Climate Change Adaptation in Economic Development Using Integrated Water Resources Management Tools

Economic Development

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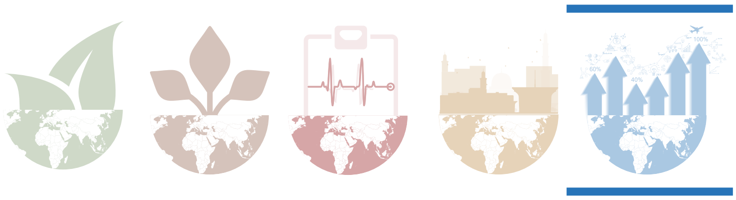
Economic and Social Commission for Western Asia



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Acronyms

ACCF	Africa Climate Change Fund
ACSAD	Arab Center for the Studies of Arid Zones and Dry Lands
ACWUA	Arab Countries Water Utilities Association
ADB	Asian Development Bank
AfDB	African Development Bank
AMT	adaptation management team
AR	assessment report
ASAP	Adaptation for Smallholder Agriculture Programme
CBFF	Congo Basin Forest Fund
CCA	climate change adaptation
GDP	gross domestic product
GHG	greenhouse gas
GIS	geographic information system
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
IAM	integrated assessment model
IDB	Inter-American Development Bank
IDB	Islamic Development Bank
IPCC	Intergovernmental Panel on Climate Change
IWRM	integrated water resources management
ODA	official development assistance or overseas donor assistance
RCM	regional climate model
RCP	representative concentration pathway
REDD	reducing emissions from deforestation and forest degradation
RICCAR	Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socio-Economic Vulnerability in the Arab Region
SCC	social cost of carbon
SSP	shared socio-economic pathways
UNDP	United Nations Development Programme
UN Environment	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VA	vulnerability assessment
WHO	World Health Organization

CH. 1

Introduction

Falaj Dares, Oman. © Fayrouz Megdiche

Introduction

About the training manual

This training manual has been developed within the activities of the United Nations Development Account (UNDA) project on developing the capacities of Arab countries for climate change adaptation by applying integrated water resources management (IWRM) tools. The project aims to provide a set of regionally appropriate IWRM tools for supporting climate change adaptation in five key sectors – namely agriculture, economic development, environment, health and human settlements – by deriving a training manual that includes the five modules on the selected sectors.

The project was led by the United Nations Economic and Social Commission for Western Asia (ESCWA) in cooperation with the United Nations Environment Programme (UN Environment) Regional Office for West Asia, and was implemented in partnership with the following organizations for three out of the five modules:

- Agriculture module: Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ);
- Health module: World Health Organization Centre for Environmental Health Activities (WHO/CEHA);
- Human settlements module: Arab Countries Water Utilities Association (ACWUA).

The Environment module and the Economic development module were prepared by UN Environment and ESCWA, respectively. This UNDA project builds on the results of the Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR) that is led by ESCWA and implemented by the League of Arab States (LAS) and United Nations organizations.

Training objectives and methodology

This training is designed to bring together a group of 25-30 professionals (see targeted stakeholders) in a facilitated and highly interactive setting in order to develop the capacities of Arab countries in the area of climate change adaptation with a specific focus on economic development and the water sector.

The expectation is that participants taking part in the training have an acceptable understanding of IWRM. The material is designed to support a facilitated, multi-day workshop that will empower participants to understand the tools and concepts needed to build programmes, direct staff and allocate resources as they develop and integrate IWRM as a concept for adaptation to climate change in the water sector in the Arab region. In addition, participants in the training will have a comprehensive exposure to impacts of climate change in the water sector and economic development in the Arab region.

The training material presents basic facts on the inter-relationship between the water sector and economic development, IWRM tools and other modern tools needed to adapt to future conditions, and how to prioritize adaptation measures and implementation considerations. Case studies and exercises from the Arab region are incorporated to learn from experiences of 'real world' projects and programmes. This economic development module aims to:

- Increase understanding of government officials and regional stakeholders of the impact of climate change on water resources;
- Analyse the linkages between climate change, water sector and economic development;
- Review the vulnerability assessment protocols and indicators in the water sector;
- Enhance government capacity to incorporate IWRM tools into strategies, policies, plans and programmes of water management in order to be better prepared for future climatic conditions, i.e. climate change adaptation (CCA);
- Present tools for adaptation in the water sector in relation to economic development;
- Review the governance framework and implementation mechanisms towards identifying the needed adaptation interventions for the sector.

The exercises included in the annex to this module are:

- Exercise 1: Climate proofing for adaptation – Scope and preparation
- Exercise 2: Climate proofing for adaptation – Analysis and assessment
- Exercise 3: Climate proofing for adaptation – Adaptation matrix

Targeted stakeholders

With water resources intersecting numerous sectors, and given the myriad forms of governmental institutions dealing with policymaking, planning and implementation, this training module benefits a wide variety of officials from the public sector, academia, non-governmental organisations and the private sector. The module will also benefit those interested to learn about the different aspects of climate change impacts on water resources, the associated linkages to economic development and the use of IWRM as a tool for climate change adaptation in these two sectors. The following target groups should find this module of particular interest:

- Decision makers and technical staff in the water and economic development sectors who are concerned with the economic dimensions of climate change and with developing and implementing policies, programmes or projects;
- Decision makers and technical staff in other government sectors concerned with water and economic development dimensions of climate change (such as spatial planning, environment, agriculture, food, disaster risk reduction, transport, industry, labour, education, etc.);
- Stakeholders involved in the development and implementation of national adaptation plans (NAPs), national adaptation programmes of action (NAPAs), nationally appropriate mitigation actions (NAMAs) and national communications;
- Representatives involved in the global United Nations Framework Convention on Climate Change (UNFCCC) process, such as negotiators and UNFCCC focal points;
- General economic development and water sectors' staff and other professionals providing water services;
- Women and other vulnerable groups of society;
- Civil society and, to a lesser extent, local community representatives;

- Non-governmental organization (NGO) experts active in the area of climate change, water and/or economic development;
- Academics, scientists and researchers working on climate change adaptation in the water sector and economic development.

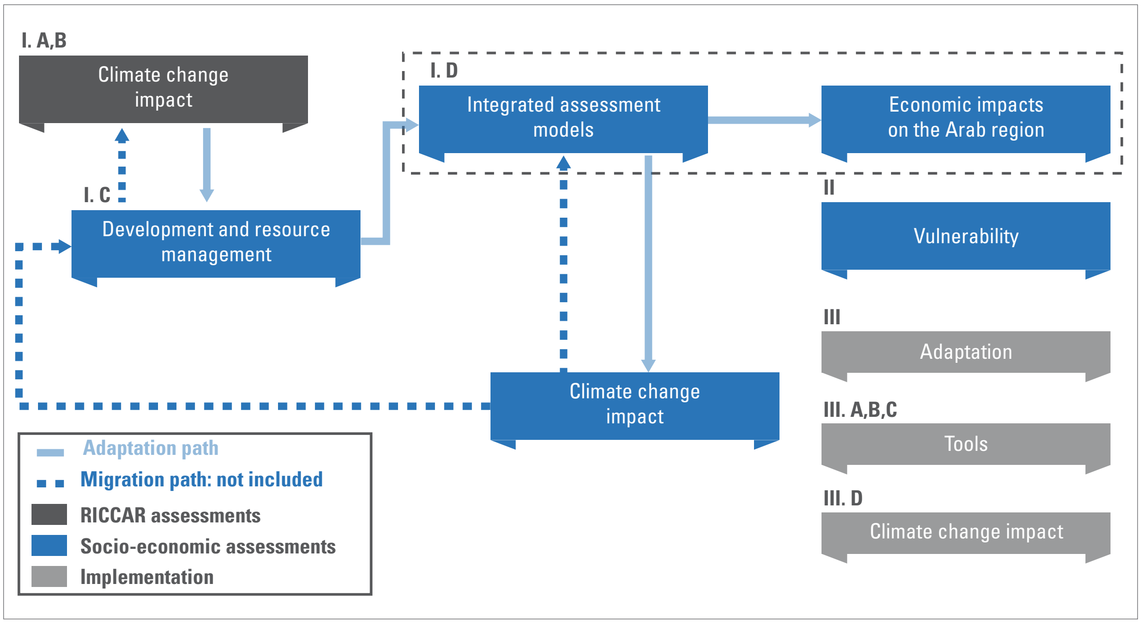
Module content

Climate change adaptation in the water-scarce Arab region is largely achieved through IWRM, and the water sector itself is significant in its contribution to economic development. In order to properly plan for such adaptation, specific information needs to be gathered. This is achieved in three phases:

1. A first step is to clarify the interactions between climate change adaptation measures and economic development (chapter 2 of this module). This is necessary because of three "dimensions" inherent to climate change impacts: they will (1) affect some economic sectors more than others ("sectoral dimension"); (2) vary across the region in the ways they affect natural resources ("geographic dimension"); and (3) evolve over the years ("time dimension").

   a. The impact of climate change will affect both the macro-economic level and the multi-sectoral development at the level of specific economic sectors (chapter 2);
   b. Climate change is likely to exacerbate natural resource scarcities, with major implications for natural economic development. This has specific implications for the Arab region (chapter 2), not only because of its endemic water scarcity, but also because of the central role played by energy exports;
   c. The way those impacts evolve over the years will affect the future sustainable economic development of the region, and will define necessary adaptation measures. As climate change exacerbates, its specific implications for Arab economic development become increasingly salient and impose a cost (chapter 2). These economic effects can be determined in three manners, by developing:

Figure 1. Organization of the module: Logical flow

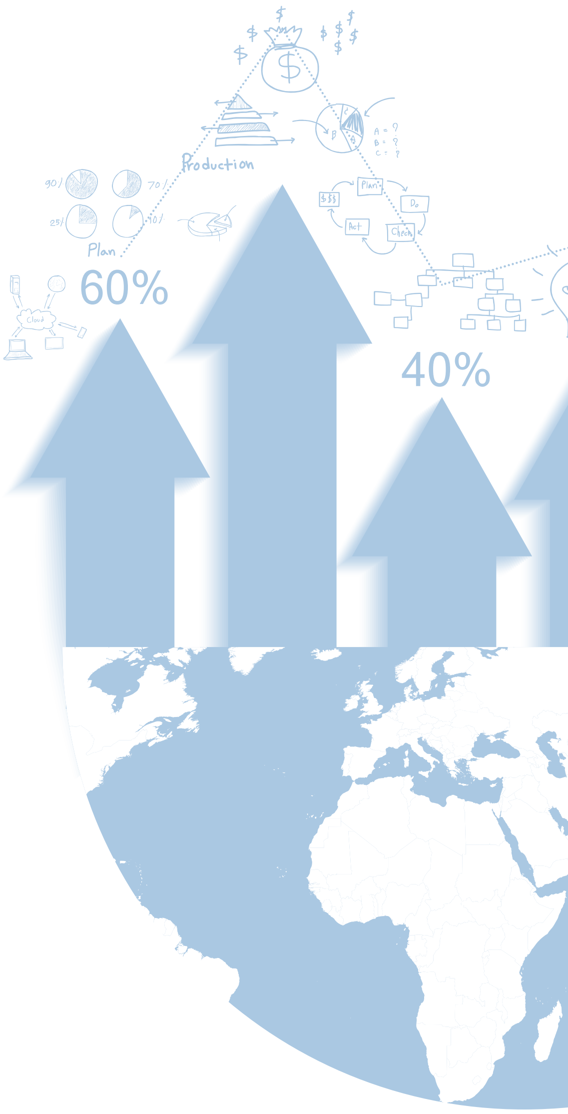


- A "big picture" of the overall costs of climate change;
- A detailed description based on the implementation of economic computer models that take into consideration climate projections;
- A detailed description of the impact of extreme weather events.

d. Once the structure of those impacts is well described, the relevant sources of climate financing can be pursued;

e. This will largely define how climate change impacts economic development and what adaptation measures are needed. This is done by:
   - Drawing upon economic models that take into consideration climate projections, the impact of extreme weather events and associated climate change assessment tools for informing decision-making (chapter 2);
   - Benefiting from climate financing and investment tools;
   - Enhancing the capacity of policymakers to develop informed policies that promote climate change adaptation.

2. In a second step, the geographic dimension of climate change can be further refined through an integrated assessment that maps the vulnerability caused by climate change impacts. The proposed methodology focuses on the socio-economic and environmental vulnerability caused by climate change impacts on water resources in the Arab region (chapter 3).
3. In a third step, the planning for adaptation can then proceed. Adaptation planning is based on determining what can be done, before prioritizing and deciding upon the best adaptation measures through a proposed "climate proofing" methodology. An adaptation matrix can then be elaborated before the concrete plans are finally formulated and recommendations for improved governance for climate change adaptation are made (chapter 4).
4. The final section of this module shows how adaptation measures can be implemented to meet the challenge of climate change (chapter 5). A methodology is proposed to help identify key "options for action" that are necessary to address the "probable chains of effects" that would result from both the climatic impacts (determined through such modelling efforts as RICCAR), their resulting economic impact and other potentially related socio-economic effects.



CH. 2

Economic Development and Natural Resources Management

CH. 2

Economic Development and Natural Resources Management

Economic development aims to create qualitative change and restructuring in a country's economy through the use of natural resources such as water and land, as well as human and physical capital. Economic development is therefore strongly linked to the natural environment, which provides society with a "natural capital" that provides resources for material and energy inputs.

Changes in the climate are therefore likely to have an effect on key ecosystem services, as they, inter alia, increase pressure on water resources, exacerbate land degradation and affect the demand for energy. Under this increased pressure on water, land and energy, economic development faces three challenges:

1. The first two challenges come from the changing climate itself, which adds new risks and uncertainties, and thus adds to the costs of doing business. Those costs are related to both foreseeable and unforeseeable climatic changes:
   a. The forecasted change in climate is set to change the underlying conditions, under which businesses operate. While it is true that, in addition to new risks, climate brings about new opportunities, businesses still need to adapt to both. This adaptation brings about a need for additional investments, and thus increases the cost of doing business;
   b. Additional costs will also come from a greater weather variability and an increased risk of rapid climate change events. The resultant risks, as well as the need to ensure against them, will also add further costs to doing business.
2. Those changes are taking place in a context where resources are already under increasing pressure as a result of human activities. This is particularly the case of the Arab region, faced with water deficits and land degradation. Furthermore, the region's growing urban settlements may increase demand for energy supplies, thereby threatening its exporting capacities and thus its main source of income.

In the Arab region, environmental challenges are rendered more difficult by social and economic challenges. To be sustainable, any future economic growth has to manage natural

Box 1. Circular economy

A "circular economy" is an economy, which balances economic development with environmental and resource protection. It places emphasis on the most efficient use and recycling of resources, and on environmental protection.

Such an economy would feature low energy consumption, low emission of pollutants and high efficiency of resource utilization. It involves applying cleaner production practices in companies, eco-industrial park development and integrated resource-based planning for development in industry, agriculture and urban areas.

resources more effectively – or risks depleting them. In other words, achieving sustainable development as well as a sustainable economic growth is not possible without a good understanding of climate change. In the long run, economic growth will depend on an increasingly complex and integrated world, with towns and cities relying on an inter-related network that provides them with services such as regular agricultural supplies, reliable energy and readily available freshwater resources.

Such growth will take place in the context of a changing climate that places increased pressure on freshwater resources and energy production. Future economic development should therefore be guided by the need for both climate change mitigation and adaptation.

1. At the global level, in particular, mitigation efforts are being made in order to diminish the "forcings" that exacerbate climate change. Those forcings are due to the cumulative effect of past human emissions in the larger economies.
2. At the local level, in particular, adaptation is needed to address the impacts of climate change, especially in regions where resources are limited. This is the case of the Arab region, an arid to semi-arid area where water is already scarce, and where the current challenges not only threaten local "efforts to achieve sustainable development", but also "the lives and livelihoods" of the people.[1]

The impacts of climate change will affect the economies in the Arab region at various levels, mostly because of its high dependence on water resources. Impacts can be seen at both the macro-economic and the local level, and for each of the various sectors such as agriculture, the productive sectors of industry, trade and services, as well as for households. In the Arab region, the changing climate will have an effect on economic development unless there is a more efficient use of natural resources such as water and energy, as well as better land management. Meeting the challenge will require a good understanding of the linkages between climate change and the economy on the one hand, and adequate means of financing on the other.

Macro-economic impacts

Economic impacts of climate change on the Arab region are related to variations in three key climatic parameters: temperature, precipitation and sea level change. The economy is sensitive to (1) the magnitude of the change in climatic parameters; (2) the increase in their variability; and (3) the rate at which this change happens.

1. The magnitude of the change is represented by both the extent of warming and the pattern of warming expressed.
   a. The extent of warming, expressed as impacts forecasted by climate models and represented by changes in the amount of rainfall and average temperatures;
      - The change in rainfall is expected to be proportionally higher in arid and semi-arid areas such as the Arab region. Those regions are expected to "receive even less rain under climate change, leading to degradation of agricultural land and impacting food security";[2]
      - It appears, however, that temperature has the larger effect on the short to medium term outlook for economic development. The developing world, and particularly the Arab region, appears to be extremely sensitive to variations in temperature, as its economies experience "large, negative effects of higher temperatures on growth".[3] Particularly impacted would be Bahrain, Jordan, Kuwait, Libya, Oman, the State of

Increased aridity can negatively impact economic growth. © Alaa Kanaan

Palestine, Qatar, Saudi Arabia, the United Arab Emirates and Yemen. Those countries are primarily concerned with investments to alleviate the pressures of hyper-aridity, such as improving management of groundwater resources, and securing additional sources of water, be it from fossil water or desalination.

b. The pattern of warming, expressed as variations in temperature and rainfall distributions. This will have an effect on various diverse sectors of the economy, such as tourism and agriculture:
   - One industry that will be affected is tourism, especially winter tourism. As the range of snowline geographically shifts, the infrastructure will have to adapt as resorts that have been built will find themselves without marketable ski slopes. This is, for example, the case of Lebanon's ski resorts, which have to adapt both to a possible 40 per cent decrease in snowfall by 2040 and a shift northward of the heaviest snow at the expense of some already established resorts;
   - In agriculture, this will have an impact at a minimum on the geographic range of plants and wildlife shifts, thus impacting agricultural activity. As long as the shift takes the range to a terrain that can be cultivated, agriculture may be able to adapt. However, in countries with limited ranges such as Lebanon, Morocco or Tunisia, agricultural activity may not be able to "move".

2. The increase in the variability of climatic parameters is likely to have major destabilizing effects on developing countries' economies.[4] Arid regions are especially vulnerable to variability in precipitation, particularly during droughts, when they experience unexpected and prolonged periods of abnormally low rainfall. In the Arab region, the resulting water shortages have been found by a number of studies to be linked to social instability and even conflict.[5]

a. The increased variability is a major issue for countries where renewable water supply is adequate on national average but where there are geographic variations among their different areas. This is the case of Algeria, Lebanon, Morocco, the State of Palestine and Tunisia. The primary concern for these countries is the investments needed to secure internal distribution across the various areas and to smooth out the year-to-year variations in supply;
b. Egypt, Iraq and the Syrian Arab Republic appear to have adequate supply of water, but their main sources of supply are from shared water sources. Their climate change adaptation strategy depends on investment decisions made upstream.

3. The rate of climate change matters. Adaptation strategies would differ depending on whether the change in temperature, precipitation or sea level rise is rapid or slow. This aspect equally affects all Arab countries.

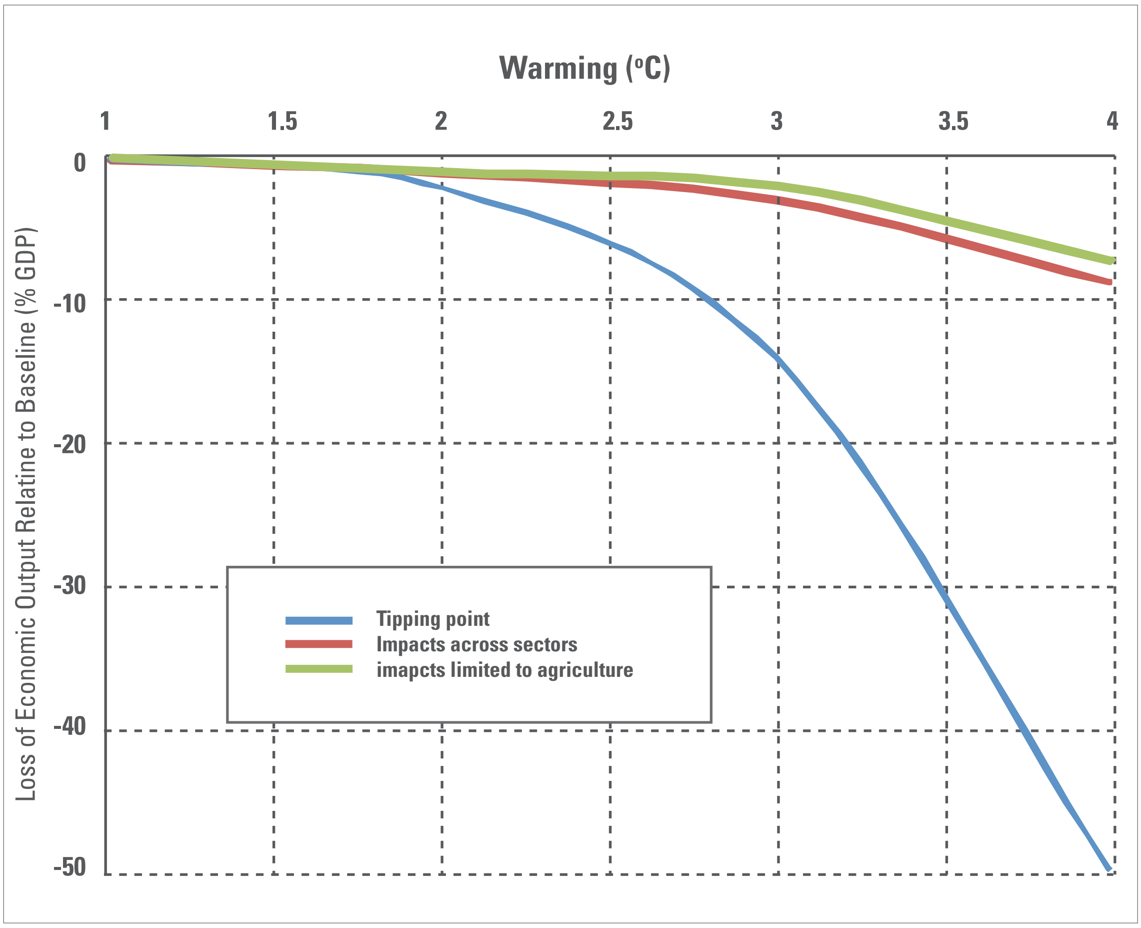
Detailed estimates of the economic impacts of those factors are harder to obtain for the Arab region because of a lack of systematic estimates at the regional level. The three main benchmark studies[6] and the Stern Review[7] have tended to focus more on mitigation at the global level.[8] Those studies strive to relate economic parameters (gross domestic product (GDP) losses) to one key climatic parameter, the projected change in average temperature. They tend to share a similar economic baseline, the period from 1990 to 2000.

In their evaluation, their estimates widely vary; for a warming of 3°C, studies project losses that vary from 2 per cent to 14 per cent, and a far wider range of variation for higher temperatures. The differences appear due to a lack of consensus on how damages evolve as warming gradually increases. While some studies consider that excessive warming could lead to a "tipping point", others do not and they disagree on whether the impacts are limited to the agricultural sector or whether the impacts extend to other sectors. Those types of studies can be classified into two broad categories of estimates, whether they take into account a "tipping point" or not (figure 2):

1. Studies consider that a warming in excess of 2°C to 3°C would lead to a "tipping point" in the growth of the world economy, whereby insufficient action starts to significantly weigh on growth.[9] By the time warming extends to 4°C (by 2100), climate change would have noticeable impacts on future growth and living standards, and annual economic output would be 50 per cent lower compared to the baseline.
2. There are two types of such studies: those that consider that economic impacts will extend beyond agriculture; and those that assume that they will be limited to this sector.

a. In general, "middle ground" estimates do not take into account "tipping points", but they consider that a wider range of industries will be affected. Those industries are insurance, tourism and water-dependent sectors such as agriculture. They estimate that, by the time a 4°C of warming is reached (around 2080), the economy would be 9 per cent smaller than the baseline.[10] This would translate into an effective loss of global GDP between 0.15 per cent and 1 per cent per year;
b. The most "optimistic" estimates[11] are based on damage functions that consider that climate damage is progressive, with no "tipping point" reached. By the time a 4°C warming is reached, annual economic output will be just 4 per cent lower than a baseline case (where no warming is experienced). Those studies therefore estimate that economic impact of climate change is likely to be small, even while agriculture is the most exposed sector to global warming.

Figure 2. Estimates of economic losses from climate change



Source: Adapted from Covington and Thamotheram, 2015.

It is possible, however, that those types of studies do not properly evaluate economic impacts in a way that is applicable for adaptation planning, either at the global scale or at the scale of the Arab region:

1. At the larger scale, those estimates are generally more focused on exploring the cost-effectiveness of global mitigation rather than on evaluating the cost of local adaptation. Because of this "big picture" focus, they generally (1) poorly evaluate linkages between different sectors, especially in water-related activities; (2) undervalue "non-market impacts", for which a dollar value is harder to assign; and (3) do not account for the long-term impact of extreme events.[12]
2. At the level of the Arab region, the methodology followed by many of those estimates is flawed because it does not fully take into account the vital socio-economic role played by the agricultural sector.

