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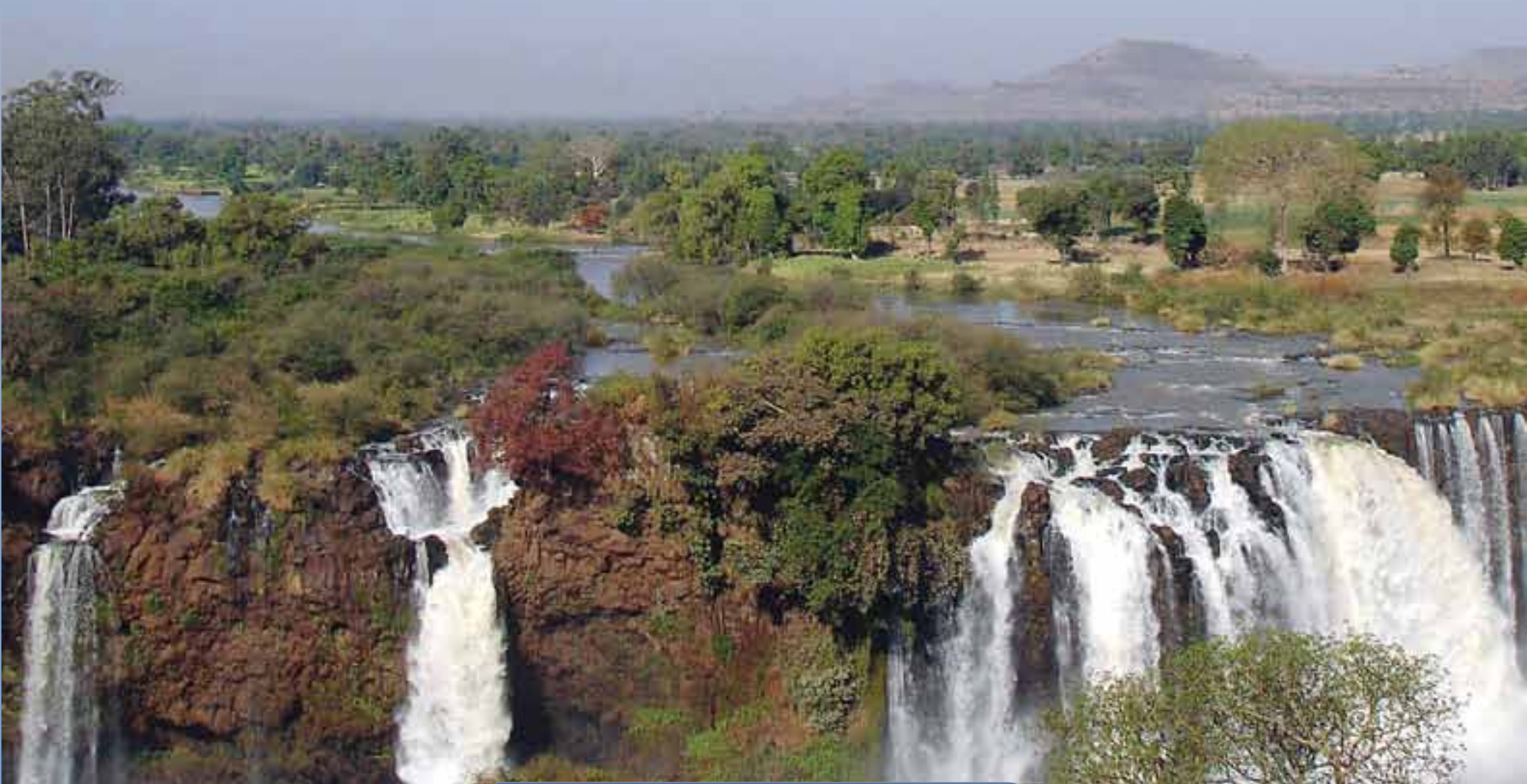
Adaptation to Climate-change Induced Water Stress in the NILE BASIN

