PREFACE

The Regional Knowledge Network on Systemic Approaches to Sustainable Water Resources Management (R-KNOW) forms part of IUCN ROWA's Regional Programme on Water Resources and Climate Change and is implemented in close cooperation with a number of key partners in the MENA Water Sector, such as CEDARE in Egypt, PHG in Palestine, SPNL in Lebanon, AOW in Jordan, the Abdelmalek Essaâdi University of Tetouan in Morocco, and EMWIS in France. R-KNOW has been started as a project funded by the European Union (2013-2015) to assist in strengthening the application of systematic approaches to sustainable water resources management in five countries (Lebanon, Jordan, Palestine, Morocco and Egypt) and to share all relevant knowledge on these issues. The partners in R-KNOW have the firm commitment to pursue their collaboration and notably through activities that contribute to the RKNOW (http://www.rknow.net).

The core of this knowledge is the information collected on practical implementation of such systemic approaches in relevant pilot projects in different contexts. As lessons learned were not sufficiently shared among those intending to apply systemic approaches, it was deemed necessary to make an inventory of and synthesise the information about the experiences already made for others to refer and learn from[1].

As part of RKNOW's Knowledge Strategy for creating and sharing knowledge, knowledge products will be developed for its different Sustainable WRM Themes. This document is the first in a series of RKNOW knowledge products, bringing together work done in the domain of sustainable water resource management through integrated and participatory development approaches.

This document will share with a broad audience of practitioners and policy makers, notably in the West Asia and Mediterranean regions, **what integrated approaches are necessary to make water resource management and climate change resilience actions a success**. It will describe the underlying conceptual framework of these different approaches that underpin successful action in the four Thematic Areas distinguished within the RKNOW:

(i) Local Water Governance,
(ii) Climate Change and Water,
(iii) **the Water, Food and Energy Nexus**, and
(iv) Innovative & Sustainable Water Technologies.

This conceptual framework recognizes that in the region targeted by RKNOW, development and management of water resources is closely inter-linked with the development and management of drylands and rangelands through appropriate ecosystem approaches. The publication will illustrate the different integrated approaches proposed by sharing hands-on experience in their implementation, presented as specific case studies prepared by the RKNOW partners. From these case studies it will draw lessons and formulate recommendations that form part of the in-depth knowledge creation and sharing process engaged by the RKNOW partners and stakeholders in their respective five countries mentioned above.

[1] http://rknow.net/index.php/en/themes-en/project-database

CHAPTER 4. The Water, Energy and Food Nexus

The Water, Energy and Food Security Nexus Approach
The Nile Valley and other Water Resource Systems in Egypt

In the development arena new attention is given to the integration of different sectors and sub-sectors in more holistic approaches to development. Water and energy and agricultural use are all key elements in the Nile Valley agro-ecosystems. Their interaction is increasingly influenced by climate change phenomena and also here it is increasingly recognized that local governance and participatory planning and decision-making with local actors of water and ecosystems is a must. This Chapter will articulate how these aspects can come together in a Water, Energy, Food and Climate Change Nexus and can strengthen IWRM approaches in a river system as the Nile.