The agricultural sector remains an important livelihood sector in the Arab region. Even if its relative importance has waned, it still contributes 13 per cent to regional GDP and about 20 per cent of exports. Moreover, in some countries, farming still employs about 40 per cent of the population.[13] Furthermore, the sector employs people whose skills remain limited to this sector of activity, and who therefore cannot easily move to other occupations, unlike what many of those studies assume.

Box 2. The "tipping point"

In the climate system, a "tipping point" is a defined as "a critical threshold when global or regional climate changes from one stable state to another stable state".[a] Beyond such a point, changes may prove irreversible. Currently, the threshold considered to be a safe limit for climate warming is considered to be 2°C. Beyond this level, little is effectively known about the long-term trends that the planetary climate would follow.

In practice, it is hard to determine when a "tipping point" has been reached, because it may be easily passed without any obvious consequences. One way to determine this is to comb through the data from climate model (CM) simulations referred to in the 5th assessment report (AR5) of the Intergovernmental Panel on Climate Change (IPCC). Such an analysis showed evidence of 37 "forced abrupt shifts" at the regional level, 18 of which occurred in simulations for warming below 2°C, suggesting "that it is likely that the Earth system will experience sharp regional transitions at moderate warming, although the prediction of any particular event has a very high uncertainty".[b]

[a] IPCC, 2014, p. 128.
[b] Drijfhout and others, 2015, p. 8.

The various studies allow to develop a form of consensus reflected in the IPCC AR5, in which the global economic costs of climate change may remain small until a 2°C warming is reached, and then begin to accumulate as the climate further warms.

Multi-sectoral development

The impacts of climate change will not be uniform across the economic spectrum; they will differ among economic sectors of activity and across geographic regions and the social spectrum.

First, the economic costs will differ among sectors of activity, with the most obviously impacted sector being agriculture. This is because agricultural production is the most closely linked to water availability and temperature. However, there will also be economic impacts of climate change on other sectors because of the implications of climate change for energy and infrastructure, as well as the essential service of water supply and water treatment:

1. Climate change will have a different impact on agriculture in industrialized nations than in developing countries. By 2080, it is expected that agricultural potential could increase by 8 per cent in developed countries, primarily as a result of longer growing seasons, but fall in the developing world by 9 per cent, because of lower water availability and higher temperatures. Agricultural yields in rain-fed areas are even more exposed to the effects of climate change.
2. The energy sector will be affected, at the very least, due to increased demand for cooling, and because of the effect of higher temperatures on industry and housing.
3. Some infrastructure will need to be rebuilt to account for effects such as sea level rise. Even a small increase in sea levels will mostly impact coastal areas, affecting not only vulnerable groundwater aquifers, but also coastal settlements.
4. The water sector, particularly supply and treatment, will require significant investments to adapt to the changing climate.

Box 3. Gender and climate change impacts

In many areas of the developing world, women in poor households disproportionally feel the impacts of climate change, be it droughts, extreme weather events or loss of food production.

- Women are often the primary collectors, users and managers of water. Therefore, when recurring droughts exacerbate water shortages, this will further add to their workloads because they would have to bring water from further away. This may even have secondary effects such as lower school enrolment for girls or less opportunity for women to engage in income-generating activities;
- Extreme events also tend to disproportionally affect women more, as evidenced by a sample of 141 countries surveyed over the period 1981-2002, which found that fatalities among young women were proportionally higher;
- Loss of food production will also adversely affect women in rural communities in developing countries, as they are responsible for at least half of the food production;
- In many areas of the developing world, women commonly face higher risks and greater burdens from the impacts of climate change. This is especially the case in situations of poverty, and is exacerbated by women's unequal participation in decision-making processes. However, cases where women were included in local decision-making have led to improved outcomes of climate-related projects and policies.

Note: For more information, see http://unfccc.int/gender_and_climate_change/items/7516.php.

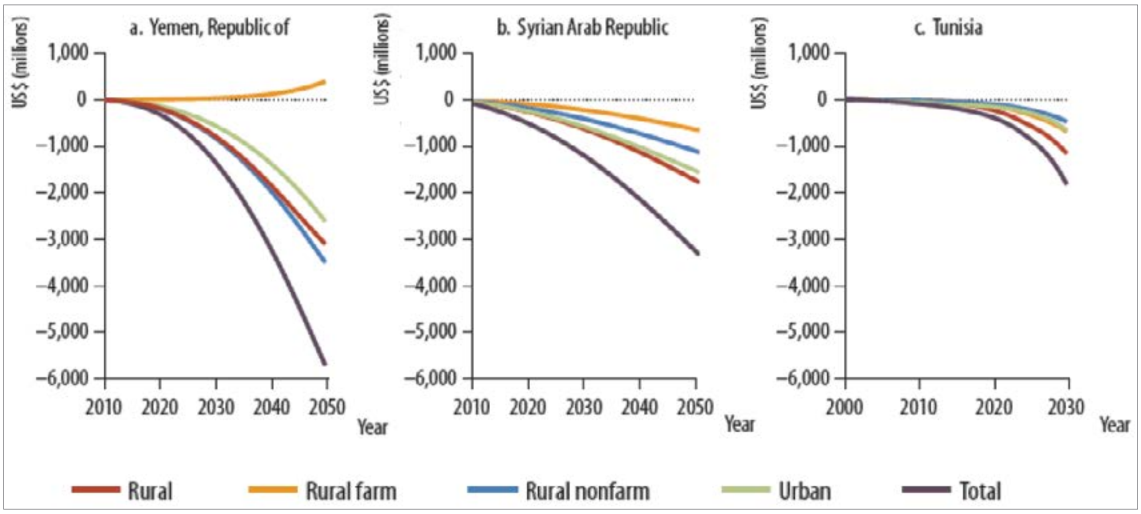
It should be noted that the full economic cost of climate change may extend beyond what can be directly computed. This is because of additional costs that will add up the value of the true economic impact of climate change, both directly and indirectly. Many of the direct adaptation costs of climate change are generally non-obvious and thus hidden, and are related to such diverse adaptation actions as infrastructure replacement, transportation changes, productivity losses, relocation, training, etc. In addition, the increased level of uncertainty and risk brought about by climate change will add indirect costs on business activity related to the banking and insurance sectors, the need for planning, etc.

Another aspect of climate change is that its effect will be essentially "socially differentiated", especially because of the strong dependence of the poor on agriculture, which is likely to be the most affected sector of activity. In addition to this social differentiation, there are regional and social variations "within and among countries, and across the Arab region as a whole".[14] The vulnerability is particularly high for poor communities, and is generally related to the following factors:

- Asset-poor communities have comparatively fewer resources, even if they may not lack the technical capacity to adapt;
- They tend to have a high dependence on marginal natural resources, especially in rural areas, which are relatively more exposed to climate change;
- They tend to be located in high risk areas, which are proportionally more vulnerable to extreme events;
- They often face social impediments; they tend to be migrants, which hinders their access to social services, or have a low level of education, which may prevent them from developing alternative livelihood strategies.

The impact of climate change on this segment of the population is likely to be further magnified by a key feature of the Arab region; that it is a net food importer, notably of key staples such as wheat. This disproportionally exposes the poor to swings in commodity prices, especially in cases where those with low income levels still have to spend a high proportion of income on food. Indeed,

Figure 3. Cumulative impacts on household income for the Syrian Arab Republic, Tunisia and Yemen



Source: World Bank, 2012, figure 1.1, p. 21.

compared to the United States where per capita income spent on food fell from 17.5 per cent in 1960 to 9.6 per cent in 2007, it reached around 40 per cent in many countries in the Arab region such as Algeria (43.7 per cent), Egypt (38.8 per cent), Iraq, Jordan (40.7 per cent), Libya (37.2 per cent), Tunisia (35.6 per cent) and Yemen (45 per cent).[15] This will have long-term implications for poor households, as income reductions accumulate over time. This is shown by projections of household income in the Syrian Arab Republic, Tunisia and Yemen (figure 3). As early as 2020, the lost income represents a measurable decrease in GDP, of 1.1 per cent in the Syrian Arab Republic, 0.4 per cent in Tunisia and 1.3 per cent in Yemen.

Management of natural resources and economic development in the Arab region

In the Arab region, climate change will affect the key pillars of sustainable economic development by increasing pressure on the key resources of water and energy. The water and energy sectors are closely linked through economic activity. Water-dependent sectors need energy for pumping, food production, heating and cooling, desalination and treatment. Energy-dependent sectors are also dependent on water for power generation and extraction.

The future development of the Arab region will therefore be inextricably linked to the development of those resources in a context of climate change.

Natural resources management and services in the Arab region

A. Water resources and water demand

The water sector of the Arab region is already feeling the dual pressure from both climate change and increased human activity. Arab countries now find themselves in a high-risk situation, with high population growth, rising urbanization, and increasing demands for natural

resources. It is a context where "climate change is contributing to the depletion and degradation of water and soil resources and putting further pressure on agricultural zones and biodiversity".[16] The region's built environment and natural ecosystems are now already witnessing "a higher frequency and intensity of floods, droughts and extreme weather events". [17]

Those issues pose unique development challenges in the water sector: (1) enhancing people's access to water and sanitation; (2) ensuring a secure water supply; and (3) maintaining the protection of vital ecosystems. Addressing those issues needs a cross-sectoral focus.

1. The need for enhancing people's access to water and sanitation comes at a time when the region's urban population is projected to grow to 75 per cent by 2050, up from 57 per cent today.[18]
    a. Many Arab countries are focusing on expanding water storage and conveyance networks and increasing dam capacity. However, this strategy alone is limited in confronting climate change; most of the dams are already below full capacity, with high evapotranspiration rates;
    b. One of the adaptation responses will be desalination, which is expected to expand fivefold by 2025. However, this is an expensive technological solution that will therefore be likely limited to energy-exporting countries;
    c. Arab countries are expanding the use of treated wastewater. In the Gulf, about 40 per cent of treated wastewater is used for animal fodder, irrigation of non-food crops and landscaping. In Jordan, treated wastewater is mixed with freshwater to provide about 20 per cent of irrigation water needs.
2. While it is already experiencing a water deficit, the region needs to secure its water supply to ensure that needs of key development are met. In aggregate, the Arab region is already using a far higher share of its renewable water resources than other regions.
3. Vital ecosystems are now under increasing threat from the over-exploitation and pollution of many of the region's watersheds and aquifers.

Current management practices generally struggle to ensure the sustainability of water supply from both a financial and an environmental perspective. The different countries in the region

Box 4. The need for diversified adaptation solutions

In adapting to climate change, it is best to deploy an array of solutions. The perils of single solutions have been illustrated by various recent examples in the Sudan and Venezuela.

Most notable is the case of Venezuela, where most of the electrical power generated in the country comes from hydroelectric power, mostly (more than 70 per cent) through a single dam, the Guri dam on the Caroni River. The reservoir level of the dam has been constantly decreasing because of persistent, prolonged droughts that have been occurring since 2010. This led to a shortage of power, further exacerbated by the country's underinvestment between 2003 and 2012, when its electricity consumption increased by 49 per cent while installed capacity expanded by only 28 per cent.[a] As a result, by the end of April 2016, the government had to suspend some of its power generation and to start rationing power.

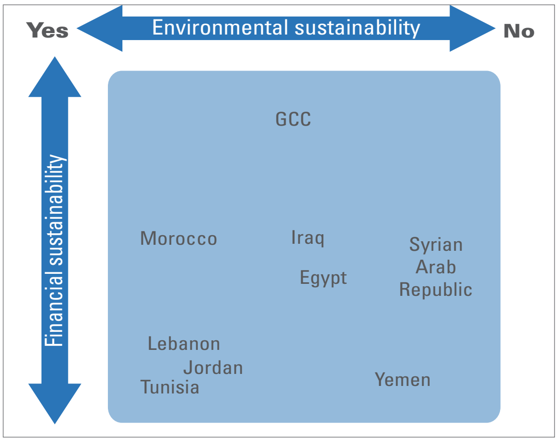
In the Arab region, the Sudan finds itself in a similar position to Venezuela, with 80 per cent of its power generated by hydropower. The country had been experiencing power cuts in the summer of 2014 and 2015, and had recently decided to dramatically increase tariffs in order to help fund much needed investments in power infrastructure.

[a] EIA, 2015.

fare differently with respect to the financial sustainability of water supply services through some form of cost recovery, and the sustainable management of the renewable water resource base (figure 4).

In general, it appears that countries that rely on surface water (Iraq, Egypt, the Syrian Arab Republic) tend to environmentally manage their resources better than those that depend on groundwater. This may be because groundwater is comparatively easier to over-exploit and more difficult to control. However, they all struggle to achieve both financial and environmental sustainability as long as public water agencies continue to try to efficiently manage the water sector alone. There are two main reasons for this: (1) the excessive focus on a single sector, and (2) the fact thatwater-use choices often depend on reasons that even a cross-sectoral focus could miss:

Figure 4. The status of sustainability and water resource management in the Arab region



Source: Adapted from the World Bank, 2009, figure 1.2, p. 5.

1. Public water agencies tend to be centralized agencies, with a sector-centric top-down approach. They and other agencies struggle with management practices that remain focused on a single sector, especially when water is often shared among many departments, each with its own focus. For example, agricultural departments are usually more interested in promoting irrigation and food production, while other ministries are generally more concerned with improving drinking water supplies and sanitation. More than ever, what is needed in dealing with those complex issues is a comprehensive approach that is coordinated across various sectors.
2. The impact of overall economic diversification and trade can often be far bigger than policies that exclusively deal with agriculture or energy. For example, while the choice of crops is a key determinant of water use in agriculture, it is far more related to the return a farmer can expect for their harvest than to the cost of either water or energy. This market price is itself dependent on various factors such as trade or access to financing and markets.

B. Land resources and demand for land

In the Arab region, about 90 per cent of the land is within areas that are classified as arid, semi-arid and dry sub-humid. Because of the relative lack of precipitation and the patchy vegetation, those types of lands tend to be prone to further desertification. Degradation causes them to lose their productivity as the natural processes are amplified by climate change, exacerbating any adverse effects from existing human activity.

The lands of the Arab region are already prone to degradation through erosion by (1) wind and (2) water, which are both exacerbated by climate change. In addition, human activity often leads to (3) nutrient loss and soil fertility decline, (4) an increase in secondary salinization and waterlogging, as well as (5) the loss of fertile land to urban expansion.[19]

1. Wind erosion appears to be one of the most common environmental problems in the Arab region. Lands degraded by wind make up about a fifth of the total degraded land.[20]

Box 5. Arid, semi-Arid and sub-humid lands

There are two factors that determine whether any land is arid, semi-arid and dry sub-humid: (1) the amount of mean annual precipitation relative to the potential evapotranspiration that defines a ratio (P/PET), and (2) length of the growing period (LOP).

- A simple classification is to rely on P/PET. The ratio ranges from 5 per cent to 20 per cent for arid areas, from 20 per cent to 50 per cent for those that are semi-arid, and from 50 per cent to 65 per cent in the case of dry sub-humid zones;
- A more precise classification is provided by LOP, which is defined as the period that both (1) meets the full needs of crops for both water and evapotranspiration, and (2) maintains the soil moisture. During this period of time, average temperatures would be no less than 5°C, while the combined amount of precipitation and soil moisture would exceed 50 per cent of the potential evapotranspiration. By this definition, areas with an LOP of less than 1 day are true deserts; with less than 75 days arid, 75 to less than 120 days (dry) semi-arid, 120 to less than 180 days (moist) semi-arid.

However, most classifications still rely on the relatively crude P/PET ratio, since determining the LOP is a difficult process requiring not only extensive calculations based on precipitation, evapotranspiration and soil moisture holding capacity, but also detailed moisture requirements of specific crops.

Wind erosion leads to either the loss of the fertile top soils, or (2) to the increased encroachment and accumulation of sands on productive agricultural land. In the Arab region, both phenomena appear to be related, as wind erosion is related to the movement of sand dunes towards agricultural areas and rangelands. Wind erosion is mainly determined by wind speed at ground level and soil cohesion.

a. Projections show that the wind speed at ground level is expected to increase and to become more intense during extreme events. This will exacerbate the impact of the exceptionally large dust storms already regularly experienced in the region;
b. The cohesion of the soil is undermined by ill-adapted land usage practices, such as overgrazing.

2. Water erosion also washes away valuable topsoil, leaving it to flow into surface streams where it can accumulate in dams and irrigation networks, causing siltation. In other cases, it covers rangelands and agricultural lands, and affects their productivity.
3. There are various processes that deteriorate the soil physical, chemical and biological properties, leading to nutrient loss and a decline in soil fertility. The main processes are often related to human activity, such as the excessive or ill-adapted use of fertilizers and pesticides. Potential consequences include: (1) a decline in soil biological activity; (2) degradation of the soil physical properties, mostly associated with chemical pollution; (3) reduced availability of major nutrients such as nitrogen, phosphorus and potassium; and (4) a build-up of toxicities, leading to an excessive increase in acidity or alkalinity.
4. Adapted irrigation techniques can often lead to the accumulation of salts in arable land, thereby decreasing their productivity. Soil salinization is a major problem in areas where agriculture relies on limited rainfall, such as most of the Arab region. It is often associated with waterlogging as excessive irrigation leads to the saturation of the soil with excess water, preventing the oxygenation of plant roots. Those are growing problems in the Arab region, affecting a large proportion of reclaimed lands in the Euphrates plain in Iraq and the Syrian Arab Republic, as well as of Saudi Arabia. Similarly, the expansion of agriculture in Egypt and the Sudan is also associated with salinization and waterlogging, leading to significant yield reductions in some areas.

5. An increasing amount of fertile lands has been lost due to inadequate urbanization and population growth. This is a recurring problem across the Arab region. In Egypt, for example, more than 18 per cent of the alluvial land was lost to urbanization in the period 1995-2010.

As climate change exacerbates the negative effects of human activity, "land degradation and desertification [are now] at the forefront of risks the region faces". [21] At the very least, more frequent droughts will prove "extremely detrimental to land productivity in irrigated agriculture, rainfed farming and rangelands, and can exacerbate land degradation". [22] As shown in table 1, the cost of land degradation may have mounted up to almost 4 per cent of annual loss in GDP in 2007-2008.

Table 1. Estimated costs of agricultural land degradation

Country	Land degradation million $	GDP (%)
Algeria	621	0.37
Comoros	20	3.86
Djibouti	2	0.21
Egypt	1,430	0.88
Iraq	770	1.82
Jordan	142	0.67
Lebanon	118	0.40
Libya	143	0.15
Mauritania	10	0.34
Morocco	1,036	1.18
Somalia	56	2.11
Sudan	906	1.62
Syrian Arab Republic	1,474	2.67
Tunisia	580	1.44
Palestine	80	1.37
Yemen	327	1.23
Total:	7,715	1.27

Source: World Bank, 2002; Larsen, 2011.

C. Energy resources and energy demand

Water resources are an important factor for energy generation. In the oil and gas industry, they are needed at all stages of production, as well as for drilling and pressure maintenance. Accordingly, 82 per cent of energy [23] and 73 per cent of power utility companies,[24] reported in a 2013 Carbon Disclosure Project (CDP) study, view water issues as a substantial risk to their businesses. In some parts of the world, power outages due to lack of cooling water are already a reality. In addition to impacting the generation of energy, climatic changes will also likely increase the demand for energy. The comparatively hot climate in the Arab region creates a relatively high need for cooling. Higher temperatures will therefore increase the demand for cooling, and thus also for energy.

The energy sector is therefore closely linked to climate change adaptation in the Arab region. Necessary adaptation measures will need to address both the use of resources and power generation.

At first sight, the Arab region's energy future appears secure; it has more than 43 per cent of the world's total proven reserves and contributes about a third of the world oil supply through its exports. Furthermore, energy resources remain in high demand for the foreseeable future. The region's economic development is still largely defined by its wealth in oil and natural gas resources. In 2010, however, as growing local demand for energy is increasingly threatening the Arab region's capacity to export, it has to face up to the need to manage more effectively its own patterns of energy consumption. Under current patterns of production and consumption, continuing economic growth will take an increasing share of energy production. With increased urbanization, consumption has also grown to the point where demand has been almost doubling every decade.[25]

Box 6. Energy intensity in the Arab region

Energy intensity is computed as the ratio of gross consumption of energy (kg of oil equivalent (KgOE)) per unit of measure of economic development (GDP, measured at purchasing power parity). This is a measure of the energy efficiency of a country's economy; the higher the "energy intensity", the less effective is a country at generating economic returns.

In the Arab region, energy intensity has been steadily increasing at a rate of 2.9 per cent per year, from 0.134 KgOE/$ in 1971 to 0.422 KgOE/$. In the period between 1971 and 2005, while regional economies grew fivefold, their energy consumption grew by a factor of 12.[a] The energy intensity of the Arab region is now almost double that of North America, and more than double that of Europe. Some of the most energy-intensive countries of the region (Lebanon, Morocco and Tunisia) are also net importers of energy.[b]

Climate change will further exacerbate energy intensity by directly impacting the energy sector. This impact will manifest itself through changes in temperature and precipitation and will be particularly pronounced in the Arab region. Higher temperatures will affect both energy demand and generation, and water shortages may affect production/extraction.

[a] (1) ESCWA, 2015.
[b] (2) UNDP-RBAS, 2012.

Because of the high "energy intensity" of Arab economies, climate change will proportionally affect the Arab region higher than other regions of the world. This high energy intensity is linked to the role that energy resources have been taking in the development of the Arab region since the onset of the 20th Century. Domestic demand will be also exacerbated by the projected higher temperatures as they likely lead to a higher demand in the future. An example is the case of Oman, a net exporter of energy that needs to import natural gas during the hot summer months to be able to cover domestic spikes in energy consumption.

The impact of rising temperatures on the energy sector is twofold:

1. Cooling and air conditioning demand alone would increase, at the very least, by more than 20 per cent by 2050, reaching a 40 per cent to 50 per cent increase by 2100. The increase may be even higher in practice, as the efficiency of many cooling systems decreases in warmer weather.
2. Furthermore, higher than average ambient temperatures may also have a negative effect on the efficiency of electrical transmission lines, thus further adding to the electricity demand. In some of the areas that are most affected by the increase in ambient temperature, power transmission networks may need to be redesigned or upgraded. In those areas, as the temperatures of the wires increase under high transmission loads, there could be:
   a. More power losses in the lines. This will either have to be compensated for by an increased production or it will require the installation of additional power lines;
   b. Increased sags in the lines, beyond safe limits. This happens when the temperature of power lines is too high. This will have to be compensated for by either replacing existing lines or installing additional power lines.

Diminished water availability would, in principle, affect hydrocarbon extraction of energy resource because it is extremely water-hungry. However, this is not a major issue in most of the oil-producing Arab countries, which deal with the issue in either of two ways:

Box 7. Water and oil extraction

In Oman, nine barrels of water are produced for every barrel of oil that is extracted. However, this water is unfit for domestic or agricultural use, because of its high concentration of dissolved minerals and salts. Oman is considering various ways in which this water could be retreated for some agricultural applications.

1. When water is needed for injection, the oil and gas industry often relies on treated seawater rather than freshwater;.
2. Generally, water that is extracted as part of the oil extraction is dumped or reused in other wells for injection. There are now attempts being made to recycle this water for other uses, because dumping it risks damaging the groundwater.

Power plants will have to step up electricity generation to meet the increased demand:

1. Both hydropower and thermal power plants will require even more water. The effectiveness of hydropower systems will be further undermined by the climate change-induced lower reservoir levels.
2. Thermal power plants will require redesign or retrofitting with new cooling towers to maintain their efficiency in higher temperature environments.
3. Some types of renewable power plants would also be affected, particularly concentrated solar power (CSP) systems that need water for steam and for cooling. Some CSP plants need as much as 3,500 litres for each megawatt hour (MWh) generated, compared to 2,000 liters/MWh for new coal-fired power plants and 1,000 liters/MWh for more efficient natural gas combined cycle power plants.

In the Arab region, there is therefore a need for improvements in resource-use efficiency to decrease energy intensity. This is a necessity for all Arab countries, whether they are net importers or net exporters of oil. A lowered energy demand would free more financial resources by reducing energy import bills and/or freeing more capacities for revenue-generating exports.

In general, energy policies tend to be sector-specific, and may lack an appreciation of water resources. They also often fail to take into account the impact of the environmental performance of other sectors on energy production. For example, in the case of hydropower, policies rarely take into account the impacts of poor agricultural and land management on erosion and sediment transport, which are the primary causes of dam siltation and turbine wear.

A wider multi-sectoral outlook is needed in the energy management policy.

Integrated water resources management

Meeting the multi-faceted challenge of climate change requires a comprehensive approach to water management that takes into account the needs of various sectors vital to economic development, as well as mainstreaming a gender-sensitive approach at all levels. To be effective, the approach should strive to equitably maximize economic and social welfare without compromising vital ecosystems. The adaptation should be sustainable, promote coordinated development and management of water, land and related resources. In addition to contributing to a more effective and efficient water management, the approach should also ensure the sustainability of ecosystems. Water development therefore needs to ensure (1) social equity; (2) economic efficiency; and (3) ecological sustainability:

1. Focusing on social equity would ensure that water management not only emphasises capacity building amongst the users of the resource, but also responds to the interests of women, men and vulnerable groups such as children and the elderly, who depend on freshwater resources. In addition, public participation should be integrated in a national dialogue across society, including opinion leaders, civil society, non-governmental organizations and other relevant social groups.
2. The need for economic efficiency encourages inter-disciplinary management of water resources across sectors. The contribution of water to development differs among the various sectors in agriculture, industry (productive sectors), domestic use and services.
3. A wider perspective is provided by focusing on ecological sustainability, as this would take into account all natural resources that affect water resources and the respective local hydrologic cycle, soils, surface water, groundwater and water quantity.