A Vulnerability Assessment Report



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NILE BASIN INITIATIVE

Adaptation to Climate-change Induced Water Stress in the Nile Basin

A Vulnerability Assessment Report

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Acronyms

BCM	Billion Cubic Metres
CDM	Clean Development Mechanism
CIDA	Canadian International Development Agency.
CRU	Climate Research Unit
DEPI	Department of Environment Policy Implementation
DHI	Danish Hydrological Institute
DRC	Democratic Republic of the Congo
ENSO	El Niño Southern Oscillation
ET	Evapotranspiration
ETV	Evapotranspiration to Lake Volume ratio
FAO	Food and Agricultural Organization of the United Nations
GCM	General Circulation Models
GDP	Gross Domestic Product
GNI	Gross National Income
GWh	Gigawatt hour
GWP	Global Water Partnership
HYDROMET	Hydro-meteorological Survey of the Equatorial Lakes
IGBP	International Geosphere Biosphere
IPCC	Inter-governmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
MCM	Million Cubic Metres
MDGs	Millennium Development Goals
MODIS	Moderate Resolution Imaging Spectroradiometer
MW	Megawatt
NAPA	National Adaptation Programmes of Action
NBI	Nile Basin Initiative
NDVI	Normalized Difference Vegetation Index
Nile-COM	Nile Council of Ministers
Nile-Sec	Nile Basin Initiative Secretariat
Nile-TAC	Nile Technical Advisory Committee
PET	Potential Evapotranspiration
PJTC	Permanent Joint Technical Commission for Nile Waters
RCM	Regional Climate Models
REDD	Reducing Emissions through Deforestation and Forest Degradation.
SAP	Subsidiary Action Programmes
SAV	Surface Area to Volume
SLR	Sea Level Rise
SRES	Special Report on Emission Scenarios
SVP	Shared Vision Programme
TECCONILE	Technical Co-operation for the Promotion of the Development and Environmental Protection of the Nile Basin
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nation's Framework Convention on Climate Change
UNLCCS	United Nations Land Cover Classification System

Sunset on the Blue Nile.

jaydoubleyougee / Foter / CC BY-NC-SA

Foreword

The Nile River Basin's rich ecological resources are vital to the 238 million people living in the region. The basin's natural environment is the ultimate source of its economic activities (production and consumption) and the sink for disposing of all its waste. At the same time, the Nile Basin's human resources are also crucial assets, providing the labour and markets for goods that drive the regional economy. This report illustrates these links between people, the economy and the environment. For example, we learn that the Nile Delta and the wider Mediterranean coast account for 30-40 per cent of Egypt's agricultural production and more than half of its tourism and industrial base. Water is central to all these activities and processes and must be available in sufficient quantities to meet environmental, consumption and social needs.

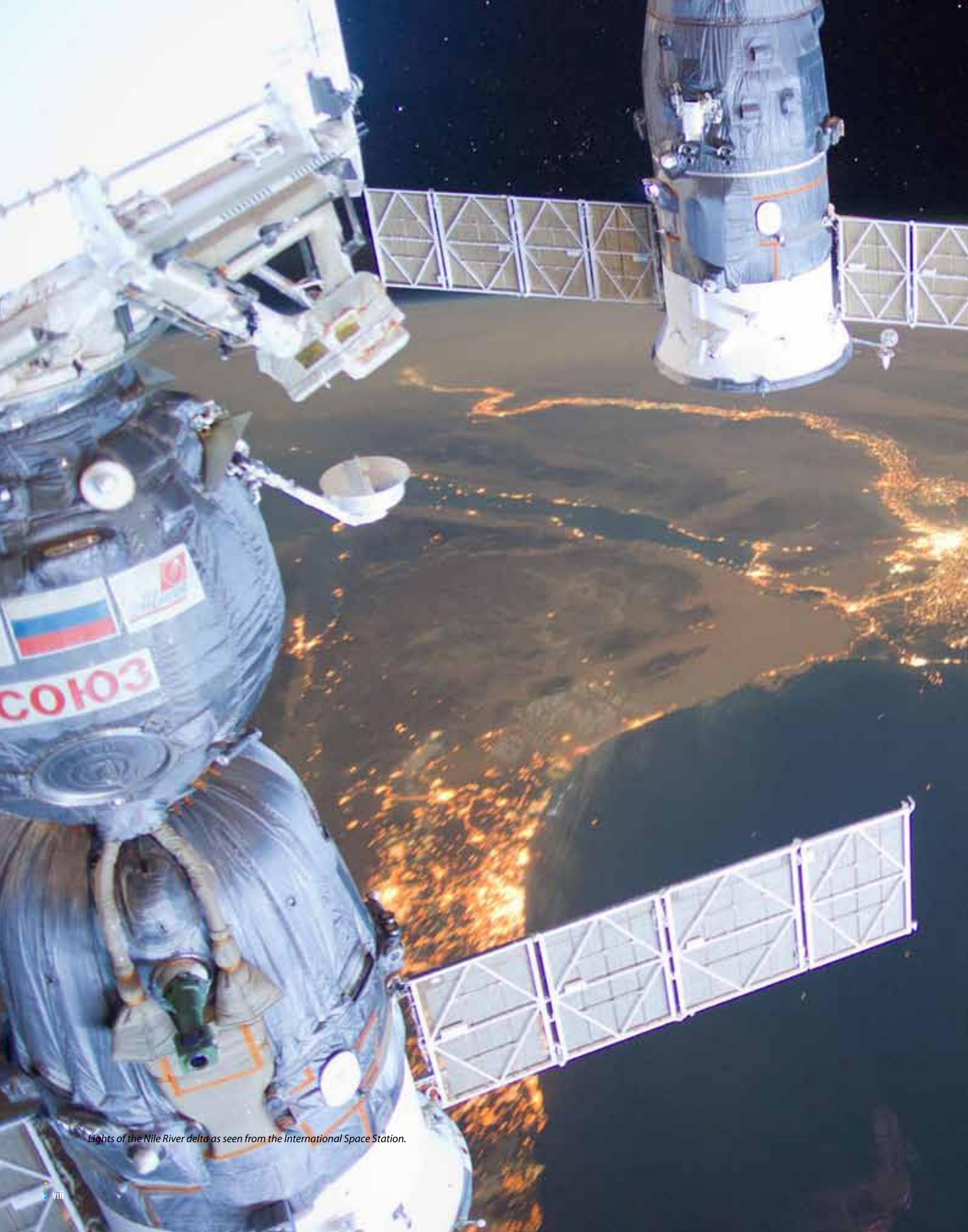
Climate change is a reality, however, and the people and environments of the Nile Basin are already feeling its impacts. Its major effect is on water availability in the region, as is abundantly evident from this Vulnerability Assessment. Examples include rising temperatures; increased flood and drought frequency; sea-level rise; and changes in natural ecosystems, such as shoreline accretion or erosion, salt-water intrusion into the Nile delta's freshwater aquifers, and glacial recession in the Ruwenzori Mountains. All of these changes are inextricably linked to the health, social, and economic well-being of the Nile Basin's people. At the local level, we see that some communities or places are more vulnerable than others to the impacts of climate change. Thus, the region's vulnerable sectors and ecosystems need encouragement and options in adopting ways to adapt to climate change and develop resilience in the face of these changes.

