows.

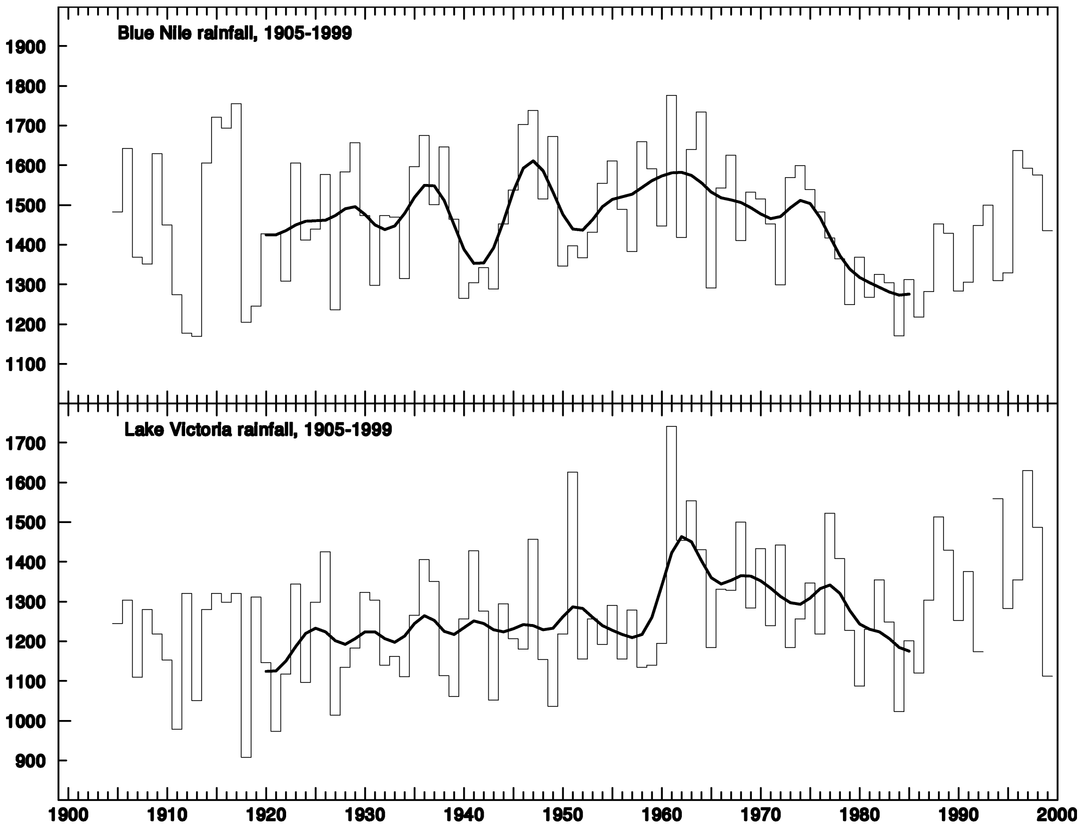
7.2 Climate variability and change in the Nile basin

This section concerns fluctuations in rainfall and river flows in the Nile basin since the beginning of modern gauge measurements of river flows began at Aswan in 1869. The source areas for the Nile are the humid highlands of East Africa and Ethiopia. Neither region experiences particularly high interannual rainfall variability, however, marked fluctuations in rainfall have occurred over decadal timescales with significant consequences for Nile flows. As it is possible to explain most of the variability in Nile flows by considering the Blue Nile (Ethiopian highlands) and Lake Victoria (East Africa, main component of the White Nile system) this section presents a hydroclimatic analysis of both regions and their integrated effects on the overall flows of the Nile.

7.2.1 Rainfall variability in the headwaters of the Nile

Figure 8 shows annual rainfall averaged over the source areas of the Blue and White Niles (represented by rain gauges located in or close to the Blue Nile and Lake Victoria, respectively) from 1905 to 1999 [23]. In the Blue Nile basin a slightly increasing trend occurred between 1905 and 1965 followed by a prolonged decline which bottomed out in 1984 and recovered during the 1990s with 1996 the wettest year since 1964 (33 years). In contrast, rainfall over Lake Victoria shows a moderate increasing trend up to 1960 followed by a prolonged increase in annual rainfall due to a combination of extremely wet years, e.g. 1961, 1963 and 1977 and small increases in other years. Annual rainfall over much of the Lake Victoria region increased from 1931-60 to 1961-90 by roughly 8% (Conway, 2002).

Figure 8. Average annual rainfall 1901-99 in the Blue Nile and Lake Victoria catchments



23 Bold line represents period with best data coverage using a 10-year Gaussian filter.

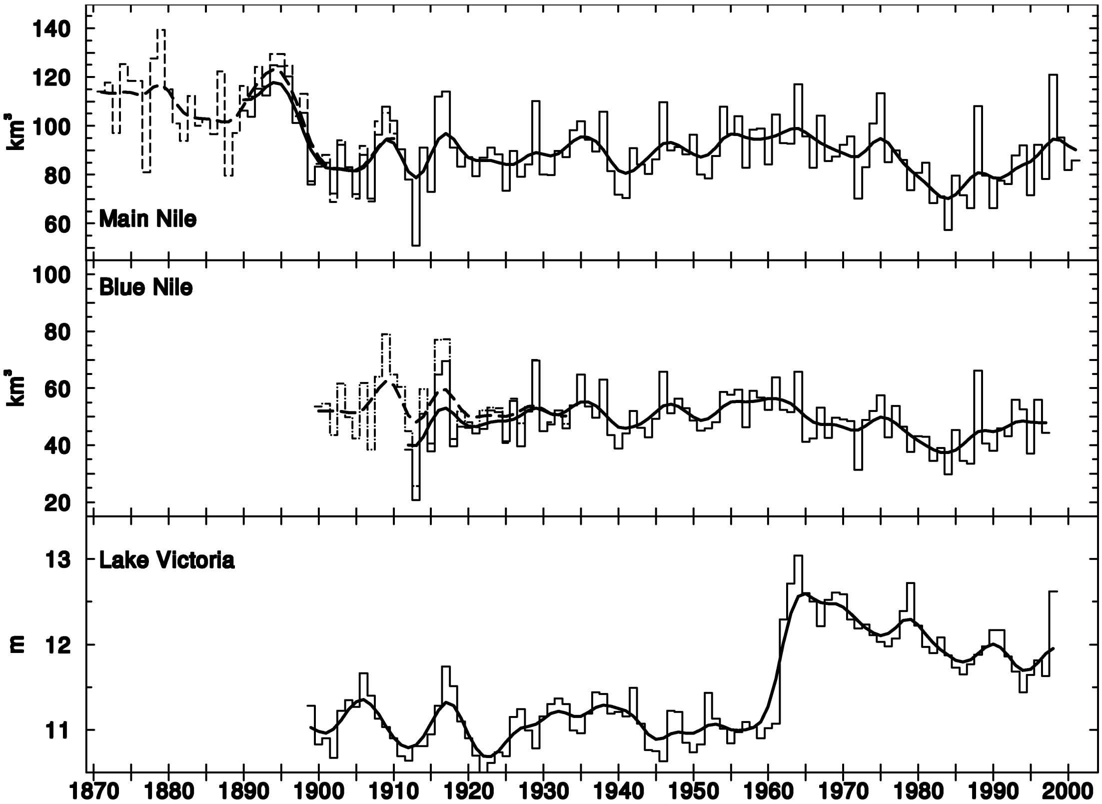
7.2.2 Variability in White and Blue Nile flows – impacts on Nile river flows

Figure 9 shows annual Blue Nile flows, Lake Victoria levels and Nile flows at Aswan[24]. Runoff in the Blue Nile basin amounts to 45.9 km^3 (equivalent to 1456 m^3s^{-1}), a depth of 261 mm (1961-1990), and a runoff coefficient of 18%. Between 1900 and 1997 annual river flow has ranged from 20.6 km^3 (1913) to 79.0 km^3 (1909), and the lowest decade-mean flow was 37.9 km^3 from 1978-87. A significant and sustained increase in Lake Victoria levels and outflows occurred in late 1961. Lake Victoria levels increased 2.25m from 1961 to their peak in 1964 equivalent to an increase in storage volume of 151km^3 and decreased steadily except for short-lived rises in 1978-79, 1990-91 and 1997-98 and they remain well above their pre-1961 levels. Lake Victoria outflows roughly doubled from 1931-60 to 1961-90.