The need for this approach is illustrated by the case of agriculture in the Arab region. It is the largest user of water in Arab countries, often accounting for more than 70 per cent of the total water demand, and as much as 90 per cent in Iraq, Oman, the Syrian Arab Republic and Yemen. An exclusive focus on economic efficiency would suggest that this is inefficient, as the region largely remains a net importer of food. However, a social equity perspective would reveal that agriculture is a key livelihood issue, especially in rural areas, home to 42 per cent of the population of Arab countries.

Furthermore, in order to ensure ecological sustainability, water must be differently managed, especially as climate change is now causing decreased water availability, while the region's population is continuing to grow. There is a need to apply new systems for sustainable production and sustainable consumption at national and local levels.

IWRM systems can address those concerns and incorporate consultative and inclusive governance structures into the process. The IPCC states that 'sustainable' water resources management is generally sought to be achieved by integrated water resources management".[26] IWRM is characterized by its unique focus, implementation and decision-making process:

1. The focus of IWRM departs from the traditional sector-centric approach and considers a cross-cutting perspective that involves all water-related economic sectors.
2. The IWRM implementation is generally centred on watersheds rather than on single water course. When dealing with an issue involving many diverse sectors, it is best to focus on the well-defined resources that they share. For freshwater, the shared resource would be the bounded hydrologic system represented by a watershed. Within the watershed, all living things and all human activities tend to be inextricably linked. For this reason, IWRM focuses on the watershed, in which it promotes the coordinated development and management of water, land and related resources.
3. Decision-making strives to be participatory, involving all stakeholders (males and females) beyond the narrow professional and managerial realm. This participatory approach is key to the success of IWRM, particularly in very complex situations that require the consideration of different priorities and interests (represented by women and men). Household, agriculture and industrial needs and interests also need to be considered and balanced in relation to one another, especially in the face of increased weather variability and unpredictability due to climate change; for example, in cases where water transfers and infrastructure investments are being considered to transport water from one watershed to another or expanded desalination capacity is under consideration. Finally, decisions should also be based on the needs of local communities and be in accordance with national strategic priorities.

In this manner, unlike traditional sector-focused approaches, IWRM recognizes the fact that water is a scarce natural resource with many interdependent users. This allows it to optimize water management under a changing climate by taking into account both (1) the technical, economic and environmental aspects of water management, and (2) the different needs and interests of various stakeholders. This approach provides for social acceptance and assures a relationship of full partnership starting from assuming responsibility and ending with a sense of ownership of the programmes.

Box 8. Shared water resources and integrated water resources management

In the management of international shared water resources, the application of IWRM works best when States are willing to cooperate over specific challenges or common goals, within the framework of the 1997 United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses.

However, in practice, cooperation on shared water basins often falters because of disagreements over article 7 of the Convention and the "obligation not to cause significant harm".

- It is often the case that downstream States, with flatter topographies than upstream States, have long established water uses. For centuries, they had been extensively relying on the watercourse for irrigation;
- Upstream States that had been hindered in the past by the mountainous terrain in their part of the basin have only recently started developing their water resources.

This creates a conflict as downstream States claim that the new projects developed by upstream States are causing harm to their historically established uses.

Box 9. Oases women watch plants and incomes grow in Morocco

Oases are natural sanctuaries around which communities are built, providing scarce water, food and refuge from the harsh surroundings. A group of more than 100 women living in Moroccan oases of Errachidia have found a unique way to earn an income and mitigate the effects of climate change on their environment, namely soil degradation and water scarcity, by cultivating medicinal and aromatic plants, using renewable energy. Medicinal and aromatic plants yield a higher profit than traditional crops, withstand the harsh climate and have low water requirements (UN Women, 2015).

Members of the Annama Association collecting medicinal and aromatic plants.
Photo: UN Women, Morocco

Created in 2012, the group started out by acquiring a hectare of land to plant the seeds using drip irrigation method and solar pump to cultivate crops. Protecting the oases is essential; on the one hand, 90 per cent of economic activity comes from the cultivated crops, and production of crops constitutes a natural barrier to degradation of such ecosystems on the other.

In only two years, these women have seen their incomes increase, allowing them to open their own bank accounts, and achieve financial independence. Since then, 12 cooperatives and 15 NGOs have joined to support the production and commercialization of the women's herbs (UN Women, 2015).

A group of women attend a workshop in the oasis of Serkla, Guelmima.
Photo: UN Women, Morocco.

Climate change implications for economic development

Climate change is impacting economic development in the Arab region, and is expected to continue to affect economic development unless appropriate adaptation strategies and plans are put in place. This concerns all sectors related to economic activity: households, agriculture and livelihoods, industry and productive sectors, as well energy generation and extraction (table 2).

A general picture of this outlook can be determined on the basis of existing benchmark studies. However, a more detailed economic assessment will need to be carried out using computer models that take better into account the data from regional climate modelling (RCM).

Table 2. Cross-cutting issues in the Arab region affected by climate change

Development challenge	Sectoral challenge	Climate change challenge			
		Precipitation decrease	Temperature increase	Sea level rise	Extreme events
Households: water and sanitation	Regular provision of safe water; desalination and water storage; wastewater collection, treatment and reuse	Freshwater	Cooling; greater demand	Coastal settlements; desalination plant intakes	Livelihoods
Human health	Vector-borne diseases; pests; vulnerable groups	Vector-borne diseases and pests	Heat stress; vector-borne diseases		Floods
Transport and trade	Air traffic; ports/storage/testing facilities; road/bridges	Dust storms	Warming of seas; wind currents	Storm surges; coastal installations	Winds; floods
Agriculture: irrigation	Improvements in irrigation water-saving technologies	Freshwater	Wilting points	Salinity of coastal aquifers	Floods; drought
Agriculture: livestock	Water and feed supply; grazing land availability	Freshwater; desertification	Heat stress		Drought

Development challenge	Sectoral challenge	Climate change challenge			
		Precipitation decrease	Temperature increase	Sea level rise	Extreme events
Agriculture: crops	Rainfed agriculture productivity losses; food security	Freshwater; land degradation	Wilting points	Salinity	Floods; droughts
Industry: various processes	Regular supply of water; water treatment at source	Water	Cooling	Coastal businesses	Business uncertainty
Electricity: power plant	Cooling efficiency	Water availability	Retrofit for cooling	Coastal power plants	Demand uncertainty
Electricity: renewables	Use in dusty and hot environments; water saving systems	Water availability	Diminished efficiency		Demand uncertainty
Electricity: power transmission	Expansion of power grids; enhanced power supply and delivery		Diminished efficiency		

Impacts of climate change on Arab economic development

The Arab economic outlook will be largely defined by the economic impact of climate change at the regional and the global levels:

1. At the regional level, the Arab economic outlook will be affected by the combined effect of the magnitude of change in climatic parameters, their rate of variation and the increase in their variability.
2. At the global level, those impacts will have a regional effect on the Arab economic outlook as well, because of the influence of global climatic systems on the regional climate, as well as of the responses to climate change of the wider economy and their effect on the region's economies.

The combination of those effects will result in three types of economic impacts:

a. Direct, related to the adverse effects of temperature increases and precipitation;
b. Indirect, related to the various response measures triggered;
c. Deferred or cumulative.

The direct impact of climate change on the Arab region will be felt by changes in (1) precipitation patterns, (2) temperature, as well as (3) in the increased frequency of extreme weather events.

1. A decrease in precipitation would stress already scarce water resources.

   a. At the very least, these risks distort the market and create competition among the various sectors, most notably between the industrial and service sector, an essential driver of economic expansion and development, and the agricultural sector, an essential element of sustainability and livelihoods. This will, in turn, have repercussions on the energy sector, a key driver of the economy;

   b. At most, perturbation in water supply may affect social stability and promote conflict. One of the latest examples is the 2007–2010 drought in the Syrian Arab Republic – "the worst drought in the instrumental record". It caused "widespread crop failure and a mass migration of farming families to urban centres", it is possible that this "drought had a catalytic effect, contributing to political unrest".[27] Precipitation decreases can also promote migration, both internal and cross-border, as populations attempt to escape from hunger, thirst and poverty.

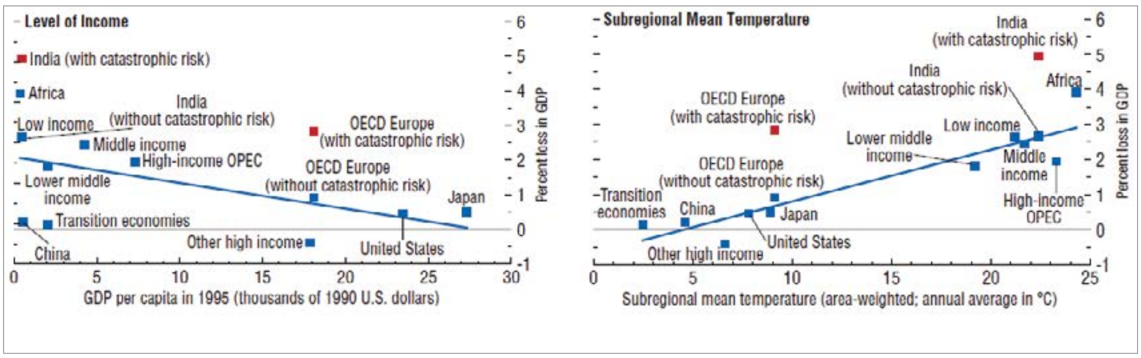
2. Economic studies suggest that an increase in temperature would adversely affect growth, but the impacts will not be equally felt, with developing countries impacted worse than industrialized nations:[28]

   a. In developing countries, it appears that temperature has an effect on GPD, as shown in figure 5. This may be linked to the fact that, in developing countries, there are known linkages between increased temperatures and decreased productivity, increased crime and mortality;

      - It is estimated that, when average temperature increases by 1°C in any given year, economic growth in developing countries would decrease by at least 1.1 per cent.[29] The effect of trade may even exacerbate the loss, as it reduces the growth in exports by 2-5.7 per cent for every 1°C increase in temperature;[30]
      - Based on studies that show a 1.1 per cent decrease in GDP for a 1°C rise in temperature, the projected average rate of warming of 0.2°C per decade will lead to a net decrease in the GDP growth of about 0.2 per cent over that same period or a 0.02 per cent decrease per year.

   b. In industrialized countries, there appears to be no discernible link between GDP and changes in temperature or precipitation. Even accounting for trade, developed countries are unlikely to be affected as most of the economic impacts appear "concentrated in exports of agricultural products and light manufactures",[31] which tend to make up a smaller proportion of their exports. Those countries may still be affected since their imports will decline because of reduced imports from poorer countries,[32] but this remains to be investigated.

Figure 5. Estimated gross domestic product losses from 2.5°C warming by region



Source: Adapted from IMF, 2008, figure 4.4, p. 138.

3. Climate change may render extreme events, such as cyclones, more frequent. Those events can have significant economic impacts in the Arab region, as in the case of 2010, when the coastal areas along the Arabian Peninsula witnessed the second largest tropical cyclone on record. Damages in Oman amounted to $700 million with 44 deaths as a result of Cyclone Phet. In poorer areas, the impacts can be more severe, as in the case of the 2006 Nile flooding in the Sudan, which caused 600 deaths and left 35,000 homeless.[33]

The Arab region may also feel indirect impacts, most of which may be due to response measures, undertaken as part of adaptation measures outside the region or mitigation efforts in industrialized countries. In theory, response measures should not have adverse impacts for others because the Rio Declaration enjoins States to "enact effective environmental legislation" while recognizing that some standards "applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries".[34]

Finally, it is also likely that the region may feel deferred impacts or cumulative impacts. This is because, compared to other domains, climate impacts are more likely to accumulate due to "induced" actions that may occur as part of society's reaction. Indeed, the urgency of the problem may often require prompt action before a complete scientific understanding is developed.

1. Impacts due to induced actions can be of two types:
   a. Generally foreseeable impacts, caused by the combination of past, present and "reasonably foreseeable" future actions;
   b. Unforeseeable impacts that result from unexpected consequences of either response measures or poorly understood inter-relations between climatic and socio-economic systems, with variations among and within countries.
2. Cumulative effects may result from long-term negative effects of temperature on the growth rate, particularly if increases in the number of high temperature days persist over time. This is particularly relevant for the Arab region, where five countries saw temperature records in 2010, the hottest year on record since climate data collection. In that year, temperatures in Kuwait had reached 52.6°C, only to be followed by 53.5°C in 2011.[35]

Box 10. Long-term mitigation and short-term adaptation

Climate change poses a potentially high cost on economic development, but one in which the distribution of causes and effects is globally but unevenly spread across generations and countries.

1. Those investigating mitigation policies focus on long-term costs of climate change impacts on future generations. However, because the analysis of climate change and its links to human activity are subject to wide margins of error, there is some disagreement on the discount rates used to estimate long-term future costs and to increase the present value of very long-term benefits.
2. For purposes of adaptation, this debate is less relevant in the short to medium term, and especially so in the case of developing countries that are disproportionally exposed to the effect of climate change. The negative effects of climate change are already being felt in many areas such as the Arab region, where it is exacerbating the prevailing arid conditions.

Therefore, for purposes of adaptation to climate change in the Arab region, it is best to focus on the needs in the short to medium term, especially since some of the negative economic impacts are already being felt.

Collected total costs of climate change

At present, there appears to be no comprehensive economic modelling of climate change impacts that is specific to the Arab region. However, the information that can be collected from various sources in the Arab region does provide an indication of the extent of the economic impact of climate change on various countries. The specific details of the impacts vary from country to country, but the main impacts can be broadly grouped in five categories: (1) drought and decrease in precipitation; (2) increases in temperature and in the frequency of heatwaves; (3) increased frequency and intensity of extreme weather events; (4) sea level rise; and (5) local impact of changes in global weather patterns:

1. The entire Arab region is expected to experience increases in the frequency of droughts and a decrease in average precipitation. While increased soil moisture drying is expected in the eastern Mediterranean coast and North Africa, arid conditions are expected to be particularly more pronounced in the northern part of the Arabian Peninsula, known as the Fertile Crescent.
   a. About 40 per cent of the Arab region workforce is employed in fields related to agriculture, a sector that will be heavily impacted by recurring droughts and decreasing precipitation. The impact will be proportionally higher in countries where agriculture plays a major role in people's livelihood such as, Iraq, Jordan, Lebanon, Mauritania, Morocco, the State of Palestine, the Sudan, the Syrian Arab Republic and Tunisia;
   b. By 2040, incomes in rural non-farm households, one of the most vulnerable groups, are likely to be reduced by 7 per cent in Tunisia and 24 per cent in Yemen.[36]
2. Increases in temperatures and in the frequency of heatwaves will exacerbate local arid conditions, particularly in Sub-Saharan countries, and more so in the hyper-arid Arabian Peninsula.
3. Increased frequency and intensity of extreme weather events such as recurring droughts or heatwaves, or an increased frequency of storms.
4. Globally, the rise in sea levels is estimated to range between 0.1 m to 0.3 m by 2050, and to reach between 0.1 m to 0.9 m by 2100. In the Arab region, different coastal areas will fare differently, with the highest sea level rise along the Atlantic coast of Morocco, and the lowest along the Mediterranean coast. However, even a small rise in sea levels would have an adverse effect on Egypt, because of the vulnerability of the low-lying, densely populated Nile Delta.

Box 11. Jordan's costs of implementing priority adaptation measures

The adaptation costs for Jordan were developed based on detailed vulnerability assessments for the sectors of agriculture and water and on quantified potential impacts under various climate change scenarios. The resulting percentage change in water availability was then used to determine the additional cost due to climate change.

It was found that the additional cost for adaptation projects in the agricultural sector was $154.3 million, covering the introduction of new crops, the implementation of new techniques for water harvesting, enhanced irrigation, and rehabilitation of desert, forest and rangeland areas. The additional cost of adaptation in the water sector was found to be $1.41 billion by 2020, reaching an additional $5 billion by 2050.

Source: Jordan National Report, May 2010. "National Environmental and Economic Development Study for Climate Change", submitted to the United Nations Framework Convention on Climate Change.

a. In terms of percent of coastal area exposed, the “top 10” coastal cities at risk are expected to be Port Said in Egypt; Al Ain, Abu Dhabi, Ajman and Dubai in the United Arab Emirates; as well as Rabat, Kenitra, Mohammedia, and Nador in Morocco;[37]
b. In terms of people affected, the impact of sea level rise is likely to have a disproportionately higher impact in Egypt because of the high density of population and economic activity in the Nile Delta. Even a 0.5 m rise in sea level would have a disproportionate effect, potentially displacing 1.5 million people in the city of Alexandria or damaging 12.5 per cent of the country’s agricultural sector. A 1 m rise in sea levels would have an even greater effect, affecting 10 per cent of Egypt’s population.[38] During storms, the city’s seafront is already facing waves up to 7.6 m in height that cause significant damages;[39]
c. Sea level rise would also exacerbate the effect of storm surges, which are also expected to intensify in some regions. Most of the countries in the Gulf Cooperation Council would be affected; in Kuwait, for example, 65.3 per cent of the country’s coastal GDP is at risk.[40] The Nile Basin and Southern Arabian Peninsula are particularly vulnerable to changes in global weather patterns, notably linked to the variability of the Indian Monsoon, itself affected by changes in El Niño southern oscillation (ENSO) and changes in the tropical convergence zone (ITCZ).

a. The Indian Monsoon directly affects the Nile Basin, particularly the Blue Nile, which accounts for much of the water that flows into Egypt and the Sudan;
b. Changes in the ENSO and changes in the ITCZ, particularly affect the southern part of the Arabian Peninsula, namely Oman, the United Arab Emirates and Yemen.

In general, the overall picture that emerges from those various manifestations of climate change is one of the projected negative effects on economic development with negative impacts on GDP projected for 2020 and 2040.

Box 12. Egypt: Confronting sea level rise

The Nile Delta is home to about 50 per cent of Egypt’s population and generates about 30 to 40 per cent of its agricultural production and 50 per cent of its industrial output. The northern delta lakes generate about 60 per cent of the output of fisheries. The Nile Delta already faces natural challenges, not least of which is beach loss due to natural erosion from waves and sea currents, exacerbated by a loss of sediments due to hydraulic works further upstream.

Adaptation projects were initiated to protect the vital Burullus Lake, focusing on a part of the coastal 70 km strip of land between the cities of Rasheed and Baltim. A 7 month-project was carried out to strengthen one part of the coast with a 250 m earth embankment, strengthened with dolomite rocks and geotextiles. The cost, about $450,000, was kept low thanks to the reliance on local manpower.

Source: Shaheen, 2016.

Integrated economic assessments of climate change

The economic evaluation of the impacts of climate change on the Arab region needs to take into account both the linkages between climate and development and how the various economic sectors will respond. At the global level, the IPCC identified various

approaches that can be followed to carry it out.[41] They can be grouped in two broad categories: (1) qualitative assessments based on limited and heterogeneous data and built from existing experience and expertise; and (2) quantitative assessments based on socio-economic impact studies. While qualitative assessments may help planners with a historic perspective, they need quantitative assessments for planning purposes because of their "forward-looking" approach.

Quantitative assessments can be developed through either a statistical or an enumerative approach. In the "statistical approach", the physical effects of climate change are related to observed variations, either across regions or within a single country. This method, however, is necessarily backward-looking, and cannot easily take into account the results of climate models (CM). While it is useful as an "entry point" to define areas for research, it is not adapted to support adaptation policymaking, which needs an approach that determines economic costs based on the climate impacts determined from CMs. It is the second approach, the "enumerative method", which is best suited to evaluate climate costs from the outputs of CMs. In this method, an economic cost would be assigned to each of the physical effects forecasted by CMs such as RICCAR for the two future periods 2046-2065 and 2081-2100 based on the 1985-2005 reference period.

The enumerative method, however, may still wrongly estimate the cost of climate change in critical ways:

1. The method requires extrapolation of economic values in three critical ways: (1) from one sector into another (some of which may not have associated market values); (2) from one region into another (which may have different adaptive capacity); (3) from one time period (the past) into another (the future).
2. The method cannot account for human responses to the impacts of climate change, which can range from changes in behaviour or resource usage to migration.

Box 13. Lebanon: A preliminary pricing of the impacts of climate change

A variant of the statistical approach was used by the Lebanese Ministry of Environment. The methodology followed did not rely on integrated assessment models (IAMs) using regional or local climate modelling, but relied on a deductive analysis based on existing climatic data available at a national, regional and global levels, in which the country-level data was extracted from global economic estimates.

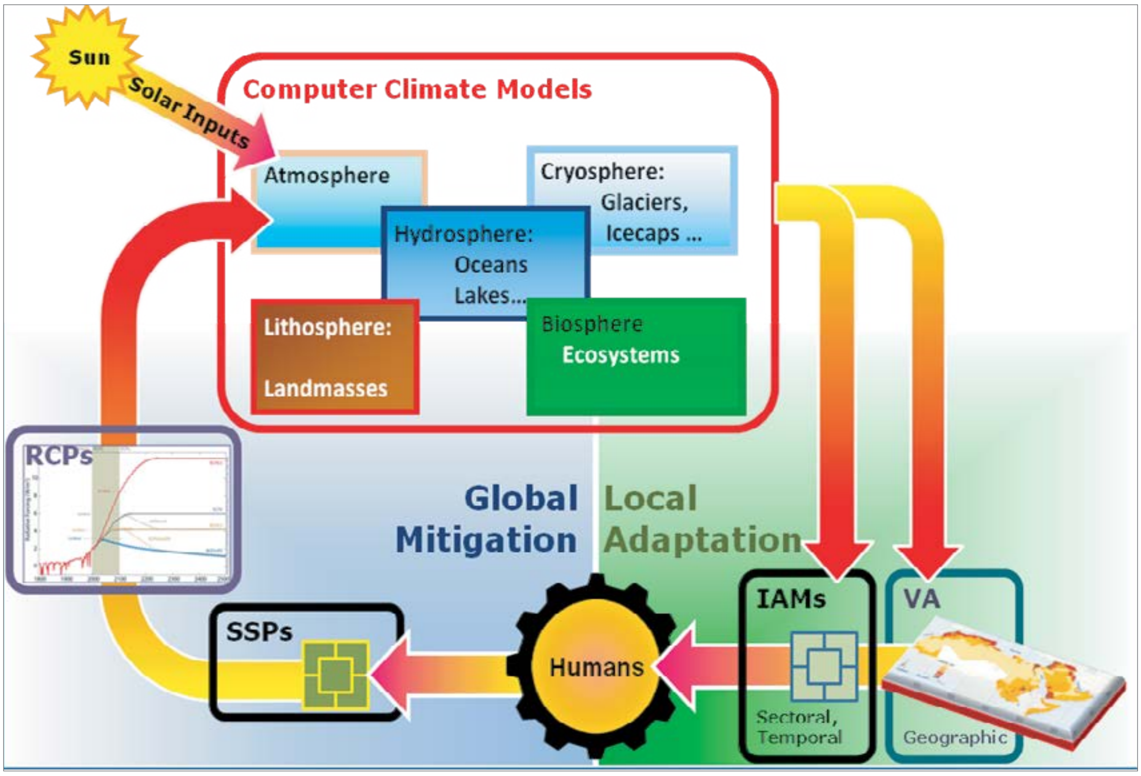
The preliminary result from the study was an estimate of the "direct damage costs" of climate change "on agricultural productivity, human health, flooding, ecosystem productivity, etc.".[a] According to this estimate, climate change would create damages that "would impose costs on Lebanon of about $320 million in 2020, $2,800 million in 2040 and $23,200 million in 2080"; this would result in an estimated reduction of GDP for Lebanon of 3 per cent by 2020, 14 per cent by 2040 and 32 per cent by 2080.[b]

[a] Aboujaoude, 2016, p. 5.
[b] Ministry of Environment/UNDP/GEF, 2015.

Quantitative assessments can be best based on the projections obtained from computed CMs. Such an approach is vital because of the unprecedented nature of climate change. Quantitative assessments are used both as "inputs" to CMs and as a way to determine the economic costs of climate impacts:

1. As "inputs", quantitative assessments are used to develop shared socio-economic pathways (SSPs) at the global scale. Under development since 2010, SSPs describe socio-economic "futures" in a quantitative manner, which helps determine the pace of increase of greenhouse gases (GHGs) in the atmosphere. This results in representative concentration pathways (RCPs) that CMs can use as input to model the climate.
2. Based on the "outputs" from CMs, quantitative assessments can help determine the economic costs of projected climate impacts. However, the tools available have some limitations as they cannot cover all three "dimensions" of the economic costs of climate change, i.e.: the effects on economic sectors (sectoral dimension); the evolution of impacts over the years (time dimension); and the spread of those impacts at the level of a country or region (geographic dimension).
    a. At present, quantitative assessments tools such as integrated assessment models (IAMs) can describe only two of the three "dimensions" of the economic costs of climate change; they can show how climate change impacts affect economic sectors more than others (sectoral dimension) and evolve over the years (time dimension). Even this implementation is limited, however, as IAMs can only consider any given sector at a time with no deferred cross-sectoral impacts;[42]
    b. To describe the geographic dimension, models need to rely more on geographic information systems (GIS) to show how climate change impacts vary across the region in the ways they affect natural resources. This is therefore the focus of the integrated vulnerability assessment (VA)[43] developed by RICCAR, which geographically maps vulnerabilities (chapter 3).