Introduction to a WEF Nexus Framework

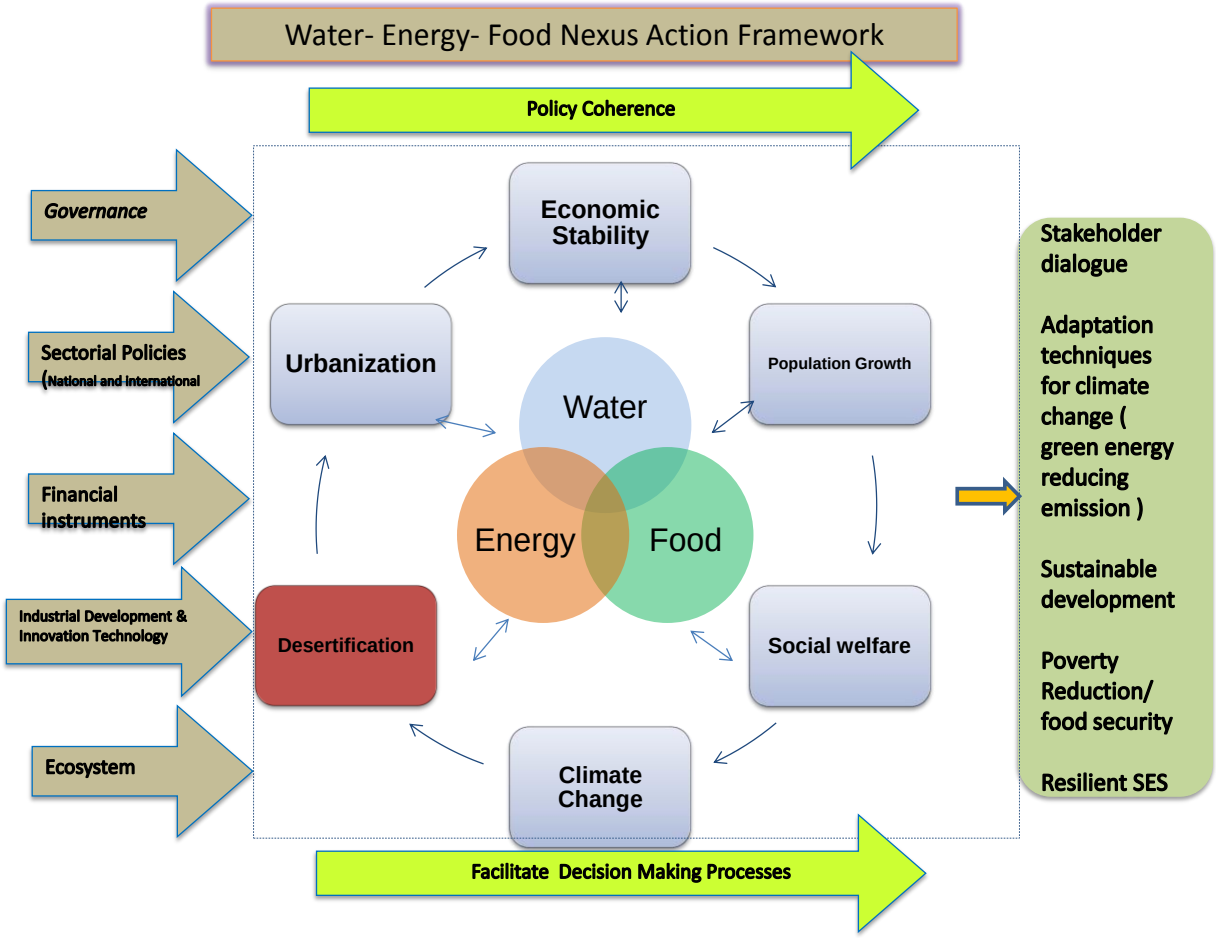
The Water, Energy and Food security (WEF) Nexus framework aims to understand how each of these three sectors relates to the other two, how synergies and complementarities among them can be enhanced and hence how these sectors can be developed in a more holistic way. Such understanding can then be used to make policy decisions promoting poverty reduction and sustainable development. The interrelatedness among the three sectors should not be considered a hindrance, rather their relationship/(s) should be seen as an opportunity to tackle development issues with a multi-sectorial integrated approach.

Also in the Arab Region coordination between water, energy and food security sectors offers important space for improvement. Where Egypt relies on the Nile River for 60% of its water supply and more than 80% of total water supply is used for agriculture, it still imports wheat and other basic food items. At the same time Egypt's long history of subsidizing energy is an important factor to be taken into account given its impact across sectors and overall development. A reform of the subsidy strategy is developed to reduce gradually the subsidies while keeping the subsidies to the lower income category.

One cannot miss the meeting ground (nexus) of water, energy and food. Their inter-connectedness is not only of today but has been important since ages and certainly in the social ecological system of the Nile Valley at work since ancient Pharaoic times. For example, agriculture needs energy and water whereas the latter can be used as an energy source in food production. In other cases, links between the sectors are more discrete, like that of biofuel production and food security (Bizikova et al., 2013). Also, advances in one sector may lead to degradation of others. Inefficient use of water in agriculture can lead to excessive energy consumption to withdraw groundwater, which may later lead to food insecurity.

The Nexus approach reaches beyond -acquiring or applying- technological advances; it requires cooperation across ministries, various levels of government and international collaboration. A nexus approach is in essence a new call for emphasizing integrated development approaches that link local and policy levels. In fact, reliable and effective governance –encouraging participatory development and local level engagement including stakeholder involvement, monitoring and evaluation of community responses - is critical to a nexus approach so as to ensure that priorities of those targeted/affected by policies are being met. The fight for poverty eradication, as again prioritized by the Sustainable Development Goals adopted in 2015 will continue to become ever more urgent, given that urbanization and climate change will add significant pressure on water, energy and food security sectors. Egypt is no exception to that.

A framework for a WEF Nexus approach implies working within three fields of management, i) governance, ii) financial instruments, iii) environmental assessment. As for the governance domain, it entails sector coordination, stakeholder dialogue for concerted actions, community participation, and strong institutional setup. The financial instruments include incentives for private sector investment in renewable energy production, and to subsidize services, prices of agricultural inputs like fertilizers, and improving export and import strategies. Environmental assessment is mandatory to assess the impacts of policies on natural resources, ecosystems, impacts of climate change, valuation of ecosystem services, and vulnerabilities and resilience of specific socio-ecosystems. The coordination of these three fields of management would support policy and decision-making and planning processes within a WEF Nexus and will highlight the tradeoffs that may be necessary. Connecting the three fields requires capacity building as a prerequisite at both institutional and human levels.