Downstream the long record of Nile flows into Egypt integrates the effects of the Blue Nile and Lake Victoria along with other lakes and wetlands on the White Nile system and varying contributions from other tributaries. Nevertheless, because of the large proportional contributions to the Nile from the Blue Nile and Lake Victoria their variability is strongly reflected in the Nile flow record. The low Blue Nile flows during the 1980s were partially offset by higher White Nile flows since the 1960s but their effects were still apparent in the Nile flows which reached their second lowest point in 1984. The recovery of rainfall in the Blue Nile during the 1990s is also reflected in the Nile flows. The period of high flows prior to 1899 has been the subject of a number of studies especially concerning the accuracy of the early gauge data but the change is real. The reduction in flows after 1899 represents a marked change in the regime and the monthly flow patterns and anecdotal evidence suggest that the high flows were due to contemporaneous high flows in the Blue and White Niles.

24 Note different vertical scales. Upper panel; Nile flows 1870-2001 (dashed line from Aswan, full line from a combination of Wadi Halfa, Kajnarty and Dongola). Middle panel; Blue Nile flows 1900-1997 (dashed line from Khartoum, full line from a combination of Roseires and el Deim).

Figure 9. Average river flows in the Main and Blue Nile and lake levels in Lake Victoria



7.2.3 Climate change scenarios

In contrast to an observed warming in parts of the basin during the 20th century (Hulme et al., 2001) there is no evidence of rainfall behaviour that might be attributed to global warming. In terms of future climate change there is high confidence that temperatures will continue to rise, probably more rapidly than before, with implications for greater losses to evaporation and transpiration. For rainfall there is much less certainty, particularly because of the low convergence in climate model results for future rainfall conditions in the key headwater regions of the Nile. Hulme et al. (2001) found a large inter-model range in seasonal rainfall changes over Africa with a set of recent GCM experiments, including differences in the direction of rainfall change over Ethiopia. Inter-model disparities in future rainfall change are also presented in IPCC (2001). A recent analysis of future rainfall change for five key regions in the Nile basin for summer (June to August, JJA) and winter (December to February, DJF) from nine climate model experiments using IPCC SRES emissions scenarios (outlined in Hulme et al., 2003, details of GCM experiments contained in Table 9.1 of IPCC Third Assessment Report, IPCC, 2001) indicates that the Blue Nile region has large divergence in climate model projections in both seasons, with JJA crucial for Nile flows. In the White Nile system (Lakes Victoria and Kyoga and the Sudd) rainfall in DJF shows inter-model convergence for a small to large increase but divergence in JJA. Unfortunately results were unavailable for the more important rainfall seasons in the White Nile region, March to May and September to November. The models are consistent for small decreases in winter rainfall in the Nile Delta, large decreases in JJA are unlikely to be significant as rainfall is negligible in these months. GCM projections for warmer temperatures are more consistent throughout the whole basin.

7.3 The significance of warming trends for increasing evaporative losses in the Nile basin

There remains low confidence in the direction and magnitude of future rainfall change in the basin, however, the observed regional warming and the high confidence (in IPCC terms) that this will continue at an increasing rate makes it prudent to review the possible effects of higher temperatures on surface water resources in the basin. That there are large expanses of open water (Lake Victoria alone is roughly 67 000 km^2) and wetlands, along with reservoirs (evaporation from the High Aswan Dam is over 10% of the Nile flow), long stretches of river channel in semi-arid to arid conditions, and extensive areas of irrigation in Sudan and Egypt suggests that surface water resources in the basin are likely to be quite sensitive to higher temperatures. Given no change in rainfall, higher temperatures will probably cause lower river flows, lake levels and reduced wetland extent. This section contains a discussion of the main losses to evaporation in the Nile system (based on figures in Sutcliffe and Parks, 1999) and a qualitative assessment of the effects of higher temperatures on these losses. There follows a short discussion of the role and importance of higher temperatures to water use in irrigation systems.

Losses to open water evaporation in Lake Victoria and the Ugandan Nile lakes, although lower than rainfall amounts are huge in volumetric terms. However, it is reasonable to speculate that some of this moisture may be recycled in the form of rainfall in the region. Evaporation rates begin to exceed rainfall when both the White and Blue Niles enter Sudan. Roughly half the inflows to the Sudd wetland system in Southern Sudan are lost to evaporation and transpiration (annual Penman evaporation is 2150mm per year). Evaporation from the Blue Nile river between Roseires and Khartoum is roughly 2km^3 (624km length, 300m width), Roseires and Sennar reservoirs have evaporation losses of roughly 0.5 km^3 each. On the White Nile, losses from north of the Sudd to just south of Khartoum (a distance of 840km) are roughly 2km^3 and the large surface area of the Jebel Aulia reservoir loses roughly 2.5 km^3. Channel losses from Khartoum to Dongola, close to the High Aswan Dam reservoir, are roughly 2.4 km^3 due to evaporation rates of 2700mm over a channel length of 1500km with average width of 600m. Finally, in the High Aswan Dam reservoir and throughout Egypt, evaporation plays a critical role in water resources management. For the High Aswan Dam alone the estimated evaporation is around 10km^3 (2700mm evaporation).

It is beyond this analysis to produce quantitative estimates of the effects of higher temperatures on evaporation and their impact on Nile flows. Qualitative results can be extrapolated from climate impact simulations of Lake Victoria levels to the other equatorial Nile lakes (Albert, Edward and Kyoga). Given no change in the other factors that affect evaporation from open water it can be assumed that higher temperatures will reduce lake levels and consequently outflows; Conway and Hulme (1996) and Sene et al. (2001) demonstrate this effect. It should be noted that changes in cloud cover, wind speed and humidity also play an important role in determining lake evaporation, but relatively little work has been done on this and GCM results for these variables have not been extensively reviewed to assess their reliability. A rise in temperature of just 1˚C, assuming a 4% increase in evaporation per degree centigrade rise in temperature, would lead to large increases in losses to evaporation (if not offset by increases in rainfall), which would significantly reduce Nile flows. The impacts of increases in evaporation rates are complex and may be affected by water level-surface area relationships, water level-outflow relationships and other hydrological conditions. A more sophisticated analysis using hydrological models of the main lakes in the system and a more realistic estimate of changes in evaporation rates (using Penman open water figures) should be undertaken to provide a better assessment of the effect of temperature rise on Nile flows.

The implications of higher temperatures for agricultural water use in Egypt (and also upstream in Sudan) could also be very high as losses are likely to increase from the Nile, the extensive system of irrigation canals, and possibly from crop water use. Estimating the possible amounts of these losses is not trivial. In terms of climate change impact this is an important issue that should be considered, alongside direct physiological effects of higher temperatures on crops. In their study of impacts of climate change on maize and wheat in Egypt, El-Shaer et al. (1997) found yields and water-use efficiency were lower than under current climate conditions, even with consideration of the beneficial effects of CO_2. Crop yield reductions were caused by higher temperatures shortening the grain-filling period. Daily evapo-transpiration increased in the warmer climate although it was partially offset by improvements in crop water use efficiency. The effects of increased atmospheric CO_2 concentrations are complex, higher levels can in some cases reduce transpiration rates by increasing stomatal resistance and hence increase runoff, whereas they may also increase plant growth leading to higher transpiration rates (Gleick et al., 2000). The actual impact will depend upon exact crop and climatic conditions. Further empirical and modelling studies are necessary to generate better estimates of the sensitivity of agricultural water use in Egypt and Sudan to higher temperatures.

7.4 Nile water allocation regime and implications for Egypt

To summarize, the discussion of the climatic influences on Nile supplies for Egypt – projected changes in rainfall in different sources of the Nile as well as their impact on the river flow into Egypt – remain considerably uncertain. More certain however is that temperatures will continue to increase as a result of climate change. This will likely increase significantly the evaporative losses from the Nile over Egypt and Sudan where the Nile flows with very little flow-gradient over a semi-arid region. Furthermore, higher temperatures will also increase demands for water – particularly for agriculture, and potentially for domestic and industrial uses.