Figure 6. The overall architecture of climate modelling



Both IAMs and SSPs are at the core of the process of determining the impacts of climate change. This is a partially iterative process in which human actions, represented by SSPs, create GHG concentrations represented by RCPs. Those RCPs are used as inputs in CMs, the output of which is used by IAMs at the local level to define sectoral and temporal impacts and by VAs to help geographically highlight the related vulnerabilities. At the global level, the SSPs can be refined to reflect any mitigation that results from direct actions or co-benefits of adaptation to inform the formulation of RCPs. It is the interaction between those various components that defines the architecture of climate modelling (figure 6).

Integrated assessment models

Integrated assessment models (IAMs) are computer models that determine the economic costs of climate change impacts by "integrating" multiple parameters that represent economic, social and environmental factors. IAMs strive to "price" the effect of climate change impacts. Those factors are of two types: those that have an obvious cost associated to them, and those that do not have an obvious cost.

1. In cases where cost estimates can be made, IAMs express them either as estimates of total economic costs or as marginal cost estimates.
    a. Estimates of the total economic cost of climate change are well suited to determine the impacts that can be assigned a direct monetary value. Those costs are directly linked to market transactions and, therefore, directly affect GDP. However, this method may not be comprehensive enough to reflect the real cost of climate change;
    b. A more limited approach is to "aggregate impacts" by adding up the total impact of climate change across various sectors or regions. While such marginal cost estimates are still limited to costs that can be directly linked to economic transactions, they have the advantage of providing a more focused cost estimate. In spite of "large gaps in current research on this topic", this method remains best suited for "economists thinking about policy design".[44]
2. The main challenge for IAMs is how to take "non-market" impacts into account for which, by definition, no cost estimate can be established. The computations are often based on several quantities that are, by their nature, unknowable or to which costs are very hard to associate. Examples of those are numerical measurement of human welfare, monetary value of both current and anticipated climate damages, or relative worth of future versus present benefits.

Box 14. The social cost of carbon (SCC)

Conceptually, most IAMs are based on the "social cost of carbon (SCC) approach", which tries to estimate how much society would have to pay in order to make up for the damages of climate change. In this way, SCC is the marginal impact of emissions above pre-industrial levels, taken to be between 250 ppm and 300 ppm CO_2. The actual calculation of SCC then greatly varies between the models, beyond this common conceptual basis.

The various IAMs differ in two critical manners: (1) their "focus" or the question they are trying to answer; and (2) their structure:

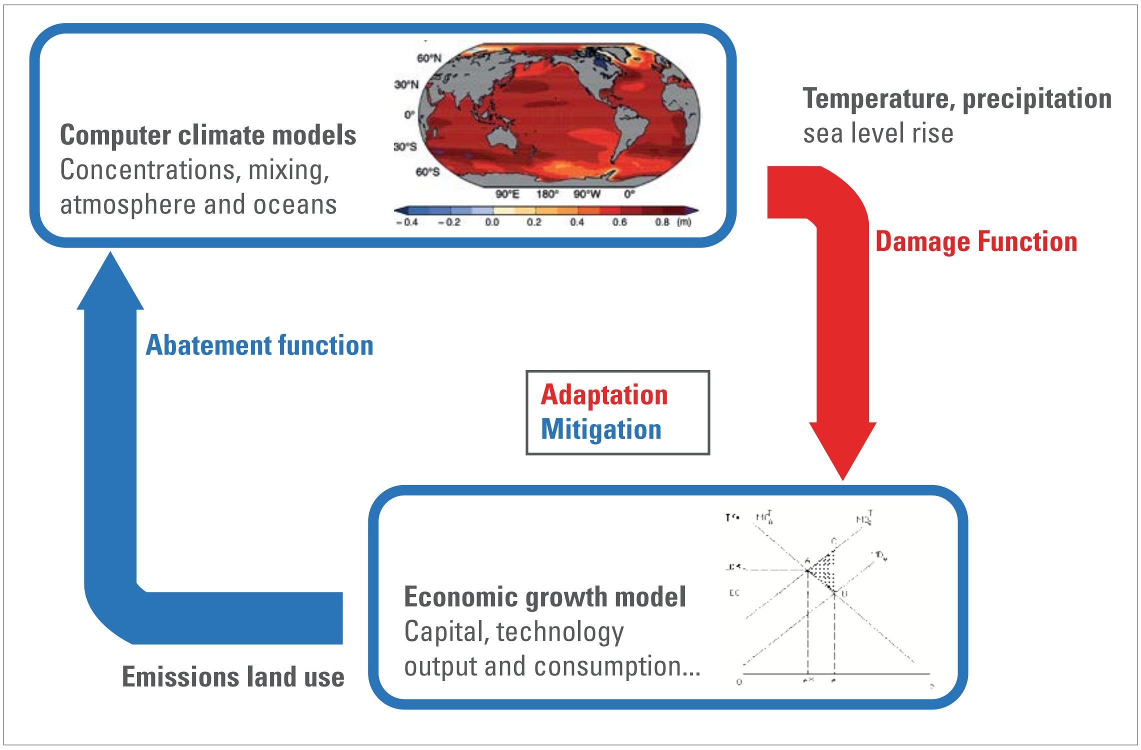
1. IAMs differ on how they try to address a problem where the parameters are interlinked. On the one hand, the economic sector results in forcings that affect the climate. On the other hand, climate change has a direct effect on the economic sector and the resulting forcings. Their focus is therefore on economic modelling that is designed to support either:

a. Climate modelling and mitigation analysis; those IAMs explore "a range of different technological, socio-economic and policy futures that could lead to a particular concentration pathway and magnitude of climate change";[45] or
b. Adaptation strategies; those IAMs strive to evaluate the impacts of climate change on various technological, socio-economic and policy futures.

2. The structures of IAMs depend on their perspective. In theory, IAMs should be structured to identify the "optimal" policy that maximizes long-term human welfare. However, they differ in the perspective and approach they take, and each resulting structure "provides a different perspective on the decisions that are necessary for setting climate and development policy".[46] Those structures generally fall into four broad categories of models: (a) equilibrium; (b) simulation; (c) cost minimization; and (d) welfare optimization.

a. The most complex models are equilibrium models. They represent the economy as a system of linked economic sectors that they try to "solve" by searching for a set of prices that will reach an "equilibrium" between supply and demand. This may be a conceptual limitation when approaching adaptation measures, since it is not clear whether there can always be a real "supply/demand" equilibrium, particularly in disaster situations.[47] Another shortcoming of such models is that they can grow to become extremely complex and intricate, without this resulting in enhanced performance;
b. Simulation models are based on forecasts about future emissions and climate conditions, and try to link climate outcomes to economic models of production, damages, consumption, investment and abatement costs. They are primarily used in mitigation studies to estimate the cost of various likely future emission paths and are generally not well suited for adaptation studies;

Figure 7. Schematic representation of a welfare optimization model



Source: Adapted from Stanton and others, 2009, figure 1, p. 168.

c. The focus of cost minimization models is to identify the most cost-effective solution that would be most compatible with a specific objective. Recent versions of such models explicitly include or link to a computer CM;
d. The simpler models are welfare optimization models. As shown in figure 7, they are useful for purposes of adaptation analysis, as they can use computer CM and use climate parameters to estimate the socio-economic impacts of climate change via a "damage function". In addition, they may allow for speculative values to be assigned to non-market "goods".

At this stage of development, IAMs could still offer general insights as to the reaction of the Arab region's economies to the projected regional impacts of climate change. For purposes of climate change adaptation in the Arab region, an implementation of the simpler IAMs would be sufficient: either the cost minimization models or the welfare optimization models. However, two main issues need to be kept in mind before the actual implementation of IAMs:

1. Care must be taken to ensure that their design is well documented and approximations made are clarified. There are fundamental challenges that IAMs have to contend with in the economic valuation of the effects of climate change. This is vital to ensure that the conclusions reached by the IAM properly inform the adaptation strategy.
2. Yet, as of 2015, there were no implementations of IAMs in the region that could provide a detailed analysis of economic impacts based on the climate change impacts projected by a regional climate model such as RICCAR, for example. The VA proposed by RICCAR may be the most applicable at this stage.

Both the IAMs and VA would need to consider climate data obtained from RICCAR's RCM implementation for the periods 2046-2065 and 2081-2100. Ideally, they would be able to compare with data from the same baseline 1985-2005 period (chapter 3). Data should therefore be available with enough details for this period.

Box 15. Damage function

A "damage function" or "impact function" represents the relationship between a climatic parameter, usually temperature, to the economic costs associated with their variation. Those relationships usually assume that damage increases with increasing temperature, sometimes after a threshold is passed.

The costs are a function of the sector impacted. For example, in the case of pollution, the damage function would be population-specific, and will change as the number of people exposed to the pollutants changes.

Source: Available from http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=678.

Limitations of integrated assessment models

The differences among IAMs can have significant consequences, as it leads some to reach conclusions that contradict scientific literature, while others appear to implicitly ignore some key imbalances.[48] The differences in model design and computations can lead to significant estimates in the economic costs of climate change, as dramatic as those shown by the studies carried out by Nordhaus and Stern.[49]

The main reason is that the implementation of IAMs has to contend with significant fundamental challenges in the economic valuation of the effects of climate change. This

challenge is related to (1) the difficulty in associating real costs to the variety of impacts; (2) applying the appropriate "discount rate"; and (3) properly understanding the correct functional forms for some of the key relationships:

1. It is not always evident how real costs can be associated with climate change impacts. Indeed, there are impacts of climate change that affect activities in which there are no established markets or for which there is no established pricing mechanism.
    a. Since they cannot be measured by market prices or revenues, it is extremely difficult to obtain a reasonable measure of those impacts. Impacts are also expressed, for example, as changes in the type of economic activity, human health impacts linked to the varying spread of infectious diseases, or ecosystem losses and decrease in biodiversity;
    b. This is relevant for developing countries, where such non-market impacts are estimated to have a particularly significant negative effect.[50] Those impacts may substabtially contribute to the total costs of climate change, as shown by studies that have included health impacts;[51]
    c. Even when there are methodologies to estimate costs, lacking economic data may cause an additional problem, particularly in developing countries, and especially since many socio-economic parameters may not be uniformly distributed over a country's territory. This is further compounded by the inability to:
        - Estimate the future level of adaptive capacity, which will affect the future cost of climate change impacts;
        - Forecast the evolution of socio-economic trends with respect to climate change.
2. The way IAMs apply a discount rate remains another point on which there is little agreement in the literature. This has significant consequences, as "different rates will yield wildly different estimates of [such important parameters as] the social cost of carbon and the optimal amount of abatement that any IAM generates".[52] It is such differences that largely explain the significant discrepancies regarding optimal abatement between two of the most cited IAM-based analyses, the research by Nordhaus and Stern that resulted in different results and widely divergent policy recommendations (box 16).[53]
3. Much research still needs to be done to establish the correct functional forms for some of the key relationships between parameters that describe climate and socio-economic systems.
    a. An example is the "damage function" that relates temperature variations to either GDP itself or to its growth rate. Since "there is no theory and no data that we can draw from [to back up this relationship, it remains a concept about which] we virtually know nothing [and IAM developers appear to] simply make up arbitrary functional forms and corresponding parameter values"; [54]
    b. This inaccuracy is compounded by the fact that the probability distributions of various socio-economic parameters remain poorly understood. This may create significant variability as "different distributions – even if they all have the same mean and variance – can yield very different results for expected outcomes",[55] and thus also for policy recommendations;
    c. Some models "incorporate simplified representations of the climate system, ecosystems, and in some cases, climate impacts[, which then need to be] calibrated against more complex climate and impact models".[56] This may be a source of additional uncertainty, as it creates its own set of approximations.

In the development of IAMs, those diverse challenges are met in a variety of ways, which results in a diversity of models that often lack transparency. In the long run, this has to be addressed to ensure a greater integration and standardization of results. However, it remains difficult to

Box 16. The discount rate

When comparing benefits and costs that arise at different points in time, economists generally draw upon the discounting principle in their cost-benefit analyses, which later inform the respective policy measures. As decisions have to be made in the present, future costs and benefits need to be converted into present values, however, also taking into account factors such as interest rates, impatience and risk in order to be able to compare those benefits to present costs. To consider these factors, future benefits are therefore discounted. While this practice is very much applicable to individual's choices that deal with shorter time periods, it has been debated whether this principle could also be applied to time frames as large as hundreds of years, as applicable to a society overall and across generations. Over such long time periods, even a low discount rate would dramatically diminish future values today and factors, such as impatience, cannot apply.

Climate change is a cross-generational issue; just as the emissions of past generations have contributed to today's climate change, today's mitigation efforts will benefit the welfare of future generations. The necessary investments will therefore depend on the relative value of present benefits (money today) over future costs (money in the future).

- A low discount rate (0.1 per cent) is chosen by those who consider that catastrophic climate change may drastically affect future generations, as it has happened many times in the past.
- However, the needs of today's development lead others to prefer a higher discount rate (3 per cent), and consider that catastrophic climate change is far less likely to cause the downfall of advanced civilizations that can develop the technologies necessary to overcome future challenges.

The heart of the debate remains an inherently ethical judgment about comparing the well-being of different generations; today's and those alive in a hundred years. "The Stern Review takes a very strong ethical position on this question, arguing that there is no reason to favour the interests of the current generation over any other. Stern consequently applies a low discount rate to future benefits [1.4 per cent], with the effect of giving the interests of generations in the distant future a heavy weighting in the calculation of overall costs and benefits. Other economists, including the US economist William Nordhaus, one of the Stern Review's sharpest critics, have argued for significantly higher rates [4 per cent]."[a]

[a] Smith, 2011, p.102.

establish "agreed upon standards for how to approach and implement integrated assessment" models. This difficulty is exacerbated as data is often presented without proper contextual information and differently analysed by specialized research groups that find it hard to share or communicate information, representing "a systemic challenge that hinders effective and meaningful inter-office or inter-agency collaboration".[57]

Economic implications of extreme events

Extreme weather events can have severe economic consequences. Their effects can occur both in the short term, when damages occur and have to be repaired, and in the medium to long term, if the impacted country cannot recover from those damages.

Natural disasters are known to have significant economic impacts in the short term, particularly on developing countries. In the period between 1990 and 2000, disasters caused damages representing between 2 per cent and 15 per cent of an exposed country's annual GDP. However, the data is less clear regarding the long-term effect of disasters in developing countries. The main reason is confusion between extreme weather events and other types of disasters:

Box 17. Extreme events and natural hazards

An extreme event could lead to a natural hazard:

- Extreme events are defined in statistical terms; they are events that strikingly deviate from the statistical mean, regardless of whether they cause a socio-economic impact;
- Natural hazards are defined in terms of their socio-economic impact, that they may "cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage[. Climate-related hazards, or] hydro-meteorological hazards […] include tropical cyclones (also known as typhoons and hurricanes); floods, including flash floods; drought; heatwaves and cold spells; and coastal storm surges. Hydro-meteorological conditions may also be a factor in other hazards such as landslides, wildland fires, locust plagues, epidemics and in the transport and dispersal of toxic substances and volcanic eruption material."[1]

A hazard would therefore be related to the socio-economic consequences of an extreme event.

[1] Available from www.unisdr.org/we/inform/terminology.

1. Disasters such as earthquakes are cataclysmic. However, they are also not happening regularly, and "frequently succeeded by higher growth rates".[58] In many cases, they are "a temporary disruption of the development process" with no long-term impacts.[59]
2. The extreme weather events that result from climate change occur more frequently and therefore tend to have more protracted effects. In the Arab region, droughts and floods already affect proportionally larger shares of the population than other extreme events such as storms and cyclones, namely 98 per cent of all people affected by climate-related disasters between 1981 and 2010.[60] The difference among weather-related extreme events lies in when they happen and how long they last:
   a. Protracted and persistent extreme events such as droughts can last over multi-year periods, and can have lasting impacts;
   b. Extreme events can also be shorter lived but come with increased frequency, such as heatwaves, storm surges and flash floods.

Beyond the direct costs incurred at the onset of the extreme events, there are many ways in which they can negatively affect overall economic development:

1. The stock of physical capital and human resources may no longer be present after the occurrence of an extreme event. This has been demonstrated by the case of the Syrian Arab Republic's north-eastern region, which was hit the hardest by the 2006-2011 drought, the worst the country had experienced in 40 years. By 2009, three years into the protracted drought, 300,000 families were negatively affected as farmers and herders lost their livelihoods.[61] The majority of those families had little choice but to permanently leave the area; between 1.25 million and 1.5 million people resettled in the eastern part of the country.[62] Due to this loss of physical capital and human resources, by 2008 the agricultural share of GDP in the Syrian Arab Republic fell to 17 per cent, down from 25 per cent in 2003.
2. The increased frequency of extreme events will contribute to an atmosphere of uncertainty that will discourage any available private capital. Public funding would struggle to make up the shortfall:

   a. The extreme event would have caused a reallocation of funds from other planned investment. In addition, the increase in public spending could lead to higher fiscal deficits and cause inflation;
   b. In cases when repair or recovery is funded by aid, this aid may not be entirely additional. Donors tend to advance commitments within existing multi-year country programmes and budget envelopes. As a result, the amount of aid provided following a natural disaster is diverted from development aid flows. Some of the countries facing extreme events already suffer from problems of over population, citizens with a low-skills base, and no risk management strategies.
3. Extreme climate events may also increase the risk of conflict. Countries where livelihoods are heavily dependent on agricultural activity are particularly vulnerable to extreme climate events. Ensuing negative growth shocks significantly increase the likelihood of conflict in the year following its onset.[63]

Climate finance

The technologies needed for climate change adaptation are diverse and their costs are significant. The 2009 Expert Group on Technology Transfer of the UNFCCC identified 165 adaptation technologies and 147 mitigation technologies that were needed for developing countries. Furthermore, they estimated in a sector-by-sector analysis that, at the global level, implementation of those various technologies for adaptation needs alone would amount to at least $49 billion to $171 billion per year.[64] However, it should be noted that this study excluded some key economic sectors (mining, manufacturing, energy, retail, finance and tourism), and did not account for the cost to protect/revive ecosystems, which may alone amount to $65 billion - 300 billion a year.[65] Adding all these costs suggests that adaptation costs may reach at least $380 billion a year.[66]

Regardless of the exact amount, no single funding channel can easily deal with such large amounts and cover such diverse needs. For this reason, a variety of funding channels are needed. In principle, adaptation to climate change would depend on specific financing that transfers the necessary funds to the ones who need it most. This financing reflects the fact that the current climatic change is related to the cumulative effect of human activities, most of which occurred in developed countries. Developing countries are now faced with a dual burden: they need to grow their economies while at the same time adapting to climate change.

The principles and criteria of climate finance recognize this. In principle, this financing would have three characteristics: (1) a structure to transfer adaptation funds from developed countries to developing countries; (2) a distinction from conventional official development assistance (ODA); (3) a focus on both sustainable development and adaptation.

Principles and criteria of climate finance

For the Arab region, the source of such “climate finance” would be to support mechanisms and financial aid to help countries implement strategies specifically targeted at climate change adaptation, with eventual mitigation co-benefits. This funding has therefore a dual focus:

1. Adaptation, through projects that support policies to deal with the negative impacts of climate change on economic development and thus promote “climate-resilient” growth;
2. Mitigation, through either actions and projects that promote clean development, or projects that promote adaptation and economic development:

a. Actions and projects that promote clean development would be carried out without additional economic burden compared to traditional schemes;
b. Projects that promote adaptation and economic development will be designed to have co-benefits of mitigation, through the implementation of appropriate low-carbon technologies.

Formally, the UNFCCC has provisions to provide financing for such needs. Some of the key principles relevant to the financial interaction between developing and developed countries were further clarified during the Kyoto Protocol and follow-up agreements and decisions by the Conference of the Parties (COP) to the UNFCCC:

Box 18. Mitigation co-benefits: the example of agriculture

There are two types of strategies in dealing with climate change: (1) mitigation, in which efforts are made to reduce the drivers of change, or (2) adaptation, in which efforts are made to reduce vulnerability to climate impacts. The two strategies can be complementary. In the agricultural sector, such actions include for example:

- New crops and cropping techniques that can both allow for more climate-resilient agriculture (adaptation), enriched carbon soil and reduced methane emissions (mitigation);
- Adequate irrigation and better land use management that would both reduce flash floods or diminish their intensity (adaptation) and help rehabilitate lands and watersheds (mitigation);
- Environmental control and maintenance and local labour involvement in public works that can help diversify rural income and thus strengthen economic resilience (adaptation), while also helping to reduce deforestation or even promote reforestation.

1. Article 4.3 of the Convention commits developed countries to provide funding for “agreed full incremental costs” of adaptation to climate change in developing countries, while ensuring “adequacy and predictability in the flow of funds and the importance of appropriate burden sharing among the developed country Parties”.[67]
   a. The Convention also specifies that funding should be “new and additional”; and provided in addition to the existing target of 0.7 per cent of gross national income of developed countries for ODA. This is necessary to ensure that finance is not diverted from funding for development needs:
      - In practice, however, there is yet no agreement on indicators that could help distinguish between ODA and non-ODA national contributions;
      - This lack of clarity has real financial implications, as shown by data on disasters in developing countries over the period 1987-2003. In those cases, donor aid “covered less than 10 per cent of the financing [needed, and] was generally used for emergency relief and not reconstruction”.[68]
   b. The predictability of funding is necessary to ensure a sustained flow of climate finance from year to year, to allow developing countries to develop adequate investment programme planning. The funding period is estimated to be about 3 to 5 years, in line with medium-term funding cycles.
2. Article 2 commits the parties to take climate action on “the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities”. This principle has two aspects; the “polluter pays” principle and the concept of “respective capabilities”:
   a. The “polluter pays” principle is relevant to climate finance because it would imply a clear distinction of the latter from aid flows. This concept relates to the fact that the current

Heavy Smoke at Oil Refinery. © Gino Santa Maria - Fotolia 118938107

change in climate is due to the cumulative effect of GHG emissions, most of which stem from developed countries. This principle serves as a normative guidance to determine the level of climate finance contributions of individual polluting countries. In practice, two aspects still need to be clarified:

- The baseline year, as this will define how to include historical cumulative emissions;
- The effect of current emissions.

b. The concept of "respective capabilities" suggests that contributions should relate to a measure of national wealth, taking into account the right to sustainable development referred to in article 3.4 of the Convention. However, there is as yet no agreement on whether this should be correlated with a sustainable and universally accepted living standard for each of its citizens, or what the baseline year for this would be.

3. Actual funding disbursement is guided by some key principles to ensure that the funds are effectively and efficiently used, and benefit those most in need. Fund disbursement mechanisms should ensure subsidiarity and national/local ownership, and that the actual spending is done in a precautionary and appropriate manner:

   a. The requirement for subsidiarity and national/local ownership is to ensure that funding priorities are decided in coordination with the "target audience", so that no "donor defined" agenda is set, and that actual disbursements meet actual adaptation spending needs;
   b. A precautionary approach is needed as policymakers need to undertake adaptation actions because of the importance to act fast. They often cannot wait to make sure all the scientific information is settled. For this reason, they still need to ensure that the funded adaptation action first "causes no harm";
   c. Appropriate climate funding is one that does not place extra burdens on recipient countries. Funded adaptation actions need to be compatible with national strategies and with the long-term objectives of sustainable development. The concept of appropriateness can be extended to include the mainstreaming of gender-responsive budgeting to ensure that women benefit from such funds.

Table 3. Some principles and criteria for climate change funding for adaptation

Funding phase	Principle	Criteria
Mobilization	Transparency and accountability	Public and timely disclosure of (1) financial contributions by individual countries, international organizations and agencies, (2) their composition and sources.
	Polluter pays	Financial contributions correlate with cumulative emissions.
	Respective capability	Financial contributions correlate with (existing) national wealth and the right to both (future) sustainable development and universally accepted minimum living standards for citizens.
	Additionality	Funds to be provided in addition to existing national ODA commitments.
	Predictability	Funding is known and secure over a multi-year, medium-term cycle.
Administration and governance	Transparency and accountability	Availability of accurate and timely information on (1) a mechanism's funding structure, (2) its financial data, (3) the structure and mandate of its board, (4) the identity of its board members, (5) a description of its decision-making process, (6) the actual funding decisions, (7) the disbursements made, (8) the implementation results achieved, (9) as well as redress mechanisms or processes and their outcomes.
	Equitable representation	Ensuring that member countries' board seats are not dependent on financial contributions, and inclusion of relevant stakeholders, while taking gender perspectives into consideration.
Disbursement and delivery	Transparency and accountability	Disclosure of funding decisions according to publicly disclosed funding criteria and guidelines and the disbursements made; duty to monitor and evaluate implementation of funding; existence of a redress mechanism or process.
	Subsidiarity and ownership	Funding decisions to be made by taking into account (1) national strategies, (2) the knowledge and needs at the lowest possible and appropriate political and institutional level and (3) gender perspectives.
	Precaution and timeliness	Absence of absolute scientific certainty should not delay swift disbursement of funding when required.
	Appropriateness	The funding modality should not impose an additional burden or injustice on the recipient country, while being socially, economically, environmentally and culturally appropriate.
	Do no harm	Climate finance investment decisions should not (1) imperil long-term sustainable development objectives of a country, (2) contradict national priorities and strategies, or (3) violate basic human rights, especially violence against women and children in all its forms.
	Direct access and vulnerability focus	Financing, technology and capacity building are to be made available to the most vulnerable countries internationally and population groups within countries (women, youth, etc.) as directly as possible, ensuring that technology transfer is in line with national priorities and strategies.