This report is one in a series of actions intended to help vulnerable peoples and places build strategies for climate-change adaptation and resilience. It is produced under the UNEP-led project 'Adapting to Climate-change Induced Water Stress in the Nile River Basin'. It aims to improve regional knowledge and information about climate change impacts in the region to trigger debate and form the basis for critical thinking and decision-making. In turn, informed decisions about adaptation strategies and transformative policies will complement and strengthen on-going efforts to manage the Nile River Basin's shared resources.

In producing this document, with support from the Swedish Government, UNEP has partnered with multinational corporations, regional organisations including the Nile Basin Initiative (NBI) and the governments of the Nile Basin. It has been exciting to see diverse communities of scientists, public servants and politicians work cooperatively to bring together scientific data and socio-economic evidence of best practices to inform and advance policy discussions and decisions.

I am sure that the options and strategies proposed in this report can help the people in the Nile Basin most vulnerable to the effects of our changing climate to increase the resilience of both their communities and the ecosystems in which they live.

Mr. Achim Steiner
Executive Director of UNEP



Lights of the Nile River delta as seen from the International Space Station.

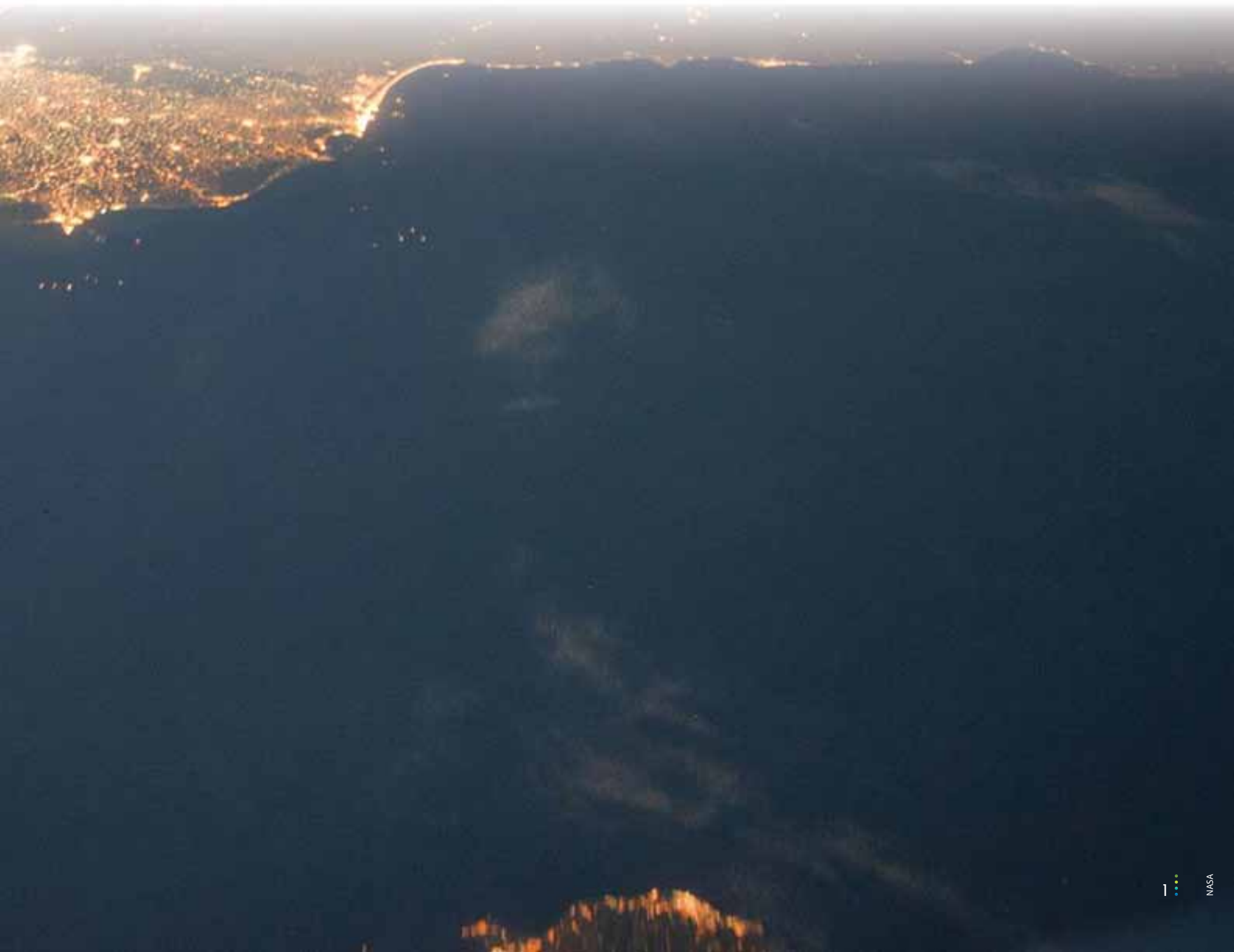
Executive Summary

Overview

This report is an output of the UNEP project Adapting to Climate-change Induced Water Stress in the Nile River Basin and was produced in collaboration with the Nile Basin Initiative, the Nile Basin Partner States, the UNEP-DHI Centre for Water and Environment and the Global Water Partnership (GWP). This publication makes use of satellite data (past and present), maps, photographs and other illustrations to highlight areas of environmental change in the Nile basin. These visual elements are accompanied by a narrative that describes, analyses and demonstrates how climate change is affecting the water resources of the Nile Basin. The compilation of this information culled from a variety of sources, provides a rich synthesis of qualitative and quantitative policy and scientific data in one place.