This potential vulnerability of Egypt's Nile flows could be seriously exacerbated should climatic impacts be accompanied by any concomitant reduction in the country's allocation of Nile waters. The current water allocation is governed by a 1929 Nile Water Agreement between Egypt and Britain which was representing Kenya, Tanzania, Sudan and Uganda. A key clause in the agreement is that "no works or other measures likely to reduce the amount of water reaching Egypt were to be constructed or taken in Sudan or in territories under British administration without prior Egyptian consent". Cooperation to build the High Aswan Dam led to a 1959 follow-up agreement between Egypt and Sudan "on the full utilization of the Nile waters", which allocated 75% (55.5 BCM/yr) of the water resources of the Nile to Egypt and 25% (18.5 BCM/yr) to Sudan. The agreement, which partitioned all of the Nile's water, was bilateral between the two most downstream countries - Egypt and Sudan, and did not include the other riparian countries which contained all the principal sources of the Nile. Egypt and Sudan also agreed that the combined needs of the other riparians could not exceed 1-2 BCM/yr. Egypt and Sudan have been close partners in the basin and a Permanent Joint Technical Commission (PJTC) has existed since the 1959 agreement (Waterbury 2002).

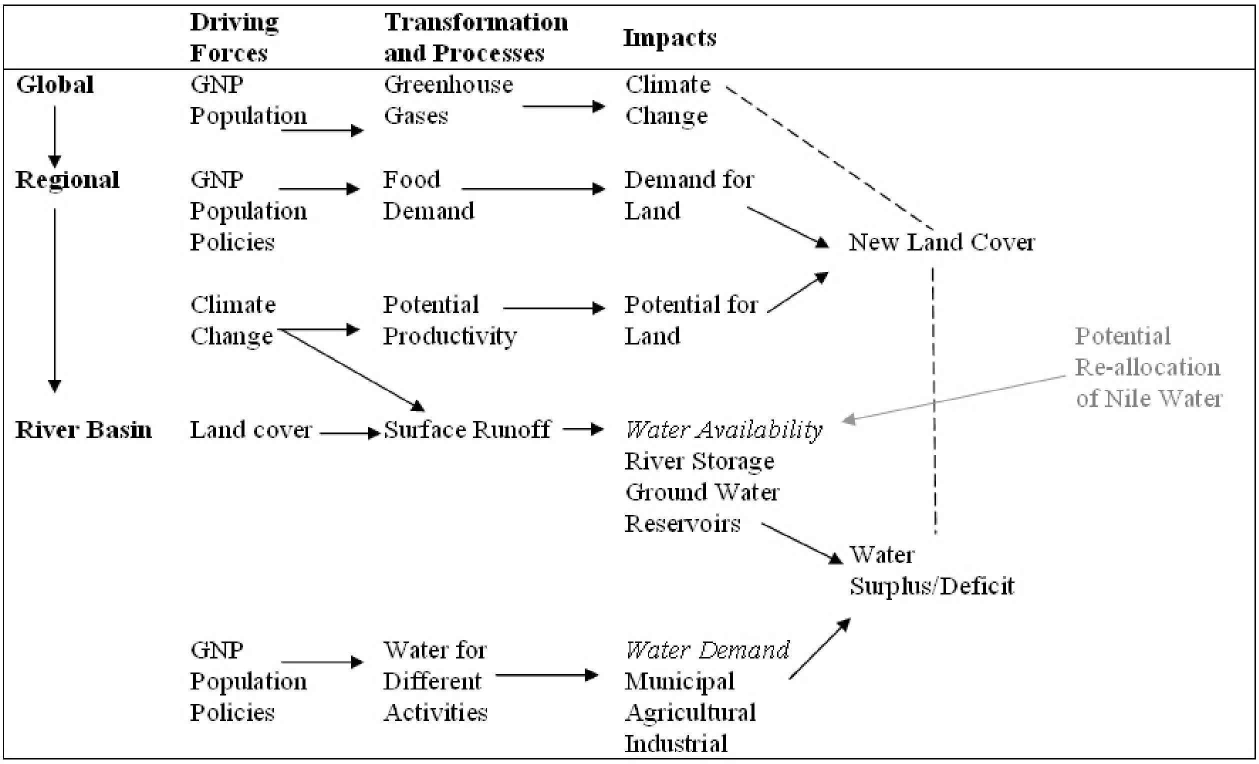
The provisions of both the 1929 and 1959 agreements have been contentious among the upper riparian countries, given the 1929 agreement was negotiated by a colonial power on behalf of some of them, while the 1959 agreement excluded them altogether. Egypt's position meanwhile is that international agreements, like country boundaries are inherited upon independence and must therefore be honoured. At conflict with Egypt's interest in status quo are the development aspirations of countries like Ethiopia, which contributes almost 70% to Nile flows but currently has very little irrigated agriculture and is vulnerable to regular and devastating famines (Broad and Agrawala, 2000). Other, more powerful riparians, have also expressed concerns. In October 2001, Kenya's Energy Minister dismissed the 1929 Nile Water Agreement as "obsolete", noting that "this agreement was negotiated without our being represented and should be reviewed. Why should we preserve our water for Egypt?" (Odinga, 2001). Thus while status quo is likely to continue in the short term, a reallocation leading to a reduction in Egypt's share of Nile waters is not entirely implausible over the medium to long-term. Combined with the contextual dependence of Egypt on the Nile, its growing demands on water and electricity, and the potential for reduction in streamflow from climate change (through enhanced evaporation and possibly reduced precipitation), there is some likelihood of adverse surprises in the future – despite the fact that

Egypt is well adapted to current climate variability through the High Aswan Dam. There is therefore a need to formulate measures to adapt to potential medium to long term reductions in water availability and to integrate such responses as part of the development process.

7.5 Towards mainstreaming adaptation responses

The range of adaptation options to cope with potential water stress over the medium to long-term should theoretically encompass the set of global, regional, and basin level factors that drive water availability and/or use in Egypt, shown schematically here in Figure 10.

Figure 10. Multi-scale drivers affecting Nile water availability in Egypt



Adapted from Conway et al. 1996

Adaptation in water resources sector in Egypt is therefore closely intertwined with development choices and pathways for the country and the region. Changes in supply due to climate change will occur alongside the certainty of demographic trends and potential abstractions by upstream riparian countries which means that Egypt already faces massive water management challenges. Changes in supply due to climate change may exacerbate or ameliorate the problem. The possibility that climate may exacerbate the problem should reinforce the need for Egypt to develop its options for coping with water shortage. If one treats policies and measures outside of Egypt's borders as exogenous, the above schematic would imply three generic adaptation responses: reducing demographic pressures; demand side management, and supply side management. This section will focus on the latter two, given that population control is already a key development priority for the government and will be implemented outside of the water resources sector.

In terms of climate change and water resources at the generic level, Frederick and Gleick (1999) and Gleick et al. (2000) stress the importance of building in and maintaining existing flexibility in planning and management, re-evaluating current approaches in the light of climate change, improving efficiency of end use and demand management, and reviewing of engineering designs, operating rules, contingency plans and allocation policies under a wider range of climate conditions than previously used. Both studies also recommend research on the implications of climate change for management of international rivers. Although these recommendations were originally intended for the United States, they are fairly universal and are highly appropriate for water resources planning and management in Egypt and in the Nile basin. Some of the more specific adaptation measures for Egypt are described in Box 4.

Box 4. Selected adaptation options for water resource management in Egypt

National and regional policies

- Implement water conservation for the agricultural (e.g. drip irrigation) and the industrial (e.g. recycling) sector.
- Enact programs for upgrading water quality and sanitation to minimize pollution, with a high priority to recycling of industrial and sewage waste.
- Build catchments and dams for water collection in flash flood areas such as Sinai, Kena and the Red Sea. Reactivate old rainwater catchments (Roman karma systems) on the north western coast and use for rain fed cultivation (to serve tourists especially during the summer). This will also reduce transport of food supplies and water from city centers to coastal resorts.
- Investigate the role of solar water desalination plants and wind energy in making up for expected shortages.
- Reconsider impact assessments of drainage water storage in northern lakes.
- Launch public awareness campaigns on water shortage, knowledge of water quality and test socio-economic impacts of selected measures.

