Environmental Quality
Authority, Palestine

ClimaSouth
Technical Paper 2

THE ECONOMICS OF CLIMATE CHANGE IN PALESTINE

February 2017

ClimaSouth Low carbon development for climate resilient societies

A project funded by the European Union

THE ECONOMICS OF CLIMATE CHANGE IN PALESTINE

February 2017

PRODUCED BY THE CLIMASOUTH PROJECT: www.climasouth.eu

Authors: Robert Tippmann[1] & Laura Baroni [2]

Graphic design & layout template: Raffaella Gemma & G.H. Mattravers Messana

Proofreading: CoDe Translations

Series editor: G.H. Mattravers Messana

ClimaSouth Team Leader: Bernardo Sala

Agriconsulting Consortium Project Directors: Ottavio Novelli / Ghizlane Lajjal

Project implemented by
AGRICONSULTING CONSORTIUM
Agriconsulting Agrer CMCC CIHEAM-IAM Bari
d'Appolonia Pescares Typsa Sviluppo Globale

CITATION: ClimaSouth Technical Paper N.2 (2016). The Economics of Climate Change in the Palestine. February 2017. Prepared by: Tippmann, R. and Baroni, L.

ACKNOWLEDGEMENTS: The authors would like to thank the Environment Quality Authority, the Ministry of Agriculture and the Palestinian Water Authority for providing them with relevant documents and feedback, Mr. Hanna Theodorie for his assistance with respect to the collection of data and acting as co-facilitator for the workshop, as well as the participants of the National Validation Workshop for their valuable input.

---

[1] Climatekos (www.climatekos.com)

[2] Trinomics B.V., Westersingel 32A 3014 GS, Rotterdam, The Netherlands.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS AND ACRONYMS

ARIJ	The Applied Research Institute - Jerusalem
CBA	Cost-Benefit Analysis
CEA	Cost-Effectiveness Analysis
CRA	Climate Risk Assessment
EPRS	European Parliament Research Service
EQA	Environment Quality Authority
FAO	Food and Agriculture Organisation of the United Nations
GDP	Gross Domestic Product
GVA	Gross Value Added
INCR	Initial National Communication Report
IPCC	Intergovernmental Panel on Climate Change
IWR	Irrigation Water Requirement
MCA	Multi-Criteria Analysis
MCM	Million Cubic Metres
MENA	Middle East and North Africa
MoA	Ministry of Agriculture
NAP	National Adaptation Plan to Climate Change
NCCC	National Climate Change Committee
PCBS	Palestine Central Bureau of Statistics
PWA	Palestinian Water Authority
RCP	Representative Concentration Pathway
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WFP	United Nations World Food Programme
WHO	World Health Organisation

EXECUTIVE SUMMARY

This report is a deliverable of the ClimaSouth project, which aims to support climate-change mitigation and adaptation in nine South Mediterranean countries. The study focuses on three sectors selected on the basis of their importance to the Palestinian economy and their vulnerability to climate change: agriculture, water and the agri-food sector. The study's objectives are to:

- conduct a qualitative assessment of the economic impacts of climate change in Palestine[2] in three inter-related sectors: agriculture, water and the agri-food sector;
- analyse the state of play in regards to the assessment of costs and benefits of adaptation options, and identify data gaps and research needs; and
- formulate recommendations for further research on the economic impacts of climate change in the three sectors and the assessment of adaptation costs and benefits.

Although significant uncertainties about the precise impacts of climate change in Palestine remain given the lack of climate projections based on downscaling to the national and local levels, as well as the limited information on the economic impacts of climate change in the country, climate change is expected to negatively impact the three studied sectors. Impacts are likely to occur through a range of pathways and to compound the consequences of other drivers of vulnerability, such as population growth and the Israeli occupation.

Agriculture

As regards the agricultural sector, changes in temperature, precipitation, water availability, atmospheric composition, and extreme climate events are generally expected to negatively affect agricultural production, which may then translate into impacts on agricultural prices, incomes, and food security. Food insecurity is already a cause of concern in Palestine, with 28.6% of Palestinian households (46.7% in Gaza and 16.3% in the West Bank) being considered either severely or marginally food-insecure in 2014, according to the latest Socio-economic and Food Security Survey in Palestine. In the absence of adaptation, climate change may exacerbate these trends. Quantitative estimates of the effects of climate change on the Palestinian agricultural sector are, however, scarce and generally limited to particular localities.

[2] This designation shall not be construed as recognition of a State of Palestine and is without prejudice to the individual positions of the Member States on this issue.

Water

The water sector is particularly vulnerable to the effects of climate change since Palestine has one of the lowest per capita water availability in the world, due to both natural and man-made constraints. Groundwater represents the main source of water for Palestinians and about half of the water extracted from groundwater wells is used for agriculture. Climate change affects water resources through changes in precipitation and temperature levels, and interactions between the two factors. Climate models predict an overall drying of the Eastern Mediterranean region, although the magnitude of projected changes in precipitation and water availability varies and should be interpreted with caution, given the large temporal variability of rainfall in the region and the inherent limitations of climate models to simulate the hydrological cycle. Recent assessments suggest regional average annual precipitation reductions of as much as 30% by the end of the century, compared to the 1961-1990 period.

Decreased precipitation translates into reduced surface runoff and groundwater. Climate change also influences groundwater systems indirectly by increasing the demand for water (e.g., for irrigation). Changes in groundwater recharge and sea level rise associated with climate change may add further pressure to the coastal aquifer in the Gaza Strip, which is already subject to unsustainable extraction rates and affected by the gradual intrusion of seawater. Another potential impact to take into account is the risk of increasing incidence of rainfall extremes, leading to flooding and adding pressure to sewage and water management systems. Moreover, the effects of climate change on the water sector cannot be viewed in isolation. Other drivers, such as rapid population growth, industrial development, urbanisation, and increasing demand for irrigation exert additional pressures on water resources. Whilst some quantitative estimates (based on modelling) of the physical impacts of climate change on Palestine's water resources exist, the *economic* impacts have not yet been quantitatively assessed.

Food security and the agri-food sector

Data on the impacts of climate change on the agri-food sector, beyond impacts on agricultural output, is more limited compared to the first two sectors analysed, both globally and in Palestine. In general terms, climate change may affect multiple links of the agri-food supply chain, from manufacturing to distribution and consumption. The Palestinian food processing industry relies on locally produced agricultural products for 50% of the raw materials used; hence, a reduction in domestic yields due to increased temperatures and reduced water availability could significantly affect the sector. Palestine is also vulnerable to shortages or increases in the prices of imported foods and raw materials, which may aggravate food insecurity.

Temperature increases may also increase post-harvest losses by causing food to spoil more rapidly or by increasing the risk of pathogen or pest infection – particularly given the lack of large-scale cold-storage facilities in Palestine - whilst transport disruptions caused by extreme events may affect the supply chain. Such negative impacts would in turn cause food prices to rise, potentially impacting food security. Regional studies also point to possible adverse impacts on food utilization, as increased temperatures and reduced water quality and quantity pose challenges to food safety.

Overall, very little information exists on the economic impacts of climate change on the Palestinian agri-food sector, and quantified (monetary) estimates are entirely lacking. An assessment of the economic impacts of climate change in this sector would entail: 1) mapping supply chains for the most important product categories or subsectors in Palestine; 2) identifying climate-related vulnerabilities at each stage of the supply chain; 3) quantifying potential losses at each stage of the supply chain under different climate (and socio-economic) scenarios.

State of play regarding the assessment of costs and benefits of adaptation measures

Our review of existing information with respect to the costs and benefits of adaptation options shows that significant progress has been made in Palestine, through the development of the National Adaptation Plan to Climate Change, towards the identification and ranking of adaptation measures on the basis of a multi-criteria analysis, but more refined data on economic impacts would be needed for a full-fledged cost-benefit analysis. In particular, whilst the National Adaptation Plan provides initial broad-brush cost estimates for each adaptation option considered, a more detailed assessment would have to look into the costs of each foreseen action/project and consider different types of costs (e.g., one-off investments and continuous costs). The time horizon of these costs would also have to be considered, and an appropriate discount rate applied to express costs in their present value. Whilst the calculation of (direct) costs is relatively straightforward insofar as it can be based mostly on market values of goods or services, the assessment of benefits presents additional challenges with respect to valuation. The results of the multi-criteria analysis conducted for the National Adaptation Plan provide an initial indication of benefits (in terms of avoided damage, efficacy, co-benefits) and ranking of adaptation options. However, the assessment of benefits for a cost-benefit-analysis (CBA) of proposed adaptation measures would require further information on:

1. the economic impact (or cost) of climate change (ideally, monetised) in each sector of interest, in order to estimate the cost of inaction, or the damage that could be avoided by implementing adaptation measures;

2. the effectiveness of each adaptation option in reducing the impacts of climate change in that sector (i.e., by how much would the costs of climate change identified in point 1) above be reduced through the adaptation measure?);

3. any additional benefits resulting from the option's implementation, ideally expressed in monetary terms.

Finally, the aggregated costs and benefits of each adaptation measure would have to be compared, in order to identify the most efficient adaptation options.

Recommendations

Main discussion points and outcomes of the National Validation Workshop in February 2017 in Ramallah

- Better scenarios and forecasting for the Palestinian territory, including spatial distribution of climate impacts and related economic impacts are needed. The need for downscaled data from regional climate models was reiterated in this context as well. Responding to questions about the limitations in the scope of the study, ClimaSouth and the Environment Quality Authority (EQA) explained that the focus on the agriculture, water and agri-food and food security sectors in the economic impacts study was a joint decision by the Palestinian government/EQA, ClimaSouth and the expert conducting the study.
- More and better data for assessing and monitoring the situation in Palestine is definitely needed, which will take some time and availability will improve over time, but action in a priority sector, subsector or a specific economic activity therein can be taken now. The pursuit of two parallel streams, i.e., a series of short term measures and a long term vision for the coming years, was recommended by the workshop participants (see below).
- Existing and increasing water scarcity in Palestine is magnified by climate change.
- Better coordination amongst stakeholders (see below) should reveal more existing, relevant data already available at research, non-governmental and international organisations present in Palestine.
- Mainstreaming and tracking of climate change action and finance was not considered in Palestine before 2015 and, although the need for doing so is known since, still needs to fully materialize across all sectors and at the level of the governorates (see below).
- The impacts of climate change, although not distinguished from 'normal' climatic variations or extreme weather events (i.e., with respect to frequency and magnitude), are already felt on the ground and perceived by farmers in Palestine.
- The proposed roadmap, a step-wise approach towards a fully functioning climate risk/impact monitoring system for Palestine is supported by the National Climate Change Committee (NCCC) representatives and the other workshop participants. At the same time, the EQA intends to cover all economic sectors with the relevant best practice methodological approaches to assess costs and benefits of adaptation options.
- The agricultural sector seems most advanced compared to the other sectors with respect to the availability of relevant data and the mainstreaming of climate change into the sector strategy. At the time of writing this report only the 2014/16 sector strategy is known, whilst the new sector strategy is currently being finalised.
- The NCCC should task the relevant subcommittee with establishing a technical working group with a view to developing an overall action plan (incl. prioritisation, sequencing/timelines, responsibilities and objectives with indicators for measuring progress) for the further development of a full-blown climate risk assessment (CRA) strategy – covering the entire

roadmap. Next to the integration of the CRA process into the emerging climate-change governance structure and processes (see also Tippmann et al. 2015) the alignment with donor priorities should be ensured with a view to funding the implementation of the action plan.

- First of all, the Ministry of Agriculture (MoA) and EQA should develop and implement, if needed with external assistance, first climate risk/impact assessment pilot activities in the agricultural sector, selecting priority actions relevant to adaptation to climate change based on the new sector strategy (e.g., with respect to olive-oil production, if applicable), to improve the knowledge on the subject matter and develop capacities.

- Overall coordination or addressing the lack of coordination amongst stakeholders has been identified as a continued problem and addressing the need for improved coordination through a functioning and operating NCCC is considered to be of the utmost importance (see also Tippmann et al. 2015).

Taking into account the outcomes of this study and the national validation workshop, the following overall roadmap crystallizes and is recommended:

1) **Build on the existing MCA and improve the overall database:** Aside from improving the monetary assessments or cost figures for adaptation measures, such improved costing should be combined with the determination or quantification of impacts with hard (local) data and related assessment approaches (see above), thereby selecting concrete localities and focusing on the three key sectors. For example, applying stochastic modelling and combining vulnerability indices for impacts with specific adaptation options and improved costing for such measures (engineering or management changes).

2) **Decide for which adaptation measures (a) CEA(s) (Cost-Effectiveness Analysis), or perhaps (a) CBA(s), may be useful or required:** Focusing on the three priority sectors and the related list of priority adaptation actions identified in the National Adaptation Plan (NAP), CEAs or CBAs Focusing on the three priority sectors and the related list of priority adaptation actions identified in the NAP, CEAs or CBAs may be needed to arrive at the best or cost-effective, concrete adaptation options within a sector/subsector and a certain locality or at concrete ratios to convince the Palestinian government, other national stakeholders or stakeholder groups and/or international development partners to engage and/or invest in a measure. To what extent entire sector studies and/or individual subsectors or activities in certain localities are needed remains to be seen.

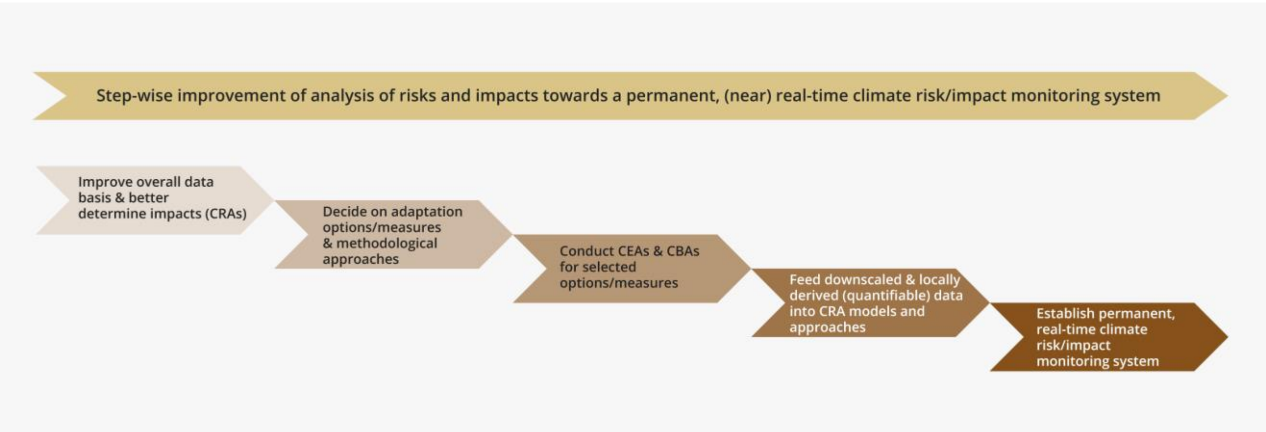
3) **Conduct CEA(s) or CBA(s) for the selected options/measures:** Again, it is too early to know which options or measures may require CEA(s) or CBA(s). More data on the (economic) impacts and the quantification of the costs and benefits of adaptation measures is required. However, all three sectors are affected by climate change, are interlinked and are crucial to the Palestinian economy. Whilst very little is known and there are no publicly available 360-degree economic impact assessments beyond agri-production in the agri-food sector, an important agricultural or agri-food subsector in Palestine such as the olive oil industry, for example, could be a good starting point in the effort to raise sufficient interest

and critical stakeholder mass. A more detailed assessment of this subsector would provide an opportunity to gain first experiences in conducting a 360-degree impact assessment and prepare (a) first CBA(s) for an important economic activity in Palestine.

4) **Feed outcomes of downscaled climate models and locally derived data into climate risk assessment models and approaches:** Together with improved local climate data or related established trends from downscaled climate models, such climate and socio-economic data derived from CEAs or CBAs could be fed into climate risk assessment models and approaches, further improving them. Locally derived data and established national or even local trends – underpinning and improving or quantifying impact assessments country-wide, at the sector level, or at the level of governorates all over the country – will allow for informed decision-making about the future course of action in Palestine through the use of hard data.

5) **Establish permanent, (near) real-time climate risk/impact monitoring system for Palestine:** The full mainstreaming of climate change into the government structures and processes - horizontally at the sector level and vertically down to the governorates, covering all 12 sectors or areas identified in the NAP as highly vulnerable to the impact of climate change - will require the establishment of a permanent, real-time climate risk/impact monitoring system at the national level. Such a system should be integrated into the emerging climate change governance and institutional framework and processes, whilst some activities or services may be outsourced to suitable non-governmental or research organisations. This in turn allows the proper integration of related climate action projects/programmes into the planning and budgeting processes of the Palestinian government, creating the planning and budget data, which is also needed with a view to tracking and Measuring, Reporting and Verifying (MRV) climate finance later on, in order to be able to report under the UNFCCC and to the climate finance donors.

Roadmap towards a permanent, (near) real-time climate risk/impact monitoring system



1. INTRODUCTION

1.1 BACKGROUND AND SOCIO-ECONOMIC TRENDS IN PALESTINE

This study is a deliverable of national activities implemented in Palestine within the framework of the ClimaSouth Project[3]. The overall objective of ClimaSouth is to assist partner countries' transition towards low-carbon economies whilst building climate resilience, thereby protecting the foundation and exploiting opportunities for economic development and employment in the region. This is pursued by strengthening the capacity of policy makers to engage effectively in the global climate change framework in line with the needs of the region, and by enhancing the institutional capacity for strategic planning in the areas of climate-change mitigation, adaptation and financing mechanisms. Within the overall ClimaSouth framework, national activities play a central role in facilitating bottom-up approaches in sharing knowledge and assistance in priority sectors affected by the impact of climate change. Against this backdrop, a study on the **economic impacts of climate change in Palestine** has been prepared.

Although significant uncertainties about the precise impacts of climate change in the region remain, climate change is expected to negatively impact Palestine and to exacerbate the consequences of non-environmental sources of vulnerability, such as population growth and the Israeli occupation (UNDP 2010).