WEF Nexus and its opportunities in Egypt

The interdependencies of the water, energy and food security sectors are vital to the development of Egypt and as a matter of fact of the Arab region as a whole. Approaching these sectors with a nexus lens in Egypt can provide a strong example of how a nexus approach can be used in the greater Arab region to address national and regional issues. However, only a small number of individual development projects

have utilized the nexus approach to bring sustainability to small parts of Egypt , and large-scale policy changes will be needed for Egypt to make substantial progress in these three sectors.

Egypt receives 55.5 billion cubic meters (bcm) each year from the water flow of the Nile River (Attia, 2009). More than 80% of this water is used for agriculture with current agriculture water demand at 57.8 bcm and expected to increase as population grows. Egyptian farmers use over 1.8 million tons of fertilizer a year and a portion of that ends up in the Nile River and groundwater as long as proper buffers and practices are not in place (Nour El-Din, 2013). Water demand is expected to increase by 20% by 2050 and by 2025 water use per capita is expected to be 600 m^3, doubling from the current rate of 300m^3 (Ministry of Water Resources and Irrigation, 2014; Abdel Kader & Abdel Rassoul, 2010; "Water and Agriculture in Egypt," 2011). Domestic water use is 7% of total consumption but this is expected to increase as population grows (Abdel Kader & Abdel Rassoul, 2010). The Ministry of Water Resources and Irrigation has created a 2050 Water Strategy including plans to reduce water losses in the Upper Nile, address water pollution and promote stakeholder engagement (Nour El Din, 2013).

Industry, transportation services and residential use are the top three consumers of energy, making up over 70% of total final consumption ("Egypt: Balances for 2011," n.d). Egypt has spent almost $100 billion over the last decade on energy subsidies that make up over a fifth of Egypt's annual budget (Associated Press [AP], 2014; Castel, 2012). The national government endorsed energy subsidies reforms in June 2014, with the Egypt's National Energy Efficiency Action Plan calling for a target energy efficiency of 5% by 2015. However currently there are limited incentives for households and industries to demonstrate smart use of energy (Regional Center for Renewable Energy and Energy Efficiency [RCREEE], 2013a).

The avian influenza epidemic of 2005, the fuel and financial crisis of 2007, and macroeconomic instability since the 2011 revolution have all made Egypt's population vulnerable to food insecurity (Breisinger, Al-Riffai, & Ecker, 2013). In 2011, the World Food Programme estimated that 17.2% of Egypt's population is food insecure and 35% of people have poor dietary diversity (WFP, 2013b). 86% of vulnerable households in Egypt claim their monthly income is insufficient for their needs in terms of calory intake (WFP, 2013a). Egypt has established food subsidies as part of its safety net to protect the poor, however, a study by the International Food Policy Research Institute (IFPRI) found that 17% of the most vulnerable households are still excluded from the national ration system (Breisinger et al., 2013). Recent reforms by the government, such as the introduction of a smart card system to keep track of purchases and the elimination of subsidies for bakers, have attempted to address these problems. The goal of these reforms is to prevent waste from

the over purchasing of wheat (Ahmed, 2014). The reforms are also meant to improve the targeting of social programs.

In short, there is large scope to improve water and energy efficiencies and the effectiveness of food security programmes. Egypt's Sustainable Agriculture Development Strategy Towards 2030 emphasizes enhancing water use efficiency in irrigated agriculture and has introduced the nexus approach for decreasing water use in agriculture. Among others, the strategy includes stabilizing rice cultivation at 1.2 million feddan, introducing irrigation on the "old" agriculture lands in the Nile Valley and the rehabilitation of irrigation systems in reclaimed "new" lands in the desert areas. These proposed changes are estimated to save Egypt 13.5 bcm of water per year ("Water and Agriculture in Egypt", 2011).

Hydropower currently makes up 83% of installed renewable energy capacity in Egypt and the government has plans to increase total installed renewable energy capacity from its actual 11% to 20% (RCREEE, 2013b). Additionally, the government's desire to diversify its renewable energy supply by increasing wind and solar energy may encourage more environmentally-friendly approaches to energy production and use notably in the agricultural/food security sector.

Lastly, water is not only a potential source for energy generation, but haulage of water, by abstraction from ground water or by "horizontal" pumping in irrigation/drainage systems, can be made more energy efficient by using renewable energy sources as wind and solar. This is essential for preserving the Nile Valley agro-ecosystems and the services they provide. Indeed investments in renewable energy may trigger financial flows from the private sector towards the water and agricultural sub-sectors that could be charged though licences and taxes. Income from such charges could then be used for investments in more efficient water and agricultural use and conservation of ecosystems. These energy charges could also be considered as payments for the services the water/land ecosystems in the Nile Valley provide to society (food, maintenance of hydrological flows and decreased pressure on ground water resources).