Source: Adapted from Schalatek and Bird, 2014.

In the run-up to the 21st Conference of the Parties (COP21) held in Paris in December 2015, there was no full agreement about the precise meaning of these principles and how to implement them. After the COP21, those principles continue to collectively serve as a normative guidance. The agreement recognized the wide differences in levels of economic development between States, and called for "support" to "be provided to developing country Parties" to help them meet mitigation targets.

However, the details of such support remained to be defined. The consensus at Paris was only that "the agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances".[69] This agreement recommends that finance flows be "consistent with a pathway towards low greenhouse gas emissions and climate-resilient development".[70] Further clarifications on newly defined funding mechanisms and commitments remain to be clarified throughout the current negotiation process.

The global climate finance architecture

The structure of global climate finance is still evolving. It remains hard to define and monitor, not least because there is no clearly agreed upon definition yet of what constitutes climate finance. As a result, the global climate finance architecture is becoming increasingly complex, with funds flowing through a multitude of channels: (1) formal multilateral financing mechanisms both within and (2) outside the UNFCCC; (3) bilateral channels; (4) national climate change funds in developing countries,[71] as detailed below.

1. Formal multilateral financing mechanisms within the UNFCCC. Such channels, in theory, are not contributor country-dominated, and thus afford developing countries greater input in decision-making. Non-governmental stakeholders are also often observers to fund meetings, and allowed varying degrees of active participation opportunities.
   a. The Global Environment Facility (GEF) was established in 1991 as an operating entity of the financial mechanism of the UNFCCC. It allocates resources according to the effectiveness of the spending on environmental outcomes, while still ensuring that all developing countries have a share of the funding:
      - For the period 2015-2018, the GEF is expected to have $3 billion for climate change;
      - The GEF also administers two other funds; the Least Developed Countries Fund (LDCF) and the Special Climate Change Fund (SCCF), both of which support national adaptation plan development and their implementation, with a country ceiling for funding of $20 million.
   b. The Adaptation Fund (AF) is also linked to the UNFCCC and is operational since 2009. Financed through a 2 per cent levy on the sale of emission credits from the Clean Development Mechanism of the Kyoto Protocol, it has a total capitalization of $642 million;
   c. The Green Climate Fund (GCF), agreed upon at the UNFCCC COP17 in Durban, is tasked with funding climate-resilient and "low-carbon development" in developing countries and is thus more focused on mitigation than adaptation. It began to fund programmes and projects in late 2015, and has $10 billion pledged to date.
2. Outside the UNFCCC framework, there is a substantial volume of climate finance. Such channels are more likely to be contributor country-dominated. But they still afford developing countries some input in decision-making.
   a. The Climate Investment Funds (CIFs) that finance "programmatic interventions" in developing countries; they are established in 2008 and administered by the World Bank in partnership with regional development banks such as the African

Box 19. Climate finance commitments in global negotiations

Climate finance is significantly referred to in the zero draft outcome document of the 2016 ECOSOC Forum on Financing for Development Follow-up (FFDF), representing one dedicated paragraph out of a 17-paragraph statement.

The draft welcomes the Paris Agreement on Climate Change adopted in December 2015 and reiterates the developed countries' intention to mobilize $100 billion per year until 2025, following the coming into force of the Paris Agreement. The forum also welcomed the decision taken on 6 November 2015 by the Board of the Green Climate Fund to approve eight projects worth $624 million for climate financing to developing countries.

Source: ENB, 2015.

Development Bank (AfDB), the Asian Development Bank (ADB), the European Bank for Reconstruction and Development (EBRD), and the Inter-American Development Bank (IDB). By 2015, the CIFs had a total pledge of $7.52 billion, including:

- The $5.2 billion Clean Technology Fund;
- The $1.16 billion Pilot Program for Climate Resilience (PPCR);
- The $0.6 billion Forest Investment Program (FIP);
- And the $0.5 billion Scaling-Up Renewable Energy Program for Low Income Countries (SREP).

b. Multilateral development banks (MDB), such as the World Bank, play a prominent role in delivering multilateral climate finance, as many have incorporated climate change considerations into their lending programmes. Most MDBs now administrate climate finance initiatives with a regional or thematic scope:
   - The World Bank's carbon finance unit has established the Forest Carbon Partnership Facility (FCPF) related to Reducing Emissions from Deforestation and Forest Degradation (REDD+ effort);[72]
   - The African Development Bank administers the Congo Basin Forest Fund (CBFF);
   - The European Investment Bank administers the EU Global Energy Efficiency and Renewable Energy Fund (GEEREF), as well as the Africa Climate Change Fund (ACCF).

3. Bilateral channels are effectively contributor country-dominated structures. Many were set-up by several developed countries that either have established climate finance initiatives or are channelling climate finance through their existing bilateral development assistance institutions.

   a. In 2014, it is estimated that $12 billion were directed through bilateral finance institutions.[73] However, this is hard to ascertain, as these channels have limited transparency and consistency and because they rely on self-classifying and self-reporting by donor countries of what constitutes climate-relevant financial flows;
   b. It appears that most of those channels tend to focus more on climate change mitigation in developing countries rather than adaptation. An example is the nationally appropriate mitigation actions (NAMAs) in developing countries, contributed to by both the UK and Germany;
   c. The main channels are: Germany's International Climate Initiative; The UK's International Climate Fund; Norway's International Forest Climate Initiative; and Australia's International Forest Carbon Initiative (IFCI).[74] Japan's Fast Track Finance (FSF) initiative is also active in the area.

Table 4. Major multilateral funds and initiatives

Fund	Name and description
AF	Adaptation Fund (GEF acts as secretariat and WB as trustee)
ACCF	Africa Climate Change Fund
ASAP	Adaptation for Smallholder Agriculture Programme
CBFF	Congo Basin Forest Fund (hosted by AfDB)
CDM	Clean Development Mechanism (implemented under the Kyoto Protocol)
CIF	Climate Investment Funds (implemented through WB, ADB, AfDB, EBRD, and IADB)
CTF	Clean Technology Fund (implemented through WB, ADB, AfDB, EBRD, and IADB)
FCPF	Forest Carbon Partnership Facility
FIP	Forest Investment Program (implemented through WB, ADB, AfDB, EBRD, and IADB)
GCCA	Global Climate Change Alliance
GCF	Green Climate Fund
GEF	Global Environment Facility
GEEREF	Global Energy Efficiency and Renewable Energy Fund (hosted by EIB)
JI	Joint Implementation (implemented under the Kyoto Protocol)
LDCF	Least Developed Countries Fund (hosted by the GEF)
PMR	Partnership for Market Readiness
PPCR	Pilot Program on Climate Resilience (implemented through WB, ADB, AfDB, EBRD, and IADB)
SCCF	Special Climate Change Fund (hosted by the GEF)
SCF	Strategic Climate Fund (implemented through the WB, ADB, AfDB, EBRD, and IADB)
SREP	Scaling Up Renewable Energy Program (implemented through the WB, ADB, AfDB, EBRD, and IADB)
UNREDD	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation

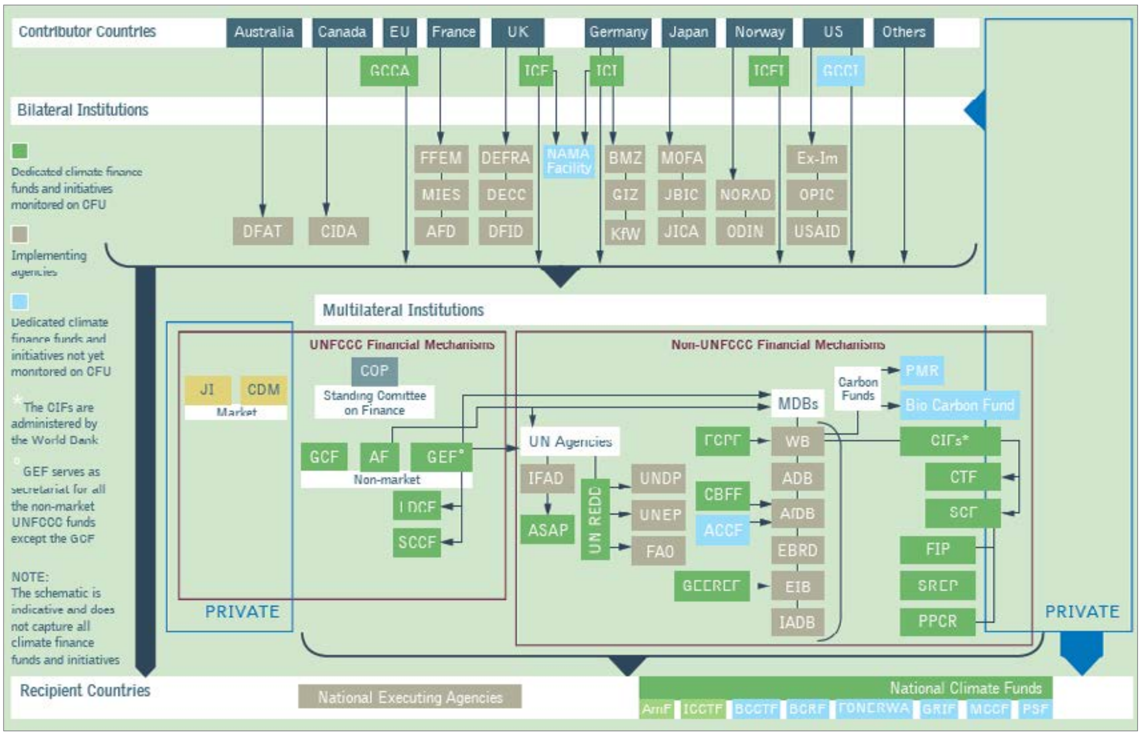
Source: Nakhooda and others, 2014

4. National climate change funds have been established in developing countries to receive and channel climate finance to fund projects. Those funds have structures of governance and modes of operation with differences in their assigned strategic objective, and in some cases, the United Nations Development Programme (UNDP) has been asked to act as administrator. Those funds channel climate finance through a variety of means, from grants and concessional loans to guarantees and private equity, but there is little available data on their activity.

The formal architecture of global climate finance is displayed in figure 8. It details the flows from contributor countries through formal multilateral financing mechanisms (within and without the UNFCCC) and through bilateral channels. It is through those channels that funds would reach recipient countries, either directly or through formal national climate change funds in developing countries.

It should be noted that, of all those channels, the multilateral financing mechanisms appear to be the most transparent. There is little detailed information on bilateral initiatives, and most of it comes from “self-reporting” of donor countries. In general, because of both the multitude of

Figure 8. The architecture of global climate finance



Source: Adapted from Nakhooda and others, 2014.

funding channels and the lack of agreement on a definition of what constitutes climate finance, the current system has two major shortcomings:

1. One cannot effectively monitor, report and verify (MRV) climate finance and ensure that the funds are effectively and equitably used; thus, robust reporting is sought;
2. It is hard to ensure that the funding is actually "new and additional" to traditional overseas donor assistance (ODA) grants and projects, as specified by the Convention.

The Paris Agreement, adopted at the COP21 in December 2015, spells out additional provisions for ensuring access to climate finance for small island States and least developed countries. In doing so, it also makes provisions for countries to pursue measures in line with their national capacities and priorities, with due consideration paid to their economic development. Arab countries can draw upon these measures when submitting their nationally determined contributions (NDCs), which include both mitigation and adaptation commitments and goals to achieve at the country level.

Box 20. Excerpts on adaptation from the Paris Agreement

"Parties hereby establish the global goal on adaptation of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development and ensuring an adequate adaptation response in the context of the temperature goal referred to in Article 2." (Article 7.1)

"Each Party should, as appropriate, submit and update periodically an adaptation communication, which may include its priorities, implementation and support needs, plans and actions, without creating any additional burden for developing country Parties." (Article 7.10)

CH. 3

Vulnerability Outlook of the Arab Region

CH. 3

Vulnerability Outlook of the Arab Region

Vulnerability and resilience

Vulnerability is a latent property; it is the propensity of a system to be harmed. Of the many definitions of vulnerability in the literature, the definition used here is that of "outcome vulnerability".[75] This concept leads to a definition in which vulnerability is a function of a system's (1) exposure to climate change; (2) sensitivity to climate change impacts; and (3) adaptive capacity to withstand those impacts:

1. Exposure describes the changes in climate parameters that might have a biophysical effect. This does not have to be a negative effect; for example, increased wind speed may worsen erosion but at the same time enhance the energy output of windmills.
2. Sensitivity is the susceptibility to climate change. It can be measured as the effect on socio-economic parameters caused by a change in exposure to a climatic parameter.
3. Adaptive capacity or resilience, refers to "the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences."[76] A resilient system can absorb stresses and remain operational, as well as adapt and evolve to thrive under the new situation.

A vulnerability assessment thus considers the potential impacts generated by the combination of exposure and sensitivity parameters, and the ways in which the adaptive capacity parameters identified can offset or enhance those potential impacts. As such, exposure and sensitivity must be taken from the perspective of "a clearly determined geographic and/or sectoral reference point".[77] This establishes the scope of the vulnerability assessment and can thus focus on a specific sector or sub-sector.

Consider, for example, changing precipitation patterns in a specific region and their potential impact on agricultural production in that region. This is first done by considering exposure, represented by the rainfall pattern, and the sensitivity of the agricultural sector to that change in rainfall patterns. The adaptation capacity of the agricultural system would then be influenced by external factors, such as the presence of a dam or wetland with the capacity to reduce flooding and agricultural land degradation. Adaptive capacity indicators thus provide us with indications of measures that can be pursued to reduce the vulnerability and enhance the resilience of the system.

Vulnerability to climate change in the Arab region

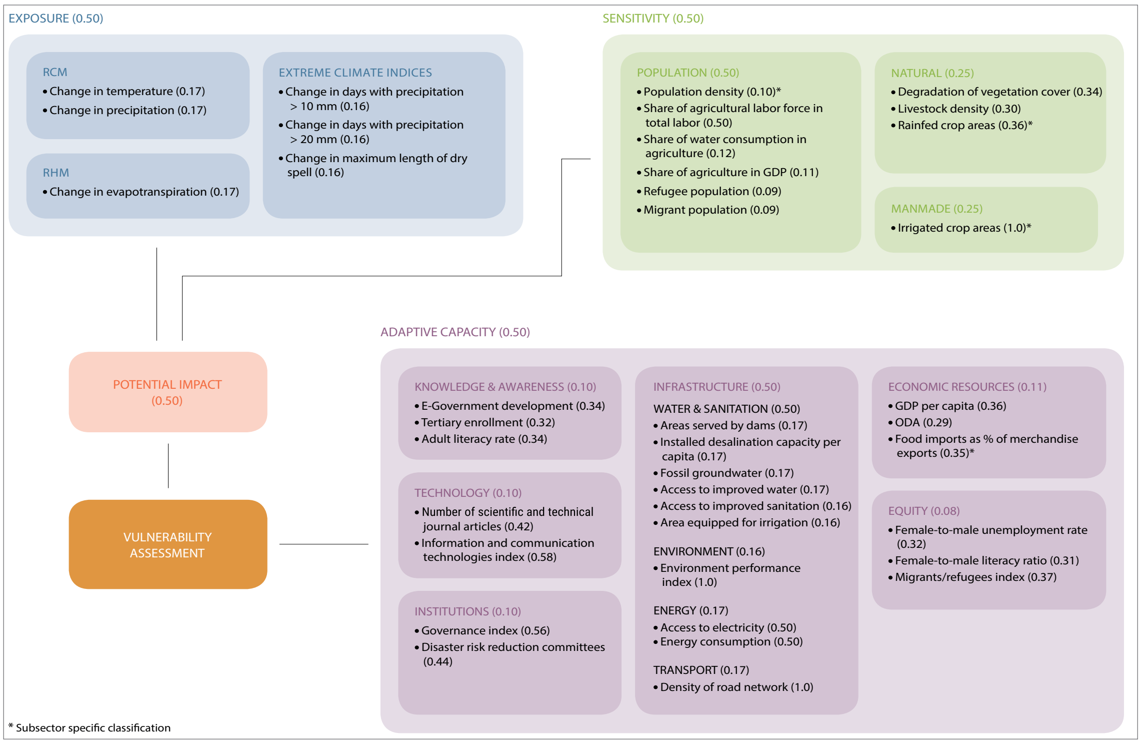
In the Arab region, the most comprehensive vulnerability assessment to date is being undertaken under RICCAR. It is focused on water resources and combines a series of single vulnerability assessments for several water-related climate change impacts on different sectors in the Arab region. It is designed to provide an integrated understanding of the vulnerability to climate change across the region and across various sectors. The assessment selected five key sectors and ten climate change impacts that could be geographically mapped (table 5).

Table 5. Sectors of the vulnerability assessment of the Arab region's water resources

Sectors	Impacts
Water	Change in water availability
Biodiversity and ecosystems	Change in area covered by forests Change in area of wetlands/marshes
Agriculture	Change in water available for crops Change of rangeland for livestock
Infrastructure and human settlements	Change in inland flooding area Change in coastal flooding area
People	Change in water available for drinking Change in health due to heat stress Change of employment rate in the agricultural sector

Source: Adapted from ESCWA, 2015, figure 3, p. 12.

Figure 9. Impact chain for change in the rate of employment in the agriculture sector



Source: RICCAR, 2017. Arab "Assessment..., Technical Annex.

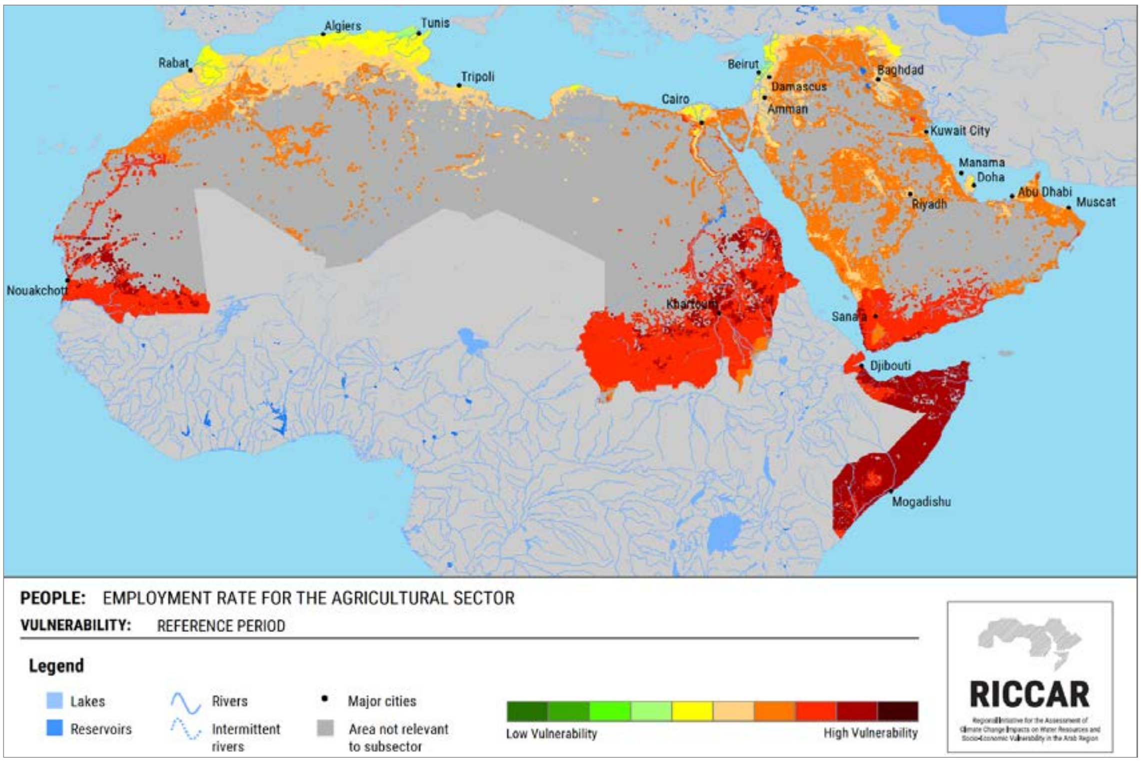
Integrated vulnerability assessment

The integrated vulnerability assessment (VA) methodology links the climate change impact assessment to a geographic mapping of socio-economic and environmental vulnerability assessment.[78] The VA complements IAMs, to help provide a representation of the three dimensions of the economic impacts of climate change:

1. While IAMs would represent both the effects on economic sectors (sectoral dimension) and the evolution of impacts over the years (time dimension), the VA would geographically map the vulnerabilities to climate change, which can thus help providing a clearer picture of the spread of those impacts at the country or regional levels (geographic dimension).
2. The VA methodology links directly to the RICCAR regional climate model and can be adapted to rely on smaller-scale climate modelling to better show the socio-economic implications of climate change at the local or country levels.

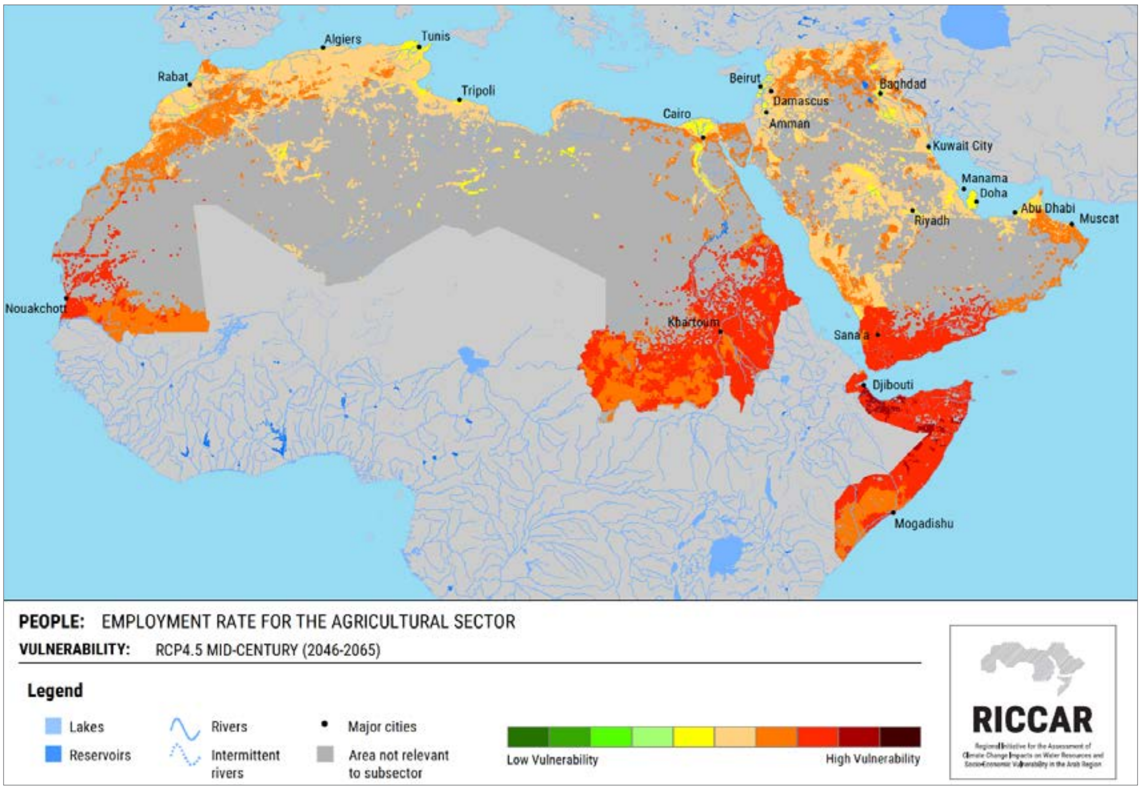
The change in rate of employment in agriculture is one of the impacts analysed in RICCAR. The potential impact is the aggregated result of 6 exposure indicators and 10 sensitivity indicators. All of the exposure indicators are equally weighted in the impact chain (figure 9), but the results indicate the strongest correlation with temperature as well as the heavy rainfall indices. Under sensitivity, the share of agricultural labor force from the population dimension, has been assigned the heaviest weight, but the results indicate a stronger correlation with the share of agriculture in GDP from the population dimension. The current employment rate in the agricultural sector is highest in the Horn of Africa and lowest in the Gulf countries.

Figure 10. Change in the rate of employment in the agricultural sector – Reference period – Overall vulnerability



Source: RICCAR, 2017.

Figure 11. Change in the rate of employment in the agricultural sector – Mid-century – Overall vulnerability for RCP4.5



Source: RICCAR, 2017.