Institutional and research measures

- Strengthen the newly established Institute of Environment and Climate Change in the Ministry of Public Work and Water Resources to study climate change impacts.
- Encourage Meteorology departments in universities and in the Ministry of Defense to allocate resources (human and funds) to study impacts of climate variability and change in Egypt.
- Strengthen cooperation and exchange of information between the departments of different ministries, research institutions and universities working on the different aspects of water resources.
- Develop an institutionalized methodology for assessment of impacts, including scenarios for impacts on water budget, evaporation, and impacts on each sector.
- Improve capacity in government departments and universities for training and implementation of water demand management approaches.
- Develop a program for ground water management to protect reservoirs from overexploitation and pollution

Water resources in Egypt satisfy the demands for irrigation, municipal/domestic water systems, industry, and electric power generation. In addition, water is needed to ensure barrage safety and efficient navigation on the Nile and its branches. Finally, water has to be spilled to the Mediterranean Sea in order to conserve the salt balance of the Delta. El Quosy (1994) estimated that the demand for irrigation, domestic and industrial supplies may reach 57.5 BCM/a, 7.3 BCM/a, and 7.5 BCM/a, respectively, by the year 2035. Adaptation on the demand-side requires minimizing reliance on water and optimizing economic return of its unit volume. Egypt has commissioned a series of strategic water assessments since the 1970s which contain extensive quantitative measurements and estimates of current and projected water supply and demand in the basin and within Egypt (see for example, Abu-Zeid and Hefny, 1991). These studies demonstrate that Egypt still has some surplus water in the system. Wichelns (2002) quotes estimates of 63.7 km^3 total annual supplies and 61.7 km^3 total annual water use so that nationally water is not yet a limiting resource. Waterbury (2002) identifies slack within the system which is or may be achieved through four main opportunities: reliance on virtual water, economic measures to improve water use efficiency, rainwater harvesting and drainage schemes in southern Sudan. Nevertheless with Egypt's population growing by roughly 1 million every nine months the current surplus is dwindling fast and the main opportunities to ease the pressure are not without cost, and there is also the possibility that upstream abstractions will increase.

Reliance on virtual water – that is water embedded in (food and other) imports - has economic and political implications and it is widely held that national food security remains an important political aim. Water demand management has potential in terms of improved use and sectoral allocation. There are numerous reviews and classifications of options for water demand management and improved agricultural water use. In terms of adaptive capacity the Ministry of Water Resources and Irrigation has strong technical expertise and capacity in water management (good for supply side options) but less capacity in terms of socio-economic and institutional management more appropriate for implementation of water demand management options. Prudent planning requires investment in development of expertise in this area. There are, however, important socio-economic and political considerations associated with introducing demand management policies in Egypt; political and institutional support will be important to promote capacity and action in this area.

On the supply-side, adaptation options include measures to improve rain-harvesting techniques, increasing extraction of ground water, recycling water, water desalination, and improving water transportation. Many supply-side options in Egypt however are generally limited by the size and accessibility of reserves and in Sudan water saving schemes, which affect water supply in Egypt, are contentious on social, political and environmental grounds and not realistic in the current political situation. As research began to appear on the implications of climate variability and change for the Nile in the early 1990s the focus was very much on drought and its implications for Nile water management (Hulme, 1990; Abu-Zeid and Abdel-Dayem, 1991; Abu-Zeid and Hefny, 1992; Conway and Hulme, 1993). Egypt is fairly well insulated against the effects of inter-annual variability because of over year storage in the High Aswan Dam but as the dry 1980s showed it is vulnerable to interdecadal variability. The effects of the dry period and the realisation that by summer of 1988 Egypt was very close to a major water shortage initiated a set of responses and anticipatory planning to cope with such future situations. Although the storage was sufficient to meet established releases (55.5km^3 per year) the government made emergency plans to counter further drought conditions, including reduction in the annual releases from the High Aswan Dam through more efficient regulation, extension of the irrigation system's winter closure period, reduction of the area under rice and improving the Nile's navigable channel to maintain levels to supply irrigation outtakes (Abu-Zeid and Abdel-Dayem, 1991). The dry period also prompted the establishment of a 'planning studies and models' department responsible for monitoring, forecasting (which at the time was based on upstream flows and levels with a roughly one month lead time) and simulation of the Nile (Abu-Zeid and Abdel-Dayem, 1991). These responses were synergistic with adaptation to potential reductions in water supply over the medium to long term. However, their urgency has declined somewhat given the capriciousness of climate, as by the mid-1990s Nile flows had returned to higher levels and Lake Nasser levels were recovering and by 1997 reached their highest point since the dam was completed.

Prolonged dry periods require additional response primarily in terms of effective contingency planning to limit reservoir releases in the face of reduced storage and inflows and to reduce the downstream effects of such actions. Equally, measures to deal with prolonged high flows and excess storage must be considered. Regular reviewing and updating of drought responses and research into improved long-term forecasting will enhance Egypt's ability to cope with prolonged drought. Climate change may also bring more prolonged and even permanent changes in Nile flows which would go beyond the capacity of current measures to deal with variability and require structural changes in current management strategies. Timescales are relevant in this respect, and given the magnitude of decadal variability it may be decades before a clear change in flow regime becomes apparent, whilst it may be beneficial to take certain planning and management steps now.

Finally, there is a need for dialog and cooperation among the Nile Basin states to address both technical issues such as sharing of data, as well as more political and sensitive ones such as water allocation. It could be argued that the best response for Egypt might be to insist on status quo and not agree to any reallocation which will inevitably decrease the share of Nile flows into Egypt. However, over the long term a co-operative mechanism to resolve water sharing issues could also be in Egypt's interest, as it would reduce the risk of uncertainty and surprise. A co-operative regime might also engender exploration of linked adaptations across the boundaries of the riparian countries whereby water allocation is linked to trade in water intensive commodities such as hydroelectricity and food products. While technical co-operation across several Nile Basin countries on issues such as data sharing has been ongoing for some time, more comprehensive co-operative agreements were forged only in the 1990s with the active involvement of several donors, including the Would Bank, the Canadian International Development Agency (CIDA) and the United Nations Development Program (UNDP). A series of Nile conferences were held, starting in 1993, eventually leading to the establishment of an international institution – the Nile Basin Initiative (NBI) – in May 1999, which now has all ten basin countries as its members. The NBI is structured around two complimentary initiatives, one top-down and the other, bottom-up: the Shared Vision Program and the Subsidiary Action Program. The objective of the Shared Vision Program is to create an enabling environment for investments and action on the ground, within a basin-wide framework. Within this basin wide framework, Subsidiary Action Programs will then devise and implement actual development projects at the sub-basin level, but involving two or more countries – national and sub-national initiatives meanwhile are left to individual countries. Subsidiary Action Programs encompass a whole range of linked water resource-economic development issues, including irrigation and drainage development, fisheries development, hydropower development and pooling, sustainable management of wetlands and watersheds, regional energy networks, including power inter-connection, regional transport and communication, promotion of trade, and disaster forecasting and management.

It is too early to assess the effectiveness of the NBI, given that it has been in existence for only a few years. Nevertheless, it marks an important beginning in terms of providing a cooperative forum to reconcile the water needs and development aspirations of all the Nile Basin countries. Climate concerns do not figure in NBI activities and might need to be incorporated, given their potential significance to all the basin countries.

8. Concluding remarks

The population, land-use and agriculture, and economic activity of Egypt are all constrained along a narrow T-shaped strip of land along the Nile and the coast around its delta, making the country extremely vulnerable to any adverse impacts on its coastal zones and water availability from the Nile. Climate change poses significant risks through sea level rise on the costal zone, which is already subsiding at rates from 3-5mm/year around the Nile delta. There is also some possibility of significant decline in Nile streamflow under climate change, although the studies reviewed in this report offer conflicting results. Nevertheless Nile water availability is likely to be increasingly stressed due to higher water demands and evaporative losses resulting from higher temperatures in the semi-arid region, which are projected consistently across various climate models. Coastal zone and water resource impacts also have serious implications for agriculture: sea level rise will adversely impact prime agricultural land in the Nile delta through inundation and salinization, while the intensive irrigated agriculture upstream would suffer from any reductions in Nile water availability. Therefore, climate change is a serious development concern for Egypt.

8.1 Attention to climate change concerns in donor portfolios and projects

Egypt receives about US $1.5 billion in donor aid per year, or about 1.5% of its GNI. An analysis of donor projects in Egypt using the OECD/World Bank Creditor Reporting System (CRS) database reveals that roughly 33% (in terms of investment dollars) and 25% (in terms of number of projects) of donor portfolios in Egypt are potentially affected by climate risks. This includes both activities in sectors which may be impacted by climate change, as well as those development activities which may influence the vulnerability of natural or human systems to climate change. These numbers are only indicative, given that any classification based on sectors suffers from problems related to over-simplification. Nevertheless, such measures can serve as a crude barometer to assess the degree to which particular projects or development strategies may need to take climate change concerns into account.