Policy makers in the Nile Basin region are increasingly faced with the challenges that climate change is presenting. They frequently grapple with questions such as: What are the potential future impacts of climate change on our water systems? What are the hotspot areas that are especially vulnerable to these changes? What can be done to manage or avert the effects of climate change? What are the implications for policy and future water management? This Assessment Report attempts to answer these questions through seven chapters which are summarized in the sections that follow.

Unless otherwise indicated, data and/or information pertaining to Sudan may also include data and/or information for the current independent state of South Sudan. Data sources specific to South Sudan are scarce considering its independence was recently obtained in 2011.



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Chapter 1: Introduction

The opening chapter presents an overview of the Nile River Basin – the people, the economy and the environment. About 238 million people live in the basin area and water, specifically from the Nile River, plays a central role in lives and livelihoods. For instance Egypt, Ethiopia and Sudan do not have significant water resources within their borders outside of the Nile and its tributaries. On the whole, the quality of life in the region is improving. Poverty rates are on the decline, literacy rates are improving with more children going to school and in most countries the health and sanitation indicators are on an upward trend. Despite this positive outlook, the report highlights wide disparities between the countries. The per capita income in Egypt is US $2 070 as compared to Burundi with US $150. Population growth rates in the basin are rapidly increasing and with it pollution, environmental degradation and the demand for water. Indeed water stress is already a concern yet the annual discharge of the Nile is not increasing.

Six million years ago geological and climatological factors played a key role in the formation of the Nile River; and these factors still impact the Nile as we know it today. Ancient civilizations were quick to realize the importance of the water resources and initiated water use agreements to that end. Some of the cooperative agreements that have defined the region since the early 1920s to the present are discussed in the report. These agreements were developed under specific political-economic contexts with the focal issues ranging from water allocation and development to environmental sustainability. The Nile Basin Initiative (NBI) is the latest such initiative. It aims to encourage regional development through the equitable use of the Nile and its resources.