Such potential financial flows and Payments for Ecosystem Services need to be coupled with agriculture policies that reduce the production of water-intensive crops and consider virtual water trades as a conservation tool for the water and energy sectors (Gelil, El-Ashry, & Saab, 2013). In the Arab Region studies estimate the effects of climate change to lead to a 3° to 7° C temperature increase by the end of the century which could reduce groundwater supplies by 40% as well as reduce crop productivity and agriculture yields ("Food security and nutrition in the Arab region: key challenges and policy options," 2012). In Egypt, rice productivity may decrease by 11%, barley by 18%, corn by 19% and wheat by 18% in 2030.

The WEF Nexus and its opportunities in the wider Arab Region

Interactions between water, energy and food security sectors are obviously important across the wider Arab region. Currently, the region's population is above 358 million and expected to upsurge 50% by 2050 ("Food security and nutrition in the Arab region: key challenges and policy options," 2012). Hence, poverty, resource depletion and degradation are increasingly distressing the region. Despite containing 43% of the world's oil reserves and huge potential for renewable energy, 35 million people in the region remain without access to modern energy services, mainly electricity (Gelil, El-Ashry, & Saab, 2013). The region possesses only 1.4% of the world's freshwater sources, making it the world's most water scarce region in absolute and relative terms (Siddiqi & Anadon, 2011; Sadik, 2013). Despite the fact that the Arab Region is the world's largest importer of wheat, the recent economic instability has left its population

even more vulnerable to food insecurity (World Bank, 2009), with a quarter of the children suffering from stunting and food insecurity. Accordingly, utilizing a nexus approach in the Arab Region has the potential to benefit all three sectors and reduce poverty through the improvement of livelihoods and job creation (Gelil, El-Ashry, & Saab, 2013).

The opportunities for utilizing a nexus approach are particularly apparent when observing the interactions between the **water** and **energy** sectors. It is estimated that the water cycle, from abstraction to post-use treatment , may use up to 15% of national electricity consumption in most Arab countries (Gelil, El-Ashry, & Saab, 2013; Siddiqi & Anadon, 2011). In Libya, 14% of total fuel consumption is used for groundwater pumping (Siddiqi & Anadon, 2011). Besides, the Arab Region is currently home to 50% of the world's desalination capacity (Mofor, 2013; Moawad, 2011). By 2050, energy demand for desalination will increase with improved desalination technology and the Arab region must consider how it will power these plants in the future. These links become even more critical when the impact of these changes in water and energy use will have on agriculture and food systems.

The benefits of conservation are also tremendous for the Arab Region. Reducing energy losses to only 10%, from the current 19.4%, would save the region $5.5 billion. Furthermore, transitioning to compact fluorescent lighting could reduce carbon emissions by 2.56% (Gelil, El-Ashry, & Saab, 2013). Expanding the water cycle could also bring immense benefits to the region. Libya, Kuwait and Qatar could meet all of their industrial water needs by recycling 25% of their annual wastewater (Siddiqi & Anadon, 2011).

Apart from these more global regional impacts a Nexus approach to water, energy and food security has already important impacts at more local levels, as is illustrated by two short cases for Qatar and Oman (Box 1 and 2) developed by a joint initiative of IUCN and the International Water Association (IWA). The objective was to explore how competing demands on water resources across the water, energy and food sectors could be addressed with private sector companies by providing multi-sector solutions through infrastructure and other means, including new technologies and investments in ecosystem services. Box 3 highlights a third case study about stakeholder engagement and knowledge sharing with innovative private sector initiative in a nexus of water, food and energy in Bahareya Oasis in the Western Desert in Giza Governorate of Egypt.

Box 1. The Sahara Forest Project in Qatar

Current models of production and single-focus technology solutions neglect and/or waste many resources that can be utilised to achieve restorative growth. The Sahara Forest Project (SFP) developed an innovative solution designed to utilise what we have enough of (using deserts, saltwater and CO_2) to produce what we need more of (food, water, and clean energy). This was done by combining already existing and proven environmental technological components, including saltwater-cooled greenhouses, solar power technologies and technologies for desert re-vegetation around a saltwater infrastructure. The synergies arising from integrating the technologies improve the performance and economics of the system compared to those of the individual components. The simple core of the concept is an infrastructure for bringing saltwater inland in low-lying desert areas. Through this infrastructure the SFP aims to

(i) generate electricity from solar power more efficiently,
(ii) operate energy- and water-efficient saltwater-cooled greenhouses for growing high value crops in the desert,
(iii) produce freshwater for irrigation or drinking, safely managing brine and harvesting useful components from the resulting salt,
(iv) grow biomass for energy purposes without competing with food cultivation, and
(v) re-vegetate desert lands.