Donor strategies do not mention climate change, although several stress the concern for water scarcity in Egypt. Some donor strategies and projects explicitly cater to improved water management and conservation in Egypt, including a shift to less water intensive crops. While not explicitly recognizing climate change, any measures to promote efficiency of water use would be synergistic with adaptation that would be required on account of additional stresses on water availability posed by climate change. Meanwhile several donors have also emphasized basin wide co-operation on the Nile waters, particularly through the Nile Basin Initiative (NBI) which was established in 1999. If successfully implemented such an initiative can help reconcile the water use and development priorities of all riparian countries, including their capacity to adapt to any reductions or other changes in Nile flows from climate change. Climate concerns however are not yet an explicit part of the NBI agenda.

Relative to water resources there are fewer donor projects on coastal zones, although some do focus on issues such as coastal and marine resource management, and conservation of coastal wetlands. The absence of climate change concerns in such projects however could be a significant omission, given the local subsidence at several locations on Egypt’s coast (particularly around the Nile delta) which would exacerbate the impacts of climate change induced sea level rise and saline intrusion.

8.2 Attention to climate change concerns in national planning

Egypt has signed or ratified a number of multilateral environmental agreements, and has a number of national level environmental and sectoral plans that intersect with responses that might be required to manage climate variability and long-term climate change. It was among the first Arab states to participate in international initiatives on climate change, and has ratified both the Framework Convention on Climate Change and the Kyoto Protocol. Egypt has several domestic initiatives to address climate change, including an inter-ministerial National Committee on Climate Change established in 1997, an ongoing GEF Climate Change Capacity Building program, the Energy Efficiency Council which is a consortium of public and private agencies, and the Integrated Coastal Zones Management Committee. The First National Communication of Egypt was submitted in 1999 and includes an assessment of climate change impacts on several key resources. The analyses of coastal vulnerability produced by national experts are among the most sophisticated in non-OECD countries, and have also been published in several international peer reviewed journals.

Despite the availability of institutions and assessments, the actual implementation of adaptation measures is faced with several obstacles. With several other pressing development priorities, including increasing costs of living and food, and loss of land productivity in coastal areas, climate change is not yet on the radar screen of national decision-makers. Further, some economic policies (including taxes, subsidies, and regulations) that shape private decision-making, resource use, and development patterns may in fact hinder the implementation of adaptation measures. Water, for example, is heavily subsidized making it difficult to implement any adaptation measures aimed at improving water conservation.

Inappropriate land-use zoning and/or subsidized disaster insurance also encourage construction in coastal areas that could become even more vulnerable with climate change. In the opinion of some national experts convincing national decision-makers of the priority of long term adaptation remains the biggest challenge – even more significant than the availability of funds to implement such measures.

8.3 Towards mainstreaming of climate concerns in development planning: constraints and opportunities

This analysis has focused on Egypt's coastal zones and Nile water resources, which were identified as most vulnerable to climate change impacts. Egypt is also at the forefront in the developing world in terms of rigorous coastal zones vulnerability and impact assessments – which have been conducted largely by its own experts. Further, there are a number of coastal protection activities already underway to improve resilience to sea-level rise, including construction of new coastal drainage systems, breakwaters and dykes, as well as several beach nourishment projects. Such measures were undertaken largely in response to current development and environmental priorities, but are synergistic with adaptation to sea level rise from climate change. Nevertheless actions are largely restricted to "hard" adaptations, and – relative to the magnitude of the problem – are still fairly limited in their coverage of vulnerable areas. Further, while detailed vulnerability analyses have been conducted for urban areas such as Alexandria, Rosetta, and Port-Said, there is also an urgent need to assess the vulnerability of several other economic centers in the Nile delta, as well as coastal agriculture, lakes and wetlands, and key coastal archeological sites to sea level rise.

Successful mainstreaming also requires an increased emphasis on "softer" adaptations, which include the implementation and enforcement of existing laws that reduce coastal vulnerability and the formulation of new regulations that correct distortions and other activities, which might exacerbate coastal vulnerability to sea level rise. For example, there is a law which requires Environmental Impact Assessments prior to the implementation of coastal projects, but its implementation has been uneven. There is also a need to monitor land use, erosion patterns in coral reef and mangrove areas, and pollution from oil spills and from land-based sources. There is also a need to reorient economic policies that help shape the behavior of private agents. For example, water is subsidized, encouraging overuse, and discourages conservation, which could be a critical to adaptation to the impacts of climate change. Yet another set of adaptation strategies closely tied to development objectives could revolve around promotion of alternate, "win-win" land use practices. Aquaculture or rice cultivation on vulnerable land on the Nile delta could, for example, harness available workforce, help improve food security, and have beneficial impacts on the soil. Meanwhile, establishment of greenbelts on coastal hinterland based on the use of treated wastewater from tourist resorts could help stabilize soil and dune movement and reduce dust impact on the Nile delta, promote carbon sequestration, reduce the impact of saline intrusion, harness rainwater, and provide employment to the local population.

Adaptation in the water resources sector in Egypt is also closely intertwined with development choices and pathways for the country and the region. Changes in supply due to climate will occur alongside the certainty of increased demographic pressures as well as the potential increases in abstractions by upstream riparian countries. The possibility that climate may exacerbate Egypt's water security should reinforce the need for it to implement options for coping with water shortage. Egypt has historically supported a population around 4-5 million (in 2000BC) to about 8 million (1000AD), down to 3 million at the beginning of the 19th century. However, by about 1950, the population was 20 million, and has since increased to about 60 million presently, and is growing by 1 million every nine months. This sharp increase was sustained in large part by significant improvements in its ability to better harness the Nile waters in the late-20th century – particularly through the High Aswan Dam – which boosted crop production via intensive agriculture. The sustainability of this trend in population growth and water use could be in question under any scenario of reduced water availability and/or loss of prime coastal agricultural land from sea level rise. There are, however, important socio-economic and political considerations associated with introducing demand management policies in Egypt; political and institutional support will be important to promote capacity and action in this area.

On the supply-side, adaptation options include measures to improve rain-harvesting techniques, increasing extraction of ground water, recycling water, water desalination, and improving water transportation. Many supply-side options in Egypt however are generally limited by the size and accessibility of reserves and in Sudan water saving schemes, which affect water supply in Egypt, are contentious on social, political and environmental grounds. Prolonged dry periods require additional response primarily in terms of effective contingency planning to limit reservoir releases in the face of reduced storage and inflows and reduce the downstream effects of such actions. Equally, measures to deal with prolonged high flows and excess storage must be considered. Regular reviewing and updating of drought responses and research into improved long-term forecasting will enhance Egypt's ability to cope with prolonged drought.

Finally, there is a need for dialog and cooperation among the Nile Basin states to address both technical issues such as sharing of data, as well as more political and sensitive ones such as water allocation. It could be argued that the best response for Egypt might be to insist on status quo and not agree to any reallocation which will inevitably decrease the share of Nile flows into Egypt. However, over the long term a co-operative mechanism to resolve water sharing issues could also be in Egypt's interest, as it would reduce the risk of uncertainty and surprise. A co-operative regime might also engender exploration of linked adaptations across the boundaries of the riparian countries whereby water allocation is linked to trade in water intensive commodities such as hydroelectricity and food products. The recently established Nile Basin Initiative is therefore a step in the right direction. However, it is too early to assess the effectiveness of the NBI, given that it has been in existence for only a few years. Nevertheless, it marks an important beginning in terms of providing a cooperative forum to reconcile the water needs, development aspirations, and climate change concerns, not only of Egypt but of all the Nile Basin countries.

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APPENDIX A. GCM PREDICTIVE ERRORS FOR EACH SCENGEN MODEL FOR EGYPT

These tables show the predictive error for annual precipitation levels for each SCENGEN model. Each model is ranked by its error score, which was computed using the formula 100*[(MODEL MEAN BASELINE / OBSERVED) - 1.0]. Error scores closest to zero are optimal. For Egypt, the first eight models had significantly lower error scores than the remaining nine; therefore, the latter nine were dropped from the analysis.

Table A.1. Predictive errors for each SCENGEN model for Egypt

	Average[a] error	Minimum error	Maximum error
Models to be kept for estimation			
CSI2TR96	13%	0%	36%
HAD2TR95	17%	0%	34%
GISSTR95	18%	0%	67%
ECH4TR98	37%	0%	81%
CSM_TR98	41%	10%	67%
HAD3TR00	60%	19%	100%
PCM_TR00	63%	5%	200%
ECH3TR95	68%	26%	100%
Models to be dropped from estimation			
BMRCTR98	92%	79%	100%
CCSRTR96	100%	49%	200%
CERFTR98	154%	34%	300%
CCC1TR99	340%	13%	700%
MRI_TR96	367%	97%	700%
IAP_TR97	396%	19%	767%
W&M_TR95	482%	6%	967%
LMD_TR98	486%	40%	1000%
GFDLTR90	531%	51%	1000%

a. SCENGEN outputs data for 5×5 degree grids. To estimate for an entire country, a 10×10 degree area was used and the data output from the resulting four 5×5 grids were averaged. The maximum and minimum of these four 5×5 grids are also reported.