Palestine became a party to the United Nations Framework Convention on Climate Change (UNFCCC) on 17 March 2016 and signed and ratified the Paris Agreement on 22 April 2016. The Paris Agreement entered into force on 4 November 2016. Palestine submitted its Initial National Communication Report (INCR) and the National Adaptation Plan (NAP) to Climate Change to the UNFCCC on 11 November 2016 during the 22nd Conference of the Parties (CoP) in Marrakesh.

According to the Palestine Central Bureau of Statistics (PCBS), the total Palestinian population in the West Bank and Gaza was approximately 4.68 million in mid-2015 (approximately 2.86 million in the West Bank, including East Jerusalem, and about 1.82 million in the Gaza Strip) (ARIJ 2015a). The population is relatively young, with almost 40% of Palestinians aged below 14 and 21.5% aged between 15 and 21. The Palestinian population is estimated to reach 6.06 million by 2025, and 11.3 million by 2050 (ibid.). The West Bank is predominantly rural with up to 60% of the population living in about 500 villages, whilst Gaza is highly urbanised with the bulk of the population living in cities, towns and eight refugee camps (UNDP 2016).

The country's Gross Domestic Product (GDP) per capita was USD 2,867 in 2015 (World Bank 2016a), whilst the real GDP growth rate was 3.5% (World Bank 2016b). In 2014, the agricultural sector, industry, and services contributed 5.5%, 23.4% and 71.1% of Gross Value Added (GVA), respectively (United Nations Statistics Division 2016). The unemployment rate was relatively high in 2016 (27% overall, 42% in the Gaza Strip and 18%

[3] http://www.climasouth.eu/en

in the West Bank) (World Bank 2016b). The trade deficit is 41% of GDP (ibid.). Palestine's Human Development Index was 0.677 in 2014, placing the country in the medium human development category (UNDP 2015).

1.2 OBJECTIVES OF THE STUDY

The aims of the study are to:

- conduct a qualitative assessment of the economic impacts of climate change in Palestine in three inter-related sectors: agriculture, water and the agri-food sector;
- analyse the state of play in regards to the assessment of costs and benefits of adaptation options, and identify data gaps and research needs; and
- formulate recommendations for further research on the economic impacts of climate change in the three sectors and the assessment of adaptation costs and benefits.

1.3 SCOPE OF THE STUDY

The study focuses on three sectors selected on the basis of their importance to the Palestinian economy and their vulnerability to climate change: agriculture, water and the agri-food sector. In terms of geographic scope, the study covers the West Bank, including East Jerusalem, and the Gaza Strip.

Agriculture is not only of great economic importance, contributing significantly to Palestine's income, exports, food security and job creation, but also of symbolic importance to the Palestinian people and their identity (UNCTAD 2015). It is also a sector where climate change is likely to have substantial negative impacts through the effects of rising temperatures, reduced precipitation and extreme events on both the quantity and quality of agricultural output, which may then affect Palestinians' livelihoods and food security.

Palestine's water resources are already under significant pressure from rapid demographic growth, economic development and restrictions imposed by Israel, and expected to become scarcer as climate change causes decreases in annual precipitation (UNDP 2010). Impacts on water resources will have knock-on implications on a range of other sectors, including agriculture, household consumption, industry, and health.

Finally, the agri-food sector is prioritised. This is due to its importance for domestic food security and climate vulnerabilities associated not only with the supply of agricultural input but also other stages of the value chain.

This report focuses on the economic impacts of climate change. Other impacts on the economy of Palestine are acknowledged, in particular with respect to occupied Palestinian territory (oPt), but in consultation with the EQA and ClimaSouth a decision was made that such other impacts are not further elaborated in this report. However, reference to the conflict-ridden environment of Palestine and its economic impact is made in Annex VI.

1.4 METHODOLOGY

The study consisted primarily of a desk-based review of available data, reports and studies around the economics of climate change and its impacts in Palestine.

A national expert provided in-country assistance by liaising with relevant public sector organisations - namely the Ministry of Agriculture (MOA), the Palestinian Water Authority (PWA) and the Environment Quality Authority (EQA), which is the National Focal Point in the ClimaSouth regional project and beneficiary of this study - as well as other non-state actors and international organisations present in Palestine in order to identify further recent studies and obtain data not publically available.

In a first step, we used the information from the Intergovernmental Panel on Climate Change (IPCC) and other regional or local scientific and applied research studies provided in Palestine's INCR and NAP to review existing climate change scenarios and projections for Palestine and the Eastern Mediterranean and identify the impact climate change is likely to have on factors such as temperature, water availability, and extreme weather events in Palestine. We then reviewed available data and literature on the impacts that changes in these factors will likely have on three sectors of the Palestinian economy: agriculture, water, and the agri-food sector. Regional-level information and studies from countries in the vicinity or sub-region of Palestine or with similar climatological and socio-economic conditions were also considered, in order to compensate for the limited availability of data on Palestine.

The final part of the study considered the economic impacts of climate change adaptation in Palestine. We examined the state of play regarding the assessment of costs and benefits of adaptation measures identified in the NAP in regards to agriculture, water and the food sector, and identified remaining information gaps and needs for a full-fledged cost-benefit analysis. The outcomes of the stakeholder consultation process carried out during the NAP's preparation provide an initial estimation of the costs associated with each adaptation option. We endeavoured to derive more fine-grained estimates of the costs and benefits of the NAP adaptation options by using information from projects implemented or ongoing in Palestine in regards to the three sectors. We presented the relevant Palestinian institutions with the portfolio and pipeline of projects and programmes, which are most likely climate-relevant, being known to the team from previous assignments, and indicating, as far as possible, the corresponding NAP adaptation options for each project/programme. We asked relevant, informed officers within each institution to:

1) determine whether a project/programme was relevant to the identified adaptation option (i.e., correct and complete our preliminary mapping of projects/programmes against NAP adaptation options);

2) determine whether climate change was mainstreamed in a project/programme and whether any relevant information on impacts and costs was available;

3) inform us of any recent project or programme not included in the list;

4) pre-select the most relevant projects/programmes and provide us, for this subset, with any information relevant to the assessment of costs and benefits.

In order to validate the results and add additional information to the assessment, a workshop with relevant stakeholders was organised in February 2017.

1.5 LIMITATIONS AND CHALLENGES OF THE STUDY

Firstly, a main limitation of the study is the paucity of data with respect to climate change projections and impacts in Palestine. Climate scenarios were developed for Palestine in the context of the NAP's preparation and used in the present study, but these scenarios are based on a review of information from neighbouring countries and an analysis of projections from models used in the Fifth Assessment Report (AR5) of the IPCC. Thus, significant uncertainties about the precise impacts of climate change in the country remain. The study supporting the preparation of the NAP reviewed what resources and capabilities would be required for Palestine to generate its own climate modelling in the future and concluded that the costs would be in the order of USD 2.1 million.

Secondly, our review of the available literature and data shows that there is currently very little information specific to Palestine on the economic impacts of climate change on the three sectors considered. Quantitative estimates exist only in regards to agricultural water demand and availability, and on the impacts of past extreme weather events (frosts and droughts) on agricultural yields and production value. For some aspects of importance to an assessment of economic impacts, such as the impacts of reduced water availability on other economic sectors (beyond agriculture) or the impacts of climate change on different stages of the food production value/supply chain, even qualitative information is missing with respect to Palestine. Given these constraints, our analysis of economic impacts is largely based on data and studies at the regional level or from countries sharing similar characteristics to Palestine.

Thirdly, our data-collection efforts also revealed that very little information is available within Palestinian institutions on the costs and benefits of adaptation measures. As discussed further in Chapter 4, our attempt to collect information on recently implemented or ongoing adaptation projects yielded no results, since Palestinian institutions (in particular, MoA and PWA) do not have detailed and verified information on the costs and benefits of projects and programmes related to climate change adaptation aside from the estimates presented in the only recently concluded NAP, yet.

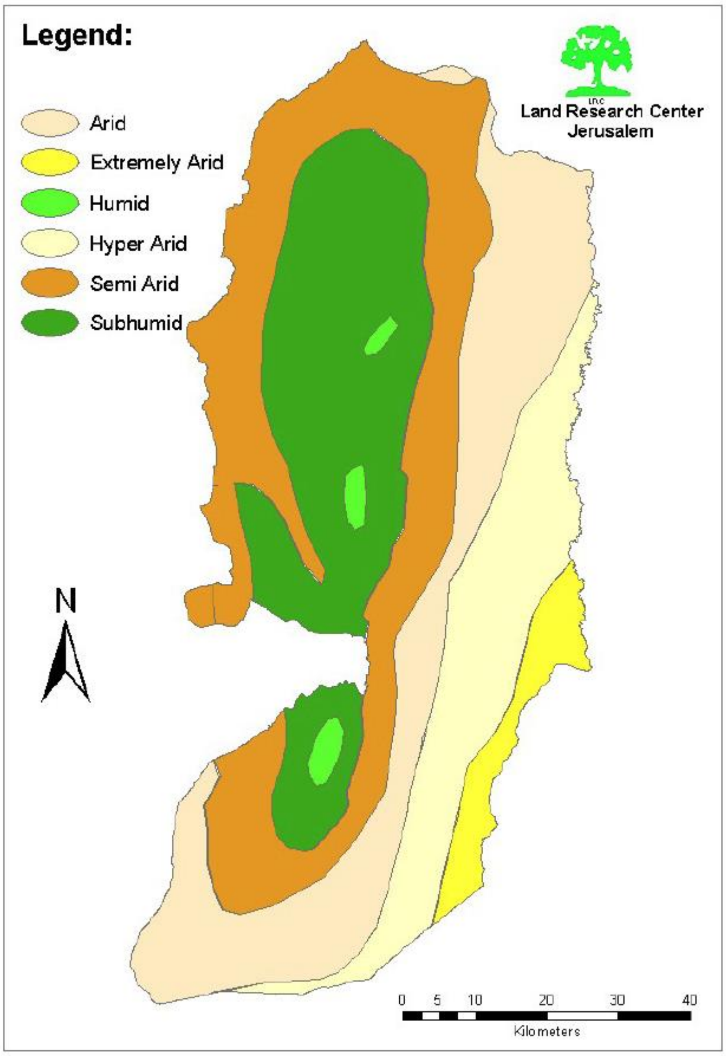
2. CLIMATE-CHANGE IMPACT TRENDS AND SCENARIOS IN PALESTINE

2.1 CURRENT CLIMATE CONDITIONS IN PALESTINE

2.1.1 WEST BANK

Palestine lies within the Mediterranean climatic zone. The climate in the West Bank can be characterised as hot and dry during the summer and cool and wet in winter. Only the southern part of the Jordan Valley has a different transitional climate between dry steppe and the extreme desert conditions of the Dead Sea region (ARIJ 2015a). The eastern slopes of the West Bank can be classified as arid to hyper arid whereas the Western parts of the West Bank can be classified as semi-arid to sub-humid (ARIJ 2015a). The distribution of climatic zones in the West Bank is presented in the figure below.

Figure 2-1. Climate classification of the West Bank



Source: UNDP (2010) *Climate Change Adaptation Strategy and Programme of Action for the Palestinian Authority*

2.1.2 GAZA

The coastal Gaza Strip has a more temperate climate even though it borders the desert. Mean summer temperatures range from 30ºC in Jericho to 25ºC in Gaza to 22ºC in Hebron (situated at 850 metres above sea level), whilst mean temperatures in winter range from 13ºC in Jericho and Gaza to 7ºC in Hebron. The mean annual rainfall in the West Bank varies from about 650 millimetres (mm) in the West to less than 100 mm in the East. The long-term annual rainfall average is about 454 mm. Rainfall in the Gaza Strip varies by governorate from North to South, with a long-term average of 372.1 mm (INCR 2016). Average annual rainfall figures for 2011-2015 are presented in Table 2-1.

Table 2-1. Average annual rainfall in Palestine 2011-2015 (West Bank and Gaza)

Year	West Bank (mm)	Gaza Strip (mm)
2011 - 2012	573	406
2012 - 2013	545	273.5
2013 - 2014	318	401
2014 - 2015	528	611.5

Source: State of Palestine (2016) *Initial National Communication Report (INCR) to the United Nations Framework Convention on Climate Change*

An assessment of historic climate trends in Palestine undertaken as part of the preparation of the NAP and the INCR to the UNFCCC reached the following conclusions with respect to climate variables (Smithers *et al.* 2016) [4]:

- **Average temperature:** There is *very high* confidence that temperatures have risen over the past 100 years, but less confidence in the quantitative rates of change because of spatial and temporal dependencies and issues of data quality. Nevertheless, there is *medium* confidence that the average temperature increased by 1°C over the 19th century and *medium* confidence that the rate of increase was highest in the final 20 years of the century.

- **Maximum and minimum temperatures and diurnal temperature range:** There is *very high* confidence that maximum and minimum temperatures have increased and *high* confidence that the number of warm days and nights has increased since 1950. However, there is only *low* confidence for any changes in diurnal temperature ranges.

[4] For the full analysis underpinning these conclusions, see Appendix 1 of the National Adaptation Plan.

- **Temperature extremes:** There is *low confidence* that temperature extremes have risen over the past 100 years, based on limited evidence. There is *low to medium confidence* that warm spells have extended in length, and *low confidence* for any changes in lengths of cold spells and frequencies of heat waves, due to lack of information.

- **Rainfall totals:** Regional analyses come to divergent conclusions regarding rainfall trends. There is *very low* confidence that annual and seasonal rainfall totals have changed in either direction over the past 50 years or so but also *very low* confidence that there has been no change in annual and seasonal rainfall totals.

- **Rainfall extremes and other related parameters**: Only *very low* confidence can be ascribed to changes in rainfall extremes because of the limited evidence combined with the relative rarity of such events. On a global scale, the IPCC AR5 concludes that confidence is *low* for any changes in drought intensities or frequencies, but notes that these are *likely* to have increased in the Mediterranean. Some of the results of peer-reviewed studies and other literature for the Levant appear consistent with the IPCC conclusions, whilst others do not.

- **Oceanic parameters:** There is *high confidence* that sea level has increased in general over recent decades, but *low confidence* in the magnitude of that increase or in the variability of that increase over time.

2.2 CLIMATE-CHANGE SCENARIOS AND PROJECTIONS FOR PALESTINE

Future-climate scenarios for the State of Palestine were developed during the preparation of Palestine's NAP to Climate Change (Smithers et al. 2016). The scenarios proposed therein are based on an assessment of climate change projections for Palestine generated through the atmosphere and ocean models used in the Fourth and Fifth Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC AR4 and AR5), together with a further set of projections from Regional Climate Models (CORDEX) covering the Levant. To derive the scenarios, Smithers et al. (2016) examined, firstly, ensemble means, standard deviations and ranges of the projections.

Secondly, the authors conducted a detailed assessment of projections using the AR5 models based on the technique of self-organizing maps (SOMs), a technique used to identify groupings within a dataset without assuming any statistical distributions[5]. To provide background and a point of comparison to the analysis of projections for Palestine, Smithers et al. also conducted a review of available official perspectives on future climate change submitted in National Communications to the UNFCCC from countries in the vicinity or region encompassing Palestine (namely, Lebanon, Jordan, Israel and Egypt), as well as a literature review of scenarios and projections contained in peer-reviewed publications and grey literature. The full analysis is provided in Appendix 1 of the NAP.

[5] For a full outline of the methodology underpinning the proposed scenarios, see Appendix 3 of the National Adaptation Plan.

The three future-climate scenarios included in Palestine's National Adaptation Plan (NAP) to Climate Change are presented below.

Table 2-2 Scenario 1. The most optimistic scenario, most likely should emissions be controlled according to the IPCC target of a global average temperature increase not exceeding 2°C.

Temperature	**Increases by ~1°C by 2025, by ~1.5°C by 2055, by ~2°C by 2090**
Temperature-related	Reduced cold periods and more frequent warmer periods, with both being increasingly prominent over time
Rainfall	Does not change, or perhaps increases slightly in the period to about 2035
Rainfall-related	A slight possibility of more flooding; a small possibility of increased periods of drought but, in general, limited change overall to rainfall characteristics

Table 2-3 Scenario 2. A mid-range scenario, most likely should emissions continue to increase along recent lines with some reductions from historic levels, but breaching the 2°C target.

Temperature	**Increases by ~1°C by 2025, by ~2°C by 2055, by ~3°C by 2090**
Temperature-related	Reduced cold periods and more frequent warmer periods, with both being more prominent over time (more so than under Scenario 1)
Rainfall	Decreases by ~10% by 2025, by ~15% by 2055, and by ~20% by 2090
Rainfall-related	Little, probably no, possibility of increased flooding risk. High likelihood of more frequent droughts. Perhaps overall less rainfall per day of rain on average

Table 2-4 Scenario 3. The most pessimistic scenario, assuming that emissions continue unabated

Temperature	**Increases by ~1.5°C by 2025, by ~2.5°C by 2055, by ~4.5°C by 2090**
Temperature-related	Reduced cold periods and more frequent warmer periods, with both being increasingly prominent over time (perhaps moderated slightly in the Gaza Strip)
Rainfall	Decreases by ~20% throughout until 2055, and to ~30% by 2090
Rainfall-related	Generally, a pattern of reductions in average daily rainfall and in contributions to total rainfall by heavier rainfall days, extended dry periods and reduced wet periods; thus an increase in drought risk throughout; however, an indication that the rare wettest days might become more frequent, particularly in the West Bank, thus, raising a possibility of an increased flood risk

The study supporting the preparation of the NAP also reviewed what resources and capabilities would be required for Palestine to generate its own climate modelling (based on downscaling approaches) in the future. The costs of climate modelling for Palestine were estimated at USD 2.12 million (Smithers et al. 2016).

3. THE IMPACTS OF CLIMATE CHANGE ON KEY SECTORS

3.1 AGRICULTURE

3.1.1 THE AGRICULTURAL SECTOR IN PALESTINE

Agriculture provides 11.5% of employment in Palestine (PCBS 2012, cited in National Agriculture Sector Strategy 2014-2016), contributes 3.6% to the GDP (PCBS 2016), and accounts for 21% of all exports (National Agriculture Sector Strategy 2014-2016). Domestic agricultural production is also vital to the country's food security, as it provides about 78% of the food consumed locally (State of Palestine 2016).