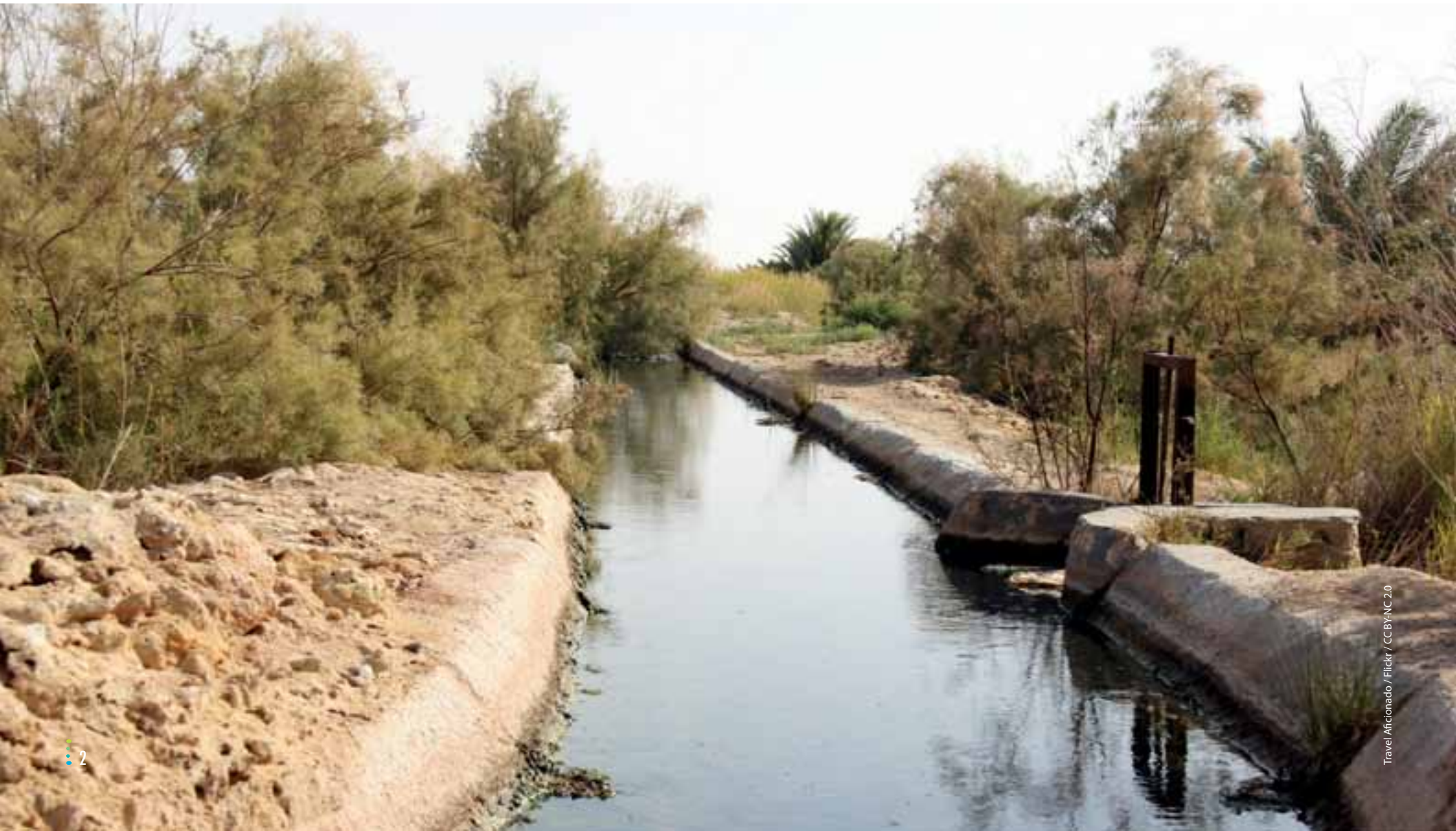
Chapter 2: Land Cover Types and Vegetation Dynamics

Changes in land cover can have impacts on the water balance of the catchment (through evaporation and evapotranspiration (ET)) and have been associated with increasing soil erosion and possible changes in surface hydrology and drainage, disturbances to the aquatic biodiversity and increased sedimentation. Over the past decades the impact of human activities on the land in the Nile Basin has increased significantly due to population explosion and associated demands.

Chapter 2 uses land cover mapping to track the changes in the landscape. Two classification systems - GLOBCOVER and MODIS (Moderate Resolution Imaging Spectroradiometer) were used to provide an overview of the land cover types in the region; and the changes in land cover between 2001 and 2009 respectively. According to GLOBCOVER 2009, land cover in the basin is dominated by barren land at 32 per cent followed by forest 21.9, cropland 11.9, mosaic vegetation 11.4, and shrubland 11.5 per cent. A country by country analysis highlights further differences at that level.

The next section of the chapter brings to light land cover changes between 2001 and 2009 using MODIS land cover change maps, first at basin and then at country level. At basin level the most significant changes that occurred between 2001 and 2009 were an increase in grasslands (from 11.7 to 14.3 per cent) and a decrease in built-up or barren lands (from 34 to 31.8 per cent) over the same time period. Cropland and natural vegetation mosaic decreased by 1.2 per cent, while the remaining land cover types (forests, shrubland, savannas wetlands and crops) changed by less than 1 per cent.