From 2009 the concept has been developed with the aim to implement and up-scale it in Qatar and Jordan. A fully functional SFP Pilot Facility was built in Qatar through a partnership between Yara International ASA, Qatar Fertilizer Company (Qafco) and the SFP. The pilot facility involved a multi-purpose built greenhouse. At one end of the greenhouse seawater is run down a surface whilst fans blow desert air over it. The evaporation of the seawater results in cool and humid air within the greenhouse, thus lowering the temperature. The condensation of moist air, using pipes cooled with the seawater, results in a fresh water source for irrigation. The energy produced for the operation of the greenhouse is generated within a concentrated solar power plant within which solar energy is used to create steam and drive turbines. By bringing together local and international entrepreneurs, scientists, business and other key players in green innovation, The SFP Test and Demonstration Centre will be a platform for research, innovation and training for sustainable solutions to the food, water and energy challenges.

Additional activities will include using the seawater for cultivating algae and halophytes for biomass, and salt extracting by evaporation. The successful operation of technologies identified by SFP indicates the effectiveness and competitiveness of the concept in challenging conditions. Findings prove that there are significant comparative advantages using saltwater for the integration of food production, re-vegetation and renewable processes.

Box 2. Use of reed beds for water treatment in Oman

In the oil and gas industry, understanding and improving water use is increasingly important as global freshwater supplies come under increased pressure and demand for energy increases. Considering this, Shell is looking into new approaches and advanced technologies to help reduce the amount of water needed and used for its operations. One aspect being worked on is the recycling of produced waste water that contains small amounts of salts and oil. Traditionally this water is disposed of by injection into deep or shallow disposal wells.

However, several organizations are looking into the use of wetlands like reed beds for water treatment.
Reed beds have proven to be capable of efficiently, and cost effectively, handling the treatment of the produced waste water from the Nimr oil fields in Oman. This treatment has double benefits:

- The ability to reuse produced waste water: in parts of Oman, fresh water is extremely scarce, but more than five barrels of produced waste water are brought to surface for every barrel of oil and this water has to be disposed of;
- A reduction or elimination of the power consumption and CO_2 emissions associated with the operation of equipment for deep well disposal.

In Oman, Petroleum Development Oman (PDO, Shell share 34%) created the world's biggest commercial reed-bed water-treatment plant: a 360 hectare facility treating 95,000 m^3 of contaminated water every day. The reed bed facility is a four-tier gravity-based wetland design. Gravity pulls the water downhill, the reeds act as filters, removing oil from the water. The oil is eaten by microbes that naturally feed on hydrocarbons underground. Locally grown *Phragmites Australis* plants are used for the purification of produced water.
The facility layout includes a pipeline, which enters the treatment plant system and leads to an oil/water separator. The water is then distributed into a wetland facility where it is channelled through the wetland terraces by gravity feed. Finally, evaporation ponds are used to recover the salt while the biomass is currently planned to be land filled. Alternative uses of the water and biomass that could offer a variety of social and environmental benefits are being explored. For example, the biomass as an energy source or the treated water made available for use by local communities.

Participatory Nexus Approaches and Knowledge Sharing

The nexus approach is at its core a management and governance tool that uses collaboration and coordination to attain holistic success across sectors. One of its main components is the use of participatory approaches in stakeholder led planning and decision-making. Participatory planning is not a linear process; rather it is an iterative cycle with internal feedbacks that ensure the constant

participation of each stakeholder in the planning and implementation process. Thus, stakeholder engagement is crucial to ensure that projects and policies are not only environmentally sustainable but also socially acceptable and supported by those groups affected and directly involved in implementation of activities on the ground.

At the end of this Chapter another more elaborate case study illustrates a participatory planning and decision-making process with mutli-level stakeholders for the nexus of water, food security and climate change resilience in Ehnasia Water District in the Nile Valley agro-ecosystems of Beni Sueif Governorate in Egypt.

Recommendations for policy and practice

Egypt is at a critical point in its development, especially after the political turmoil of recent years. Its perspectives for development will only be further complicated by population growth, urbanization and climate change. The nexus approach presents an opportunity for Egypt to make strides in water, energy and food security - without comprising its natural or social environment- through effective governance adopting inclusive approaches, ultimately aiming at economic growth.

Based on the analysis of potential and case studies for a WEF Nexus approach, the following recommendations are put forth to promote sustainable development of each of the nexus' three sectors in Egypt:

1. Development of a national grant award for development projects utilizing the nexus approach to promote coordination and collaboration across sectors.
2. Creation of a national nexus knowledge platform to enable information sharing.
3. Implementation of a Nexus steering committee comprised of policymakers, researchers and civic organizations to oversee development projects in these three sectors.
4. Earmarking a portion of the expenses saved from reforming energy and bread subsidies for renewable energy, sustainable agriculture and water conservation projects.
5. Paying attention to extending the life cycle of food, water and energy by increasing energy efficiency and improved management of wastewater and organic waste.