According to the 2012/2013 agricultural census (MoA 2013), in 2012/2013 there were 111,310 agricultural holdings in Palestine, covering a total area of 1.38 million dunums[6] (about 21% of the country's territory), of which 85.6% was located in the West Bank and 14.4% in the Gaza Strip (MoA 2013). The large majority of field crops and horticultural crops are rain-fed. The area and distribution of crop types is presented in Table 3-1.

Table 3-1. Area and distribution of crop types in 2012/2013

	Total area (dunums)	Rain-fed	Irrigated
Field crops	386,079	97%	3%
Vegetable crops	206,812	12%	88%
Horticultural crops	792,918	87%	12%

Source: Based on data from MoA (2013), unpublished

Of particular socio-economic and cultural importance is the olive tree, whose fruit, oil, sediment, wood and leaves are used by Palestinian households as the basis for a range of food staples, as well as soap, fuel, decorative crafts, and medicinal uses (UNCTAD 2015). In 2010, olive groves covered 462,823 dunums, or 85.3% of the total area of horticultural trees. 94% of olive groves in 2010 were rain-fed. The olive sector contributes 15% of total agricultural income and provides 3 to 4 million days of seasonal employment per year, thus mitigating the impact of unemployment and poverty and supporting 100,000 Palestinian families (UNCTAD 2015).

Table 3-2. Numbers and distribution of the most common livestock in 2012/2013

	Total (heads)	West Bank	Gaza Strip
Cows	42,389	70.8%	29.8%
Sheep	666,489	91.6%	8.4%
Goats	269,158	96.5%	3.5%

Source: Based on data from MoA (2013), unpublished

[6] One dunum is equal to 0.1 hectare or 0.001 km^2.

Although the potential for agricultural production in Palestine is high, the actual outputs are limited by a range of factors, including: the small size of land available and safely and regularly accessible (given Israeli control of Area C, the construction of the separation barrier, and the expansion of Israeli settlements) (see Annex VI for more details); the shortage and increasing costs of agricultural input and equipment; limited irrigation; adverse climatic conditions in recent years, such as drought, irregular rainfall and frost; restricted marketing opportunities and limited access to international markets (ARIJ and WFP 2010; State of Palestine 2016). Agricultural yield in Palestine amounts on average to half of Jordan's and 43% of the yield in Israel, despite very similar natural environments (UNCTAD 2015).

Some of the factors limiting agricultural production stem from - or are compounded by - the restrictions imposed by Israel. For example, restrictions on fertilizer imports result in decreased productivity and increased costs, whilst restrictions on water use, the movement of farmers and trade impose financial and time costs on Palestinian producers (UNCTAD 2015) (see Annex VI for more details).

3.1.2 THE IMPACTS OF CLIMATE CHANGE ON AGRICULTURE

Whilst it is challenging to predict with certainty the impacts of climate change on agricultural systems, a growing body of literature suggests that climate change will affect the sector in a multitude of ways, with negative impacts prevailing (for a review, see, e.g., FAO 2016a, World Bank 2014, Porter et al. 2014, Jobbins and Henley 2015). The impacts will occur through different channels and will affect each of the four dimensions of food security: access, availability, utilisation and stability[7] (FAO 2016a), as outlined in Table 3-3 (adapted from Jobbins and Henley 2015).

The severity of the impacts will be determined by both the extent of the changes and the vulnerability of the system or population group under stress (FAO 2016a). The pathways through which climate change may impact agricultural systems and, in turn, food security are summarised in Figure 3-1. Changes in temperature, precipitation, water availability, extreme climate events, and atmospheric composition will have direct effects on agricultural production, which may then translate into impacts on agricultural prices, incomes and livelihoods.

---

[7] *Availability* refers to the supply side of food security, determined by the level of production, stock levels and exchange. Economic and physical *access* to available food, mainly from the household perspective, is determined by overall household income, disposable income for food, food prices, as well as gifts and transfers. *Utilisation* refers to the way individuals are able to consume food, which has a direct impact on nutritional status and is closely linked to feeding practices, preparation and distribution of food between household members. *Stability* denotes the maintenance of food security through time (Jobbins and Henley 2015).

Table 3-3. Climate-change impacts on different aspects of food security

Food security dimension	Potential impacts
Availability	Reduced rainfall and increased evapotranspiration reducing yields from rain-fed agriculture and pastoralism Reduced soil fertility and increased land degradation from increased temperatures, evaporation, and drought Climate change induced crop and livestock pests and diseases Higher post-harvest losses as a result of climate change
Access	Loss of agricultural income due to reduced yields and higher costs of production input such as water Climate-change impacts on food production could lead to higher global and local food prices Difficulties in accessing food due to displacement driven by climate extremes and disasters
Stability	Greater instability of supply due to increased frequency and severity of extreme events, including droughts Instability of incomes from agriculture
Utilisation	Impact on food safety due to increased temperatures Impacts on nutrition resulting from reduced water quality and quantity Climate induced morbidity

Source: Jobbins, G., and Henley, G. (2015) *Food in an uncertain future: the impacts of climate change on food security and nutrition in the Middle East and North Africa*

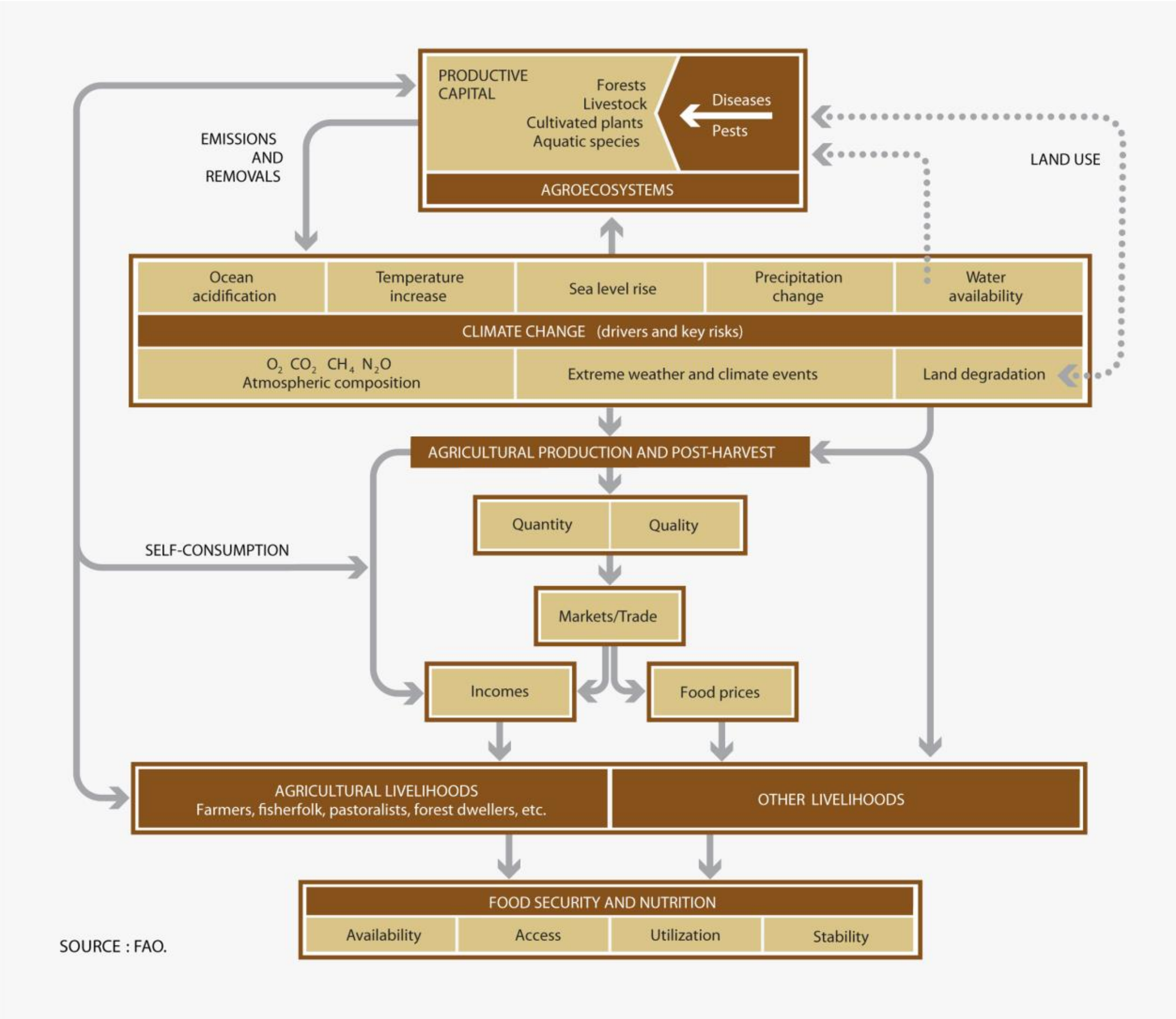
Changes in atmospheric composition can have the following impacts:

- Elevated atmospheric CO2 concentrations can have a 'fertilisation effect' on certain crops (e.g., wheat and barley), increasing yields;
- Increases in tropospheric ozone (O3) and its secondary by-products damage vegetation by reducing photosynthesis and other physiological functions, which decreases the quality and quantity of yields.

The effects of climate change on agricultural production are expected to translate into negative impacts on agricultural incomes and prices, with repercussions on food security (FAO 2016a; Jobbins and Henley 2015). Past periods of rapid food and cereal price increases following climate extremes such as heat waves, drought and intense rainfall indicate a sensitivity of markets to such events (Field et al. 2014). Increased trade is expected to play a role in adjusting to the shifts in agricultural and food production patterns resulting from climate change (FAO 2016a), as long as this potential is not curtailed by trade restrictive measures. At the same time, climate change will compound the effects of other drivers of food insecurity and vulnerability in the Middle East, such as rapid population growth, urbanisation, conflicts and instability (Jobbins and Henley 2015).

Annex II discusses the general impacts on agriculture in more detail and presents global quantitative estimates of climate-related impacts on yields.

Figure 3-1. Impact pathways: from climate change to food security



Source: FAO (2016) *The State of Food and Agriculture 2016*

Temperature changes affect agricultural production through impacts on:

- Timing and/or duration of physiological processes in plants, which may result in reduced yields;
- Nutritional quality of fruit and vegetable crops;
- Soil carbon level and salinity;
- Negative effects on livestock physiological processes, leading to e.g., reduced milk yields;
- Geographical ranges and intensity of pests and diseases.

Changes in precipitation and reduced water availability lead to:

- Water stress in plants, affecting plant growth, photosynthesis and respiration;
- Land degradation;
- Water stress in livestock.

Regional projections

The Middle East and North Africa (MENA) region is amongst the most water-scarce regions of the world, and climate change is expected to exacerbate existing water challenges (GIZ, 2012). Firstly, precipitation changes have a direct impact on rain-fed agriculture. Evans (2009) predicts that rain-fed agriculture in the Eastern Mediterranean will decline by more than 170,000 km^2 by the end of the century due to declining means and increasing variability of precipitation.

Higher temperatures and less rainfall are also predicted to reduce river flow, slow the rate of aquifer recharge, and increase aridity in the region (Elasha 2010). Thus, whilst water demand will increase due to high temperatures and increased evapotranspiration, water supply for irrigation is likely to decrease. Climate change is also expected to exacerbate desertification in the region, with longer dry periods degrading soil quality and reducing the length of time rangelands can be grazed (GIZ 2012).

Quantitative estimates of climate-change impacts on crops in the MENA region vary, but they point towards decreasing yields (see, for example, the estimates reviewed in World Bank 2014, Selvaraju 2013). Bosello and Eboli (2013) modelled the impact of climate change on GDP, changes in agricultural production and agricultural prices in southern and eastern Mediterranean countries. In the Middle East,[8] by 2050 the production of wheat, cereal crops, sugar crops, and vegetables and fruit is projected to decrease by 0.41%, 0.16%, 0.03% and 0.25%, respectively, compared to a no-climate-change baseline (temperature increase of 1.9°C compared with 2000). These changes translate into relatively small price increases and a slightly negative impact on GDP (-0.01%).

Simulations by Biewald et al. (2015) show that under the high-end IPCC Representative Concentration Pathway (RCP8.5) corresponding to an average temperature increase of 3.7°C at the end of the century, average yields of food crops in the MENA region would decrease by more than 7% by 2030, resulting in regional increases in the cost of food[9] of 17% to 35% (depending on the socio-economic scenario).

The modelling by Ferisse et al. (2013) of climate-change impacts on typical Mediterranean crops (under the A1B scenario of the IPCC Special Report on Emissions Scenarios[10]) shows almost unchanged or slightly increased yields of durum wheat throughout most of the Mediterranean Basin (with the exception of the southern Iberian peninsula and Morocco), decreases in grape yields, and a reduction of the suitable cultivation area for olive trees in parts of North Africa and the Near East, together with a gradual expansion northward and eastward of the suitable area.

---

[8] Palestine is analysed as part of a Middle East aggregate, which also includes Jordan, Syria, Israel, Lebanon, Bahrain, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, the United Arab Emirates and Yemen.

[9] Defined as the average production costs of food and feed crops in a specific spatial area.

[10] A1B is a midrange scenario which assumes rapid economic growth, low population growth, with human population peaking mid-century, and the rapid introduction of new and more efficient technologies. Under A1B, global mean temperature is projected to increase by 2.8ºC in 2090–2099 relative to 1980–1999 (IPCC 2007).

Similarly, Tanasijevic et al. (2014) find (based on modelling using the A1B scenario) that the potentially cultivable areas for olive growing in the Mediterranean region are expected to extend northward and to higher altitudes, increasing by 25% over the course of the next 50 years. At the same time, however, net irrigation requirements are predicted to increase by 18.5%. Increased evapotranspiration and reduced precipitation will increase the stress on rain-fed olive cultivation, making it unfeasible in the Southern and Eastern Mediterranean. Abandonment of traditional olive groves would lead to landscape deterioration, increased erosion and severe social consequences (Tanasijevic et al. 2014, p. 66). Other research (Ponti et al. 2014) suggests that a temperature increase of 1.8ºC would result in a 4.1% increase in total olive yields throughout the Mediterranean Basin, but changes in profit will not be uniform, with economic losses predicted for some olive-producing areas, including the Middle East. This will affect particularly small olive farms in marginal areas, which are critical to conserving soil, maintaining biodiversity, and reducing fire risk (Ponti et al. 2014). Table 3-4 (below) presents an overview of these projections.

Table 3-4. Summary of projected impacts in the Middle East/Eastern Mediterranean

Impact on	Quantitative estimates	Source
Rain-fed agriculture	Decline by >170,000 km^2 by 2100 in the Eastern Mediterranean	Evans (2009)
Crop yields	Production of wheat, cereal crops, sugar crops, and vegetables and fruit is projected to decrease by 0.41%, 0.16%, 0.03% and 0.25%, respectively, in the Middle East by 2050.	Bosello and Eboli (2013)
	Under the RCP8.5 scenario, average yields of food crops in the MENA region would decrease by more than 7% by 2030, resulting in regional increases in the cost of food of 17% to 35%.	Biewald et al. (2015)
	Under the A1B scenario, yields of durum wheat remain unchanged or slightly increase throughout most of the Mediterranean Basin; grape yields decrease.	Ferisse et al. (2013)
Olive cultivation	Under the A1B scenario, the suitable cultivation area for olive trees decreases in parts of North Africa and the Near East but expands northward and eastward.	Ferisse et al. (2013)
	Under the A1B scenario, potentially cultivable areas for olives in the Mediterranean region increase by 25% over the course of the next 50 years; net irrigation requirements increase by 18.5%. Water stress renders rain-fed olive cultivation unfeasible in the Southern and Eastern Mediterranean.	Tanasijevic et al. (2014)
	A temperature rise of 1.8ºC would result in a 4.1% increase in total olive yields throughout the Mediterranean Basin but decreased profit in parts of the Middle East.	Ponti et al. (2014)

3.1.3 ESTIMATED IMPACTS OF CLIMATE CHANGE ON AGRICULTURE IN PALESTINE

The climate-change impacts highlighted above are generally relevant in the Palestinian context. The potential consequences of climate change risks on agriculture in Palestine are summarised in the table below (based on Mimi and Jamous 2010, and Horizon and Climatekos 2013). These effects may then translate into increased agricultural production costs, higher food prices, decreased incomes and profitability for farmers, and deteriorating rural livelihoods and food security. As a consequence, farmers may be driven to sell part or all of their productive assets, such as seeds for next year's crop, sheep and goats, as a compensation measure, paving the way for structural poverty (Horizon and Climatekos 2013). Food insecurity is already a cause of concern in Palestine, with 28.6% of Palestinian households considered either severely or marginally food-insecure in 2014, according to the latest Socio-economic and Food Security Survey in Palestine (PCBS and Food Security Sector 2016). The proportion was as high as 46.7% in Gaza as compared to 16.3% in the West Bank. In the absence of adaptation, climate change may exacerbate these trends.

Table 3-5. Potential climate-change impacts on agriculture in Palestine

Main climatic causes of risk	Consequences on the agricultural sector
Changes in monthly precipitation distribution	Crop area changes due to decrease in optimal farming conditions
Increased temperatures in critical periods	
Increased erosion	
Loss of soil water-retention capacity	
Increased soil salinity	
Sea level rise affecting coastal soil in the Gaza Strip	
Changes in monthly precipitation distribution	Decreased crop productivity
Increases in seasonal temperature variability	
Increased temperatures in critical periods (heat stress)	
Increased evapotranspiration (leading to water stress)	
Loss of soil water-retention capacity	
Increased incidence of agricultural pests and pathogens	
Decreasing livestock carrying capacity of grazing areas (due to changes in temperature and water availability)	Decreased livestock productivity
Increased temperatures (heat stress)	
Decreased water availability	
Increase of extreme events frequency/intensity	Increased risk of floods (affecting crops, livestock and agricultural infrastructure)
Loss of soil water-retention capacity	
Decreased annual and/or seasonal precipitation	Increased risk of drought and water scarcity
Increase in the frequency of extreme conditions (droughts and heat waves)	
Decreased groundwater availability/quality	
Sea water intrusion into groundwater in Gaza (which will add to its salinity and decrease its	

suitability for irrigation)	
Increased demand on aquifers leading to further depletion	
Conflicts amongst water users due to drought and water scarcity	
Increased average and extreme temperature	Increased irrigation requirements
Increased evapotranspiration in plants	
Increased frequency of drought and heat stress conditions	
Decreased precipitation	
Decreased water availability	

Quantitative estimates of the effects of climate change on the Palestinian agricultural sector are scarce. Simulations conducted by the Coastal Municipalities Water Utility (CMWU) using the CROPWAT model indicate that an annual average increase in temperature of 1ºC will increase crop water requirements in the Gaza Strip by 6% to 11% (UNDP 2010).