Irrigated agriculture means that farmers are less dependent on rainfall for high yields.



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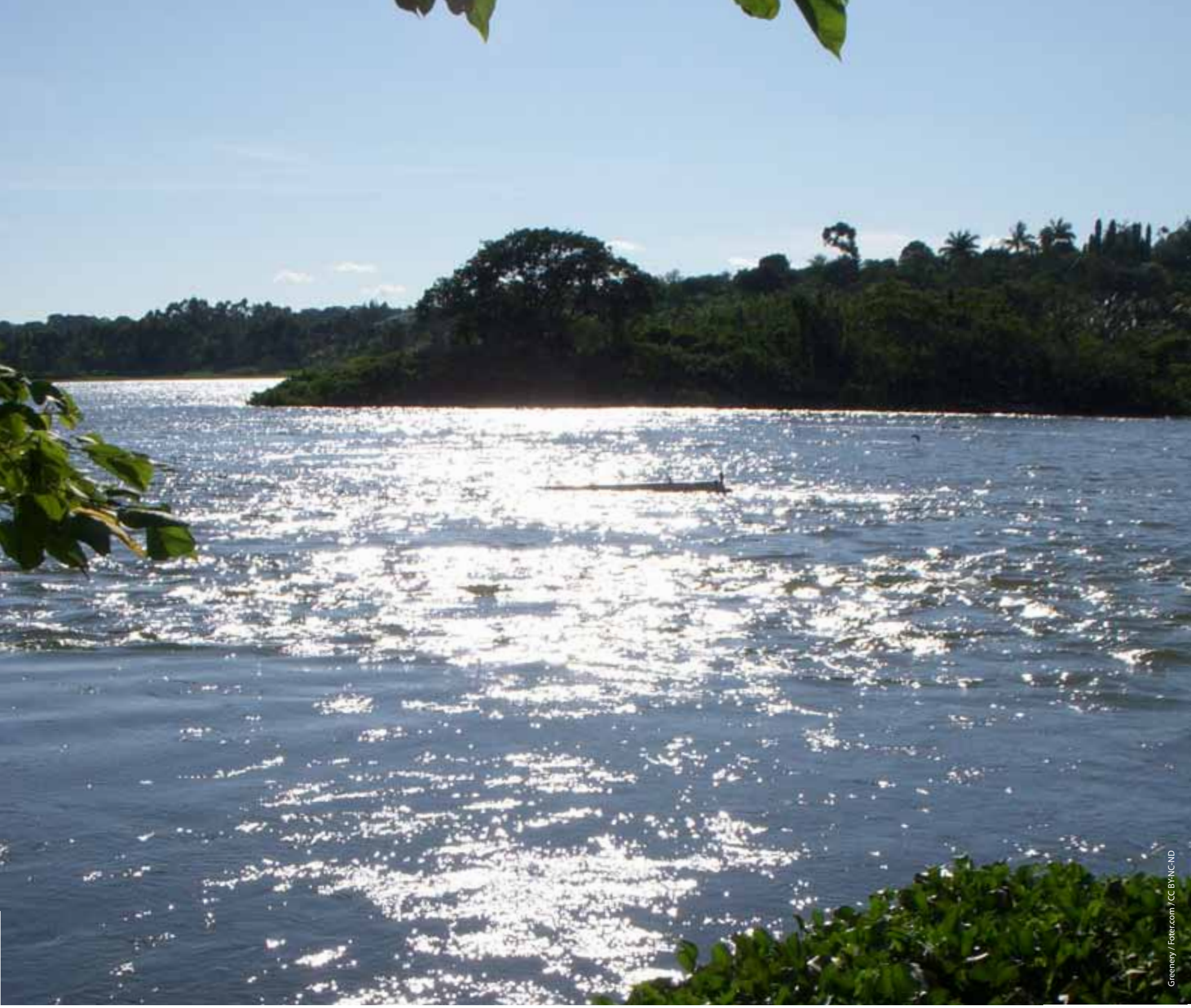


Lake Victoria near the source of the Nile.

Chapter 3: Climate and Hydrological Review

The third chapter attempts to tie together the elements of climate, (rainfall and temperature) and aspects of hydrology (river flows, lakes and underground water storage) and human-landscape features (land cover or land use change) all of which have sensitive interactions that ultimately affect the availability of water.

The discussion indicates that the Nile River is extremely sensitive to changes in precipitation and temperature. Precipitation has impacts on lake levels and river discharges; while increases in temperature have been found to affect the rates of evaporation and evapotranspiration influencing the water balance of the basin.

Land cover and land use change are important because different vegetation types have different evapotranspiration (ET) values. Heavily vegetated areas tend to have higher rates of evapotranspiration than areas of sparse vegetation. For instance in the Nile Basin, forests have the highest mean ET (1 258 mm/yr) while grasslands have the lowest (536 mm/yr). Evaporation data from the major lakes and reservoirs is also presented. MODIS maps are used to highlight evaporation and evapotranspiration data at basin level over three years: 2001, 2005 and 2010. Then the analysis is broken down for the different sub-basins and land cover types for the time period 2001 to 2010.