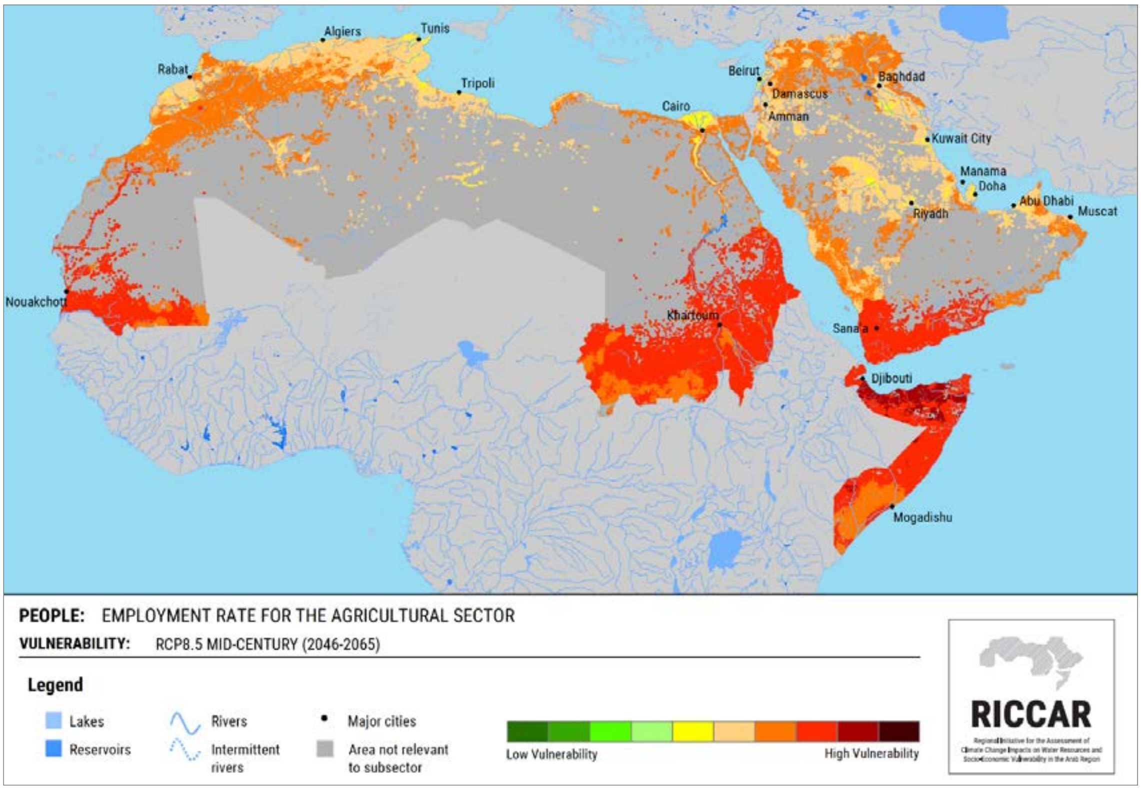
Overall vulnerability is the aggregated result of potential impact and adaptive capacity (figure 10). With the exception of isolated coastal areas located in the Maghreb and the Levant, the region is classified as having moderate to high vulnerability, with a gradient of increasing vulnerability from north to south.

The projected change in the rate of employment in agriculture is shown in figures 11 and 12 till mid-century for RCP4.5 and RCP8.5. The best opportunities for employment in the agriculture sector are located in the Nile Delta region and in the Tigris-Euphrates Valley. However, in general, the vulnerability maps indicate a moderate-to-high vulnerability for employment, suggesting a decrease in opportunities in agriculture. The employment rate in the agricultural sector is impacted by stressors such as rural-urban migration, international labor migration, decline in arable land and water scarcity.

The VA methodology helps policymakers address vulnerability in a gradual process that starts with a determination of the sectors and impacts that should be prioritized for the VA; the region's size and the time scale; the relevant indicators for assessing vulnerability; and the data aggregation method. The implementation of the VA methodology needs indicators that can be geographically mapped to provide vulnerability estimates for the Arab region. In general, IAMs focus on parameters that are hard to geographically "map":

1. Of those parameters that can be conceptually mapped geographically, there are two types:
    a. Some parameters can be directly measured, such as the structure of the economic sector;

Figure 12. Change in the rate of employment in the agricultural sector – Mid-century – Overall vulnerability for RCP8.5



Source: RICCAR, 2017.

   b. Others can be inferred from various sources, such as income distribution variations or even "climigration", referring to the situation when people are forced to permanently move away due to the creeping effects of climate change.

2. Other parameters are much harder to map, and may not be included in the VA mapping. Those are parameters that tend to be computed in IAMs such as employment, growth of per capita income, trade, the effects of globalization, etc.

CH. 4

Adaptation to Climate Change

CH. 4

Adaptation to Climate Change

Adaptation refers to enabling policies, strategies, actions and processes that allow a country or region to cope with, manage and adjust to changing climatic conditions.

There are two considerations for the adaptation of socio-economic systems to climate change: the type of adaptation and the technology for adaptation.

1. The type of adaptation can be either (1) reactive or autonomous; occurring after the impacts of climate change have become evident; or (2) anticipatory, taking place before they are apparent (figure 13). The majority of adaptation measures tend to occur spontaneously, as nature and society adjust to changing conditions. Planned adaptation measures can be undertaken whenever there is increased awareness that conditions are changing and there are reliable forecasts of changes.
2. In general, technologies are classified as either soft or hard:
    a. Soft technologies are those based on technical knowledge and skills such as insurance schemes, crop rotation and setback zones, as well as technical knowledge about adaptation techniques. Those technologies are "incomplete", meaning that their implementation needs constant involvement from people, and may require constant updating and changes. An example of soft technologies is the implementation of IWRM techniques;
    b. Hard technologies are based on physical tools and equipment. Those technologies are "complete", meaning that once they are implemented, they require little changes or little creative input. Examples of hard technology implementation include seawalls, drought-resistant seed varieties and irrigation channels;

Figure 13. Types of adaptation strategies

		Anticipatory	Reactive
Natural systems			• Changes in growth; • Ecosystem change; • Migration.
Human systems	Private sector	• Insurance; • Reconstruction; • Redesign.	• Change in business practice; • Insurance premiums; • New equipment.
	Public sector	• Early warning systems; • Codes, Standards; • Incentives relative to adaptation.	• Disaster conpensation; • Enforcement of rules and codes; • Emergency reconstruction.

c. In practice, the type of technology matters less than how it is used, and technologies for adaptation are usually an assembly or mix of those two types of technologies. For example, adaptation measures that involve the installation of reservoirs and irrigation channels (a hard technology) will be lost without the operational guidance and maintenance that can best take place within IWRM (a soft technology).

Box 21. Index insurance

One alternative to managing weather and climate risk is a type of "index insurance" that uses a weather index. With such "index insurance contracts",[a] premiums or assessed damages are determined based on agreed-on thresholds for some climatic parameters, such as the amount of rainfall as recorded by gauges. Such a system is simple to implement and has low transaction costs.

[a] World Bank, 2012.

Because of the unprecedented nature of climate change, adaptation planning should emphasize anticipatory actions, while still allowing for the flexibility to undertake reactive measures if and when necessary. Anticipatory actions need to be planned based on:

1. Information on the economic sectors impacted by climate and the time span of those effects (provided, to a certain extent, by IAM implementations), as well as the geographic extent of the affected areas (provided by mapping generated by the VA). Ideally, the implementation of either IAMs or VA would depend on local climatic models. If no climatic modelling is available at the country level, then the IAM or VA would have to be carried out based on a regional climate model such as RICCAR.
2. A mix of both hard and soft technologies that promote local capacity to understand impacts and develop the necessary responses.
   a. Those technologies would depend on the local capacity to understand impacts, develop the necessary responses, and coordinate implementation; and technologies that are suited to the specific local needs and conditions;
   b. Based on the national adaptation programmes of action (NAPAs), submitted by developing countries to the UNFCCC secretariat,[79] the focus is mostly on water resources, as well as on agriculture and food security (table 6). It is therefore necessary that any climate change adaptation strategy has IWRM at its core.
3. The financial resources to fund those measures. Based on national communications submitted by developing countries, it was estimated that, by 2030, between $28 billion and $67 billion would be needed to enable their adaptation efforts, which is equivalent to about 0.2 per cent to 0.8 per cent of global investment flows.[80]

What can be done: Preparing for adaptation

Adaptation means working to limit any resulting negative effects on the economic system. Because of the diversity of socio-economic systems affected by climate change, adaptation plans have to take into account a variety of factors that reduce a society's vulnerability. Adaptation will therefore have to address the economy's:

1. Exposure to climate change, by minimizing any adverse costs resulting from climatic impacts. The construction of water reservoirs, for instance, would provide additional water

Table 6. Main adaptation measures identified by Arab countries

Vulnerable sector	Potential adaptation measures	Country
Water resources	Increase water supply: groundwater, reservoirs, watershed management, desalination	Algeria, Djibouti, Egypt, Jordan, Saudi Arabia, the United Arab Emirates
	Increase water supply: reservoirs, watershed management	Lebanon
	Decrease water demand: reduce water losses, water recycling, change irrigation practices	Algeria, Egypt, Jordan, the United Arab Emirates
	Decrease water demand: education and outreach, new tax system	Lebanon
	Decrease water demand: water savings in agriculture	Algeria, Egypt, Mauritania, the United Arab Emirates
	Improved water management	Algeria, Egypt
	Reduce water pollution	Jordan, Mauritania
	Water protection measures	Djibouti
	Methods to mitigate seawater intrusion	Mauritania
	Improved water harvesting practices; Drought adaptation strategies	Sudan
Agriculture and food security	Soil conservation New crops	Algeria, Egypt, Lebanon Egypt, the United Arab Emirates
	Rangeland management; endogenous pasture regeneration	Djibouti, the Sudan
	Forecast for pest and disease control; seed banks	Lebanon
	Agricultural practices under increasing heat stress	Sudan
	Soil conservation	Algeria, Egypt, Lebanon
	New crops	Egypt, the United Arab Emirates
	Rangeland management; endogenous pasture regeneration	Djibouti, the Sudan
	Forecast for pest and disease control; seed banks	Lebanon
	Agricultural practices under increasing heat stress	Sudan
Coastal zones and marine ecosystems	Improved urban planning; integrated coastal zone management	Algeria, Saudi Arabia
	Coastal protection measures / sea walls	Egypt, Mauritania, Saudi Arabia, the United Arab Emirates
	Beach reinforcement / nourishment	Egypt, the United Arab Emirates
	Shoreline protection and restoration of marine protected areas (corals)	Djibouti
	Flood protection against coastal zone inundation	Mauritania

Source: Adapted from UNFCCC, 2007.

and create a "buffer" allowing farmers to adjust their water consumption in case of a drought.

2. Sensitivity to climate change, by minimizing the relative change in those costs. This means that any losses incurred by climate change impacts do not increase and accumulate over time.

The implementation of any adaptation framework therefore requires an understanding of the parameters and the impacts involved, the risks associated with them and the means of implementation, both in terms of finances and human capacity. It should be noted that, to determine a system's adaptive capacity, the forecasts from computer models are used as a guide, not as a "must do". Effective adaptation requires a prioritization of resources to face expected challenges in the most reliable manner. Such an approach may help identify adaptation actions that take advantage of any new opportunities offered by climate change. This is especially important in the Arab region where resources are already limited.

Setting up an adaptation team

The complexity of climate challenge elicits adaptation responses that are just as complex, and that involve a wide and diverse group of stakeholders. This is why it may be recommended to develop an adaptation management team (AMT), a multi-stakeholder team to help better inform policymaking, representing both male and female experts in various sciences related to climate change, water, agriculture, economicts, demographics and sociology. The primary responsibility of the AMT would be to understand, analyse and review the challenges posed by climate change impacts and their associated socio-economic effects. This will serve to support the elaboration of policy and to determine protocols for follow-up actions as well as monitoring and evaluation. A different team should be set up for monitoring and evaluation to prevent conflicts of interest. The AMT has two roles: (1) a strategic focus on policy formulation; and (2) a technical focus on the evaluation of impacts and risks:

1. Since strategic planning is focused on policy formulation, it concentrates on broader sustainable development issues, to ensure that adaptation policies are in line with national priorities, and that they take into account existing policies. At this level, policy-specific risks also need to be evaluated.
2. Strategic planning relies on technical planning, in which the climate change impacts obtained by various assessment models are evaluated.

Adaptation risk management

Risk is the result of the "uncertainty of outcome", determined as the product of the probability of a given event with its impact or cost. In the context of climate change, a risk-based approach will thus provide policymakers with a wider focus that takes into account not only the impacts of events but also their probability of occurrence.

This is the best approach to policymaking in a context of climate change, especially since the knowable base in this domain remains under development because of the assumptions that frame the question or methods of analysis.[81]

A policy that takes risks into account would therefore allow for better prioritization among events, since the magnitude of the negative impacts would not be the only determining parameter. The risk evaluation needs to be documented, since not all assessment models compute risk in the same manner, especially when they are evaluating the three different dimensions of climate

change: sectoral, time, and geographic. From a perspective of policymaking, risks have two aspects:

1. The first aspect is related to the effect of uncertainty on policy objectives. This uncertainty has two aspects: (1) a risk to achieve objectives, and (2) the possibility of unintended consequences:
   a. The risk to achieve objectives is faced when a policy, programme or project fails to achieve its intended objective;
   b. In some cases, there is a risk that a policy, programme or project will have an unintended consequence.
2. The second aspect of risks results directly from impacts of climate change and their effects on socio-economic systems and can be categorised in one of two types:
   a. Manageable risks that can be "priced" and insured against. Those are cases where the probabilities of occurrence are known, or where the impact is affordable. In this case, analysis tools can help water managers carry out the necessary cost-benefit analysis and undertake the proper adaptation measures;
   b. Unmanageable risks that cannot be "priced", since they result in losses that cannot be recovered. Those are cases when the impact is unaffordable, regardless of how low the probability of occurrence is estimated to be. Care must be taken to avoid those risks or, if there is no other way, one has to plan for "hedges" against the eventual losses.

It is also useful to consider long-term unseen risks, which are cases where the hidden physiological, social and cultural effects are not recognized, noting that such risks have a high cost.

Those aspects are summarized in table 7.

Risks are difficult to readily identify. For this reason, one of the most reliable methods to do so is to follow a standard process, centred around a "group analysis" technique – an integrated tool similar to the enterprise risk management (ERM) technique. This technique focuses on identifying various risk factors that can add to those associated with the socio-economic systems impacted by climate change, through a multi-step process to:

1. Identify existing adaptation options. This is centred on identifying, in sequence, the risks to socio-economic systems due to climate change impacts; their causes; and any controls that may be already in place to reduce the likelihood of the event or to minimize its impact.
2. Establish the "risk matrix" based on rating, likelihood and consequence descriptors, as shown in table 8. At this stage, the risk rating descriptors should be already established, clarifying what is meant when (1) a likelihood is rare, unlikely, possible, likely, or very likely, or (2) an impact that is negligible, minor, moderate, significant, or severe.
3. Additional controls may be needed for risks that are rated as high or extreme in order to help reduce them to an acceptable level. From the social point of view, this is a theoretical model with possible limitations if socio-economic conditions are not appropriately presented.

Table 7. The types of risk

	Low exposure/ affordable impact	High exposure/ unaffordable impact
Low likelihood	Adaptation; affordable risk	High cost of adaptation; manageable risk
High/ unknown likelihood	Adaptation; potentially expensive risk	Adaptation may not be possible; unaffordable risk

The risks can then be ranked and classified in a matrix, as shown in table 8. Once those risks are classified, decision-making can then be better informed as it moves to implementing the climate change adaptation framework.

Integrated water resources management

The IWRM collectively considers the cross-cutting goals of social, economic and environmental sustainability, and ensures that water management decisions consider the impact of each sectoral use on the other sectors. This moves the focus away from a sector-centric approach, and allows the elaboration of coherent and coordinated cross-sectoral policies. Such an approach makes IWRM a very useful tool for climate change adaptation. This is especially the case since climate change raises issues and challenges that are essentially cross-sectoral. The method has the following characteristics:

1. It depends on the shared adoption of key concepts and principles.
2. It follows an iterative approach in which decision-making is shared among the various technical departments concerned and the relevant stakeholders.
3. The method cannot be partially implemented, as shown by cases where it failed to produce results. The implementation should concern all the functions of water resources management: water allocation; pollution control; monitoring; financial management; flood and drought management; information management; basin planning; and stakeholder participation.

A. Key concepts and principles of integrated water resources management

IWRM is based on key concepts and principles. The three main concepts are:

1. Freshwater is critical to sustain life. It is a finite and vulnerable resource that is not only essential to sustain life, but is also vital for the needs of development and the protection of the environment.
    a. The amount of freshwater available within any given watershed is typically finite. The hydrological cycle only renews a fixed quantity of water per period. This quantity cannot be significantly increased by human actions without either making large expenditures of energy, as in desalination projects, or displacing the shortage to other watersheds, as in cross-basin transfers;
    b. As a resource, water is both critical for life and essential for development. Yet, water is also vulnerable to the side effects of human settlements and economic development. For this reason, any effective management of water resources needs to consider land

Table 8. Risk matrix: Risk ranking

	Impact				
Likelihood	**Negligible**	**Minor**	**Moderate**	**Significant**	**Severe**
Rare	Low	Low	Low/Medium	Medium	Medium
Unlikely	Low	Low/Medium	Low/Medium	Medium	Medium/High
Possible	Low	Low/Medium	Medium	Medium/High	Medium/High
Likely	Low	Low/Medium	Medium	Medium/High	High
Very likely	Low/Medium	Medium	Medium/High	High	High

and water use as part of a continuum, in which social and economic development behaves with the protection of natural ecosystems, while society should seek patterns of sustainable consumption.

2. Water is both an economic good and a social good, since it has an economic value for many of its competing uses.
   a. When considering the vital need for life and thus for households, water is viewed as a social good. This ensures that water allocation in those cases is designed with the aim to meeting the social goals of equity, poverty alleviation and safeguarding health. In addition, environmental security and protection are also considered;
   b. For purposes of allocation among competing economic sectors, water is viewed as an economic good. Allocation and investment decisions are then guided by the relative economic value of alternative water uses, and thus help formulate and adjust national development strategies.
3. Everyone is a stakeholder when it comes to water. This leads to a development and management practice that is based on a participatory approach, involving all concerned stakeholders in both information gathering and decision-making, users in all sectors, planners and policymakers. The objective of this participation is to:
   a. Emphasize involvement in decision-making at the earliest stages, the level where it is most feasible to bring in consultation and input from the wider possible sources of inputs;
   b. Enhance transparency and accountability in decision-making, and thus ensure wider social acceptance and thus more successful projects in terms of scale, design, operation and maintenance;
   c. Protect environmental resources and local cultural values, while ensuring that development needs are met;
   d. Improve cost recovery, a key factor in generating revenue and financing both water management activities and investment projects.

B. Overview of integrated water resources management tools

The IWRM implementation begins by considering that the interactions with any specific watershed are defined by two types of systems:

1. The biophysical system, defined by all the biological and physical parameters of the water basin, such as: climate, topography, land cover, surface water, hydrology, groundwater hydrology, soils, water quality and ecosystems;
2. The socio-economic system, defined by the stakeholders that need to store, allocate, regulate and deliver water. The action of those stakeholders can be confined to the watershed or extend beyond its boundaries.

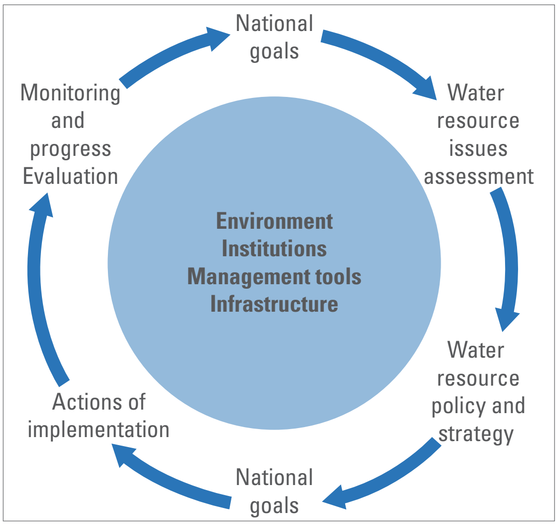
The IWRM implementation then involves managers from various sectors and stakeholders from beyond the narrow professional and managerial realm to bring in a cross-cutting perspective to water management. Rather than being centred on any given sector, the analysis focuses on a watershed and relies on an enabling environment of institutional structures and management instruments. As shown in figure 14, the implementation then promotes the coordinated development and management of water, land and related resources, and an iterative process that: (1) starts with an assessment of water resource issues that can (2) form the basis of the establishment of policies and strategies. Then, (3) an IRWM implementation plan can be developed based on those policies and strategies; and (4) can lead to implemented actions that are (5) monitored and their progress evaluated over the course of implementation.

C. Importance of integrated water resources management for adaptation to climate change

Water is the resource that is impacted the most by climate change. This is because the hydrological cycle within any watershed will be dramatically affected by the forecasted changes in precipitation, temperature, the expected increase in climate variability, and the frequency and intensity of extreme weather events.

In this context, it is an IWRM that "provides an important framework to achieve adaptation measures across socio-economic, environmental and administrative systems".[82] IWRM can promote wider acceptance and implementation of climate change adaptation measures.

Figure 14. Planning and implementation stages of the integrated water resources management



1. Climate change adaptation is dealt with through strategies that focus both on the demand and the supply side:
   a. Measures at the demand side include those that improve water use efficiency such as water recycling, expanded use of economic incentives to allocate water across economic sectors, while still ensuring that the needs of social equity are met;
   b. At the supply side, investments could be targeted depending on the forecasted climate impact, be it increases in storage capacity or changes in water abstraction methods and patterns.
2. Adaptation should be carried out across multiple sectors, since most are water-dependent in one form or another. Indeed, water resource management often has implications on many other policy areas.

D. Limitations of integrated water resources management

When properly applied, the well-established IWRM methodology can complement climate change adaptation efforts very appropriately. However, the evidence from surveys and regional assessments carried out by the World Bank[83] suggests that the implementation of IWRM has not always been effective in addressing the challenge of adaptation to climate change, especially in cases where:

1. The implementation has been piecemeal, with principles being selectively adopted and applied.
   a. There is a need for greater harmonization across the water sector, to ensure a wider implementation of IWRM. By definition, an integrated approach to water management cannot be carried out by a water agency alone. It requires the involvement of all water-dependent sectors.
2. Environmental considerations have not been traditionally linked to decisions about water allocation.
   a. Water-sector policies should be supported by environmental assessments that show "the linkages between environmental health, human health, and economic growth."[84]

This is done in coordination with the concerned agencies to ensure that there are no duplicate requirements and procedures;

b. In this respect, the implementation of IWRM remains slow at the regional and local levels in developing countries, and remains to be formalized in developed countries. In developed countries, few nations, like Germany, have adopted a formal policy of environmental management.

3. Stakeholders are not well apprised of the impacts of climate change and their extent.

   a. Public involvement in water management is essential, particularly the involvement of professional and public drivers. This is done in an environment that promotes greater inclusion of local stakeholders in decisions through public disclosure and active participation;
   b. The involvement of a third party can often help facilitate and overcome initial scepticism. This is especially necessary in cases where development has allowed water to be shared across watersheds;
   c. Women's representation is absent especially in decision-making positions at all levels;
   d. Civil society and non-governmental organizations have weak or no representation;
   e. Platforms for open dialogue are absent at the national and regional levels concerning climate change, water, agriculture and other relevant issues.

The ultimate success of IWRM implementation requires a long-term commitment. It will take years to see a measurable impact of water sector reforms. Many investments will also be needed over the course of those years, to help a basin move from a sector-based approach to an integrated approach that is best suited for climate change adaptation.

Mapping existing climate funding

The Arab region has many pressing adaptation needs in the sectors of water, energy, food security, livelihoods, health, as well as general infrastructure and human settlements. However, the climate funds active in the Arab region are far more focused on mitigation than on adaptation, through a few power generation projects. As a result, most adaptation funding in the Arab region is local.

E. Climate funds: largely focus on mitigation

As of 2014, there were 12 funds active in the Arab region; 11 multilateral funds and 1 bilateral fund (table 9):

1. Of the 11 multilateral funds, the largest contributions come from the Clean Technology Fund (CTF), and concentrated on a small number of large projects in the form of loans or concessional loans in a few countries. The CTF has approved a total of $725 million for 5 projects in Egypt and Morocco, mostly as concessional loans. In addition, the CTF's Pilot Program for Climate Resilience (PPCR) has approved $20.50 million for 2 projects.
2. The bilateral fund active in the region is Germany's International Climate Initiative, which has approved $32.46 million for 7 projects.

By 2014, there were 68 projects funded for a total of about $993 million, 84 per cent of which were for mitigation activities. Most of the funding was in the form of loans or concessional loans ($723 million). Egypt and Morocco have been granted concessional loans for large-scale wind and concentrated solar power (CSP)[85] that represent the largest share of the total approved climate finance. Such loans constitute, by far, the largest share of climate finance, and are targeted for mitigation projects in those countries.

Table 9. Multilateral funds active in the Arab region

Fund	Amount approved ($ million)	Number of projects
Adaptation for Smallholder Agriculture Programme (ASAP)	18.00	3
Adaptation Fund (AF)	19.42	3
Clean Technology Fund (CTF)	725.00	5
Global Environment Facility-Strategic Priority on Adaptation (GEF-SPA)	55.04	1
Global Environment Facility - 2006-2010 funding period (GEF4)	4.62	16
Global Environment Facility – 2011-2014 funding period (GEF5)	33.85	13
Global Climate Change Alliance (GCCA)	4.05	1
Least Developed Countries Fund (LDCF)	34.56	8
MDG Achievement Fund (MGF-F)	8.00	2
CTF Pilot Program for Climate Resilience (PPCR)	20.50	2
Special Climate Change Fund (SCCF)	38.01	7

Source: Adapted from Barnard and others, 2014.

F. National funds: Support focus on adaptation

By 2015, most of the adaptation funding in the Arab region has been largely local, with very little involvement from global climate funds. Because of the impacts of climate change on water scarcity, much of the adaptation effort in the Arab region has been focused on the water sector.