Mimi and Jamous (2010) apply the CROPWAT model to several incremental climate-change scenarios for the West Bank governorates of Jericho and Al-Aghwar to estimate additional irrigation water demand. The total irrigation water requirement (IWR) corresponding to temperature changes of +1ºC, +2ºC and +3ºC and precipitation changes of -20%, -10%, +10% and +20% (relative to current monthly averages) is shown in the following Table 3-6. The results indicate that increasing temperatures compound the effects of decreasing precipitation on IWR. The greatest threat occurs when a temperature increase of 3ºC is accompanied by a 20% decrease in precipitation levels. Under this scenario, the amount of water for irrigation would have to increase by 2.9 million cubic metres per year (MCM/Y). At the current average water prices in the West Bank (approximately 5 Israeli New Sheqels (NIS) or EUR 1.25) (PCBS 2014), the annual costs of this additional irrigation water demand would be EUR 3.6 million (assuming that water sources are available to satisfy this demand and prices do not increase with growing water scarcity). Similarly, Mizyed (2009) shows that a temperature increase of 6ºC in the West Bank would increase agricultural water demand by as much as 17% due to increased evapotranspiration.

Table 3-6. Irrigation water requirement for Jericho and Al-Aghwar governorates under different scenarios in MCM/Y

	T	T+1	T+2	T+3
P-20%	21.05	21.63	22.23	22.83
P-10%	20.24	20.82	21.42	22.01
P	19.95	20.53	21.12	21.71
P+10%	19.66	20.24	20.83	21.42
P+20%	19.38	19.96	20.54	21.13

The header row indicates temperature changes of +1ºC, +2ºC and +3ºC relative to the current monthly averages T. The first column indicates precipitation changes of -20%, -10%, +10% and +20% relative to current monthly averages P.

Source: Mimi and Jamous (2010), p.188.

As part of a broader study on climate-related vulnerabilities of agricultural communities in (post)occupation environments, Mason and Mimi (2014) surveyed 57 agricultural households in the Jordan Rift Valley, the eastern section of the West Bank running adjacent to the

Jordan River. 91% of the farmers surveyed referred to climate change as the main bio-physical factor affecting their agricultural practices. Farmers' perceptions also corroborated the results of scientific research identifying a regional drying trend; 91% of surveyed farmers noticed a significant decrease in the amount of rainfall, reporting that rainfall decreased by more than half compared to ten years ago, whilst 83% of farmers stated that the impact of drought had increased in the past ten years. This change in rainfall significantly affects the recharge rate of the groundwater aquifers, which are the main water source for the Jordan Valley. In fact, 67% of interviewed farmers agreed that the quantity of water available for agricultural use is decreasing and that current water supplies are insufficient to irrigate the land they cultivated in the past. Furthermore, over 55% of farmers indicated that the quality of water used for agriculture is deteriorating, mainly referring to high salinity of groundwater from agricultural wells which, in their perception, is due to over-pumping from groundwater wells, the decrease in rainfall and low recharge rates.

The economic impacts of past incidences of drought and frost provide an indication of the extent of expected future losses, should such events become more frequent due to climate change. According to the Ministry of Agriculture, the estimated losses of the main rain-fed crops due to drought and frost over the course of the 2007-2008 agricultural season exceeded USD 113.5 million (ARIJ and WFP 2010). Table 3-7 shows the estimated losses per crop.

Similarly, it is estimated that heat waves during the flowering season in 2010 reduced olive production by 20%, whilst frost in 2015 destroyed grape production of 170 hectares (3,825 tons) and partially destroyed 300 hectares (3,750 tons) in the Hebron and Bethlehem governorates (Smithers et al. 2016). In Beit Umar (a town in the Hebron Governorate), weather-related losses in grape production during 2015 were estimated to reach approximately 4,500 tons (Smithers et al. 2016).

Table 3-7. Estimated losses of the main rain-fed crops due to drought and frost over the agricultural season 2007/2008

Crop	Area (dunum)	Total Production (ton)	Yield Reduction (%)	Value of losses (USD million)
Wheat	207,542	38,395	40	6.9
Fodder crops	66,686	22,673	35	4.5
Fruits	90,207	30,743	35	10.7
Olives	866,917	134,372	40	60.7
Grape	67,216	48,395	35	14.1

Drought affects both farmers, by limiting water supply to crops, and herders who can no longer rely on pastures for grazing, due to drying and the decline in grazing capacity. The combined effect of rising fodder and water prices places herders in a cycle of debt and increases the risk of overgrazing and ecosystem degradation, as the number of livestock exceeds the land's carrying capacity (ARIJ and WFP 2010, p.69). Restrictions on movement and access to grazing areas and pastures compound these negative trends (ARIJ and WFP 2010).

In the Gaza Strip, sea level rise is expected to affect coastal agriculture, which represents 31% of the Gaza Strip's total agricultural production. Agricultural land makes up approximately 43% of the coastal area. Sea level rise (currently 1.5mm per year) will accelerate coastal erosion and increase saltwater intrusion, affecting the nearest farms, particularly on low-lying land (Smithers et al. 2016).

During the stakeholder consultation undertaken for the development of the National Adaptation Plan (NAP) to Climate Change, several subsectors and related aspects were identified as 'highly vulnerable' in regards to agriculture. Table 3-8 (based on Smithers et al. 2016) presents the highly vulnerable issues identified for the West Bank and Gaza and the key climate sensitivities and impacts involved. The total cost of the adaptation interventions proposed in the NAP for the agriculture sector has been estimated at USD 1237 million over ten years (Smithers et al. 2016).

Table 3-8. Highly vulnerable issues in the agricultural sector in the West Bank and Gaza Strip

Issue	West Bank	Gaza Strip	Climate sensitivity/impacts
Olive production	✔	✔	Sensitive to frost, heat waves, drought, wind speed, amount and distribution of rainfall, and hail.
Grape production	✔		Sensitive to frost, hail, drought, amount and distribution of rainfall.
Stone fruits	✔		
Rain-fed vegetables	✔	✔	Dependent on precipitation. Rainfall postpones the planting date, and low temperatures delay maturation.
Field crops	✔		Sensitive to drought, amount and distribution of rainfall, and heat waves. Rainfall postpones the planting date, and low temperatures delay maturation.
Irrigated vegetables	✔	✔	Sensitive to frost, drought, high temperatures, and wind speeds of more than 80 km/h. Green houses are sensitive to heavy snow, high wind velocity, and very low temperatures. Heavy snow and high wind speed damage the foundations of greenhouses and their plastic covers.
Grazing area and soil erosion	✔		The grazing area on the eastern slopes is the most sensitive to climatic conditions. Overgrazing, low rainfall and drought combine to reduce vegetation cover, species-richness and productivity, and increase wind erosion, rangeland fires and the spread of invasive plant species. Loss of vegetation makes soils sensitive to gully erosion resulting from intense rainfall events and flash floods, which can remove a substantial amount of fertile topsoil.

Issue	West Bank	Gaza Strip	Climate sensitivity/impacts
Irrigation water	✔	✔	Sensitive to rainfall amount and distribution, and shifts in the rainy season. Drought decreases the quantity of water that can be allocated to agriculture, whilst at the same time increasing crops' water requirement. This increases the costs of production (including electricity for pumping).
Livestock production	✔	✔	Heat and cold waves reduce productivity in cattle and poultry. E.g. in 2015, 15% of chickens in the Gaza Strip died as a result of a heat wave (12ºC above the annual average). Cold waves reduce the amount of milk production. Sheep are sensitive to cold (new-borns and small lambs). Adult sheep are sensitive to heat waves (during the fertilisation period). The cost of agricultural production increases during climate extremes; e.g., more electricity for cooling in livestock barns is required during heat waves.
Cost of agricultural production		✔	The cost of agricultural production increases in response to climatic extremes. E.g. as a result of heat waves, there may be a requirement for more: water for irrigation; shade-netting to minimize the impact of the sun; pest control; electricity for cooling in livestock barns.
Employment		✔	Any shortage of rainfall will affect the area and type of agricultural production, likely resulting in loss of employment.
Citrus		✔	Citrus trees are sensitive to frost, which destroys the buds, young leaves, and flowers with consequent loss of fruit.
Coastal agriculture		✔	Sea-level rise will accelerate coastal erosion and increase saltwater intrusion.

3.2 WATER

3.2.1 THE WATER SECTOR IN PALESTINE

Palestine has one of the lowest per capita water availability in the world, due to both natural and man-made constraints (ARIJ 2015a). The average domestic water consumption is only 72 litres per capita per day (l/c/d) in the West Bank and 96 l/c/d in the Gaza Strip (State of Palestine 2016), below the 100 l/c/d minimum recommended by the World Health Organisation. Table 3-9 shows the sources of water available in Palestine in 2014.

Table 3-9. Water availability by source, 2014

Source	West Bank (MCM)	Gaza Strip (MCM)	Total (MCM)
Annual Pumped Quantity from Groundwater Wells[11]	75.6	170.7	246.3
Annual Discharge of Springs Water	28.2	-	28.2
Desalinated Drinking Water	-	4.7	4.7
Annual Quantity of Water Purchased from Israeli Water Company (Mekorot)	60	3.5	63.5
Annual Available Water Quantity	**163.8**	**178.9**	**342.7**

Source: Palestinian Central Bureau of Statistics (undated), *Variety tables of water, 2014*, available at http://www.pcbs.gov.ps/site/lang__en/771/default.aspx#, based on data from the Palestinian Water Authority (2015)

Groundwater represents the main source of water for Palestinians and about half of the water extracted from groundwater wells is used for agriculture (Table 3-10).

Table 3-10. Uses of water pumped from wells in 2014

	Domestic	**Agriculture**	**Total**
West Bank	41.4 MCM (54.8%)	34.2 MCM (45.2%)	75.6 MCM
Gaza Strip	85.0 MCM (49.8%)	85.7 MCM (50.2%)	170.7 MCM
Total	126.4 MCM (51.3%)	119.9 MCM (48.7%)	246.3 MCM

Source: Palestinian Central Bureau of Statistics (undated), *Variety tables of water, 2014*, available at http://www.pcbs.gov.ps/site/lang__en/771/default.aspx#, based on data from the Palestinian Water Authority (2015)

The West Bank comprises three aquifers – the Western, North-Eastern and Eastern Aquifers – whilst the Coastal Aquifer is the only source of water in the Gaza Strip. Table 3-11 presents estimates of the average total rainfall and aquifer recharge rates in 2011/2012.

Table 3-11. Average rainfall and aquifer recharge in the West Bank and Gaza Strip

Aquifer	Average rainfall 2011/2012 (mm)	Recharge volume 2011/2012 (MCM)	Long-term average recharge (MCM)
Western Aquifer	581	359	318-430
North-Eastern Aquifer	517	152	135-187
Eastern Aquifer	483	210	125-197
Total West Bank	519	721	578-814
Gaza Coastal Aquifer	372	64	55-60

Source: ARIJ (2015a) Status of the Environment in the State of Palestine 2015

The Coastal Aquifer is deteriorating as a result of over-abstraction and pollution. In recent years, the aquifer has been pumped at a rate of 200 million cubic metres (MCM) per year, four times higher than the sustainable yield (ARIJ 2015a). It is estimated that 90-95% of the

[11] Excludes water abstracted from unlicensed wells.

water in the Gaza Strip is unfit for human consumption and the Coastal Aquifer risks becoming depleted by 2020 (EPRS 2016).

The surface water resources in Palestine consist of the Jordan River (to which Palestinians currently do not have access) and the ephemeral wadis (formed surface runoff during the rainy season) flowing towards the Mediterranean, the Jordan Valley and the Dead Sea. Rain water is used on a small scale in some villages, where it is captured in cisterns for domestic use or in agricultural ponds for irrigation (ARIJ 2015a).

In the West Bank, only 81% of localities are connected to the water network. Unconnected communities depend on water tankers transporting water from nearby networked sources, rainwater collection methods, bottled water, untreated spring water, and agricultural wells (ARIJ 2015a). Connected communities also have recourse to such sources to satisfy domestic need, due to the irregular and infrequent supply through the water network. In fact, only 50.9% of households in the West Bank are supplied with water on a daily basis (ARIJ 2015a, citing PCBS data). In the Gaza Strip, 93% of households are connected to the water network, but only 30% have a daily water supply (ibid.). Water losses through leaking pipes and illegal connections are high, estimated at 49% in Jerusalem governorate and 59% in the Gaza Strip in 2014 (PWA 2015, cited in ARIJ 2015a).

Wastewater treatment facilities exist in only a few localities of the West Bank and almost none of the treated water is reused in agriculture or industrial processes (ARIJ 2015a). In the Gaza Strip, the first regional wastewater treatment plant was completed in 2014 as part of a World Bank project, but the plant is still not operational (EPRS 2016).

Water prices vary amongst governorates, with an average of approximately NIS 4 (EUR 1) per cubic metre Table 3-12). In addition, many Palestinian communities have high reliance on tanked water for basic needs, paying 3 to 6 times more than the price of piped water (ARIJ 2015a). See Annex VI for more details of the impacts of the de facto control of Israel over the water sector through the Joint Water Committee.

Table 3-12. Average consumer price for water in the West Bank and Gaza Strip, 2014

	Price (NIS/m^3)		
	Gaza Strip	West Bank*	Palestine
Water tariffs for 0-5 m^3 consumption groups - monthly bill	1.50	4.21	**3.34**
Water tariffs for 5.1 - 10 m^3 consumption groups - monthly bill	1.66	4.58	**3.65**
Water tariffs for 10.1 – 20 m^3 consumption groups - monthly bill	2.50	6.0	**4.9**

Source: Palestinian Central Bureau of Statistics (undated), *Variety tables of water, 2014*, available at http://www.pcbs.gov.ps/site/lang__en/771/default.aspx#, based on data from the Consumer Price Index Survey (2014)

3.2.2 THE IMPACTS OF CLIMATE CHANGE ON WATER RESOURCES

Climate-change impacts are likely to exacerbate existing water deficits and challenges in the Eastern Mediterranean. According to the IPCC Fifth Assessment Report, there is robust evidence and high agreement that climate change will reduce renewable surface water and groundwater resources significantly in most mid-latitude and dry subtropical regions, which will intensify competition for water amongst agriculture, ecosystems, settlements, and industry (limited evidence, medium agreement) (Jiménez Cisneros and Oki 2014). Both 'green water' (water available to plants in soil, directly resulting from precipitation and hence supporting rain-fed agriculture) and 'blue water' (water in rivers and lakes, groundwater and other water bodies, used for irrigation and direct human consumption) are at risk (World Bank 2014).

Climate change affects water resources through changes in precipitation and temperature levels, and interactions between the two factors. Reductions in water availability will generally be greater than the underlying precipitation decrease, due to increases in potential evapotranspiration from warmer temperatures and non-linearity in the hydrological system (e.g., as precipitation is transformed into river runoff or groundwater recharge) (World Bank 2014). Declining rainfall directly results in reduced green water availability. At the same time, in areas where the soil dries out due to a decline in precipitation, less heat can be converted into latent heat and thus more heat is present to warm surface temperatures. Higher surface temperatures then lead to enhanced evapotranspiration (World Bank 2014). Decreasing precipitation combined with higher temperatures is also expected to cause a reduction in surface runoff and groundwater recharge (i.e., blue water). The trend towards decreasing water availability will be compounded by higher variability and more extremes, such as droughts and floods, decreasing reliability of water resources and increasing uncertainty in water management (World Bank 2014).

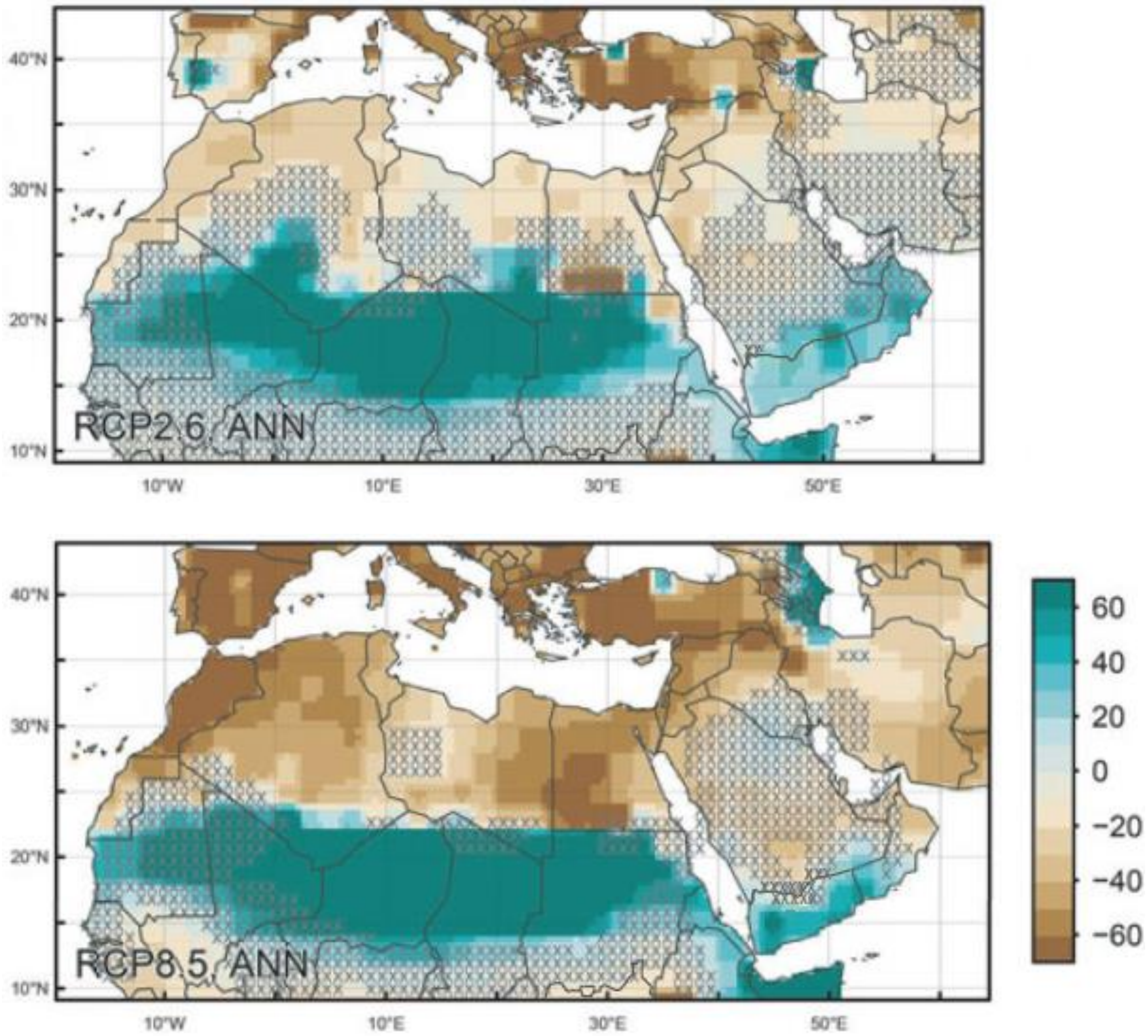
Figure 3-4 shows the predicted change in the aridity index[12] for the MENA region by the end of the century, relative to the period of 1951 to 1980, under the two Representative Concentration Pathway (RCP) scenarios of IPCC AR5, RCP2.6 and RCP8.5.[13] Note that a negative change corresponds to a shift to more arid conditions. Drier conditions are expected throughout most of the region north of 25°N under the more optimistic RCP2.6 scenario, with more dramatic increases in aridity projected under RCP8.5.