The next section of the chapter is a discussion on the water storage systems of the Nile Basin. Five types of water storage

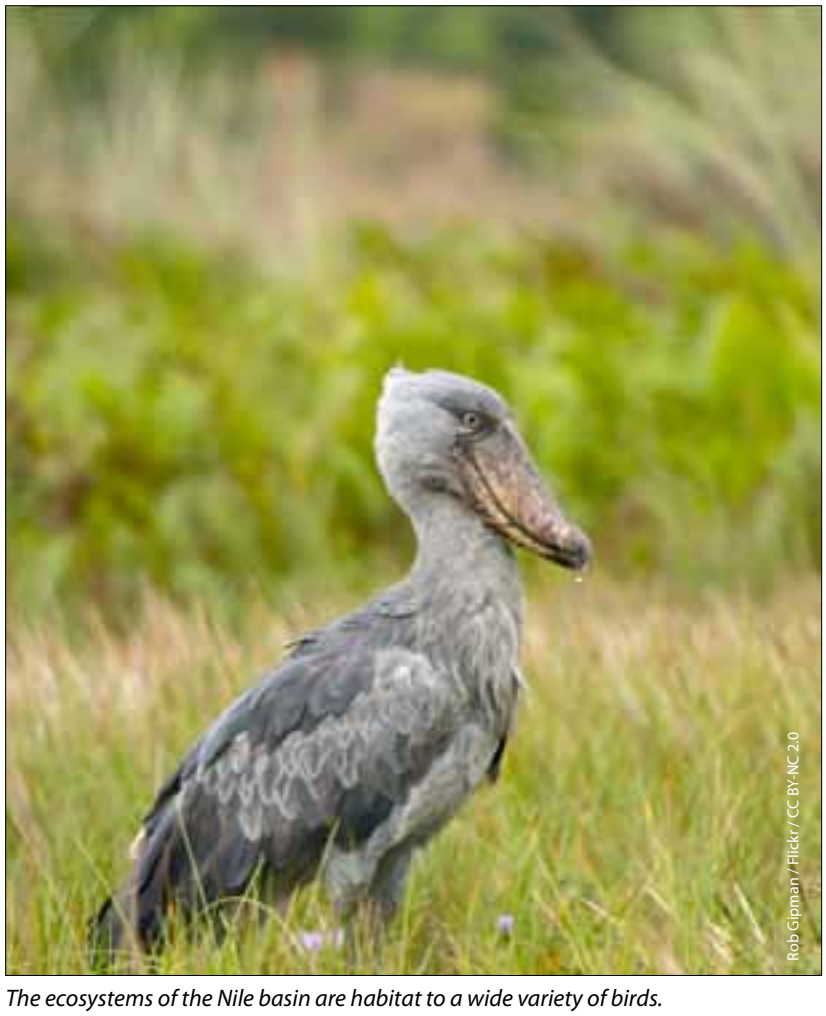
ILRI / Flickr / CC BY-NC-SA 2.0

Fincha Lake, Horro, Ethiopia.

systems are discussed in this chapter – lakes, wetlands, reservoirs, rivers, and underground aquifers. Open water covers about 90 000 km^2 or 3 per cent of the basin's total area. Each of these are discussed highlighting their areal extent and other key information such as total catchment area, total surface area of the water body, rainfall over the water body, runoff and annual evaporation rate.

The chapter concludes with a detailed presentation on the groundwater resources in the basin. Groundwater occurs in the transboundary aquifers, local tectonic basins and wide hydrogeological basins throughout the Nile basin. It is a strategic resource that can and is already being used to supplement scarce surface water resources. Seventy per cent of the basin population depend on groundwater. This percentage varies by country. In Sudan, it is as high as 80 per cent. Details of groundwater storage and abstraction, recharge and discharge for each country are provided.

Generally speaking there is a dearth of data on groundwater. This situation needs to be addressed if the resource is to be sustainably managed and utilized. The clear recommendation from this section is the need for detailed monitoring information in future so as to manage the resources based on sound hydrogeological knowledge especially as groundwater has potential to support adaptation options.



The ecosystems of the Nile basin are habitat to a wide variety of birds.

Chapter 4: Water Availability and Demand

This chapter recognizes that water is central to the wellbeing of human society. As such it must be available in sufficient quantities to meet consumption and social needs. The chapter starts with a discussion on the 'blue and green water' concept. In the downstream countries where precipitation is high green water is most important, in the upstream countries especially Egypt and the northern part of Sudan where precipitation is low, blue water assumes greater significance. Mean annual precipitation over the Nile Basin is estimated at only 1 660 BCM per year of which merely 84 BCM per year translates into river flow (blue water) in the Nile.