Climate Change Resilience in the Ehnasia Water District
The Nile Valley, Egypt

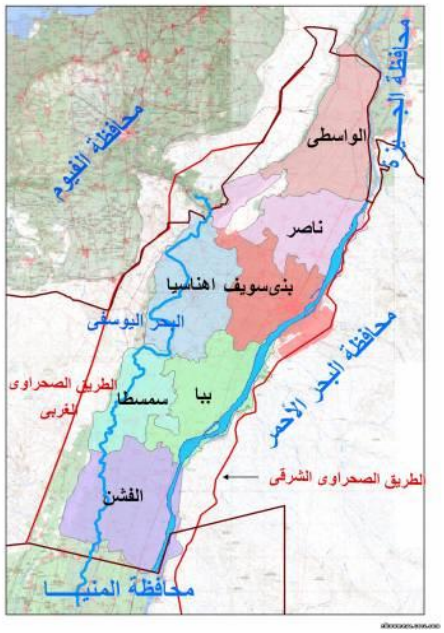
Description of Ehnasia water District in the Nile Valley

Ehnasia Water District is situated in Beni Sueif Governorate, just south of Cairo and forms part of the complex irrigation/drainage water management systems that have evolved over 5,000 years in the Nile Valley. For about two centuries (2242- 2452) BC, Ehnasia was the capital of Egypt during the era of the ninth and tenth dynasties. Agriculture is the most significant economic activity in the governorate. Most of the population, about 2.59 million, work in agriculture (according to the estimated census of 2012).

Ehnasia District is 17 km south west of Beni Suef city. It is bounded by Naser district from the north, Somosta District from the south, Beni Suef District from the east and Fayoum desert from the west. The

lands in this governorate extend alongside Nile shores for about 155km. The Nile in this area is about 9km width in average. Most of the agricultural lands are located west of the Nile. The western part of the district is close to the desert areas. Some of these desert areas (6000 feddan) were reclaimed through the Youth Project. This area is a natural border that separates the governorates of Beni Suef and Fayoum.

With a total area of the district of 1007.55 sq km (218.87 sq km being inhabited), Ehnasia is one of the biggest agricultural districts in Beni Suef Governorate. It has about 17% of the agricultural land in Beni Suef. The District has five local village units namely (El Awanaa, El Nowiera, Brawa, Nena and Qay). Such local village units oversee 36 mother villages and 153 hamlets. The population of Ehnasia district is about 320 thousand (according to the estimated census of 2012). Most of the population, almost 80%, work in agriculture. Ehnasia district depends mainly on two sources of water; the Youssefi and Ibrahimia sub canals. The biggest sub canal is El Sultani canal. The total area of the cultivated land is about 44.8 thousand Feddan in addition to the reclaimed area. These areas are irrigated by the side canals originating directly from Youssefi and Ibrahimia canals using the triple shifts system. Reuse of drainage water is practiced to supplement irrigation water in lands at the tail ends of the canals. The most significant crops are cotton, wheat, onion and tomatoes. Natural mineral resources include lime stone, gypsum, gravel and sands.



The most significant challenges that face irrigation and water management in Ehnasia are: limited water resources, increasing water demand that exceeds the water supply in summer, continuous increase in population, negative behavior and practices of upstream farmers, reclamation of desert lands unaccounted for in national plans, and very low annual rainfall rate. Moreover, as mentioned in the report of the local development plan that was made for Ehnasia District by the Social Fund for Development with participation of local community representatives mismanagement of solid waste, high level of subsurface water in agricultural land, and increased soil salinity were identified as additional problems.

Climate change resilience is a multi-sector and multi-actor concern and hence different stakeholders at different levels need to be involved. The key categories of stakeholders relevant in Ehnasia Distirict for this are:

- Governmental institutions: research centers, Directorate of Agriculture, affiliated bodies, agriculture district; affiliated districts and units, the Public Directorate of Irrigation, the General Directorate of Drainage, Irrigation and Drainage Directorate, and the Bank of Development and Agriculture**.**
- Non-governmental organizations: CSOs, CDAs, WUAs, agricultural associations and cooperatives; and media.
- Private organizations: shops selling pesticides, seeds and fertilizers; pesticides' factories,
- Individuals: male and female farmers; landowners and tenants

Participatory planning and decision processes (2007 – 2013)

In view of above concerns and issues, the Centre for Environment and Development for the Arab Region and Europe (CEDARE), and the Coptic Evangelical Organization for Social Services (CEOSS) partnered to implement a pilot project to explore how climate change resilience can be strengthened within the framework of sustainable water resource management (IUCN SEARCH[2] Programme 2010-2013). This pilot project built on an in-depth participatory and stakeholder led planning and decision making process to come to better and sustainable resource management of the Nile water flow in the District (IUCN REWARD[3] programme 2007-2010).