---

[12] The aridity index (AI) is calculated as the total annual precipitation divided by the annual potential evapotranspiration. A smaller AI value indicates a larger water deficit (i.e., more arid conditions).

[13] RCP 2.6 assumes that global annual GHG emissions peak between 2010 and 2020 and decline substantially thereafter. Under this scenario, Global Mean Surface Temperature Change is likely to be in the range of 0.4 to 1.6ºC by 2046-2065 and 0.3 to 1.7ºC by 2081-2100. In RCP 8.5, emissions continue to rise throughout the 21st century, corresponding to a Global Mean Surface Temperature Change in the range of 1.4 to 2.6ºC by 2046-2065 and 2.6 to 4.8ºC by 2081-2100 (see IPCC 2014, *Summary for Policymakers*, available at: http://www.climatechange2013.org/images/report/WG1AR5_SPM_FINAL.pdf)

Figure 3-2. Multi-model mean of the percentage change in the aridity index under RCP2.6 (2°C world, top) and RCP8.5 (4°C world, bottom) for the Middle East and North Africa by 2071–2099 relative to 1951–1980



Hatched areas indicate uncertain results, with two or more out of five models disagreeing on the direction of change.

Source: World Bank (2014) *Turn Down the Heat: Confronting the New Climate Normal*, p.126.

Climate models predict an overall drying of the Eastern Mediterranean region, although the magnitude of projected changes in precipitation and water availability varies and should be interpreted with caution given the large temporal variability of rainfall in the region and the inherent limitations of climate models to simulate the hydrological cycle (Lelieveld et al. 2012; GIZ 2012; ARIJ 2015a). Recent results (based on the IPCC SRES A1B emissions scenario) suggest average annual precipitation reductions in the region of as much as 30% by the end of the century, compared to the 1961-1990 period (see, e.g., Lelieveld et al. 2012, Önol and Semazzi 2009; Smiatek et al. 2014; Chenoweth et al. 2011).

Decreased precipitation translates into reduced blue water resources. For instance, Smiatek and Kunstmann (2015) modelled climate-change impacts on three catchments of the Upper Jordan River using the RCP4.5 scenario.[14] The results indicate a reduction of 7.4% by 2031-2060 and 17.5% by 2071-2100 in the river's discharge. Changes in rainfall amounts may be amplified in the stream-flow discharge and volume, due to reductions in soil moisture resulting from fewer rainfall events and longer dry spells between rainfall events in the wet season (Chiew et al. 2010; Peleg et al. 2015). For example, a study of climate-change impacts on surface runoff in two catchments in Israel (Peleg et al. 2015) shows that a reduction in rainfall by 15% and 18% would result in a reduction in mean annual stream-flow volumes of 45% and 47%, respectively.

In addition to impacts on surface runoff, climate change also influences groundwater systems both directly, by decreasing the rate of replenishment by recharge, and indirectly through changes in groundwater use (ARIJ 2015a). Groundwater is already severely over-extracted (beyond the recharge rate) in most MENA countries, and further declines in groundwater level due to reduced precipitation and increased evapotranspiration will make extraction more energy-intensive and expensive (World Bank 2014). Coastal aquifers will be affected by climate change not only through changes in groundwater recharge but also through the rise in sea level, which contributes to saltwater intrusion. The salinisation of coastal groundwater is also caused by unsustainably high extraction rates, which may be further exacerbated by the growing water demand (e.g., for irrigation) associated with climate change (Jiménez Cisneros and Oki, 2014).

Another potential impact to take into account is the risk of increasing incidence of rainfall extremes, leading to flooding and adding pressure to sewage and water management systems. However, only very low confidence can be ascribed to changes in rainfall extremes as a result of climate change because of the limited evidence and the relative rarity of such events (Smithers et al. 2016). The IPCC AR5 notes that it is likely that the number of heavy rainfall events has increased in some regions since the mid-twentieth century, but confidence in this is highest in North America and Europe where there are substantial networks of quality recording instruments (Smithers et al. 2016).

In addition to effects on the quantity of water resources, climate change can also reduce water availability through negative impacts on water quality. There is medium evidence and high agreement that climate change will pose risks to drinking water quality even with conventional treatment. These risks occur through increased temperature, increases in sediment, nutrient and pollutant loadings due to heavy rainfall, reduced dilution of pollutants during droughts, and disruption of treatment facilities during floods (Jiménez Cisneros and Oki, 2014).

The effects of climate change on the water sector cannot be viewed in isolation, as other drivers such as rapid population growth, industrial development, urbanisation, and increasing demand for irrigation exert additional pressures on water resources (Elasha 2010).

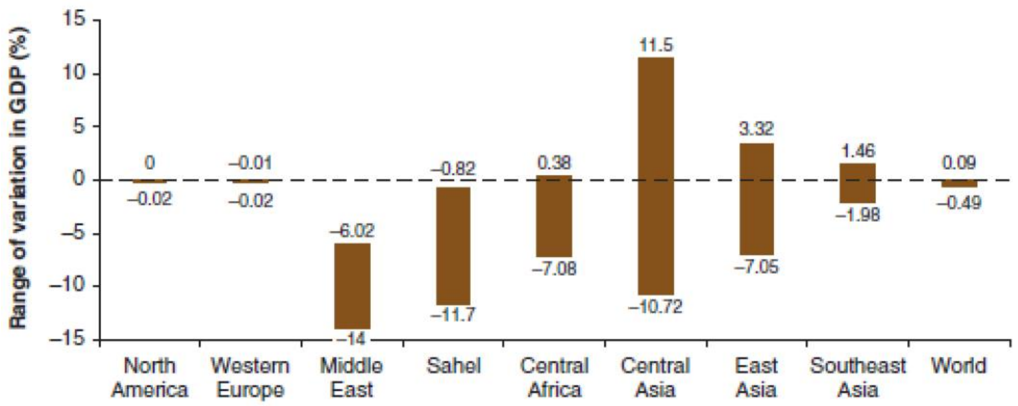
[14] Under this scenario, emissions peak around 2040 and decline thereafter. Global mean surface-temperature change is likely to be in the range of 0.9 to 2ºC by 2046-2065 and 1.1 to 2.6ºC by 2081-2100.

Climate-induced effects on the water sector can, in turn, impede development through four main pathways:

- if water is a scarce factor of production and is poorly allocated or inefficiently used, this would impact on broad economic performance;
- water-related natural disasters directly destroy lives and assets;
- water-related diseases have longer-term impacts on health, nutrition, education and human capital with consequences for poverty and economic growth; and
- water-related shocks can ignite or exacerbate civil conflicts (World Bank 2016c).

Simulations by the World Bank using a Computable General Equilibrium model indicate that water-related climate-change impacts will reduce GDP in the Middle East by 6 to 14%, depending on the policy response. Figure 3-3 shows the predicted changes in GDP per region by 2050. The lower bounds of the figure represent changes under a scenario where water allocation does not respond to the growing shortages and changing comparative advantage of different sectors across the globe. The upper bounds depict a world in which governments respond to water shortages and 25% of water is allocated to higher value uses.

Figure 3-3. Water-related impacts of climate change on GDP in 2050



Source: World Bank (2016) *High and dry: Climate change, water and the economy*, p.13.

3.2.3 ESTIMATED IMPACTS OF CLIMATE CHANGE ON PALESTINE'S WATER SECTOR

The impacts identified at regional level or in neighbouring countries broadly apply to the Palestinian water sector as well. A few studies have attempted to model the impacts of climate change on Palestine's water resources. Using the regional climate model PRECIS (Providing Regional Climates for Impact Studies) and based on the IPCC A1B emissions scenario, Chenoweth et al. (2011) predict precipitation decreases of 15% by mid-century and 23% by the end of the century, lowering per capita internal water resources in Palestine to 67 m^3 by 2050 compared to 190 m^3 in 2010. The discharge of the Jordan River is projected to decrease by 22% by mid-century and 30% by the end of the century, which will likely limit the scope for gaining a share of this river (Chenoweth et al. 2011). Previous modelling studies suggest even larger impacts on the Jordan River. Simulations using the GLOWA-Jordan River Regional Climate model coupled with the hydrological model WaSiM forecast discharge reductions of as much as 40% by 2070-2099 (Khatib 2009, cited in UNDP 2010). The Japanese Meteorological Agency Atmosphere General Circulation Model (JMA-AGCM) run for the eastern Mediterranean JMA-AGCM projects a 82-98% collapse in the Jordan River flow (at an unspecified location) by 2100 (Kitoh et al. 2008, cited in UNDP 2010).

Mizyed (2009) assesses the impacts of climate change on water resource availability and agricultural water demand in the West Bank, based on three temperature scenarios (of 2, 4 and 6ºC increase) and two precipitation scenarios (no change and a 16% precipitation reduction). A 16% reduction in precipitation could cause annual groundwater recharge to decrease by about 30% of its current levels. When this effect is combined with a 6ºC increase in temperature, the reduction in groundwater recharge is projected to reach 50%.

Extreme rainfall leading to flash floods is particularly problematic as the regional water management infrastructure lacks resilience (Smithers et al. 2016). Storm-water systems in the West Bank are under-designed and poorly managed, leading to localised flooding in urban areas where there are too few drains, or where their capacity is insufficient to deal with heavy precipitation (Smithers et al. 2016). Should flash floods become more common as a result of climate change, the pressure on an already overstretched infrastructure would increase. However, as discussed above, the effect of climate change on the risk of extreme rainfall events is uncertain.

Changes in groundwater recharge and sea level rise associated with climate change may also add further pressure to the Coastal Aquifer in the Gaza Strip, which is already subject to unsustainable extraction rates and affected by the gradual intrusion of seawater and upwelling of saline groundwater. High salinity levels make large parts of the aquifer unsuitable for drinking water, domestic applications and for many irrigated crops (Smithers et al. 2016).

The issues identified as 'highly vulnerable' during the stakeholder consultation undertaken for the development of the NAP are presented in the table below (based on Smithers et al. 2016).

Table 3-13. Highly vulnerable issues in the water sector in the West Bank and Gaza Strip

Issue	West Bank	Gaza Strip	Climate sensitivity/impacts
Groundwater supply	✔	✔	Reduced rainfall results in lower groundwater recharge, as does high-intensity rainfall due to increased runoff. High temperatures increase demand for water, and hence abstraction rates. The coastal aquifer is the main source of groundwater in the Gaza Strip (shared with Israel and Egypt), but damaged by over-pumping. The aquifer provides a sustainable yield in the Gaza Strip of around 55 million cubic metres per year, but Palestinians in Gaza consume in excess of 200 million cubic metres per year from the aquifer. Large number of unlicensed wells drilled due to the lack of secure access to water.

Issue	West Bank	Gaza Strip	Climate sensitivity/impacts
Flood management	✔	✔	Storm-water systems in the West Bank are ill-equipped to cope with flooding caused by intense rainfall.
Condition of infrastructure	✔		As above. Water losses from open canals, dams and agricultural ponds due to high evaporation and the presence of cracks and leaks.
Groundwater quality		✔	Severely deteriorated water quality of the coastal aquifer due to over-pumping. Saltwater intrusion, which results from over-pumping of the aquifer and inland saline water underlying freshwater in the aquifer rising upward into the freshwater zone, will be exacerbated by sea-level rise. The coastal aquifer is also susceptible to pollution, as it has a shallow water table with high permeability. The aquifer is unconfined in many places in the Gaza Strip, hence contaminants readily infiltrate through the soil's surface layer. Intensive agriculture has increased nitrates levels. Most sewage is either returned raw to lagoons, wadis and the sea, or seeps through the soil ultimately reaching the aquifer.

To date, quantitative estimates of the economic impact of climate change on Palestine's water resources have not been developed. (Refer to chapters 4 and 5 on gaps and what must be done next.) The total cost of the adaptation interventions proposed in the NAP for the water sector has been estimated at USD 893 million over ten years (Smithers et al. 2016).

3.3 FOOD SECURITY AND THE AGRI-FOOD SECTOR

3.3.1 FOOD SECURITY AND THE AGRI-FOOD SECTOR IN PALESTINE

The food and beverage manufacturing sector is the second largest industrial sector in Palestine in terms of employment (PCBS 2014). In 2014, the sector consisted of 2,292 enterprises and employed 13,325 persons, contributing to 25% of the gross added value of the industrial sector (USD 429.5 million) (PCBS 2014). The sector had an output of USD 955.4 million in 2014.

According to the Palestinian Food Industries Union, important agri-food processing industries in the West Bank include canned vegetables and fruits, oils and vegetable fats, wheat flour and grains, and pasta (ARIJ 2015b). An important subsector is olive-oil production. The 272 operational olive presses existing in Palestine in 2015 employed 1,353 workers (70% of whom were wage workers). The value added of olive pressing activities in 2015 was USD 7.2 million, with output of USD 10.3 million and intermediate consumption of USD 3.1 million (MAS 2016).

The majority of food and beverage production is consumed locally (77% in the West Bank and 12% in the Gaza Strip), whilst 6% is exported to Israel and 5% to other markets (Palestinian National Action Plan on Sustainable Consumption and Production 2016). The Palestinian food processing industry contributes to 50% of the local market; the other 50% of locally consumed food is imported (ibid.).

According to data from the Palestine International Chamber of Commerce, the production input for food manufacturing was estimated at USD 494.6 million in 2014, of which 84% was spent on raw materials, 7% on fuels and oil, 3% on electricity, 1% on water, and 6% on other input. Locally produced agricultural products account for 50% of the raw materials used in food processing (ibid.). A survey of the food industry sector conducted by ARIJ (2015b) found that 70% of the wheat used for the production of food commodities is imported (notably from Russia and the United States). A higher rate of self-sufficiency was reported for other products; for example, olive and olive oil, cucumbers, dates, tomatoes, eggplants, almonds, and grapes used in food processing come from local sources. Approximately 50% to 70% of the supply of potatoes and citrus fruits used in food processing is imported from Israel (ARIJ 2015b).

The food and beverage manufacturing sector uses 25% of the water consumed in the industrial sector (Palestinian National Action Plan on Sustainable Consumption and Production 2016).

Interviews with food processors and factory owners conducted within the ARIJ (2015b) study highlighted the following challenges faced by the Palestinian food industry sector:

- the high cost of input for agricultural products, due to fluctuations in their available quantities and lack of coordination between farmers on cultivation and collection dates, in addition to their seasonality;
- unfair competition between local and Israeli products, given that these products are allowed into the Palestinian local market, and the absence of protection policies for Palestinian infant industries;
- barriers to entry into new markets due to the high costs of exporting and the Israeli restrictions on crossings;
- the limited local market size and its inability to absorb all local production, particularly during the ongoing financial and economic crisis, resulting in the closure of many factories; and
- the high cost of transportation, delivery and storage.

In addition, with respect to agricultural production, the National Adaptation Plan notes that current post-harvesting storage techniques are inadequate. For example, there is a lack of large-scale grading and refrigerated cold storage (Smithers et al. 2016).

As discussed in Section 3.3.3, climate change may exacerbate some of these challenges by impacting on a number of factors related to food production.

3.3.2 THE IMPACTS OF CLIMATE CHANGE ON FOOD SECURITY AND THE AGRI-FOOD SECTOR

Impacts on input of food production

Climate change may impact the agri-food sector in multiple ways. Firstly, as discussed in Section 3.1.2, climate change and extreme events such as floods and drought may affect yields and quality of agricultural products used as input in food manufacturing. Moreover, increased water scarcity will reduce the availability and/or increase the costs of water used in this sector.

Another input to food production potentially affected by climate change is energy. Climate change may affect energy costs, whilst extreme weather events such as storms and floods may cause shortages in electricity supply.

Impacts on prices

Declining agricultural production and water availability could thus not only affect the livelihoods of farmers but also drive up the costs of food manufacturing, with consequences on consumer prices. Increased prices would threaten the food security of households struggling with current costs, and may render food markets more volatile, particularly if countries are unable to increase trade to offset unpredictable price spikes caused by climate shock (Jobbins and Henley 2015).

Based on a review of studies using projected yield impacts as input to general or partial equilibrium models of commodity trade, the IPCC AR5 (Porter et al. 2014) concludes that it is *very likely* that changes in temperature and precipitation (without considering effects of increased atmospheric CO_2 concentrations), will lead to increased food prices by 2050. The range of estimated increases is, however, large (3% to 84%). The combined effect of climate and CO_2 change (but ignoring impacts related to O_3, pests and diseases) appears *about as likely as not* to increase prices, with projected impacts ranging from –30% to +45% by 2050 (Porter et al. 2014). There is also *medium confidence* that climate change will lead to higher food prices beyond 2050. Significantly, however, the magnitude of price impacts depends largely on the type of economic, climate, and crop models chosen (ibid.).