The availability of water or the actual per capita renewable water resources is on the decline influenced by variations in precipitation, the hydropolitics of the region and pressures from the rapidly growing population, among others. Together, the countries of the Nile Basin use almost 90 per cent of the region's renewable water resources. Egypt and Sudan, which need water from outside their borders, account for the largest Nile water withdrawals at 57 and 31 per cent of the total renewable water withdrawals, respectively. Per capita withdrawals for these two countries are almost 10 to 15 times the amounts withdrawn by other countries in the basin.

Countries, such as Egypt, that have effectively and efficiently utilized the waters of the Nile have shown great economic and social progress. Per capita GDP in Egypt is three times higher than that of Sudan, the country with the second highest GDP in the region and 18 times higher than that of the DRC which has the lowest. The upshot now is that individual basin countries are increasingly eager to make greater use of the river, so that they, too, can approach the same levels of development.

Three main water uses are discussed in this chapter: agriculture, energy generation and transport. Agriculture accounts for more than 80 per cent of water withdrawals in the region. In the upstream countries, agriculture is mostly rain fed whereas in the downstream countries agriculture relies solely on the Nile river water. In Egypt alone, about 30 per cent of the water abstracted from the Nile is devoted to irrigation.

There is tremendous potential for hydroelectric power development especially where the gradient is high. Despite this potential, the sector is underdeveloped, expensive and unreliable. Some countries have prioritized hydropower development to close this unmet need. Ethiopia, for instance, is developing the 6 000 MW Renaissance Dam on the Blue Nile; and Rwanda is developing the 80 MW Regional Rusumo Falls Hydroelectric project.

The role that the Nile plays in providing transport routes is also highlighted. This is especially important in the Sudds in South Sudan during the rainy season when roads become impassable. The Nile however is not wholly navigable due to the cataracts that occur along its course.

Villager in the Nile Basin drinking from a hand pump used to extract groundwater.

Water.org / Flickr / CC BY-NC-SA 2.0

Chapter 5: Vulnerability and Hotspots in the Basin

This chapter briefly reviews how key climate parameters – temperature, precipitation, evaporation and evapotranspiration – will react under various future climate scenarios. It discusses how changes in those parameters may impact the flow of the Nile waters and thus freshwater availability in the basin. All climate scenarios indicate negative impacts on the Nile flows and wider catchment area. These changes may predispose the local communities to a host of attendant hazards affecting their ability to cope. This vulnerability is of concern as the ability or inability to cope will have effects on social, ecological and economic systems.

Against that background, the chapter employs a hotspot methodology to identify key ecosystems or regions that may be especially vulnerable to climate change. The main aim being to draw attention to these hotspots as places that may require special attention from the research, local and development communities to ensure healthy environmental dynamics are maintained or restored. The hotspots were identified using 10 selection criteria: water shortages, availability of surface water sources, groundwater shortages, environmental degradation, population dependency, ecosystem dependency, groundwater regime, mean annual rainfall, socioeconomic benefit and contribution to the sustainability of the Nile Basin. Six hotspot areas identified as a result of this exercise—the Nile delta, Nile Valley, Ethiopian plateau, Nile confluence, the Sudd wetlands and Mt. Ruwenzori.

The last section of the chapter is a visual evaluation of the hotspots using time series satellite imagery over a series of years to show evidence of environmental change. Some of the issues discussed include the expansion of urban areas, glacial recession, formation of new lakes and drying of others, sinking deltas and salt water intrusion, agricultural expansion and hydroelectric power generation.

Chapter 6: Impacts of Climate Change

The discussion in this chapter focuses on the impacts of climate change using the results of various climate scenarios. The scenario analysis tracked hydrological regimes in three hotspots – the Nile delta, Nile Valley and the Ethiopian plateau, chosen because of their extreme sensitivity to climate change and their importance in the overall sustainability of the Nile Basin.

The analysis indicates that under a scenario where the temperature rises, the heavily populated, low lying Nile delta is likely to experience shoreline accretion or erosion, sea level rise and salt water intrusion into freshwater aquifers. It is already retreating at 100 m per year affecting an area of about 24 900 km^2 with potential risks to large cities, industry, agriculture and tourism. The Nile delta and wider Mediterranean coast account for 30-40 per cent of Egypt's agricultural production and more than half of Egypt's tourism and industrial base.

Future changes to the Nile Valley aquifer will be based on how climate change and water resource development and abstraction projects affect the recharge capacity of the shallow aquifer. Changes in the Nile Valley in Egypt have been linked to upstream changes in the Ruwenzori mountains, the Ethiopian plateau, the Nile confluence in Sudan and flows in both the Blue and White Nile. These climate change impacts in those areas will determine the recharge of the Nile Valley's crystalline and volcanic aquifers.