For the Nile Source, the first eleven models had significantly lower error scores than the remaining six; therefore, the latter six were dropped from the analysis.

Table A.2. Predictive errors by model for Nile source (Egypt study)

	Average[a] error	Minimum error	Maximum error
Models to be kept for estimation			
CSI2TR96	18%	3%	34%
CCSRTR96	25%	19%	39%
GFDLTR90	29%	12%	66%
CERFTR98	30%	1%	72%
ECH3TR95	41%	22%	68%
HAD3TR00	42%	1%	103%
ECH4TR98	44%	16%	83%
HAD2TR95	46%	4%	78%
BMRCTR98	55%	13%	97%
GISSTR95	63%	23%	95%
IAP_TR97	65%	13%	109%
Models to be dropped from estimation			
LMD_TR98	75%	18%	120%
PCM_TR00	85%	7%	234%
CSM_TR98	90%	4%	223%
W&M_TR95	107%	13%	198%
CCC1TR99	119%	56%	178%
MRI_TR96	205%	119%	370%

a. SCENGEN outputs data for 5×5 degree grids. To estimate for the source of the Nile, a 10×15 degree area was used and the data output from the resulting four 5×5 grids were averaged. The maximum and minimum of these six 5×5 grids are also reported.

APPENDIX B. LIST OF PURPOSE CODES INCLUDED IN THE SELECTION OF CLIMATE-AFFECTED PROJECTS, ORGANIZED BY THE DAC SECTOR CODE

DAC code	General sector name	Purpose codes that are included in the selection
110	Education	-
120	Health	12250 (infectious disease control)
130	Population	-
140	Water supply and Sanitation	14000 14010 14015 14020 (water supply and sanitation – large systems) 14030 (water supply and sanitation – small systems) 14040 (river development) 14050 (waste management/disposal) 14081 (education/training: water supply and sanitation)
150	Government & civil society	15010 (economic & development policy/planning)
160	Other social infrastructure and services	16330 (settlement) and 16340 (reconstruction relief)
210*	Transport and storage	All purpose codes
220	Communications	-
230	Energy	23030 (renewable energy) 23065 (hydro-electric power plants) [23067 (solar energy)] 23068 (wind power) 23069 (ocean power)
240	Banking and financial services	-
250	Business and other services	-
310	Agriculture, forestry, fishing	All purpose codes
320	Industry, mining, construction	-
330	Trade and tourism	33200 (tourism, general) 33210 (tourism policy and admin. management)
410	General environment protection	41000 (general environmental protection) 41010 (environmental policy and management) 41020 (biosphere protection) 41030 (biodiversity) 41040 (site preservation) 41050 (flood prevention/control)# 41081 (environmental education/training) 41082 (environmental research)
420	Women in development	-
430	Other multi-sector	43030 (urban development) 43040 (rural development)
510	Structural adjustment	-
520*	Food aid excluding relief aid	52000 (dev. food aid/food security assist.) 52010 (food security programmes/food aid)
530	Other general programme and commodity assistance	-
600	Action relating to debt	-
700*	Emergency relief	70000 (emergency assistance, general) #
710*	Relief food aid	71000 (emergency food aid, general) # 71010 (emergency food aid) #
720*	Non-food emergency and distress relief	72000 (other emergency and distress relief) # 72010 (emergency/distress relief) #
910	Administrative costs of donors	-
920	Support to NGOs	-
930	Unallocated/unspecified	-
* sector codes that are excluded in the second selection (low estimate). # purpose codes that are included in the emergency selection		

APPENDIX C. REVIEW OF NATIONAL AND INTERNATIONAL STRATEGIES AND REPORTS

C.1 UN Framework Convention on Climate Change (UNFCCC)

Egypt submitted its first national communication to the United Nations Framework Convention on Climate Change in 1999. It pays extensive attention to the risks facing the country due to climate change and sea-level rise, mainly in relation to agriculture, water resources, human health, and the coastal zone (particularly the Nile Delta). The analysis also includes economic loss estimates for sea level rise in several coastal cities. A large range of adaptation options are identified, most of them no-regrets. The implementation arrangements are less clear. The National Communication built on results of the US country studies programme, which provided support for the preparation of a national action plan on climate change, for both mitigation and adaptation[25].

C.2 Ramsar Convention on Wetlands

Despite to obvious vulnerability of wetlands to climate change and particularly sea level rise, Egypt's national report to the Seventh Conference of the Parties of the Ramsar convention on wetlands (1999) says explicitly "there is no dialogue or cooperative actions to date" [with activities under the UNFCCC]. While Egypt's *National planning tool for the implementation of the Ramsar Convention on Wetlands* puts a high priority on cooperation between conventions, this is only explicit for cooperation with the UNCBD; climate change is not mentioned.

C.3 UN Convention on Biodiversity (UNCBD)

Climate change is not mentioned in Egypt's First National Report to the United Nations Convention on Biodiversity (UNCBD), or in its National Strategy and Action Plan for Biodiversity Conservation. Nevertheless, it is clear that many of the threats to biodiversity that are pointed out in these documents, such as coastal tourism development, may well be aggravated by climate change and sea level rise. While most of the proposed measures to conserve biodiversity will still be valid, the additional risks do at least deserve attention, and might require specific mitigation actions, for instance in the case of changes to optimal land use planning in coastal areas when sea level rise is taken into account.

C. 4 UN Convention to Combat Desertification (UNCCD)

Egypt's National Action Plan for Combating Desertification (submitted to the UNCCD in 2002) provides a detailed overview of desertification issues in Egypt, with descriptions of geomorphology, climate, soil, water and human resources in various regions of the country, the desertification process, as well as previous and ongoing activities to address it. It underlines the complexity of the issue, and the variety of responses needed in different places. At the national level, it recommends a high-level political decision-making process, and an integration of anti-desertification strategies into national development planning. Ten concrete programmes of action are listed, ranging from public participation and awareness raising to drainage and irrigation rehabilitation. Climate change is mentioned only once, in the context of

25 The first stage of the Country Studies Program resulted in the "Framework of National Action Plan for dealing with Climate Change" (Egyptian Environmental Affairs Agency, 1995). Results of the second stage are reported in, among others, "Vulnerability Assessment of the Coastal Zone of Egypt to the Impacts of Sea Level Rise" (El-Raey et al., n.d.), and "Vulnerability Assessment of Fresh Water Resources in Egypt to Climatic Changes" (Dia El Din El Quosy, n.d.)

the risk of shoreline erosion in the Nile Delta (which has already increased over the past decades, for various reasons). Egypt's first national report to the UNCCD does not mention climate change at all.

C.5 World Summit on Sustainable Development (WSSD)

In the Country Profile that was prepared for the WSSD, climate change is mentioned only in a separate section on protection of the atmosphere, and only in the context of mitigation. The report also mentions that the main Egyptian body dealing with climate change is the National Coordinating Committee on Climate Change and Ozone. This combination highlights the way climate change was originally seen: mostly an "air-pollution" problem, to be dealt with through mitigation. Adaptation generally requires a different approach, with a committee that can help mainstream these concerns into development planning in all sectors.

APPENDIX D. REVIEW OF SELECTED DONOR STRATEGIES

D.1 African Development Bank

Country Strategy Paper 2000-2002 (2000)

Water is not mentioned in the Executive Summary of the African Development Bank Country Strategy Paper for Egypt. Here, the Strategy finds *"The main constraints to economic development are the low and stagnant domestic savings ratio, the significant and persistent trade deficit in the balance of payments due to stagnation in earnings from traditional exports, and slippages in the implementation of structural reforms as well as financial sector privatisation and trade liberalisation."*

In the main document however, water scarcity is considered a key constraint to Egypt's development: **"***Extremely limited land and water resources constitute the major physical constraints to the development of the Egyptian economy. Arable land is only about 3 percent of total land area and is being constantly encroached into by urban and industrial expansion. Moreover, the quality of land has also been degraded. Egypt's water needs are almost wholly provided by the River Nile, in which the country's share amounts to 55.5 billion cubic meters and is almost being exhausted"*. While this seems like a valid assessment, the final sentence of that same paragraph is puzzling: *"The objective of increasing the inhabited area of the country from 5 percent to 25 percent of the total area by 2017 is therefore very sound."* It appears that the strategy's proposed expansion of agricultural lands will not solve the water issues, particularly in the light of growing demand in the upper Nile countries, and potentially climate change. Elsewhere in the strategy, targeted measures for improved water management are proposed, including water pricing and other incentives, irrigation infrastructure, pollution control, and even desalination of seawater.