In the water sector, the available funding has been focusing on the key needs highlighted in chapter 2: (1) enhancing people's access to water and sanitation; (2) ensuring a secure water supply. Fewer funds are directly being invested in (3) maintaining the protection of vital ecosystems. The Islamic Development Bank (IDB) estimates that the water sector alone will require an estimated $200 billion over 10 years across the region just to meet the growing demand.[86]

1. Significant investments were made for enhancing people's access to water and sanitation. Some Arab countries are expanding the waste collection and water treatment, while others have yet to find the necessary funds. In Saudi Arabia, $40 billion are planned to be spent on water distribution (38 per cent), as well as sewage collection and water treatment (62 per cent).
2. The need to secure the water supply will require significant efforts to help ensure the Arab region does not continue to overuse its renewable water resources. In addition to better management practices, investments will be needed to enhance water treatment, improve infrastructure and increase supply.[87]

    a. Most necessary investments in infrastructure are focused on a key aspect of adaptation in the water sector, namely the need to expand water storage and conveyance networks to help smooth out variations in water availability;
    b. In the Gulf, domestic water supply is expected to expand fivefold by 2025 after heavy investments in desalination plants. By 2020, new funding will target desalination plants to be installed in Kuwait ($7 billion needed by 2025), Saudi Arabia ($56 billion) and the United Arab Emirates ($10 billion).

In general, most Arab countries will struggle to make the necessary investments. In theory, most funding sources to those countries are financed through grants, loans from external public donors or private sources through build-operate-transfer (BOT) projects. However, in practice, the amounts required are too high for many Arab countries to fund by themselves. As an example, Jordan's water strategy called for investing $8.24 billion over the 2009-2022 period, corresponding to more than 160 per cent of its 2013 GDP.

Without climate financing, the adaptation efforts of Arab countries are likely to be limited in scope. Between 2000 and 2010, when the water sector represented 20 per cent to 30 per cent of government expenditures in Algeria, Egypt and Yemen, the average level of investment in the region varied between 1.7 per cent and 3.6 per cent of GDP. In comparison, meeting the challenge of climate change would require sustained investment in the water sector, estimated at about 4.5 per cent of GDP.[88]

What needs to be done: Climate proofing

What needs to be done is defined by adaptation actions that take place at different levels within any country. Adaptation actions are defined by standard approaches such as climate proofing. This approach considers that adaptation takes place at three different levels "below" the national level: (1) the local level where communities strive to respond to the impacts of climate change; (2) the sectoral level; and (3) the national level of policy and planning. National adaptation strategies therefore need to be elaborate to account for both specific national intentions and local needs, while being responsive to gender perspectives.

Any climate proofing methodology needs to be based on a "climate lens" that strives to address not only the challenges posed by climate change but also any opportunities that may arise from it. The methodology is therefore based on a determination of impacts, both the biophysical impacts of climate change (determined as part of climate simulations such as RICCAR), and their associated socio-economic costs evaluated by IAMs and the VA on various sectors, over time, and across a country's geography. It is divided into two phases:

1. Identification of the appropriate level. Integrating climate change adaptation into planning may occur at different levels: national, sectoral, local and the project levels.
2. Identification of "entry points". Integrating climate change adaptation at different levels implies the need to identify appropriate entry points along the project or policy cycle. These entry points enable climate-related action to be incorporated into planning even if this had not originally been envisaged. Entry points have to be socially and culturally accepted taking gender aspects and youth participation into consideration.

The climate proofing methodology is implemented in three steps: (1) scope and preparation; (2) analysis and assessment; (3) options for action.

Step 1: Scope and preparation

The preparation phase consists of all the preliminary work necessary to ensure that key risks and opportunities are identified at the earliest possible moment, in line with national needs and sustainable development objectives. This phase aims to ask four questions:

- What are the current strategies, policies and programmes for climate change adaptation?
- What is the effect of current policies and programmes on key ecosystem services and socio-economic sectors? How is this affecting national priorities and sustainable development?

- What is the expected effect of climate change impacts on those relevant socio-economic sectors? How will this affect national priorities and sustainable development?
- Given the desired adaptation outcome, what is the scope of the current assessment?

When they undertake this phase, public sector agencies often do not have all the personnel able to undertake all the activities required for project preparation, and they often require the assistance of outside consultants or specialized agencies. It is therefore necessary that, even at this early stage, the adequate resources are secured to properly carry out this step. This will allow for more savings down the road. The expected outcome of this phase should be:

1. A "scope statement" document that (1) outlines the goals of the adaptation plan or policy; (2) describes how it fits in with Sustainable Development Goals (SDGs) and national priorities; (3) lists its expected outcomes; and (4) sets the timeline for its implementation and review period;
2. A summary "master list" of the socio-economic sectors that are expected to be impacted by climate change;
3. Summary tables of the climate change impacts and of their associated socio-economic effects, including gender issues.

Step 2: Analysis and assessment

The analysis only reviews adaptation actions in light of climate change impacts as determined by computer climate models (CMs) and of their socio-economic effects as determined by IAMs (among sectors and across time) and the VA (across the country's geography). This step asks a two-part question regarding vulnerability and risk:

- Where is the vulnerability to changes in climate? (distribution among sectors and geography, evolution over time);
- Among those vulnerable sectors or systems, what are the actual risks that need to be addressed? What are the cross-sectoral impacts?

The expected outcome of the analysis and assessment phase should be:

1. An evaluation of the vulnerability of the system.
2. An updated assessment of risks, including an updated risk matrix for the various risks (table 8) and a prioritized list of risks to use as input for identifying adaptation options.

At this stage, a "one-way" information flow is assumed. This is a valid approach for evaluation projects at scales limited to the regional, national, or local level and for limited, well-defined time frames.

Step 3: Options for action

Once the analysis is complete and the chain of events established, policymakers need to know their options for action (OA). The main question to answer is therefore:

- What are the potential adaptation options that reduce vulnerability and potentially provide new benefits in terms of socio-economic and environmental conditions?

The process has two objectives: (1) to highlight the appropriate adaptation actions; and (2) to identify any eventual opportunities that may be presented by climate change. The expected outcome of this process is a list of OAs that are prioritized according to specific possibilities: whether they promote climate change adaptation; the costs they impose, thus allowing to determine funding needs; the planning horizon; and the technical skills required for implementation.

1. National needs and priorities can help determine both the strategic relevance and economic aspects of OAs.
   a. The strategic relevance of the OA, which can highlight whether it (1) concerns severely affected and vulnerable regions or fields of action; (2) has a reliable and long-term, goal-oriented effect (i.e. risk reduction); and (3) prevents irreversible and dramatic damages;
   b. The economic aspects of the OA are determined based on (1) whether the medium- or long-term benefit of the option is greater compared to its costs (including non-monetary aspects); and (2) how efficient is the use of resources.
2. The urgency of the action that needs to be taken. This depends on whether climatic trends and impacts are already occurring or will occur in the near future, and if decisions about long-term investments and development paths are taken.
3. The OA needs to be validated with respect to any negative side effects it may have on (1) national needs and priorities, as well as on the objectives of sustainable development and biodiversity. It should be noted that not all side effects are negative, and they can be minimized.
   a. It is possible that the OA may also engender positive effects that can benefit sustainability, and thus create new opportunities. This is defined as "no regrets" because any investments the OA would have required would still generate economic benefits even if the climate change impact did not occur;
   b. In order to minimize negative side effects, the OA should offer a level of flexibility to allow it to be (1) modified, (2) further developed, or even (3) reversed if the situation changes or new conditions appear.
4. The political and social acceptance of the OA is finally determined based on a "window of opportunity", the favourable time frame for implementing it.

Box 22. "No-regret', 'low-regret' and 'win-win' adaptation actions

When undertaking adaptation actions, there is a concern that, if the adverse effects of climate change do not materialize, the money invested would have been wasted.

- No-regret actions are adaptation actions that impose no burden. They are (1) cost-effective under current conditions; (2) do not pose any additional risks; and (3) do not force trade-offs with other policy objectives;
- Low-regret adaptation actions impose only very low costs compared to the potential benefits;
- Win-win actions are achieved when adaptation actions bring in associated benefits, such as job creation or improved gender equity.

Examples of such actions in the water sector include reducing the risk of water shortages through improvements in water efficiency and in the water utility infrastructure that reduce losses caused by leakage. In the agricultural sector, the risk of flooding could be reduced through the construction of holding ditches for excess run-off, and planting of trees and shrubs to reduce run-off.

Adaptation matrix

Adaptation priorities are established by the adaptation team, through workshops to review a consolidated list of potential impacts, risks and associated adaptation actions. The focus of the adaptation matrix is the national policy level to help frame the climate proofing framework for adaptation.

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1. The matrix is established through an iterative process that progresses in stages, based on:
   a. A review of the current situation, with a discussion of the driving forces of current developments to establish the key drivers of climate change and the region/area/sector that will be affected;
   b. The drivers are then evaluated to see how they affect the national vision of the future concerning the relevant regions and the key economic sectors under consideration. This does not necessarily rely on specific considerations of climate change, but is mostly informed by the stakeholders' knowledge and experience of the region or sector under consideration.
2. The established vision is challenged with boundary conditions. Those are obtained from forecasts on the evolution of the climate change impacts obtained from computer climate modelling work such as RICCAR, as well as on the related effects of socio-economic systems obtained from either IAMs or VAs. This is done to:
   a. Test the vision of the future against the forecasts and thus establish specific, credible scenarios;
   b. Develop impact chains for each of the selected climate futures or scenarios.
3. As part of brainstorming, participants move to identify, review and evaluate impacts and adaptation options. Under the constraints presented by the boundary conditions, they will consider horizons associated with computer climate modelling efforts such as RICCAR, a short-term planning horizon for the next 15 to 20 years (up to 2030) or a medium- to long-term planning (2050 to 2100). Participants work on:
   a. Refining the various impact chains;
   b. Developing recommended adaptation options, both "hard" and "soft".
4. The development of adaptation pathways can then proceed. Based on the various adaptation options identified, a series of actions that are deemed crucial to enhance future adaptive capacity for each of the scenarios will constitute an "adaptation matrix". The actions in the adaptation matrix are then ranked in order of importance and associated actions such as "must do", "monitor" or "investigate further".
   a. Actions marked "must do" would be further prioritized for implementation;
   b. Those marked as "monitor" can wait to be implemented till a certain threshold of climate change is reached;

c. Actions for which there is no clear cost/benefit rational, are classified as "investigate further", and need more consideration till a decision is taken.

The result of this process is a summary table that lists the various adaptation options. Within each category, adaptation options can be classified according to priority (table 10).

Table 10. Sample adaptation action evaluation criteria

Category	Criteria	Priority		
		Low	Medium	High
Sustainability	Mitigation co-benefits	Decreased GHG emission	No change to GHG emission	Increased GHG emission
	Water security	Increased waste	No effect on usage	Reduced water waste
	Food security	New crops	Reforestation	Reduced land degradation
	Energy security	-	-	-
	Equity	Benefits few	Benefits many	Significant benefits to many
	Implementation cost (relative to cost of inaction)	High	Moderate	Low
Effectiveness	Robustness	Effective for a narrow range of plausible futures	Effective across many plausible futures	Effective across a wide range of plausible futures
Risk and uncertainty	Urgency	Impact likelihood: longer term	Impact likelihood: near to medium term	Impact already occurring
Opportunity	Ancillary benefits (contribution to the national strategy)	None or little	Some	Significant
	Regret/ No regret	None or little benefit	Some benefit	Significant benefit
	Window of opportunity for implementation	Not currently	Could be created	Exists
Implementation	Funding sources	External funding sources required but not identified	External funding sources required and likely to be secured	Funding is externally or internally available
	Institutional	Requires coordination with/action by other jurisdictions	Requires external approval	Within local control

Adaptation plans

In elaborating adaptation plans, policymakers can follow best practices and learn from existing adaptation plans. However, governance remains a key issue as the best adaptation plans can do little in the absence of appropriate structures.

Best practices

Adaptation plans need to be built around the national vision for development. To this end, it is best that the implementation of plans be managed by a permanent team or taskforce for climate change adaptation. This team would facilitate regular training in a way that leverages local knowledge and ensure that adaptation plans are developed in a way that takes into account climate change mitigation and structured in such a way as to allow for matching grants or joint funding.

1. Set up and maintain a permanent climate change “adaptation team” to coordinate the integration of climate change adaptation into planning. Ideally, the team would work as part of a coherent “national vision” on the future of energy. The team would be tasked with responding to both types of adaptation: (1) reactive or autonomous responses, which are related to disaster response occurring after the impacts of climate change have become evident, and (2) anticipatory responses, which are planned and take place before impacts are apparent.
   a. For both types of adaptation responses, the team would be structured so as to work not only at the national and sectoral levels but also at the local level in order to best benefit from local knowledge and skills;
   b. In order to ensure the sustainability of planned anticipatory response solutions, the adaptation team would need to cultivate and maintain stakeholder engagement;
   c. Local implementation of measures should be monitored for both planned adaptation and emergency response to ensure that they are compatible with IWRM. In addition, cost-benefit analyses need to be carried out and local best practices need to be refined based on the results obtained.

2. The adaptation team would facilitate regular training, capacity building and information dissemination in a way that benefits from local knowledge. This is done in a way to:
   a. Facilitate the “trickle-up” of local knowledge, by implicating people “in the field” in the development of solutions and the preparation of reports;
   b. Regularly review the actual impacts of climate change and the effect of related decisions and policies on people’s responses to change, on changes in foreign direct investment and trade, on operation and maintenance needs, on business competitiveness, etc.;
   c. Publish regular reports and guidance documents for implementation and integrate local coping strategies with adaptation databases such as the UNFCCC.[89]

3. Avoid “silver bullets”. Adaptation to climate change will come from a variety of solutions and not a single solution. This has a technical and a managerial aspect:
   a. Technically, this requires the use of multiple solutions for power production, avoiding reliance on a single source. This was demonstrated by the case of countries with overreliance on hydropower, a source of energy that is also vulnerable to changes of rainfall due to climate change;
   b. From a management perspective, it is vital to maintain focus on all three key aspects of IWRM, namely social equity, economic efficiency and ecological sustainability. This will ensure that the solutions chosen are sustainable, as they would promote coordinated development and management of resources that take into account both the needs of livelihoods and the services ecosystems can provide.

Riff mountain barrier. © Mauro Rodrigues - Fotolia 131606006

4. Try to optimize resources by focusing on policies that also aim to enhance sound environmental management, social progress and efficient resource utilization. This will best allow adaptation efforts to be effective in "reducing both present and future risks related to climate variability and extremes,"[90] as well as optimize resource utilization and minimize risks. Therefore, policies need to:
   a. Build on any current actions that were already undertaken to cope with the current climate variability and the increase in extreme events;
   b. Take into account relevant forecasts of climate evolution to establish the exposure for each sector and thus develop a picture of the current state of vulnerability, and how it will evolve over time.
5. Link adaptation plans to climate change mitigation in a way that mitigation is a "co-benefit" of adaptation by ensuring proper coordination between NAPAs and Intended Nationally Determined Contributions (INDCs). This is a strategic necessity for the purposes of development planning, because of the cross-cutting implications of climate change adaptation:
   a. This is supported by the recognition by the 2015 Paris Agreement of the need to prioritize "the ability to adapt to the adverse impacts of climate change and foster climate resilience[, in addition to pursuing] low greenhouse gas emissions development[, and to do so] in a manner that does not threaten food production";[91]
   b. This would be particularly essential in case any future binding agreement is reached. This was not the case by 2015, as the 2015 Paris Agreement did not mandate that INDCs be made into hard "commitments".
      - However, the issue may still be raised in a later agreement, as there are many factors that may lead to it. This is especially the case since the Paris Outcome called for "pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels",[92] which would require significantly more effort than its other goal of "holding the increase in the global average temperature to well below 2°C above pre-industrial levels";[93]
      - There may be informal, long-term implications that stem from a binding commitment in article 4 to report on the individual mitigation targets every five years. This is further supported by a transparency provision in article 13. Those two requirements could place pressure on many developing countries, as they may lack adequate capacity to effectively meet this commitment while they still struggle to pursue economic development.
   c. An added benefit of coordination between NAPAs and INDCs is that it will guide the investment in any "green infrastructure" and ensure that projects are properly targeted;
   d. This would facilitate funding, as many adaptation actions still have mitigation benefits, and there appear to be more funds available for mitigation actions. This is likely to be the case in the future, as the current consensus that emerged from the Paris Agreement called for "finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development".[94]

6. Structure bilaterally funded projects with a "matching grant" structure in which the recipient country provides its share "in kind" i.e. in land, manpower, forested areas, etc. Early evidence suggests that such plans are "already providing capacity building for adaptation".[95] However, the evidence presented remains subjective, and more comprehensive economic analysis is needed:
   a. This approach would have the added benefit that it would empower local communities. This will best leverage local skills and knowledge;
   b. An updated "map of funding" should be established and maintained to ensure continuous tracking of the available means of finance.

Box 23. The Paris Agreement and "loss and damage"

The term "loss and damage" denotes those climate change impacts that occur, in spite of mitigation or adaptation efforts, as a result of either extreme events (droughts, hurricanes, etc.) or long-term climatic changes (temperature increase, sea level rise, etc.).

The consensus that led to the "Paris Outcome" was made possible by a compromise on the "loss and damage" mechanism. While the Agreement states that "parties recognize the importance of averting, minimizing and addressing loss and damage associated with the adverse effects of climate change,"[a] it also "agrees that article 8 of the Agreement does not involve or provide a basis for any liability or compensation."[b]

[a] UNFCCC, 2015, Adoption of the Agreement, No. 59, p. 8.
[b] UNFCCC, 2015, Article 2, No. 1.a, p. 22.

Targets of adaptation plans

As part of the UNFCCC process, countries identify their immediate priorities for adaptation options and document them as part of the NAPA. From those collected NAPAs, the UNFCCC identified 27 key priority areas for adaptation,[96] some of which are relevant for Arab countries:

1. Enhanced forecasting for farming, as well as for extreme events (disaster management);
2. Improved tools for water management, including storage, rainwater harvesting, and irrigation techniques;
3. Food security through (1) crop diversification, the introduction of crops that are more tolerant of drought, flood and land salinity; (2) improved livestock and fisheries breeding and farming techniques; (3) local food banks for people and livestock;
4. Better land and land use management through: (1) erosion control and soil conservation measures; (2) better forestry techniques, especially for wood and charcoal production; (3) sustainable town planning;
5. Coastal zone management, including coral monitoring (Red Sea and coastal areas along the Arabian Peninsula) and enhanced coastal defences.
6. Capacity building to integrate climate change into sectoral development plans, involving local communities in adaptation activities.

The main sectoral adaptation options and responses highlighted the diverse range of practices that can be used to adapt to climate change and include both reactive and anticipatory responses (table 11).

Table 11. Adaptation measures in key vulnerable sectors

	Anticipatory adaptation	Reactive adaptation
Water resources	• Protection of groundwater resources • Improved management and maintenance • Protection of water catchment areas • Desalination • Rainwater harvesting	• Better use of recycled water • Conservation of water catchment areas • Water policy reform • Flood controls and drought monitoring
Agriculture and food security	• Erosion control • Dam construction for irrigation • Introduction of new crops • Crop management • Soil fertility maintenance • Seed banks	• Development of crops tolerant/ resistant to drought, salt and insects/ pests • Soil-water management • Early warning systems for extreme events
Human health	• Public health management • Improved housing and living conditions	• Early warning system and emergency response • Disease/vector surveillance and monitoring • Enhanced environmental quality
Human settlements	• Zoning	• Flood control
Terrestrial ecosystems	• Control of deforestation, reforestation and afforestation • Agroforestry to improve forest goods and services • National forest fire management plans	• Parks/reserves, protected areas and biodiversity corridors • Identification/development of climate change resistant species • Development and maintenance of seed banks
Coastal zones and marine ecosystems	• Protection and conservation of coral reefs and littoral vegetation • Protection of economic infrastructure • Measures for coastal erosion control and protection	• Integrated coastal zone management • Research and monitoring

Source: UNFCCC, 2007, Table V-5, p. 3.

Governance

Governance is the essential enabler of adaptation to climate change. Good governance needs to rely on formal rules and procedures to allow for (1) the evaluation of the necessary decisions in light of national needs and vision, and (2) for their implementation over time and across the various economic sectors.

1. The evaluation of necessary decisions requires governance that can take on board new knowledge. Because of the ever evolving nature of adaptation needs, this requires transparency of information in a participatory environment.

   a. Transparency can be enhanced by formal reporting requirements and mandated scrutiny by local stakeholders;
   b. A participatory environment would ensure that adaptation measures apply to local needs and conditions.
2. The implementation of adaptation measures needs to be carried out with a long-term outlook, in which governance would need to allocate resources among various sectors, mediate among stakeholders, and create and maintain key relationships.
   a. A participatory environment is vital to strengthen national strategies, as it would allow for "bottom-up" input that incorporates local knowledge and experience, and thus enhances their effectiveness and applicability.

Box 24. Participation is more than consultation

Participation means that stakeholders at all levels of the social structure have an impact on decisions at the different levels of management. This means that:

- Consultative mechanisms should be designed to allow stakeholders to participate in the decision-making, and to question and potentially change previous decisions;
- Stakeholder meetings should not necessarily focus on consensus. Provisions should be made to have in place conflict resolution mechanisms such as arbitration;
- Participatory capacity should be created and nurtured, particularly seeking out marginalized groups. This extends beyond simple awareness raising, confidence building and education, to the establishment of reliable information channels and the provision of the necessary resources to facilitate participation.

In many parts of the Arab countries, where traditional structures of local coordination remain in place, they can be effectively leveraged towards ensuring a good implementation of adaptation measures. By providing local knowledge, they can effectively complement and support the work of central institutions. However, this still requires (1) the necessary transparency and accountability, with (2) institutions that have managerial competence and technical capacity (3) that foster an environment of reliability and predictability of the rule of law.

1. Institutions should implement recognized standards of transparency and accountability because climate change adaptation funds are derived from a variety of sources, from the private sector to national and global funding entities. At the global level, this will ensure that national interests are well equitably represented in climate funding decisions. Contrary to traditional ODA delivery mechanisms, climate funds need to be governed based on equitable representation. This requires that all participants "talk" the same language and have comparable technical capacities.
   a. Securing transparency in the administration of public climate funding will ensure that information is publicly available regarding both a mechanism's funding structure, its financial data, the structure of its board, its decision-making process and details on any actual funding decisions and disbursements that are made, as well as on the implementation results. This information is to be made in an accurate and timely fashion;
   b. Accountability would be strengthened by ensuring broad stakeholder participation and representation in the administration of climate funding. This requires the existence of mechanisms and institutions that ensure both procedural rights for males and females to challenge climate funding decisions or climate finance project implementation and clear oversight to document decisions and their results.

2. The need is not merely to ensure technical and managerial competence but also to maintain it. This is particularly critical in the context of climate change, where new skills need to complement past experiences as new knowledge develops and rapid changes occur. Having skilled staff is not sufficient and institutions need to:
   a. Be structured in such a way as to make good use of these skills:
      - In cases where the main issue is delayed action and slow decision-making, this is done by avoiding excessive centralization and by providing managers and staff with more autonomy on operational issues. In return, they have more accountability for performance, with an evaluation system that focuses more on measurable achievable results;
      - However, in cases where delayed action is caused by a lack of reliability and organizational discipline, the focus would be on strengthening the basic management systems of government. To a certain extent, this may bring in increased bureaucratization to both ensure processes are followed and document reasons for delays at all levels of the organization.

   b. Link career advancement to a programme of continuous education and training. It is also necessary for this on-going capacity-building activity to include local stakeholders (males and females) whenever possible to better facilitate future cooperation and implementation of adaptation actions.
3. Any successful implementation will depend on the reliability and predictability of the rule of law. This does not necessarily mean that more detailed and specific regulations are needed; indeed, excessive specifications can even be counter-productive. What is needed is a measure of balancing between:
   a. Discretion to ensure a flexible and speedy application of new rules and regulation; and
   b. Administrative procedures and external oversight for the speedy review and appeal of decisions and accountability (appeal mechanisms, judicial review, ombudsmen, etc.).

Furthermore, there should be participation and involvement of government, private sector and civil society in the formulation of laws, which should embody gender perspectives.

CH. 5

Applications

Applications

Climate proofing for adaptation

The climate proofing methodology is implemented in three steps: (1) scope and preparation; (2) analysis and assessment; (3) options for action. At each step in this framework process, it is important to ensure the involvement of the adaptation management team and to ascertain whether it has the appropriate individuals, technical capabilities and resources.

Step 1: Scope and preparation

This phase is both technical and financial in nature and is divided in two broad phases: the initiation phase is to ensure that the climate proofing methodology is applicable in the case considered; then, the technical preparation phase is to define specific preparation activities that need to be undertaken and ensure that risks are well understood, objectives are well outlined, expected outcomes are clearly defined, and resources are optimally utilized and appropriately allocated. Typical preparation activities are shown in table 12.

Table 12. Typical preparation activities

Initiation phase	
Key question	**Example**
Do climatic trends, such as increasing temperatures or sea level rise, potentially have an impact on planning? If so, specify.	Low impact Medium impact
Is the time horizon of the planning relevant to these climatic trends?	Short-term planning horizon: high relevance Long-term planning horizon: medium relevance
Does the planning refer to elements (exposure units) that are particularly affected by climate change?	Sectors, policy aspects, geographic area, specific target group in agriculture; energy production policy; coastal zones; dry land regions; mountain regions; fishermen
Technical preparation objective	
Main objective	**Example**
Identification of trends	Current and future climatic trends (temperature, precipitation, sea level); socio-economic trends
Vision and objectives of national sustainable development strategies	Overall objectives; expected outcomes with well defined metrics

Technical preparation objective	
Main objective	**Example**
Overall assessment to determine the impact of climate change on SDGs: • The ways in which SDGs can be affected by climate change • The areas and sectors most at risk • Identification and consultation of stakeholders	• "Increase and diversify agricultural production and rural incomes in rural areas" • "Rain-fed agricultural production depends on predictable crop yields that are affected by temperature and rainfall, and this will have a negative effect on rural incomes" • At the national (agencies) and local (private sector) levels
Funding availability and sources	
Concept validation and design	Project concept development; suitability of the policies considered; and preliminary design or outline
Cost and capital estimates	Including operational costs

Source: Adapted from GIZ, 2011, p. 14.