Price increases will, in turn, increase the risk of food insecurity (see also Section 3.1.2). At the same time, the IPCC also concludes that it is *likely* that socioeconomic and technological trends, including changes in institutions and policies, will be a relatively stronger driver of food security over the next few decades than climate change (ibid.).

Impacts on transport and storage

In addition to the effects on food-production input, climate-change impacts may occur at the transport and storage stage. Food losses during transport and storage are already high in the MENA region, and will remain vulnerable to climatic events unless infrastructure is well-designed and maintained (Jobbins and Henley 2015). For example, rising temperatures and more extreme events may increase post-harvest losses by causing food to spoil more rapidly (particularly where there is limited capacity for cold storage) or by increasing the risk of pathogen or pest infection (Jobbins and Henley 2015), whilst transport disruptions caused by extreme events may affect the supply chain. Measures taken to mitigate such losses -- for example, increased cooling and improved storage capacities -- may translate into higher costs.

Reduced labour productivity

Heat extremes may also impact the economy (including the food production sector) through reducing labour productivity. The proportion of the workforce expected to be particularly affected by reduced productivity due to temperature spikes between 2010 and 2030 is estimated to range between 10% and 20% in most MENA countries (Jobbins and Henley 2015).

Changes in demand

Finally, through its impact on yields, incomes and prices, climate change may affect the demand for food products insofar as households will have less disposable income to spend on food.

An international survey by the Carbon Disclosure Project focusing on supply chains (CDP 2013) found that 70% of the 2415 participating companies believed that climate change had the potential to significantly affect their revenue. Respondents saw precipitation and temperature extremes, droughts, extreme weather events and sea level rise as having major cost implications. Respondents identified the following impacts of change in precipitation extremes or droughts (the proportion of respondents perceiving each risk is shown in brackets):

- reduction/disruption in production capacity (44%);
- increased operational costs (31%);
- inability to do business (11%);
- reduced demand for goods/services (6%);
- increased capital costs (4%);
- other (3%); and
- more widespread social disadvantages (1%).

The potential impacts of climate change on each link of the food-production supply chain are summarised in the following table.

Table 3-14. Climate-change impacts on the food supply chain

Supply chain link	Climate-change impacts/risks
Manufacturing	Decreased availability/quality/price of input (resulting in reduced production and/or increased consumer prices); Damage or destruction of assets due to extreme weather events; Disruption of plants and production lines; Changes in the effectiveness/efficiency of production processes (due to, e.g., decreased labour productivity, increased electricity consumption); Increased regulation with respect to carbon emissions.
Transportation	Damage to transport infrastructure caused by extreme weather events;

Supply chain link	Climate-change impacts/risks
	Increased losses during transport (e.g., due to food spoiling more rapidly or rising incidence of pests/pathogens).
Warehousing and storage	Vulnerability of infrastructure, personnel, communications, etc. in case of extreme weather events; Increased losses during storage (e.g., due to food spoiling more rapidly or rising incidence of pests/pathogens); Increased demand for energy (e.g., for cooling) and improved storage capabilities.
Trade	Changes in the price of commodities on international markets; Changes in trade patterns (imports, exports).
Consumption	Increase in food prices, with consequences on food security; Decrease in livelihoods/incomes affecting purchasing power and hence demand; Impacts on food utilisation, e.g., challenges related to food safety due to increased temperatures and reduced water quality and quantity.

Source: Adapted from Dasaklis and Pappis (2013) and Jobbins and Henley (2015)

As underscored in the IPCC AR5, to date, studies of the impacts of climate change on the food system have largely focussed on the production stage (e.g., impacts on agricultural output) and much less on aspects such as food processing, distribution, access and consumption (Porter et al. 2014). A small number of recent studies tackle climate-change impacts on the supply or value chain from the perspective of risk management. For example, Scholtz and Von Bormann (2016) develop a set of scenarios to capture climate-related risks and opportunities in the South African agri-food value chain, with the aim of informing planning and risk management by industry and policy-makers. The UK Environment Agency (2013) published a framework designed to help businesses identify climate-induced risks to their supply chains and increase their climate resilience. Michael and Crossley (2012) assess, through a survey, the preparedness of businesses operating in the Australian food-supply chain to deal with future climate risks. Similar assessments could be undertaken in Palestine, as discussed further in the following section.

3.3.3 ESTIMATED IMPACTS OF CLIMATE CHANGE ON PALESTINE'S FOOD SECURITY AND AGRI-FOOD SECTOR

The general and regional impacts described above are also relevant in the case of Palestine. As discussed in sections 3.1.3 and 3.2.3, climate change is expected to negatively affect agricultural production and water resources, two key input to the agri-food production sector. The Palestinian food processing industry relies on locally produced agricultural products for 50% of the raw materials used (Palestinian National Action Plan on Sustainable Consumption and Production 2016), hence a reduction in domestic yields could significantly affect the sector.

Adverse weather conditions are thought to have affected domestic prices in the past; for example, historically-high prices of fresh vegetables, poultry, and dairy production in 2013 were attributed mainly to frost and heat waves (Smithers et al. 2016, p.30). Palestine is also vulnerable to shortages or increases in the price of imported food or raw materials, which may aggravate food insecurity within the population (already at high levels of 46.7% in the

Gaza Strip and 16.3% in the West Bank, according to the 2014 Socio-economic and Food Security Survey). In fact, the two issues identified as 'highly vulnerable' with respect to food production during the stakeholder consultation undertaken for the development of the NAP were domestic and imported food prices, both for the West Bank and for the Gaza Strip.

At the same time, there is insufficient technical capability to deal with the effects of climate change on storage; for example, there is a lack of large-scale cold-storage facilities both in the West Bank and in the Gaza Strip (Smithers et al. 2016).

The NAP also identified a number of 'highly vulnerable issues' in regards to the industry sector as a whole, which are also of relevance to food manufacturing. In the West Bank, climate change is expected to impact the value of raw materials imported; for example, more raw materials may be needed for manufacturing beverages in hot weather or for producing flour and sugar during cold weather (Smithers et al. 2016). Infrastructure needed by industry is also at risk, for instance extreme events may exacerbate irregularities in water supply (Smithers et al. 2016).

In the Gaza Strip, climate change is expected to affect the value of industrial products exported. For example, in the absence of suitable storage facilities, high temperatures can damage the quality of products destined for export during waiting times at the border. Such issues also apply to the value of raw materials exported (Smithers et al. 2016).

The total cost of the adaptation interventions proposed in the NAP for the food sector has been estimated at USD 443 million over ten years. In addition, the cost of adaptation measures in the industry sector – some of which may relate to the food production sector – has been estimated at USD 249 million over ten years (Smithers et al. 2016). However and overall, very little information exists in regards to the economic impacts of climate change on the Palestinian agri-food sector. (Refer to chapters 4 and 5 on gaps and what must be done next.)

4. COST-BENEFIT ANALYSIS OF CLIMATE CHANGE ADAPTATION MEASURES

4.1 INTERNATIONAL BEST PRACTICE IN COST-BENEFIT ANALYSIS OF ADAPTATION OPTIONS

The IPCC defines adaptation as "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (Chambwera et al. 2014). Adaptation can be described as a four-stage process, entailing: (i) assessment of climate-change impacts, vulnerability and risks; (ii) planning for adaptation (i.e., choosing amongst different adaptation options); (iii) implementation of the chosen adaptation measures; and (iv) monitoring and evaluation of adaptation interventions (UNFCCC 2011). Adaptation is an iterative process, with the findings from stage (iv) feeding back into the first stage.

Assessing the costs and benefits of different adaptation options plays an important role during the second (planning) stage of the adaptation process, as it informs decision-makers about when and where to act and how to allocate scarce financial and technological resources (UNFCCC 2011).

Several approaches exist to assess the costs and benefits of adaptation options, the most common of which are shown below.

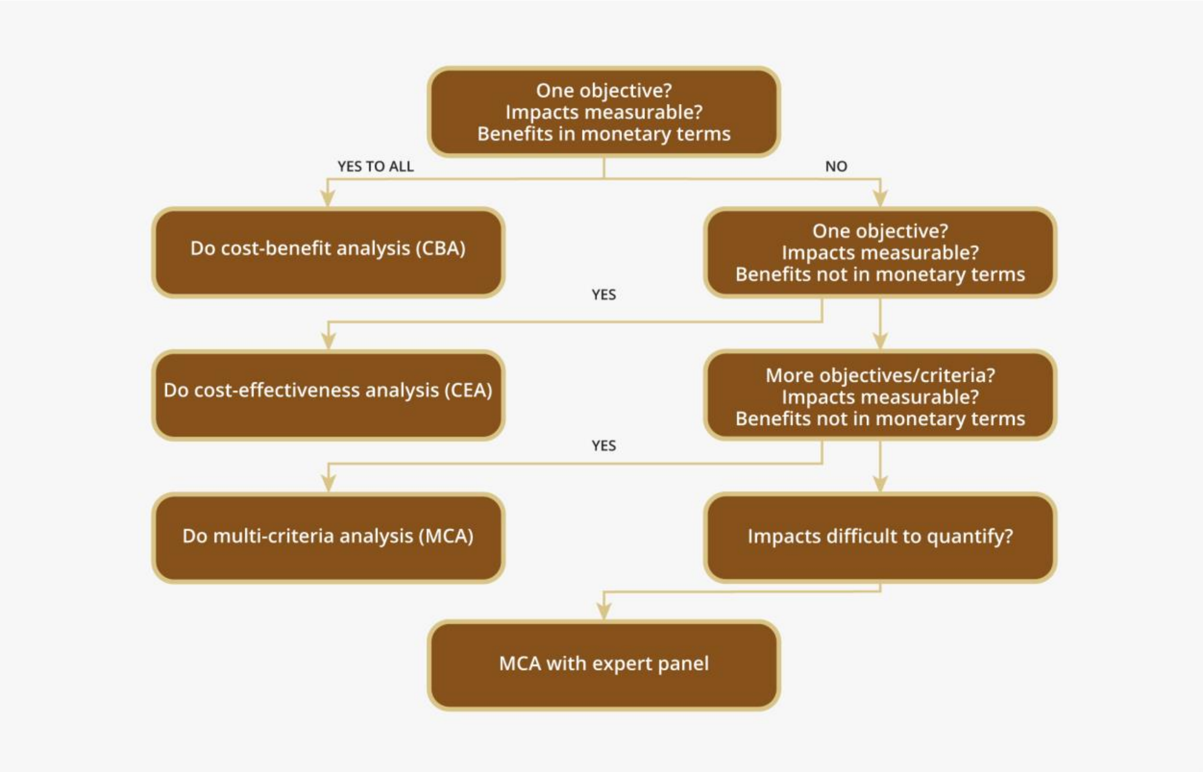
1) Cost-Benefit Analysis (CBA), which involves quantifying, expressing in monetary terms, and comparing all the costs and benefits associated with a policy, project or measure.

2) Cost-Effectiveness Analysis (CEA), which is used to identify the least costly adaptation option(s) for achieving the objectives set. CEA is commonly applied when the benefits of adaptation are difficult to express in monetary terms, but the costs can be quantified.

3) Multi-criteria Analysis (MCA), which consists of assessing different adaptation options against a number of selected criteria. Each criterion is given a weighting. The robustness of an MCA result depends on the certainty of the information regarding the selected criteria, the relative priorities (weights) given to the criteria, and the extent to which the weights and scores per criterion are commonly agreed upon by stakeholders. The method is suitable when benefits are difficult to quantify and when other criteria in addition to efficiency and effectiveness have to be taken into consideration.

Figure 4-1 presents a decision tree indicating under which circumstances each of the three approaches is appropriate.

Figure 4-1 Decision tree of possible approaches for assessing the costs and benefits of adaptation options



Source: UNFCCC (2011) Assessing the costs and benefits of adaptation options. An overview of approaches.

The main steps in applying CBA are outlined below (based on UNFCCC 2011 and FAO 2016b):

- Agree on the adaptation objective and identify potential adaptation options.
- Establish a baseline, which represents the situation without the adaptation intervention being carried out.
- Define the boundaries of the analysis, i.e., whose costs and benefits should be taken into account, what is the time horizon of the evaluation.
- Identify, quantify and aggregate the costs over specific time periods. The costs of an adaptation action include both direct costs (e.g., investment and regulatory) and indirect costs (e.g., social welfare losses and transitional costs).
- Identify, quantify and aggregate the benefits over specific time periods. Benefits of an adaptation intervention should include the avoided damage costs of climate-change impacts, as well as any co-benefits of the adaptation action. To identify costs and benefits, the analyst should establish that there is a cause-and-effect relationship between the adaptation action and the utility of individuals within the boundaries of the

analysis. The monetary value of benefits can be either determined from their market prices, in the case of goods and services for which markets exist and function well, or estimated in indirect ways through non-market valuation approaches, such as stated and revealed preference methods, or replacement cost methods[15].

- Discount benefits and costs to estimate present value. Discount rates are commonly used to estimate the present values of the costs and benefits of the adaptation options considered since it is not possible to directly compare values that occur at different points in time. Costs and benefits occurring in the future are usually assigned a lower value than those arising in the present. The choice of discount rate can significantly affect the results of CBA, therefore many authors recommend applying a range of discount rates and conducting sensitivity analyses to test to what extent the result is affected by changes in the discount rate.

- Compare the aggregated costs and benefits. Once the costs and benefits have been monetised and discounted, the relative efficiency of adaptation options can be determined based on:

  - the *net present value* (NPV), i.e., the difference between the present value of the benefits and the present value of the costs; the NPV should be greater than zero for an option to be acceptable;

  - the *benefit-cost ratio* (BCR), i.e., the ratio of the present value of the benefits to the present value of the costs; the BCR should be greater than 1 for the option to be acceptable; and

  - the *internal rate of return* (IRR) of the proposed investment in adaptation, i.e., the discount rate that makes the NPV equal to zero; the higher the IRR is, the more desirable the adaptation option will be.

The main strength of the CBA approach is that it allows planners or decision-makers to compare diverse impacts using a single metric (monetary value) (UNFCCC 2011). One limitation of CBA is its emphasis on efficiency (i.e., whether the output achieved are optimal relative to the resources allocated). For example, CBA does not give prominence to other criteria such as equity (i.e., how the aggregate costs and benefits are distributed amongst the stakeholder groups). The distributional aspect of net benefits can be addressed by giving weights to different costs and benefits, for example by giving a larger weight to benefits for the poor, but this entails subjective decisions about the weighting coefficients (UNFCCC 2011). Another limitation is that all costs and benefits must be monetised in order to allow comparison, whereas certain social and environmental goods and services (e.g., those related to human health and ecosystem services) are difficult to quantify in monetary terms

[15] The stated preference (or contingent valuation) method involves asking individuals directly, through a survey, how much they would be willing to pay for specific goods or services, contingent on a hypothetical scenario and description of the goods/services. The revealed preferences approach is based on direct observation of choices that are assumed to reflect the values individuals assign to specific goods/services (e.g., travel costs incurred by visitors to a natural area are used as a proxy for the value of the site). Measuring replacement costs involves calculating the costs of providing an ecosystem service through other means (usually artificially).

since they are not traded on markets. Several approaches exist to measure such non-market values, but are subject to a number of methodological difficulties.

Boxes 4-1 and 4-2 provide examples of how CBA has been applied in practice to assess adaptation measures in Uganda and Canada, in order to illustrate the type of work that Palestine could undertake in the future for an economic assessment of adaptation options.

Box 4-1 Cost-Benefit Analysis of water sector adaptation in Uganda

As part of a national-level assessment of the economic impacts of climate change in Uganda, cost-benefit analysis was applied to evaluate the efficiency of proposed adaptation measures in the water sector (Taylor et al. 2014).

In a first step, the authors calculated estimates of future unmet water demand due to climate change by sector (livestock and agriculture, households, and industry). Total unmet demand under climate change was estimated to rise from 3.7 MCM/year in 2010 to 1,651 MCM/year in 2050. This unmet demand was then valued in monetary terms by using values derived from contingent valuation surveys in which respondents were asked to indicate their willingness to pay for water supply. The overall cost of unmet water demand in 2050 was estimated to be in the order of USD 5.5 billion.

The study then compared the costs of adaptation options with the value of the reduction in unmet demand associated with the options. In terms of adaptation options, the authors considered the interventions documented in Uganda's national Climate Change Policy Costed Adaptation Strategy, i.e., a programme of actions focusing on improvements in water use efficiency, a programme addressing water supply issues for agriculture and industry, and a programme for setting up an Integrated Water Resources Management system that would help reduce losses from droughts and floods. The benefits of each programme - in terms of effectiveness in reducing unmet demand – were assessed. The authors then calculated the minimum percentage reduction in damages that the programme must achieve in order to obtain a 10 percent rate of return on investment. The results indicate that even with a very small impact on unmet demand, all three programmes would generate this return on investment. This suggests that the benefits of adaptation actions in the water sector are very high and investments are justified.

Box 4-2 Cost-Benefit Analysis of adaptation in regards to the timber sector, Canada

In Canada (National Round Table on the Environment and the Economy 2011), the costs and benefits of adaptation in regards to timber production were assessed as follows:

• The physical impacts of climate change on the sector were defined as shifts in timber quantities from forest fires, forest productivity, and pest disturbance in a changing climate.

• Estimates of the expected changes in timber supply for different regions and climate-change scenarios (high climate change, low climate change) were developed.

• The costs and benefits of changes in timber quantities to the broader economy were calculated using computable general equilibrium (CGE) modelling. CGE models integrate consumer demand, labour and capital supply, and markets for production input and output. CGE models were run for each region under both rapid and slow growth scenarios. The models were then rerun with forest sector output adjusted based on the estimated changes in timber supply due to climate change. Comparing the economic indicators across model runs with and without climate change reveals the economy-wide impacts of different climate futures.

• The cumulative costs of climate change were calculated by summing up the annual costs from 2010 to 2080 and applying a 3% discount rate.

• Three adaptation strategies were selected for investigation due to their potential to cost-effectively reduce the impacts of climate change on timber quantities.

• To estimate the economic impact of their implementation, the authors reran the regional CGE models making adjustments to the expected changes in forest sector output to account for the effect of adaptation measures. They then compared economic indicators from this modelling with the costs of adaptation.