In the section on Environment, water is again the central theme: "*Environmental problems and issues in Egypt are dominated by the critical need to manage the scarce common resources of water and cultivable land more effectively to meet the growing needs of the population. While groundwater resources are available, they are predominantly non-renewable reserves; and their quality is rapidly degrading due to the excess irrigation waters contaminating the ground aquifers. Sources of surface and groundwater pollution include water from irrigation drainage canals, municipal and industrial wastewater discharges. Poor water management in agriculture is also leading to the salinisation of good agricultural land, reducing its productivity and requiring large investments for rehabilitation of such lands.”*

The Strategy pays very little attention to coastal and marine management issues, although the issue of increasing pollution is highlighted briefly. Climate change is neglected altogether, despite its potential implications for, for instance, water, agriculture, and coastal and marine resources. It should be noted however, that the AfDB’s strategy focuses mostly on other sectors (private sector development, human resources development, and physical infrastructure). Nevertheless, its work in agriculture and mini-hydropower might well benefit from an explicit consideration of the additional risks.

D.2 IFAD

Country Strategic Opportunities Paper (2002)

Water scarcity is a prominent issue throughout IFAD's programs: "the most important constraint hindering agricultural growth and self-sufficiency is the availability of irrigated land in a country that receives hardly any rainfall." Global warming is not mentioned, even though it might be an additional consideration in relation to many water scarcity issues. Nevertheless, IFAD's programs most likely contribute to reduced vulnerability.

IFAD's activities in Egypt focus on the "newlands", desert land that is reclaimed by the Egyptian government for distribution to poor and disadvantaged groups. Activities include technology transfer, (ii) improved water-use efficiency and sustainability of the irrigation system, as well as support for off-farm enterprises, marketing and agroprocessing, and formal and rural finance institutions. Given the additional water needs in these areas, water efficiency measures are an essential element of adaptation to current and future climate and water stresses.

The COSOP also highlights the fact that Egypt remains a food deficit country which imports nearly 40% of its food, while at the same exploiting a comparative advantage in a number of export crops, and increasing the proportion of acreage devoted to export crops (including cotton, rice, fruits, vegetables and flowers). Water usage implications (including of the choice of export crops) are not discussed. At the end of the COSOP, a "stakeholders Matrix" identifies project actors and their roles for all important sectors that IFAD covers in Egypt. Curiously, it has been completely filled out except for the cells relating to water management.

D.3 World Bank

Country Assistance Strategy (2001)

The World Bank Country Assistance Strategy (2001) does not mention climate change, but pays ample attention to several key issues related to Egypt's long-term challenges in this area. In particular, the World Bank plays a facilitating role in the Nile Basin Initiative (NBI) – with Burundi, Democratic Republic of Congo, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda.

Climate-related issues come up in several other places as well. For instance, the CAS mentions that there are large land reclamation efforts underway, for which costs and benefits will have to be carefully assessed. Climate change and particularly sea level rise, while not discussed, could affect such analyses, particularly in the medium- to long-term. The CAS also recognizes that water scarcity will be a critical challenge for the future of Egypt (although climate change is missing in this context). Compounding the problem of water scarcity are issues related to the quality of water because of water-logging, salinity and degradation by pollution. While the CAS notes that the Nile Basin Initiative should help, it also points out that increased investments will be needed for the operation and maintenance of the drainage and irrigation systems in the new and old lands, which will make the institution of a viable cost recovery program Water allocation will also require attention: since agriculture uses more than 80 percent of available water, a key option will be to reallocate water within agriculture, by moving gradually out of water-intensive crops such as rice and sugarcane. In the context of environmental issues, acute water scarcity, declining water quality, and land degradation are all listed among the key environmental issues facing Egypt, but climate change is not mentioned as an additional risk. The CAS notes: "*It will be extremely important to assess more systematically the economic damages from environmental degradation to raise public awareness*." It would be useful to include potential climate change risks in these analyses.

D.4 CIDA

Country Development Programming Framework 2001-2011 (2001)

Canada's programs focus on small and medium enterprise development and basic education (integrated with several cross-cutting issues, including sustainable development). For these two main focal areas, climate risks are likely to be limited. The strategy recognizes the challenges Egypt faces in terms of sustainable water and natural resources management, but does not explicitly discuss Egypt's vulnerability to climate change. Nevertheless, it is mentioned that climate change related activities could be initiated under the Canadian Climate Change Development Fund (CCCDF). Until now this has not materialized.

D.5 Danida - Strategy for Danish-Egypt Development Cooperation (1996)

While Egypt's vulnerability to climate change is not explicitly discussed, the environmental section of Danida's strategy for Egypt lists several problems that would be aggravated by climate change, including coastal erosion (partly related to uncontrolled construction), freshwater scarcity and siltation, and damage to marine ecosystems, particularly the Red Sea coral reefs.Danida concentrates its work in Egypt in environment, energy, and water supply and sanitation (in upper Egypt). The environmental efforts include coastal environmental protection, but the strategy contains no reference to sea level rise. On the other hand, the work in energy emphasizes new and renewable energy and energy conservation.

D.6 European Commission - Country Strategy Paper 2002-2006 and National Indicative Programme 2002-2004

The objectives of the EU's development assistance to Egypt are mostly to promote the effective implementation of the EU-Egypt Association Agreement (by support to enterprises and institutions, aimed at competitive internal and external markets), to support the process of economic transition, and to support stability and sustainable and balanced socio-economic development. The latter objective includes the protection of Egypt's fragile environment, including the establishment of a comprehensive legislative, institutional and compliance system. Climate change is not mentioned anywhere, possibly due to the sectors in which the EU is primarily involved, which do not include water, agriculture and coastal resources.

APPENDIX E. REVIEW OF SELECTED DEVELOPMENT PROJECTS/PROGRAMMES

Projects dealing explicitly with climate related risks

E.1 US Country Studies Program

The US Country Studies Programme has supported work on climate change vulnerability and adaptation, in preparation for the first national communications (see under international conventions).

E.2 Dutch/Danish support for ICZM

In addition, both the Netherlands Climate Change Studies Assistance Program and Danida supported coastal vulnerability assessments, which resulted in a Framework Integrated Coastal Zone Management (ICZM) programme. According to these studies, the key issues are shore erosion and flooding, irrational land use, water pollution and deterioration of natural resources. The Danish program[26] provided support for the shore protection authority, the coastal research institute, and the hydraulic research institute to manage the Egyptian shoreline and reduce losses due to erosion. In its background description, it recognizes many pressures on the coastline, including rapid development, changes in sediment flows in the Nile delta due to the construction of the Aswan dam, pollution, and damage to the coral reefs due to uncontrolled construction and other human activities. Climate change and sea level rise are not mentioned. Nevertheless, the program will contribute to better and more sustainable management of coastal resources, and thus to adaptation to climate change and sea level rise as well.

E.3 Germany/BMU

Climate Change and Conflict study

This German-funded study on climate change on conflict contained a case study on Egypt. It concludes that Egypt will face severe environmentally induced security challenges due to the competition for the Nile's water in the decades to come: "Egypt is affected both by the effects of temperature increases and sea-level rises (chapter 4.5). The first will increase the evapotranspiration and the water needs of agriculture and has been projected to result in declining yields for all major agricultural food products. Thus, climate change may also intensify the process of desertification and make it irreversible in some cases. The sea-level rise in the Nile Delta will inundate some of the most fertile agricultural land and most densely populated regions. At the same time the population growth in Egypt and in the other nine riparian countries of the Nile will increase the demand for scarce water. In the framework of the Nile Basin Initiative the international community, with major support from the World Bank, has been active to avoid future water conflicts from arising. Egypt has become both a country of emigration (so far primarily to other Arab countries) but also of increasing immigration (of refugees and asylum seekers) from countries in Sub-Saharan Africa."

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[26] Technical Assistance Program to A: Shore Protection Authority Phase 2, B: Coastal Research Institute, and C: Hydraulic Research Institute. Water Consult (for Danida), 1997.