Step 2: Analysis and assessment

The analysis is based on the concept of a "chain of events". For each exposed sector or geographic area, a "probable chain of effects for climate change" is established, considering both the biophysical and the socio-economic effects of climate change.

1. The biophysical impacts that relate to physical phenomena resulting from climate change, based on the data obtained from computer CMs. This evaluation determines:
   a. What the available data is and from what sources;
   b. What the data "says" i.e. what the available interpretations for the data are. Example: "RICCAR projections show a hotter, longer dry season and wetter, shorter rainy season";
   c. What other data sources are needed to devise adaptation strategies and how they can be obtained.
2. The socio-economic effects that relate to economic phenomena can be either:
   a. Caused by the biophysical effect. Example: "In rural areas, decreased productivity of rain-fed agriculture because of the hotter and longer dry seasons and the increased risk of flooding during wetter and shorter rainy seasons"; or
   b. The direct result of the climatic trend. Example: "In rural areas, income decreases due to lower rain-fed agricultural productivity and damages and expenses increase due to more frequent and intense flooding".

For each element in the chain of events, the relevance of the biophysical and socio-economic effects needs to be ascertained. This relevance is assessed with regards to the probability of the effects occurring; their impact on project objectives; and the ability of institutions and groups to adapt to changes without external support.

Step 3: Options for action

The OAs are prioritized according to the specific possibilities and scored depending on four main criteria (table 13).

Table 13. Options for action and selection criteria

Criteria	Scores for selected OA (1-5) based on:			
	National needs	Urgency	Side effects	Acceptance
Do the benefits from these OAs promote climate change adaptation?				
Compared to the benefits, are the additional costs reasonable?				
Taking into account the costs and benefits, are the required funds available to implement this option? If not, is additional funding available?				
Would the benefits of this option for action also occur in the long term?				
Is the planning horizon for the option for action in line with the planning horizon for the climatic trends?				
Do the required technical skills to implement the option for action exist? If not, which skills have to be acquired?				

Source: Adapted from GIZ, 2011, p. 18.

Endnotes and References >>>

Endnotes

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2 UNFCCC, 2007, p. 24.
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4 Hsiang, Meng and Cane, 2011.
5 Dell and others, 2008.
6 Mendelsohn and others, 2000; Nordhaus and Boyer, 2000; and Tol, 2002.
7 Stern, 2007.
8 IMF, 2008, pp. 136-7.
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17 Ibid.
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Annex >>>

Annex

Exercises: Climate proofing for adaptation

For the purposes of these exercises, the case is based on real case histories that have been modified and "fictionalized" to help address a diversity of issues and to minimize any preconceptions or prior assumptions.

The case is presented in a manner that will allow it to be used either for self-learning, or as part of a training programme for adaptation practitioners. It is designed based on the "Harvard case methodology" for practice-oriented, interactive learning, and is designed so that the "message" of the case is not directly "explained" in order not to "box in" readers or trainees within any specific conclusion and to let them draw upon their own experience.

A. Case description

The case presented here is that of a "coastal province". It is a low-lying coastal alluvial plain with at least half of its area below 2 m mean sea level. Winters tend to be humid, with irregular rainfall and storms, and summers are hot and dry.

- The issue: It is feared that climate change will not only endanger efforts to alleviate poverty but also exacerbate this problem. Those likely consequences are not yet reflected in public planning;
- The need: is to increase adaptive capacity in the province by integrating climate change issues into livelihood enhancement and community development planning.

The regional characteristics are as follows:

1. Climate change: The region is particularly vulnerable to climate change, particularly sea level rise and the related seawater intrusion and storm surges as well as an increasing frequency of extreme weather events such as flooding.
2. Biodiversity: The region is one of the 8 main "Vavilov centers" of biodiversity, where the wild relatives of most of the world's domesticated plants originated, together with sites recognized as UNESCO World Natural Heritage. However, it increasingly suffers from ongoing land degradation and its ecosystems endure illegal/unregulated hunting and fishing.
3. Socio-economic:
    a. Food security is an important consideration throughout the region. There has been a general improvement in various indicators of hunger or child malnutrition. Livelihoods in the region generally rely on a mix of subsistence farming and commercial activity;
    b. Households supplement their incomes through other employment in small industry around the region and in support of the growing infrastructure development;

    c. Local managers have strong practical knowledge and experience, but not much theoretical know-how regarding climate change.
4. Development: The region's natural landscape has been largely transformed for agriculture and fisheries.
    a. The national strategy is to enable this transition towards more commercial activity. The expansion of infrastructure in the region is supposed to help support this transition. Since the 1960s, the population has increasing access to education through adequate schooling and basic healthcare through dispensaries and a couple of hospitals;
    b. Energy in the region is generally supplied through the grid, and power comes episodically. Technically, there is the potential for renewable energy sources (solar and wind), but there is little local financing for the necessary investments;
    c. Since the 1960s, the ecological transformation of the region has accelerated due to rapid population growth and large-scale infrastructure development. There is some small-scale commercial activity in the region and still very few bank branches;
    d. Water is supplied through groundwater and some surface water. Groundwater is increasingly threatened by issues related to population growth (over-pumping and contamination).

The climate proofing methodology is implemented here in three exercises: (1) scope and preparation; (2) analysis and assessment; (3) options for action.

B. Exercises

Exercise 1: Scope and preparation

This phase is both technical and financial in nature and is divided in two broad phases: the initiation phase to ensure that the climate proofing methodology is applicable in the case considered, and the technical preparation.

1. Initiation phase:
    a. Do climatic trends, such as increasing temperatures or sea level rise, potentially have an impact on planning? If so, specify.
    b. Is the time horizon of the planning relevant to these climatic trends?
    c. Does the planning refer to elements (exposure units), which are particularly affected by climate change?
2. Technical preparation phase is to define specific preparation activities that need to be undertaken:
    a. Are risks well understood?
        - What are the current climatic trends?
        - What is the impact of climate change on SDGs at the local level? How can SDGs be affected by climate change?
        - What are the areas and sectors that are most at risk?
        - Identification and consultation of stakeholders
    b. Are the objectives of the intervention well outlined? What are the expected outcomes?
    c. What are the available resources?

Exercise 2: Analysis and assessment

Base your analysis on the concept of a "chain of events". For each exposed sector or geographic area, establish a "probable chains of effects for climate change", considering both the biophysical and socio-economic effects of climate change:

1. The biophysical impacts that relate to physical phenomena resulting from climate change:
    a. This only needs to be based on the data obtained from computer CMs.
2. The socio-economic effects that relate to economic phenomena. In this context, what is the impact on livelihoods? How will this affect the transition to more commercial activities? And what are the risks that result from this? Those effects can be either related to the biophysical effect or the direct result of the climatic trends.

For each element in the chain of events, how relevant are those biophysical and socio-economic effects?

1. What is the probability of the effects occurring?
2. What is the impact of effects on the project objectives?
3. What is the ability of institutions and groups to adapt to changes without external support?

Exercise 3: Adaptation matrix

Adaptation priorities are established in teamwork. The matrix is built as a list of potential impacts, risks and their associated adaptation actions. In this case, the focus of the adaptation matrix is the national policy level following three steps:

Table 1. Options for action and selection criteria (OA)

Criteria	Scores for selected OA (1-5) based on:			
	National needs	Urgency	Side effects	Acceptance
Do the benefits from this OA promote climate change adaptation?				
Compared to the benefits, are the additional costs reasonable?				
Taking into account the costs and benefits, are the required funds available to implement this option?				
Would the benefits of this option for action also occur in the long term?				
Is the planning horizon for the option for action in line with the planning horizon for the climatic trends?				
Do the required technical skills to implement the option for action exist?				

1. First, list the possible "options for action" to secure the main objective; ensure sustainable livelihoods and help enhance viable long-term economic activity in the region.
2. Second, "grade" each one of those options in the table "options for action and selection".

Third, list the options for action in the order of importance. They can also be listed in a table, such as the one titled "adaptation actions and measures".

Table 2. Adaptation actions and measures

Adaptation category	Adaptation	Adaptation action		
		Low priority	Medium priority	High priority
Sustainability	Mitigation co-benefits			
	Water security			
	Food security			
	Energy security			
	Equity			
	Implementation cost (relative to cost of inaction)			
Effectiveness	Robustness			
Risk and uncertainty	Urgency			
Opportunity	Ancillary benefits (Based on contribution to national strategy)			
	Regret/ No regret			
	Window of opportunity to implementation			
Implementation	Funding sources			
	Institutional			

C. One set of solutions

Exercise 1: Scope and preparation

This phase is both technical and financial in nature and is divided in two broad phases: the initiation phase to ensure that the climate proofing methodology is applicable in the case considered, and the technical preparation. The necessary preparation activities are summarized in the following table.

Table 3. Typical preparation activities

Initiation phase	
Key question	**Example**
Do climatic trends, such as increasing temperatures or sea level rise, potentially have an impact on planning? If so, specify.	High impact due to sensitivity of the region to temperature increases and vulnerability to seawater intrusion.
Is the time horizon of planning relevant to these climatic trends?	All the long-term plans will have an effect on the short-term, because of the need to ensure livelihoods and secure food security.
Does planning refer to elements (exposure units), which are particularly affected by climate change?	• Need for subsistence agriculture, the demands of commercial agriculture; • Implementation of measures to maintain biodiversity; • Region-wide approach to deal with seawater intrusion and confront flooding and storm surges.
Technical preparation objective	
Main objective	**Example**
Identification of trends	• Increasing surface temperatures; • A higher risk of extreme weather events such as droughts; • Increase in seawater intrusion and storm surges.
Vision and objectives of national sustainable development strategies	• Infrastructure expansion and local experienced managers; • Household livelihoods balanced between input from subsistence agriculture and income from commercial agriculture and other revenue streams; • Measurable enhancement in biodiversity; • Clear plans (including for infrastructure) to confront seawater intrusion, flooding and storm surges.
Overall assessment to determine the impact of climate change on SDGs: 1. The ways in which SDGs can be affected by climate change. 2. The areas and sectors that are most at risk. 3. Identification and consultation of stakeholders.	
Funding availability and sources	• Local manpower and skills, experienced managers; • Local funding not available but there is funding for infrastructure expansion in the region.
Concept validation and design	
Cost and capital estimates	

Exercise 2: Analysis and assessment

The analysis is based on the concept of a "chain of events". For each exposed sector or geographic area, a "probable chains of effects for climate change" is established, considering both the biophysical and socio-economic effects of climate change:

1. The biophysical impacts that relate to physical phenomena resulting from climate change, based on the data obtained from computer CMs:
   a. The coastal province's expected to experience an increase of temperature between 1.5°C and 2°C in the run-up to 2050, in addition to an increase in the frequency of natural disasters and their intensity, especially heavy/cyclonic storms, floods and droughts.
2. The socio-economic effects that relate to economic phenomena, and can be either:
   a. caused by the biophysical effect:
      - Livelihoods have generally diversified "portfolios" where, in addition to their main occupation, households engage in a range of activities to supplement their needs. This can be both a risk and as advantage;
        - On the one hand, when there is a shift in the productivity of one sector, households can offset with production in other sectors;
        - On the other hand, climate change may simultaneously affect many sectors, leaving them with few alternatives. For this reason, marketed foods remain important to subsistence-based households that, in all cases, still engage in some commercial activity and are, therefore, vulnerable to either price shifts or external food shortages.
      - The transition to commercial agriculture may fail to enhance livelihoods of the poor in particular. The risk to livelihoods stems from:
        - Loss of access to "commons" where they previously collected non-timber forest products;
        - A transition from subsistence to contract-based farming may be disadvantageous to the rural poor, especially in areas where there is no strong land tenure or secure water rights;
        - Some may lack the skills to adapt, particularly in areas with poor access to public services;
        - Price risk will be a particular challenge, particularly if there is no way to "shield" small-holder commercial farmers from swings in international commodity markets. This will particularly affect low income households, especially due to the added volatility of "input" prices such as fertilizer cost.
   b. Or the direct result of the climatic trend:
      - The food security of most households in the region depends on natural systems and the environment goods and services they provide, but not in the same manner for all. For this reason, the progress shown in the region's development may be misleading. Indeed, if we consider data that suggests a general improvement in various indicators such as hunger or child malnutrition, those are generally aggregate numbers. They tend to obscure important differences in food insecurity amongst different groups or areas. Indeed, there are differences in either (1) livelihood activities within the region, or (2) the types of returns they get from the same activity. Different households in the same region may therefore fare differently under the same impact of climate change;
      - Climate change may exacerbate the environmental problems related to the transition to commercial farming. Commercial agriculture already leads to an increase in the use of fertilizers and pesticides, more intensive land use, and clearance of forests, shrubs and marshes, the "commons" on which the poor depend for environmental goods and services.

For each element in the chain of events, the relevance of biophysical and socio-economic effects needs to be ascertained. This relevance is assessed with regards to the (1) probability of effects occurring; (2) the impact of effects on project objectives; and (3) the ability of institutions and groups to adapt to the changes without external support.

1. Probability of effects occurring:
   a. Already, during the last 50 years, the annual average surface temperature has increased by approximately 0.5°C - 0.7°C, while the sea level along the coastline has risen by approximately 20 cm. Climate change has already resulted in more severe and/or frequent occurrences of natural disasters, especially heavy/cyclonic storms, floods and droughts.
2. Impact of effects on project objectives:
   a. In spite of a reasonable inventory of climate data on the region, there is a need for better information on existing impacts at the local level and on the local population's perceptions of those trends.
3. Ability of institutions and groups to adapt to changes without external support.
   a. The region shows good numbers in various indicators of human wellbeing, such as decreasing hunger or child malnutrition. However, numbers should be taken with caution because they are generally aggregate and tend to obscure important differences in food insecurity amongst different groups or areas. Indeed, there are differences in either livelihood activities within the region or the types of returns they get from the same activity. As a result, different households in the same region may fare differently under the same impact of climate change.

Exercise 3: Options for action for adaptation matrix

The matrix is built as a list of potential impacts, risks and their associated adaptation actions to focus on the national policy level. It can be done in three steps:

1. First, the possible "options for action" (OA) to ensure sustainable livelihoods and help enhance viable long-term economic activity in the region. The OAs leverage the fact that there is a strong local experience and skills in management and a national priority to enhance the region's infrastructure. Those OAs are: minimize pesticide usage (OA1); improve management of solid waste (OA2) and wastewater (OA3); manage groundwater (OA4); introduce new crops (OA5); and create a fund to help "buffer" market fluctuations (OA6).
   a. OA1: Minimize pesticide usage to help mitigate adverse impacts on biodiversity and minimize risks of water pollution;
   b. Improve management of solid waste (OA2) and wastewater (OA3), this has two objectives: help reduce waste and minimize groundwater contamination:
      - Reduced water waste will help minimize the risk of over-pumping of the groundwater;
      - Cleaner water will help mitigate the risk of contamination of the groundwater, especially since the expansion of commercial agriculture could bring about greater risks of fertilizer pollution;
      - A further benefit is to help mitigate adverse impacts on biodiversity by preempting the effect of fertilizer runoffs on the seashore and the related fisheries.
   c. OA4: Manage groundwater, with a focus to minimize the risks of overdrawing the aquifer and the increased risk of seawater intrusion;
   d. OA5: Introduce new crops may also be necessary in order to address the shifts in

growing areas and patterns. An additional focus would be to help with reforestation and to help reduce land degradation;

e. OA6: Economic measures are needed to help secure commercial farming activity, such as mechanisms or funds to help "buffer" the swings in commodity prices due to either market forces or climate effects. Those measures need to be effective across a wide range of possible scenarios and may require funding from outside the region.

2. Second, each one of those options are "graded" in the table "options for action and selection". The measures listed above are labelled in the table as follows:
   a. OA1: Develop measures to locally manage and minimize pesticide usage for commercial farming activities;
      - This is a policy that can be rapidly adapted, with few economic side-effects because commercial farming activity is still at its beginnings in the region. It would have wide acceptance if it is locally implemented and managed, and therefore may require some level of capacity building on pesticide management and pest control;
      - The policy will help promote climate change adaptation by preempting an additional stressor to the ecosystem;
      - Since it is implemented at such an early stage, compared to the benefits, any additional costs that it would impose, if any, are likely to be very reasonable. Furthermore, its benefits would likely accrue for the long term, and its planning horizon would be in line with the expected horizon of climatic trends?

Table 4. OA1: Minimize pesticide usage

Criteria	Scores for selected OA (1-5) based on:			
	National needs	Urgency	Side effects	Acceptance
Do the benefits from this OA promote climate change adaptation?	Yes	5	-	5
Compared to the benefits, are the additional costs reasonable?	Yes	5	-	5
Taking into account the costs and benefits, are the required funds available to implement this option?	Yes	4	-	4
Would the benefits of this option for action also occur in the long term?	Yes	5	-	5
Is the planning horizon for the option for action in line with the planning horizon for the climatic trends?	Yes	5	-	5
Do the required technical skills to implement the option for action exist?	No	5	-	4

b. OA2: Management of solid waste will have two main benefits: it will positively impact the quality of the water table and create opportunities for other applications such as fertilizer substitution or the use of biofuels;
   - This measure, if applied early enough and before the expansion of commercial farming, may prove more cost-effective to implement, will generate more acceptance, and would have long-term and lasting benefits;
   - The successful implementation of this measure would require training in two key aspects: technical training in the skills needed to implement it, in a way that takes into account local knowledge and experience; and management training to ensure that the implementation is properly coordinated.

Table 5. OA2: Solid waste management

Criteria	Scores for selected OA (1-5) based on:			
	National needs	Urgency	Side effects	Acceptance
Do the benefits from this OA promote climate change adaptation?	Yes	5	Food contamination	5
Compared to the benefits, are the additional costs reasonable?	Yes	5	Initial cost	3
Taking into account the costs and benefits, are the required funds available to implement this option?	No	3	-	3
Would the benefits of this option for action also occur in the long term?	Yes	5	-	5
Is the planning horizon for the option for action in line with the planning horizon for the climatic trends?	Yes	5	-	5
Do the required technical skills to implement the option for action exist?	No	4	-	3

c. OA3: Management of liquid waste and wastewater will be essential to help minimize groundwater contamination;
    - An added benefit is that, provided the treatment is appropriate, properly treated and even partially treated water can be used for aquifer recharge. In this case, this would have another benefit, it would help preempt seawater intrusion by minimizing aquifer drawdown;
    - The successful implementation of this measure would require training for regional managers on both the technical requirements to implement it and the management aspect, potentially as part of IWRM.

Table 6. OA3: Liquid waste management

Criteria	Scores for selected OA (1-5) based on:			
	National needs	Urgency	Side effects	Acceptance
Do the benefits from this OA promote climate change adaptation?	Yes	5	-	5
Compared to the benefits, are the additional costs reasonable?	Yes	5	Initial cost	3
Taking into account the costs and benefits, are the required funds available to implement this option?	No	3	-	3
Would the benefits of this option for action also occur in the long term?	Yes	5	-	5
Is the planning horizon for the option for action in line with the planning horizon for the climatic trends?	Yes	5	-	5
Do the required technical skills to implement the option for action exist?	No	4	-	3

d. OA4: The management of groundwater is essential to promote climate change adaptation. At the very least, it would be achieved through simple measures such as local well licensing and monitoring;
   - With proper training in IWRM and local acceptance and management "buy-in", the additional costs would be minimized and the measure could be implemented with local funds;
   - Here as well, the sooner the measure is implemented, the lower the costs, and the better the long-term results. It would also allow for a detailed monitoring of seawater intrusion along the coast, which would help find a long-term resolution to this issue;
   - For optimal results, this measure needs to be implemented together with OA3, the management of wastewater.

Table 7. OA4: Groundwater management

Criteria	Scores for selected OA (1-5) based on:			
	National needs	Urgency	Side effects	Acceptance
Do the benefits from this OA promote climate change adaptation?	Yes	5	-	5
Compared to the benefits, are the additional costs reasonable?	Yes	5	-	3
Taking into account the costs and benefits, are the required funds available to implement this option?	Yes	3	-	3
Would the benefits of this option for action also occur in the long term?	Yes	5	-	5
Is the planning horizon for the option for action in line with the planning horizon for the climatic trends?	Yes	5	-	5
Do the required technical skills to implement the option for action exist?	No	4	-	3

e. OA5: Continuing evaluation and monitoring may be needed to verify if and when the introduction of new crops is needed;
   - In case crop patterns do shift, the benefits from this OA will go a long way to promote climate change adaptation;
   - This would be done at minimal costs, provided the evaluation is ongoing in the long term and takes into account new data and climate projections as they become available. The costs would then be minimized, especially if there are local capacity-building efforts and continuing support for information dissemination.

Table 8. OA5: Introduction of new crops

Criteria	Scores for selected OA (1-5) based on:			
	National needs	Urgency	Side effects	Acceptance
Do the benefits from this OA promote climate change adaptation?	Yes	5	-	5
Compared to the benefits, are the additional costs reasonable?	Yes	5	-	3
Taking into account the costs and benefits, are the required funds available to implement this option?	Yes	3	-	3
Would the benefits of this option for action also occur in the long term?	Yes	5	-	5
Is the planning horizon for the option for action in line with the planning horizon for the climatic trends?	Yes	5	-	5
Do the required technical skills to implement the option for action exist?	No	4	Unclear	3

f. OA6: Economic measures are needed to help secure commercial farming activity, such as mechanisms or funds to help "buffer" the swings in commodity prices due to either market forces or climate effects. Those measures need to be effective across a wide range of possible scenarios and may require funding from outside the region.
   - This measure has long-term benefits but it is primarily aimed at livelihoods and only indirectly promotes climate change adaptation;
   - The costs may be high and the required funds may not be locally available to implement this option. The option may need subsidies in the medium term at least. In addition, it may need large-scale capacity building and dissemination of information, which could prove costly.

Table 9. OA6: Establishment of a "market buffer"

Criteria	Scores for selected OA (1-5) based on:			
	National needs	Urgency	Side effects	Acceptance
Do the benefits from this OA promote climate change adaptation?	No	3	-	3
Compared to the benefits, are the additional costs reasonable?	No	5	-	3
Taking into account the costs and benefits, are the required funds available to implement this option?	No	3	-	3
Would the benefits of this option for action also occur in the long term?	-	3	-	3
Is the planning horizon for the option for action in line with the planning horizon for the climatic trends?	-	-	-	-
Do the required technical skills to implement the option for action exist?	No	5	-	5

Adaptation matrix

The matrix is established based on the "options for action" (OAs) outlined in the tables above. These OAs are: minimize pesticide usage (OA1); improve management of solid waste (OA2) and wastewater (OA3); manage groundwater (OA4); introduce new crops (OA5); and create a fund to help "buffer" market fluctuations (OA6).

The result is a table of "options for action and their priority", which "maps" the OAs that have the highest priority. The net result is to show that:

1. The highest priority should be given to OA2, OA3 and OA4, namely to improve management of solid waste and wastewater, and manage groundwater. In addition, OA1 (minimize pesticide usage) may be helpful for water quality.
2. The system's robustness would be enhanced through the implementation of OA6 (create a fund to help "buffer" market fluctuations in the price of commodities). However, this may require funding that may not be locally available and will have to be designed to be in line with national priorities.
3. The other OAs are not as critical to implement. However, when conceiving local capacity-building efforts, it may be more cost-effective to include training for the remaining options, OA1 and OA4 (minimize pesticide usage and introduce new crops).

Table 10. Adaptation matrix: "Options for action" and their priority

Category	Criteria	Options for action (OA) and their priority		
		Low	Medium	High
Sustainability	Mitigation co-benefits	OA2; OA3; OA4		OA1
	Water security	OA1	OA2	OA1; OA3; OA4
	Food security	OA5		OA6
	Energy security	OA2; OA6	OA4	OA2
	Equity		OA6	OA4
Effectiveness	Robustness	OA6		OA2; OA3; OA4
Risk and uncertainty	Urgency	Impact is already occurring		
Opportunity	Ancillary benefits (contribution to national strategy)		OA6	OA4
	Regret/ No regret	OA6; OA5		OA2; OA3; OA4
	Window of opportunity to implementation	OA6	OA1	OA2; OA3; OA4
Implementation	Funding sources	Funding is unknown at this stage		
	Institutional	OA6	OA1	OA2; OA3; OA4

ENVIRONMENT

Climate Change Adaptation and Ecosystem-Based Management
Using Integrated Water Resources Management Tools

AGRICULTURE

Climate Change Adaptation in Agriculture, Forestry and Fisheries
Using Integrated Water Resources Management Tools

HEALTH

Climate Change Adaptation in the Health Sector
Using Integrated Water Resources Management Tools

HUMAN SETTLEMENTS

Climate Change Adaptation in Human Settlements
Using Integrated Water Resources Management Tools

ECONOMIC DEVELOPMENT

Climate Change Adaptation in Economic Development
Using Integrated Water Resources Management Tools

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