The following methodologies were adopted in all project phases. First, capacity building in using tools to engage in participatory stakeholder planning and tools to adapt to climate change. Second, engage in participatory planning and management. Last, documentation of methodologies and learning processes, as well as exchanging valuable information and knowledge at all levels. The project adopted a

[2] SEARCH stands for “Social, Ecological and Agricultural Resilience in the Face of Climate Change” and is a three year regional project funded by the EU and implemented in five countries; namely Lebanon, Egypt, Jordan, Palestine, and Morocco, aiming to develop and pilot a resilience framework for adaptation to climate change in watershed ecosystems.

[3] REWARD is the multi-donor/mulit project “Regional Water Resources and Dryland Programme” implemented by the IUCN ROWA Office since 2007

participatory stakeholder planning approach as described at the end of Chapter 1: Visioning, Assessing, Strategizing, Planning, Implementing & Reflecting.

Visioning

In an early stage of the process the following provisional vision was agreed upon by the different stakeholders for Ehnasia district:

> ***Increased agricultural productivity in order to improve the livelihoods of farmers in Ehnasia, while seeking a clean environment.***

In order to achieve such a vision problems associated with climate change were further analyzed and categorized by farmers, local communities, and agricultural associations together with staff of agricultural expansion and irrigation sectors. This resulted in four main categories of problems: (1) **poor crop production and low farmers income (**lack of awareness on climate change, weak marketing of some crops, high prices of seeds and production requirements, weak usage of agricultural machinery and old drainage network); (2) **increase in plant diseases and pests (**emergence of new pests because of rising temperatures, shortening of pests' life cycle, increase of fungal and pests diseases, rise of humidity rate that may cause infection of pest and fungal diseases and hence may lead to increased use of pesticides); (3) **poor solid waste management practices (**lack of farmers awareness on waste management and recycling methods, farmers' believe that recycling needs certain skills that they don't possess, weak marketing of products and by-products of recycling and poor waste management by governmental institutions); and (4) **summer irrigation problems (**lack of irrigation water in some areas at the tail ends of canals in summer and non-commitment to the cultivation cycle, affecting water distribution).

Assessing:

In cooperation with most of the relevant stakeholders mentioned above, an assessment was conducted using the RIDA framework. This simple framework looks to water in terms of Resources, Infrastructure, Demand and Access. It helps in developing a structure to collect and analyze relevant information. Tools such as PRA, Problem Tree and CRISTAL were also used in analyzing the factors influencing agricultural production. Basic sources of data were the knowledge of representatives of governmental and non-governmental organizations, meetings held with farmers, PRA's that were conducted in a participatory way, and outcomes of a Problem Trees Analysis to better understand cause-effect relationships. Secondary sources of data were governmental data published by stakeholders such as Ministries of Environment, Agriculture, Water Resources and Irrigation, researchers, studies, articles and opinions on the field of climate change in addition to the meetings held in the areas where the project is implemented. As part of the assessment a reflection was made on vulnerability and adaptive capacity of local people and the study area (the social-ecosystem) to climate change. Vulnerability and adaptive capacity concepts as defined by the IPCC (2008) are discussed in Chapter 1. A vulnerability assessment of the study area was made displaying the affected areas/sectors, events, exposure and degree of sensitivity of the system, and the degree of adaptive capacity of the area. Moreover, a Vulnerability Map for Ehnasia was developed by CEDARE, displaying the Human Development Index (HDI) for Beni-Sueif - as one of the indicators for vulnerability - and identifying the areas most vulnerable to climate change. The map proved that Ehnasia District is among the lowest HDI ranked areas, indicating that it is very vulnerable socially, economically, health wise to climate change as well as to food security.

The discussion on adaptive capacity covered the current practices of local inhabitants to handle climate change impacts, whether these practices are enough and effective and how they could be strengthened to cope with climate change and how obstacles faced in implementing these adaptive practices can be tackled. To this effect, a number of tools were used to measure the adaptive capacity of the study area, potential impacts of climate change, consequent problems, sectors that have less ability to face impacts of climate change as well as identifying the places most vulnerable to such hazards. As a result, a matrix of such adaptive capacity was developed displaying the risk, impacts, coping measures, effectiveness and suggested adaptation measure. Challenges like lack of funding, lack of climate change awareness, limited water resources, fragmentation of land ownership (majority of farmers own less than 2 feddans) and lack of coordination between stakeholders and farmers were further discussed.