The results show that implementing the three adaptation strategies (in combination) would have a present-value cost of $2 billion to $4 billion between now and 2080, whilst the present value of the benefits of adaptation ranges from $20 billion to $138 billion (applying a 3% discount rate). Even after adaptation, some impacts remain and their costs are estimated at $5 billion to $37 billion.

4.2 STATE OF AFFAIRS WITH RESPECT TO ADAPTATION MEASURES AND REQUIRED RESOURCES FOR IMPLEMENTATION IN PALESTINE

The process of developing Palestine's NAP included a stakeholder consultation process aimed at the identification and prioritisation of adaptation options on the basis of multi-criteria analysis. For each vulnerable sector, a range of adaptation options were identified which seek to reduce vulnerabilities by decreasing climate sensitivity or increasing adaptive capacity, and which are relevant to all three future-climate scenarios established in the NAP (see Section 2.3). The stakeholder consultation undertaken during the NAP's preparation also served to identify the scale of the costs associated with the design and implementation of each adaptation option, including operational costs (e.g., human resources) and investment costs. Further information on the approach underpinning the estimates is provided in Annex III.

Broad-brush cost estimates were assigned for each adaptation option. Some costs appear more accurate than others, insofar as they are based on the extrapolation of values from concrete proposed, implemented or ongoing projects.

The following tables 4-2 and 4-3 present the adaptation options identified in regards to the agriculture, water, and food sectors in the West Bank and Gaza Strip, the corresponding total costs over the next ten years[16] and, where available, information on how the costs were estimated. The tables are adapted from the NAP Annex 4 and the corresponding performance matrices in Excel format.

The total costs of implementing the agriculture, water and food-related adaptation options proposed in the NAP have been estimated at USD 1 billion, USD 369.3 million[17], and USD

[16] Annex 4 of the NAP also presents a breakdown of the costs over the short term (year 1-5) and medium-term period (year 6-10).

[17] Including the costs (USD 58 million) of an adaptation option considered in the NAP under the industry sector ("Improve water supply through wastewater collection and treatment systems")

289.5, respectively, in the West Bank. For the Gaza Strip, the total costs amount to USD 645.8 million for agriculture, USD 582.7 million in the water sector, and USD 153.75 million in the food sector. In addition, the cost of several adaptation measures in the industry sector which are partially related to the agri-food industry (as detailed in tables 4.2 and 4.3) has been estimated at USD 28 million for the West Bank and USD 49 million for the Gaza Strip. However, in the absence of more fine-grained estimates per activity envisaged under each adaptation option in the industry sector, it is not possible to distinguish the agri-food related component of these estimates from the costs pertaining to adaptation in other industry subsectors.

The values above represent, however, ballpark figures that would have to be further refined in order to allow for a full quantitative cost-benefit analysis of adaptation in these sectors.

Table 4-1. Adaptation options identified in the NAP development process and their corresponding costs (West Bank)

Highly vulnerable issue	Adaptation option	Total estimated costs over the next 10 years (USD)	Details of cost estimates
AGRICULTURE			
Irrigated vegetables	Enhance sustainable community-level irrigation schemes and infrastructure	19,400,000	Years 1-5: Planning - $3,200,000 Year 6-10: Implementation - over an area of 30,000 dunum, approximately $16,200,000 based on the following unit costs per dunum: $200 for a modern irrigation grid; $200 for seedlings of drought-resistant varieties; $70 for plastic to cover the soil; and $70 for compost (total per dunum, $540).
Production of olives, grapes, stone fruits, rain-fed vegetables and field crops	Climate-smart agriculture	146,000,000	
Irrigation water	Improve water-use efficiency and using alternative water resources	140,000,000	The average cost of installing a pump and conveyance system per dunum is about $1,127. Hence, the cost of implementation across 30,000 dunums over the next five years is approx. $33,810,000.[18]
Grazing area and soil erosion	Land-use planning and management - greening, afforestation, and rangeland development	600,000,000	Adapting land management is anticipated to cost approx. $1000 per dunum. Years 1-5: Management of 300,000 dunums, approx. $300,000,000 Years 6-10: Management of a further 300,000 dunums, approx. $300,000,000
Production of olives, grapes, stone fruits, rain-	Agricultural disaster risk reduction and management (DRR/M)[19]	88,000,000	

[18] This information is extracted from the Excel performance matrix but does not match the value reported in the NAP.

[19] This option does not appear in the Excel performance matrix, but is included in the NAP.

Highly vulnerable issue	Adaptation option	Total estimated costs over the next 10 years (USD)	Details of cost estimates
fed vegetables, field crops and livestock			
Livestock production	Increase the availability of animal feed (including plant and organic residues) at an affordable price	16,000,000	The estimated cost of an appropriate basket of measures for 30,000 dunums is approx. $16,200,000 distributed over two phases: Years 1-5: approx. $8,000,000 Years 6 -10: approx. $8,000,000.
Livestock production	Improve livestock production pens	15,000,000	The cost of erecting a closed building of approx. 1,000 m^2, fully equipped with an HVAC system for breeding chickens and turkeys is approx. $150,000. Thus, the cost of erecting approx. 100,000 m^2 of fully equipped buildings over the next five years is approx. $15,000,000
WATER			
Condition of infrastructure	Rehabilitate water sources: wells, canals and springs	4,400,000	Years 1-5: $200,000 for a technical study to determine actions required to reduce losses from water sources in three districts $2,000,000 for implementing required actions in three districts Years 6-10: $200,000 for a technical study to determine actions required to reduce losses from water sources in an additional three districts $2,000,000 for implementing required actions in three districts
Condition of infrastructure	Control of leakage from distribution systems	16,500,000	Years 1-5 $250,000 for a technical study to determine actions required to reduce leaks from distribution systems in three districts $8,000,000 for implementation the study in three districts to reduce the loss Years 6-10 $250,000 for a technical study to determine actions required to reduce leaks from distribution systems in three more districts

Highly vulnerable issue	Adaptation option	Total estimated costs over the next 10 years (USD)	Details of cost estimates
			$8,000,000 for implementation the study in three districts to reduce the loss
Groundwater supply	Fairly and equitably allocate trans-boundary water resources between Israel and Palestine.	117,600,000	Years 1-5 $400,000 for designing and implementing a system to monitor and document Israel's use of Palestine's water resources. $200,000 for implementation an international campaign to raise awareness of the issue. $7,000,000 for well drilling in the Western Basin $10,000,000 for a water carrier from the Jordan River to the West Bank $30,000,000 for a national water carrier in the West Bank Years 6-10 $20,000,000 for water carrier from the Jordan River to the West Bank $50,000,000 for national water carrier in the West Bank"
Groundwater supply	Enhance the use of additional and alternative water resources for non-domestic purposes	152,000,000	Years 1-5 $50,000,000 for development of wastewater collection systems, treatment plants and reuse projects. $5,000,000 for development of saline water projects. $20,000,000 for development of water-harvesting projects and dams $2,000,000 for development of water-recharge wells Years 6-10 $50,000,000 for development of wastewater collection systems, treatment plants and reuse projects $3,000,000 for development of saline water projects $20,000,000 for development of water-harvesting projects and dams $2,000,000 for development of water-recharge wells

Highly vulnerable issue	Adaptation option	Total estimated costs over the next 10 years (USD)	Details of cost estimates
Flood management	Develop and improve storm-water systems and drainage infrastructure	20,800,000	Years 1-5 $400,000 for a technical study to identify required improvements in three major cities $10,000,000 for implementation required improvements in three major cities Years 6-10 $400,000 for a technical study to identify required improvements in three more major cities $10,000,000 for implementation required improvements in three major cities
Infrastructure	Improve water supply through wastewater collection and treatment systems[20]	58,000,000	N/A
FOOD			
Domestic food prices	Enhancing agricultural value chain and improving infrastructure for livestock production	227,500,000	N/A
Domestic food prices	Greenhouse management	25,000,000	N/A
Domestic food prices	Construction of large-scale cold storage	33,000,000	N/A
Imported food prices	Construct large-scale steel silos for grain to enable import and storage during periods when prices on international markets are low	4,000,000	N/A
INDUSTRY (including agri-food production)[21]			

[20] Considered in the NAP under the Industry sector adaptation options

Highly vulnerable issue	Adaptation option	Total estimated costs over the next 10 years (USD)	Details of cost estimates
Value of raw materials imported	Replace imported raw materials with local materials whenever possible	28,000,000	N/A

Table 4-2. Adaptation options identified in the NAP development process and their corresponding costs (Gaza Strip)

Highly vulnerable issue	Adaptation option	Total estimated costs over the next 10 years (USD)	Details of cost estimates
AGRICULTURE			
Citrus, olive production, vegetable production, employment	Climate-smart agriculture: Management of crop production systems including soil and water resources for better environmental sustainability along with improved economic profitability for farmers	40,400,000	N/A
Irrigation water	Improve water-use efficiency and using alternative water resources	14,270,000	N/A
Cost of agricultural production	Establishment of farmers' support (subsidies, awareness training programs)	85,000,000	N/A
Cost of agricultural production	Agricultural disaster risk reduction and management (DRR/M)	44,000,000	N/A
Livestock production	Improve livestock production pens	15,000,000	N/A
Coastal agriculture	Introduction of new saline-tolerant crops[22]	500,000	N/A

[21] The cost value below relates to several industry sub-sectors, not only agri-food.

[22] Considered in the NAP under the Costal adaptation options

Highly vulnerable issue	Adaptation option	Total estimated costs over the next 10 years (USD)	Details of cost estimates
Employment and gender	Supporting improvements in efficient use of water in women's private small-scale agricultural projects[23]	3,000,000	N/A
Food security and gender	Encouraging women to use their home gardens to produce food[24]	3,200,000	N/A
WATER			
Groundwater supply	Increase share of imported water	1,000,000	Estimated costs for the rehabilitation and installation of water-supply networks in years 1-5 would be approx. $1,000,000. This figure takes into account that there are existing projects to increase the amount of water supply from external resources that need to be expanded.
Groundwater supply	Enhance the use of additional and alternative water resources for non-domestic purposes	61,000,000	Years 1-5 $20,000,000 for development of wastewater collection systems, treatment plants and reuse projects. $2,000,000 for development of saline water projects. $5,000,000 for development of water-harvesting projects and dams $1,000,000 for development of water-recharge wells Years 6-10 $20,000,000 for development of wastewater collection systems, treatment plants and reuse projects $2,000,000 for development of saline water projects. $10,000,000 for development of water-harvesting projects and

[23] Considered in the NAP under the Gender-related adaptation options

[24] Considered in the NAP under the Gender-related adaptation options

Highly vulnerable issue	Adaptation option	Total estimated costs over the next 10 years (USD)	Details of cost estimates
			dams $1,000,000 for development of water-recharge wells
Groundwater quality and supply	Build a large desalination plant for Gaza	510,000,000	Years 1-5 $500,000,000 for building and operating the plant. Years 6-10 $10,000,000 for maintenance
Flood management	Develop and improve storm-water systems and drainage infrastructure	10,200,000	Years 1-5 $200,000 for a technical study to identify required improvements in three major cities $5,000,000 for implementation required improvements in three major cities Years 6-10 $200,000 for a technical study to identify required improvements in three more major cities $5,000,000 for implementation required improvements in three major cities
Coastal agriculture	Rain-water harvesting	500,000	N/A
FOOD			
Domestic food prices	Enhancing agricultural value chain and improving infrastructure for livestock production	121,250,000	N/A
Domestic food prices	Greenhouse management	12,500,000	N/A
Domestic food prices	Construction of large-scale cold storage	15,000,000	N/A
Imported food prices	Construct large-scale steel silos for grain to enable import and storage during periods when prices on international markets are	5,000,000	N/A

Highly vulnerable issue	Adaptation option	Total estimated costs over the next 10 years (USD)	Details of cost estimates
	low		
INDUSTRY (including agri-food production)[25]			
Value of industrial products exported	Provision of suitable storage facilities for Industrial products intended for export	18,000,000	N/A
Value of raw materials exported	Improve handling, fumigation, packaging, and storage techniques for raw materials intended for export	1,000,000	N/A
Value of industrial products exported	Rehabilitation of industrial facilities	30,000,000	N/A

[25] The cost values below relate to several industry sub-sectors, not only agri-food.

4.3 STATE OF AFFAIRS WITH RESPECT TO BENEFITS OF ADAPTATION MEASURES IN PALESTINE

In addition to cost estimates, the NAP also provides a multi-criteria analysis of the various adaptation options in order to derive a ranking of options. Stakeholders were presented with a "performance matrix" and asked to qualitatively evaluate each adaptation option, by giving it a score of "Low" (1), "Medium" (5) or "High" (10), on each of the following criteria: impact if the adaptation option is not implemented (i.e., the costs of inaction, or the avoided damage if the option is implemented), efficacy, timing/urgency for action, social acceptance, availability of technology, knowledge and skills, costs, and co-benefits for adaptation in other sectors and for mitigation. Further details of the methodology are provided in Annex III.

Box 4-3. Highest-ranking adaptation options per sector in the West Bank and Gaza Strip

West Bank

Agriculture:

Enhance sustainable community-level irrigation schemes and infrastructure.

Climate-smart agriculture.

Improve water-use efficiency and using alternative water resources.

Land-use planning and management, i.e., greening, afforestation, and rangeland development.

Water

Rehabilitate water sources: wells, canals and springs.

Control of leakage from distribution systems.

Allocate trans-boundary water resources equitably and reasonably between Israel and Palestine.

Food

Enhancing agricultural value chain and improving infrastructure for livestock production.

Greenhouse management.

Construction of large-scale cold storage.

Gaza Strip

Agriculture

Climate-smart agriculture: Management of crop production systems including soil and water resources for better environmental sustainability along with improved economic profitability for farmers.

Improve water-use efficiency and using alternative water resources.

Establishment of farmers' support (subsidies, awareness training programs).

Water

Increase the share of imported water.

Enhance the use of additional and alternative water resources for non-domestic purposes.

Build a large desalination plant for Gaza.

Food

Enhancing agricultural value chain and improving infrastructure for livestock production.

Greenhouse management

Construction of large-scale cold storage.

The outcomes of the NAP stakeholder consultation provide only broad-brush qualitative evaluations of the options' benefits (in terms of avoided damage, efficacy, co-benefits). For example, the information included in the Performance Matrix suggests that the assessment of efficacy was based on whether the measure would be relevant under all three climate scenarios, and not on estimations of the *extent* to which the measure would contribute to alleviating the impact of climate change on the respective highly vulnerable issue. Similarly, the consideration of co-benefits involved enumerating possible co-benefits, rather than estimating their magnitude.

As part of the present study, we endeavoured to derive more fine-grained estimates of the costs and benefits of the NAP adaptation options by using information from projects implemented or ongoing in Palestine in regards to the three sectors. We presented the relevant Palestinian institutions (MoA and PWA) with a list of projects and programmes known to the team from previous assignments, indicating as far as possible which of the NAP adaptation options each project/programme corresponded to. We asked relevant, informed officers within each institution to:

1. determine whether a project/programme was relevant to the identified adaptation option (i.e., correct and complete our preliminary mapping of projects/programmes against NAP adaptation options);

2. determine whether climate change was mainstreamed in a project/programme and whether any relevant information on impacts and costs was available;

3. inform us of any recent project or programme not included in the list; and

4. preselect the most relevant projects/programmes and provide us, for this subset, with any information relevant to the assessment of costs and benefits.

The full questionnaire and list of projects/programmes is included in Annex IV.

MoA and PWA examined the list of projects/programmes and looked into their portfolio, but were not yet able to provide such information on costs and benefits since such data will still need to be gathered and analysed.

4.4 MISSING DATA AND GAPS TOWARDS FULL-FLEDGED COST-BENEFIT ANALYSIS IN PALESTINE

As discussed in Section 4.2, the NAP provides initial estimates of the cost of adaptation in each sector, but more refined evaluations would be needed for some of the adaptation measures for a full-fledged CBA. For example, for the adaptation measure "Develop and improve storm-water systems and drainage infrastructure", the costs over the first five years were estimated as: "USD 400,000 for a technical study to identify required improvements in three major cities; USD 10,000,000 for implementation required improvements in three major cities." The calculations behind this value are not shown in the NAP and accompanying Performance Matrix, but the values appear to be broad estimates. A more detailed assessment would have to look into the costs of each foreseen action/project and consider different types of costs (one-off investments and continuous costs, costs of building new infrastructure or rehabilitating existing assets, operational and maintenance costs, etc.). The time horizon of these costs would also have to be considered, and an appropriate discount rate applied to express costs in their present value.

Whilst the calculation of (direct) costs is relatively straightforward insofar as it can be based mostly on market values of goods or services, the assessment of benefits presents additional challenges with respect to valuation. The results of the MCA conducted for the NAP provide an initial indication of benefits and ranking of adaptation options. However, the assessment of benefits for a CBA of proposed adaptation measures would require further information on:

1. the economic impact (or cost) of climate change (ideally, monetised) in each sector of interest, in order to estimate the cost of inaction, or the damage that could be avoided by implementing adaptation measures;

2. the effectiveness of each adaptation option in reducing the impacts of climate change in that sector (i.e., by how much would the costs of climate change identified in point 1) above be reduced through the adaptation measure?); and

3. any additional benefits resulting from the option's implementation, ideally expressed in monetary terms.

Finally, the aggregated costs and benefits of each adaptation measure would have to be compared (e.g., on the basis of their net present value, benefit-cost ratio, or internal rate of return), in order to identify the most efficient adaptation options.

4.5 RESEARCH NEEDS

The multi-criteria analysis underpinning the NAP provides a first estimate of the relative performance of different adaptation options. As noted in Section 4.1, MCA is a suitable approach in contexts where quantitative data on impacts is limited and where consideration should be given to multiple criteria (in addition to efficiency and effectiveness). However, there is scope for further economic assessment of the costs and benefits of identified adaptation options in order to conduct a full cost-benefit analysis.

5. CONCLUSIONS AND RECOMMENDED PROPOSED ACTIONS

5.1 ASSESSING ECONOMIC IMPACTS OF CLIMATE CHANGE, AND COSTS AND BENEFITS OF ADAPTATION ACTIONS IN PALESTINE

5.1.1 CLIMATE CHANGE TRENDS, SCENARIO DEVELOPMENT AND IMPACT ASSESSMENT: CURRENT STATE AND GAPS

Currently, climate change projections and scenarios are derived from regional data from the regional and neighbouring countries and interpretations from global and regional models.