Other development programmes and projects

E.4 World Bank/GEF Red Sea Coastal and marine Resource Management Project

Project Completion Report (2002)

This project aimed to protect biodiversity and prevent pollution in the Red Sea, through policy and regulatory development and implementation, capacity building in multi-sectoral coastal zone management, development and implementation of public-private partnerships, and the development of databases and inventories of coastal and marine ecosystems and resources.The project, which was completed satisfactorily in 2002, clearly contributed to the preservation of Egypt's coastal and marine resources, both in the short and longer term. While climate change is not mentioned in the Implementation Completion Report, and does not seem to have been considered in the project itself, the activities have almost certainly made Egypt's Red Sea coastal and marine resources more resilient to climate change.

E.5 World Bank/GEF Second Matruh Resource Management Project

Project Appraisal Document (2003)

The project's main goal is to improve the livelihood of disadvantaged rural people living in the Northwest Coastal are of Egypt, through community development, improved access to services and income generation, while at the same time strengthening local capacity for conservation, rehabilitation and sustainable management of natural resources. It builds on a successful first phase.

The appraisal document discusses climate-related risks at length. Contrary to most of Egypt, the project area depends entirely on rain fed agriculture. Given the low precipitation (occurring only in a narrow strip of land along the coast), water scarcity is a key challenge, and rainfall variability is a key source of risk and vulnerability, exemplified by the very strong correlation between crop yields and rainfall. At the same time, torrential rains and heavy winds also cause serious damage. Agricultural pests are another, partly climate-influenced, threat. For economic and physical reasons, crop diversity is low. All these elements of biophysical vulnerability are mutually interrelated with poverty, socio-economic vulnerability, and institutional weaknesses. Coping mechanisms include using drought-adapted species, low-input farming (which has severe economic implications), tailoring both the timing and area of sowed crops to the time and quantity of the rain, and mixing field crops with horticulture and livestock, as well as non-agricultural economic activities (mainly by Bedouin women). The project is tailored to the traditional coping strategies, building on them or complementing them where needed. Despite the extensive attention to climate-related vulnerability and adaptation, climate *change* is not discussed in this context. At the same time, it is doubtful that climate change considerations would have altered the outcomes of the analysis substantially, given that the likely scenario is simply that the risks related to rainfall variability will increase, and those risks are already a key focus of the project.

However, the lack of explicit attention to climate *change* related risks is surprising in the light of the fact that the project is funded (partly) by the GEF. It has been submitted under Operational Program 12 "Integrated ecosystem management", which provides a comprehensive approach to address more than one environmental conventions, in this case particularly the UNCCD, UNCBD, and UNFCCC, and to generate both local and global benefits. The Appraisal Document identifies three elements that qualify for OP12: (i) conservation and sustainable use of biological diversity (ii) reduction of net emissions and increased storage of greenhouse gases, and (iii) conservation and sustainable use of water bodies, including watersheds and coastal zones. The latter includes the project's adaptation aspects, but only implicitly; the key GEF climate change element is related to mitigation.

E.6 World Bank Integrated irrigation Improvement and Management Project

Initial Project Information Document (2003)

This project, which is planned to start in 2004, aims to increase the productivity and sustainability of water use, in the face of growing demand and potentially decreasing supply (mainly due to developments in the upper Nile countries). Elements include preparation and implementation of integrated water management plans, rehabilitation and improvement of irrigation and drainage infrastructure, a (planned) GEF-supported environmental management plan, and on-farm demonstration projects. Although potential pressures due to climate change are not mentioned explicitly, this is an excellent component of an adaptation strategy for Egypt.

E.7 African Development Bank El-Beheira Second Rural Development Project

Project Information Sheet, 1997

This land improvement project includes soil surveys, soil improvement, agricultural production improvement activities, livestock, and improvement of extension services, transportation facilities, rural infrastructure and health facilities. The project information sheet pays no attention to climate change, or to water scarcity issues in general. Nevertheless, the latter must have been addressed in more detailed project plans and implementation.

E.8 GEF/UNDP Conservation of Wetland and Coastal Ecosystems in the Mediterranean Region

Project Document (1999)

This regional project aims to support the sustainable management of the biological diversity of the coastal areas and wetlands in six Mediterranean countries, including Egypt. The project mainly focuses on coordination, institutional strengthening and awareness raising, but also contains demonstration projects at the most important sites. While climate change may not be a direct threat to the soft project components, it certainly affects the longer-term issues that the project intends to address. However, climate change is not mentioned in the project document.

E.9 Nile Basin Initiative (NBI)
www.nbi.org

This initiative brings together the twelve countries that are part of the Nile River Basin, all the way from its Ruvyironza River in Burundi and Lake Victoria to the Egyptian Nile Delta, where the water flows into the Mediterranean. The intergovernmental initiative contains two main pillars: a shared vision between all countries, and a program of subsidiary activities at the lowest appropriate level, but with benefits to other partner countries. These activities can include, for instance, watershed management, irrigation, water supply and sanitation, desertification control, hydropower, fisheries management, and flood control, as well as general joint development opportunities not directly related to water management, such as infrastructure, communications, disaster management, regional tourism development, etc. While climate change is not a primary motivation behind the initiative, this type of regional collaboration is an excellent adaptation strategy, and particularly crucial for downstream countries such as Egypt.

E.10 Worldbank/UNDP/GEF Nile Transboundary Environmental Action

Project Appraisal Document

The first of the projects that are developed under the NBI Shared Vision Program (SVP) is a GEF-funded regional environment project "Nile Transboundary Environmental Action". An annex of the Project Appraisal Document with all basin wide environmental threats contains a separate section on climate change, listing a range of possibly severe implications, but no specific adaptation options. Relative to other environmental threats (which include, for instance, soil erosion, riverbank and lakeshore degradation, pollution, mining impacts, eutrophication, water-borne diseases, floods and droughts, and risks to biodiversity and wetlands), climate change is ranked as a "low-to-moderate" risk (in reality, it is of course just another risk factor affecting almost all the other threats). Climate change is not discussed in the main Project Appraisal Document

E.11 Efficient water for agricultural production

NBI Shared Vision Programme subproject

The Nile Basin Initiative Shared Vision Programme subproject "*efficient water for agricultural production"* does not discuss climate change in any way. At the same time, it does point to the seriousness of the challenges ahead, even regardless of climate change. For instance, it notes the high spatial and temporal rainfall variability in the upper flow areas (which does not affect Egypt very much, because there is very little rain anyhow). At the same, crop yields in Egypt are among the highest in the entire flow area, mainly because of extensive irrigation, which is currently absent in the upper areas. Further irrigation development in these areas could significantly boost agricultural output, but would also affect the flows towards Egypt.

E.12 Water Resources Planning and Management

NBI Shared Vision Programme subproject

Another NBI Shared Vision Programme subproject "*Water Resources Planning and Management"* does not discuss climate change explicitly either. At the same time, climate-related water issues are being addressed throughout the document, and climate itself is listed as an important input variable for the river basin modeling that is used in the so-called Nile Basin Decision Support System.

APPENDIX F. DOCUMENTATION

Statistics

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Government documents

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- First National Communication

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- Report to the Seventh Conference of the Parties of the Ramsar convention on wetlands (1999)
- National planning tool for the implementation of the Ramsar Convention on
- Wetlands

UN Convention to Combat Desertification (UNCCD) ***www.unccd.int***

UN Convention on Biodiversity (UNCBD) ***www.biodiv.org***

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- Country Profile

Donor agencies

African Development Bank www.afdb.org

- Country Strategy Paper 2000-2002
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- Technical Assistance Program to A: Shore Protection Authority Phase 2, B: Coastal Research Institute, and C: Hydraulic Research Institute. Water Consult (for Danida), 1997.

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- Country Assistance Strategy (2001)
- Matruh Resource Management Project, Implementation Completion Report (2003)
- Second Matruh Resource Management Project, Project Appraisal Document (2003), and Environmental Assessment, Vol. 1, 2, and 3 (2003)
- Integrated irrigation Improvement and Management Project, Initial Project Information Document (2003)

Nile Basin Initiative www.nbi.org

- Shared Vision Programme subproject "Efficient Water for Agricultural Production"
- Shared Vision Programme subproject "Water Resources Planning and Management"
- World Bank/UNDP/GEF regional Nile Transboundary Environmental Action project, Draft Project Plan (2001), Project Appraisal Document (2003)