Strategizing:
As described at the end of Chapter 1, in this phase of the planning cycle stakeholders decide on a number of strategies (broad sets of potential practical actions) to achieve their vision – under a range of possible future scenarios. The result of this is a selected number of priority activities that form part of an agreed strategy, and high quality plans to implement them, while ensuring sufficient funding for their implementation.

1.1. Meetings at different levels were held in order to develop strategies in Ehnasia that address climate change resilience for water resource management and agricultural production. Scenario building followed a three phase approach: scenario development, scenario finalization, and strategy development under different scenarios. This basically entails developing the final vision, identifying factors affecting the vision, and finally categorizing these factors with respect to their importance and uncertainty. The most influential factors and challenges to achieve the vision for Ehanisia in the eight possible scenarios are: availability of funds, exposure to climate change impacts, awareness of climate change issues and improvement of agricultural productivity. However, only three – of the eight potential - scenarios were relevant for Ehnasia. Hence various resilience strategies were developed under these three scenarios aiming at reducing vulnerability and increasing adaptive capacity of the area.

Scenario building and strategy development for Ehnasia District has indeed given high importance to strengthening resilience. Resilience, as explained in Chapter 1, is defined by IPCC (2008) as: "*The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change*". Strengthening resilience of the social-ecosystem of Ehnasia District to enable achieving the vision for the District will be realized through reduction of vulnerability and increasing adaptive capacity of the area. The four main strategies for strengthening resilience were therefore discussed under the anticipated scenarios. These four integrated resilience strategies are:

- Enhancing diversity: of the economy, livelihoods and nature
- Promoting sustainable infrastructure and technology: that combine both engineered and 'natural infrastructure', as well as adaptable and sustainable technologies reducing vulnerabilities .

- Mobilizing self-organization: a critical characteristic of resilient, highly adaptive systems is self-organization of local communities and is implemented in practice through participatory governance and empowerment of people in adaptive institutions.
- Facilitating learning: ensuring that individuals and institutions can use new skills and technologies needed to adapt and make better use of climate information and adaptation strategies.

With the further information acquired during scenario building and strategy development a more specific resilience focused vision was developed for Ehnasia District by 2020. This vision is formulated as follows:

> ***A climate change resilient vision for Ehnasia District**:*
> *A more competent and resilient community to cope with climate change, to decrease risks, and achieve optimal agricultural productivity in order to ensure appropriate income for the community and people working in the field of agriculture.*

Proposed innovative approaches and/or technologies

To achieve this vision suggested interventions include:

a) ensure participation of farmers in water resources management and planning, while narrowing the gap between theory and farmer practice;
b) raise awareness of farmers on climate change
c) implement aggregated crops system and improve agricultural marketing;
d) promote a culture of water saving and nature conservation;
e) safe disposal of solid and liquid wastes;
f) support the maintenance of water-ways and use of sage as organic fertilizers to replace chemicals;
g) enforce environmental and irrigation law enforcement

In order to explore practical ways to undertake some of these proposed interventions a number of pilot projects have been designed and decided upon:

Pilot Project 1: "Farmer field schools" in El-Masharka and Mayana villages in the field of awareness and climate change (intervention a and b)
This participatory farmer applied research model was tested under the name of "Specialized Farmers Field School" in 2012- 2013 by the SEARCH project in cooperation and coordination with the Agricultural Directorate of Beni Sueif, aiming at raising awareness and adaptation to climate changes. Consequently, awareness increased in the field of adaptation to climate change, contributing to the adaptive capacity and hence resilience, socially, ecologically as well as agriculturally. Moreover, the knowledge level of the targeted groups increased by 25%.

Pilot project 2: Plantation of tolerant and economic trees to maximize the use of water (intervention d)
Based upon the resilience strategy developed in Ehnasia to rationalize water consumption, a pilot project called "Cultivating Moringa Trees" was implemented. This type of tree is useful for adaptation to climate change, as its water consumption is very low and it can be cultivated on the sides of waterways, gardens, around houses and roads, while it has important fodder quality and other economic benefits as roots and leaves are sold at high prices. Awareness-raising sessions were held on the importance of this tree for

community representatives. Accordingly, 500 seedlings and 1500 seeds were cultivated, nurtured and provided to farmers at a low price.

Lessons learned for up-scaling

A National Policy Workshop was organized by the SEARCH project in Egypt to share results and how these results have been obtained with concerned stakeholders including Ministries of Water Resources and Irrigation, Agriculture, and Environment, the National Water Research Center, Environment and Climate Change Institute, Shores Protection Institute, Central Laboratory for Climate, CEOSS, Maiana Village Civil Society and CEDARE. The recommendation that came out from the workshop – can be categorized into four groups: **Participation**, **Dissemination, Thinking and Behavior Change and Policy.** As lessons learned from other case studies, they will be further described sand analyzed in Chapter 6.