More accurate projections and scenario development relying on downscaling to the national and local levels, exhaustive and countrywide, using and integrating locally derived data are not available yet. Thus, significant uncertainties about the precise impacts of climate change in the country remain. These drawbacks are linked to and feed into the issues around impacts and economic-impact assessments in Palestine. However, the ongoing "EXACT" project funded by UNDP precisely addresses the lack of downscaling of hydro climate models and related vulnerability studies and adaptation planning. The project is foreseen to be concluded by December 2017.

5.1.2 ECONOMIC-IMPACT ASSESSMENT: CURRENT STATE AND GAPS

The NAP development process and the related stakeholder consultation achieved a first and very much needed identification of highly vulnerable issues and the key climate sensitivity or impacts in the agricultural, water and agri-food sectors in the West Bank and Gaza Strip (see Table 5-1 below). All three sectors are interlinked and most information is available on impacts in the agricultural sector, covering many aspects in the other two sectors as well, whereas the least is known about food security and the agri-food sector.

Broad, general assessments on certain aspects (e.g., impacts on coastal aquifers in Gaza) and a country-wide quantitative economic-impact assessment of past extreme weather events (drought and frost in the agriculture sector) already exist, whilst the determination or integration of future climate-change impact scenarios is the next step (see above). In addition, isolated case studies modelling climate-change scenarios and related economic impacts for particular localities have already been determined and are useful first experiences to build on (e.g., application of the CROPWAT model to several incremental climate-change scenarios for the West Bank governorates of Jericho and Al-Aghwar).

Isolated qualitative studies or surveys on specific aspects or specific localities (very small samples) exist, such as a survey amongst 57 agricultural households in the Jordan Rift Valley (Mason and Mimi, 2014). The modelling case studies and the qualitative study on agricultural households either relied on regional level data and made general judgments on impacts (e.g., coastal aquifers) or did not yet look into the collection of relevant primary local data to underpin modelling efforts and (economic) impact assessments.

Table 5-1. Summary of identified highly vulnerable issues in the agricultural, water and agri-food sectors, corresponding adaptation options and costs as per the National Adaptation Plan in the West Bank and the Gaza Strip [26]

Issue	West Bank	Gaza Strip	Climate sensitivity/impacts or risks determined	West Bank	Adaptation option identified	Total estimated costs over the next 10 years (USD)	Gaza Strip	Adaptation option identified	Total estimated costs over the next 10 years (USD)
Agriculture									
Olive production	✔	✔	✔	✔	✔	✔	✔	✔	✔
Grape production	✔	N/A	✔	✔	✔	✔	✔	✔	✔
Stone fruits	✔	N/A	N/A	✔	✔	✔	✔	✔	✔
Rain-fed vegetables	✔	✔	✔	✔	✔	✔	✔	✔	✔
Field crops	✔	N/A	✔	✔	✔	✔	✔	✔	✔
Irrigated vegetables	✔	✔	✔	✔	✔	✔	✔	✔	✔
Grazing area and soil erosion	✔	N/A	✔	✔	✔	✔	N/A	N/A	N/A
Irrigation water	✔	✔	✔	✔	✔	✔	✔	✔	✔
Livestock production	✔	✔	✔	✔	✔	✔	✔	✔	✔
Cost of agricultural production	N/A	✔	✔	N/A	N/A	N/A	✔	✔	✔
Employment	N/A	✔	✔	N/A	N/A	N/A	✔	✔	✔
Citrus	N/A	✔	✔	N/A	N/A	N/A	✔	✔	✔
Coastal agriculture	N/A	✔	✔	N/A	N/A	N/A	✔	✔	✔
Water									
Groundwater supply	✔	✔	✔	✔	✔	✔	✔	✔	✔
Flood management	✔	✔	✔	✔	✔	✔	✔	✔	✔
Condition of infrastructure	✔	N/A	✔	✔	✔	✔	N/A	N/A	N/A
Groundwater quality	N/A	✔	✔	N/A	N/A	N/A	✔	✔	✔

[26] There are some inconsistencies and unclear aspects regarding definitions and categorisations of issues and related adaptation options and allocations of costs crosscutting the West Bank and Gaza that cannot be further clarified as part of this study. These issues need to be clarified and further worked on as part of the recommended next steps.

Issue	West Bank	Gaza Strip	Climate sensitivity/impacts or risks determined	West Bank	Adaptation option identified	Total estimated costs over the next 10 years (USD)	Gaza Strip	Adaptation option identified	Total estimated costs over the next 10 years (USD)
Coastal agriculture	N/A	✔	✔	N/A	N/A	N/A	✔	✔	✔
Agri-food (i.e., supply chain link)									
Manufacturing	N/A	N/A	✔	N/A	N/A	N/A	N/A	N/A	N/A
Transportation	N/A	N/A	✔	N/A	N/A	N/A	N/A	N/A	N/A
Warehousing and storage	N/A	N/A	✔	N/A	N/A	N/A	N/A	N/A	N/A
Trade	N/A	N/A	✔	N/A	N/A	N/A	N/A	N/A	N/A
Consumption	N/A	N/A	✔	N/A	N/A	N/A	N/A	N/A	N/A
Domestic food prices	✔	✔	N/A	✔	✔	✔	✔	✔	✔
Imported food prices	N/A	N/A	N/A	✔	✔	✔	✔	✔	✔
Value of raw materials imported[27]	✔	N/A	✔	✔	✔	✔	N/A	N/A	N/A
Value of industrial products exported[28]	N/A	✔	N/A	N/A	N/A	N/A	✔	✔	✔
Value of raw materials exported[29]	N/A	✔	N/A	N/A	N/A	N/A	✔	✔	✔

[27] Examined in the NAP in regards to several industry sub-sectors as opposed to agri-food exclusively.

[28] Ibid.

[29] Ibid.

5.1.3 ADAPTATION COSTS AND BENEFITS: CURRENT STATE AND GAPS

With the MCA as part of the NAP development process, Palestine and the Palestinian government have taken the first step in identifying, prioritizing and then ranking adaptation options in the three priority sectors - arriving at first cost estimates and broad-brush qualitative evaluations of the options' benefits (in terms of avoided damage, efficacy, co-benefits). A clear best-practice process and methodology has been applied here to identify a range of adaptation options in the three sectors with a view to decreasing climate sensitivity or increasing adaptive capacity that are relevant to the future-climate scenarios as per the NAP. Furthermore, the scale of the costs associated with the design and implementation of each adaptation option, including operational costs (e.g., human resources) and investment costs has been established.[30] Finally, this process allows one to arrive at broad-brush cost estimates and calculate the overall total cost of implementing the agriculture, water and food-related adaptation options proposed in the NAP (see Table 5-1 above).

The robustness of an MCA result, however, depends on the certainty of the information regarding the selected criteria, the relative priorities (weights) given to the criteria, and the extent to which the weights and scores per criterion are commonly agreed upon by stakeholders.

5.2 RECOMMENDATIONS ON THE WAY FORWARD AND THE NEXT STEPS

Firstly, building on the outcomes of the "EXACT" project (see above), we recommend the enabling of the Department of Meteorology (DoM) to downscale climate data and collect further local level climate data through the establishment of a unit with the required technical and human resources to regularly provide real-time and updated climate data to be fed into climate risk and economic-impact assessments and related monitoring. Secondly, such full-fledged climate risk and economic-impact assessments in the 12 sectors identified in the NAP as highly vulnerable as well as the monitoring need to be integrated into the emerging climate change institutional framework of the Palestinian government. Outsourcing the implementation of these activities, partially or fully, to a well-positioned institution or newly created competence centre may be considered. Third, whilst these first two recommendations will require longer timeframes to be fully implemented, a prioritisation is required with a view to sensitizing the Palestinian government and non-governmental stakeholders to the issues around climate-change impacts based on hard data - initiating first climate risk and economic-impact assessments in the three priority sectors and for selected subsectors or economic activities as per the NAP.

[30] Some costs appear more accurate than others, insofar as they are based on the extrapolation of values from concretely proposed, implemented or ongoing projects.

5.2.1 INTRODUCE CLIMATE MODELLING, DOWNSCALING AND COLLECTION OF LOCAL LEVEL CLIMATE DATA

The Palestinian government, more specifically the DoM at the Ministry of Transport, must be enabled to conduct the downscaling of global and regional climate models to the national and local/governorate level. The climate modelling may be contracted out to a qualified service provider from the scientific or applied research community, whereas the collection of local level climate data may rest with the DoM through equipping the DoM with the relevant weather station network and other required technical equipment. The study supporting the preparation of the NAP reviewed what resources and capabilities would be required for Palestine to generate its own climate modelling in the future and concluded that the costs would be in the order of USD 2.1 million.

5.2.2 QUANTIFY CLIMATE RISKS AND ECONOMIC IMPACTS

The Palestinian government or the relevant line ministries or agencies, i.e., MoA and PWA, need to conduct or contract out detailed climate risk and economic-impact assessments in the sectors highly vulnerable to climate change as per the NAP – arriving at a better understanding of the risks, costs and benefits to make the (economic) case for action now and not later. Quantifying the risks, costs and benefits is often very useful, but not always and in all cases needed (immediately) to convince (public) stakeholders to make decisions and act. However, making sustained investment decisions over many years as well as engaging the private sector in related actions and mobilizing private capital will greatly benefit or, in some cases, even require quantifiable risks, costs and benefits.

Cutting edge risk assessment approaches and tools

Contemporary risk assessment lacks robust, quantitative methodologies that inform the best options for adaptation to climate change. Currently, first R&D studies and projects by specialised players are underway introducing or integrating stochastic risk assessment tools (which have traditionally been used in the financial services sector) with climate risk assessments, with a view to determining the best timing and costing options for investment in adaptation through probabilistic scenario analysis. Such approaches go beyond and are complementary to existing 'soft' approaches applied by technical cooperation agencies such as GIZ, for example.

Related quantitative risk assessment frameworks and methodologies allow for combining or integrating expert advice and climate and economic data to inform the best means of using stochastic risk assessment tools for particular regions and activities. Such approaches are aimed at public and private organisations, planners and decision-makers where there is high asset risk to climate-change impacts.

Detailed economic impacts assessments

Empowering policy makers, businesses and other actors in Palestine to identify and then implement appropriate risk management approaches to increase their preparedness for climate risks, eventually underpinned by hard, quantifiable data (see above), requires economic-impact assessments – building on and using such climate risk assessments as described above as a follow-up measure and next step.

Box 5-1 outlines two examples, one for the water sector and one for the agri-food sector, which are by no means exhaustive with respect to scope and scale, but provide a first indication of what such economic assessments in the water or agri-food sector entail.

Box 5-1. Examples of the scopes and scales of detailed assessments of economic impacts on the water and the agri-food sectors

A quantitative assessment of economic impacts related to the water sector would involve:

- quantifying (in physical terms) the impacts of different climate scenarios (notably, the scenarios developed in the context of the INCR and NAP) on Palestine's water supply;
- modelling future water demand in the country, taking into consideration socio-economic developments (e.g., population growth, economic growth, urbanisation). Since this requires a number of assumptions, the modelling may have to be based on alternative socio-economic scenarios;
- calculating future unmet water demand and modelling the distribution of unmet demand amongst sectors (domestic use/drinking water, agriculture, manufacturing, sanitation, etc.);
- Ideally, determining which proportion of unmet demand is attributable to climate-change impacts, and which would occur independently (under a no-climate-change scenario);
- determining (ideally through economic modelling) the impacts of (climate-induced) unmet water demand in each sector (i.e., in terms of changes in production output, impacts on health, food security, trade, employment, etc.);
- ascribing monetary values to these impacts. For some impacts, market values could be used (e.g., the costs of agricultural yield losses or reduced production in a given industrial sector can be based on prices and revenue values), whereas for others more complex approaches would be needed, e.g., the value users ascribe to household water shortages could be estimated through contingent valuation surveys (see Section 4.1), the valuation of impacts on health could take into account healthcare costs as well as other consequent economic losses, such as reduced labour productivity; and
- in addition to impacts in terms of unmet demand, for the part of future demand that can be met, climate-induced effects on supply may alter prices. Thus, a full economic assessment would also have to model water price impacts in different sectors attributable to climate change.

An assessment of the economic impacts on the agri-food sector would involve:

1. mapping supply chains for the most important product categories/subsectors in Palestine;
2. identifying climate-related vulnerabilities at each stage of the supply chain; and
3. quantifying potential losses at each stage of the supply chain under different scenarios (i.e., assessing risk); this could be based, for example, on expert opinion of actors in the supply chain, extrapolation of the values of losses incurred due to past extreme events (droughts, floods), and/or economic modelling.

5.2.3 OPTIONS FOR THE FURTHER ANALYSIS OF THE COSTS AND BENEFITS – STARTING WITH THE THREE PRIORITY SECTORS

Bearing in mind what the Palestinian government has already achieved in the context of elaborating the NAP as well as existing constraints and hurdles with respect to data and capacity needs in the context of further analysing the costs and benefits of adaptation options, per entire sectors and for specific measures or subsectors, the following options crystallize for Palestine and the government (see Table 5-2 below).

Table 5-2 provides a high-level overview of the options ranging from the already implemented MCA as part of the NAP, to CEA(s) to full-fledged CBA(s), as well as a step-wise approach as a fourth option – showing key pros and cons. A full-fledged CBA for an entire sector or subsector/activities, for example, would have to look into the costs of each foreseen action/project and consider different types of costs (one-off investments and continuous costs, costs of building new infrastructure or rehabilitating existing assets, operational and maintenance costs, etc.). The time horizon of these costs would also have to be considered, and an appropriate discount rate applied to express costs in their present value.

Table 5-2. Options for the further analysis of the costs and benefits of climate change adaptation in the Palestinian context

Option	Pros	Cons
1. Full-fledged CBA for the 3 sectors, or selected priority NAP actions from the 3 sectors	Arrive at or support decision-making with respect to a policy, project or measure based on quantifiable data and cost-benefit ratio	Most (monetary) data intensive, requiring quantifiable data on costs of adaptation and benefits Rather lengthy implementation process
2. CEA (same features as above for the CBA)	Identify the least costly adaptation option(s), if needed, based on (improved) costs of adaptation measures	Cost-benefit ratio cannot be determined
3. MCA	Already implemented (to some extent) and makes it possible to arrive at the identification of (no-regrets) adaptation option(s) to support decision-making	Cost-benefit ratio cannot be determined
4. Step-wise approach – improving MCA whilst conducting CEA(s) or CBA(s) over time as well	Thorough data collection and analysis process – allowing one to arrive at full-fledged CBA over time (if and where needed), whilst providing interim results the different stakeholder groups can work with/make use of	Rather lengthy implementation process

In addition to the more fine-grained estimates of the costs of adaptation options for a full-fledged CBA, further work on the benefits is needed. Some of the criteria used in the MCA - in particular, climate change impacts in the absence of the adaptation measure (or the damage avoided by implementing the measure), the option's efficacy (or effectiveness in alleviating negative impacts of climate change), and its co-benefits – also represent benefit components that should be included in a cost-benefit analysis. As in the case of costs, the outcomes of the NAP stakeholder consultation provide first evaluations of these benefits, but further data would be needed for a full CBA.

In this context, the Palestinian government in consultation with other key stakeholder groups will need to further analyse these options and decide on the best way forward. A roadmap suggesting the broad approach over a longer period of time is presented in Section 5.2.5.

5.2.4 OUTCOMES OF THE NATIONAL VALIDATION WORKSHOP

Box 5-2 below summarizes the conclusions of the National Validation Workshop held in Ramallah on 13 February 2017.

Box 5-2 Main discussion points and outcomes of the National Validation Workshop in February 2017 in Ramallah

- Better scenarios and forecasting for the Palestinian territory, including spatial distribution of climate impacts and related economic impacts, are needed. The need for downscaled data from regional climate models was reiterated in this context as well. Responding to questions about the limitations in the scope of the study, ClimaSouth and Environment Quality Authority (EQA) explained that the focus on the agriculture, water and agri-food and food security sectors in the economic impacts study was a joint decision by the Palestinian government/EQA, ClimaSouth and the expert conducting the study.
- More and better data for assessing and monitoring the situation in Palestine is definitely needed, which will take some time and availability will improve over time, but action in a priority sector, subsector or a specific economic activity therein can be taken now. The pursuit of two parallel streams, a series of short term measures and a long term vision for the coming years, was recommended by the workshop participants (see below).
- Existing and increasing water scarcity in Palestine is magnified by climate change.
- A better coordination amongst stakeholders (see below) should reveal more existing, relevant data already available at research, non-governmental and international organisations present in Palestine.
- Mainstreaming and tracking of climate change action and finance was not considered in Palestine before 2015 and, although the need for doing so is known since, still needs to fully materialize across all sectors and at the level of the governorates (see below).
- The impacts of climate change, although not distinguished from 'normal' climatic variations or extreme weather events (i.e., with respect to frequency and magnitude), are already felt on the ground and perceived by farmers in Palestine.
- The proposed roadmap, a step-wise approach towards a fully functioning climate risk/impact monitoring system for Palestine is supported by the National Climate Change Committee (NCCC) representatives and the other workshop participants. At the same time, the EQA intends to cover all economic sectors with the relevant best practice methodological approaches to assess costs and benefits of adaptation options.
- The agricultural sector seems most advanced compared to the other sectors with respect to the

availability of relevant data and the mainstreaming of climate change into the sector strategy. At the time of writing this report only the 2014/16 sector strategy is known, whilst the new sector strategy is currently being finalised.

- The NCCC should task the relevant subcommittee with establishing a technical working group with a view to developing an overall action plan (incl. prioritisation, sequencing/timelines, responsibilities and objectives with indicators for measuring progress) for the further development of a full-blown climate risk assessment (CRA) strategy – covering the entire roadmap. Next to the integration of the CRA process into the emerging climate-change governance structure and processes (see also Tippmann et al. 2015) the alignment with donor priorities should be ensured with a view to funding the implementation of the action plan.
- First of all, the MoA and EQA should develop and implement, if needed with external assistance, (a) first climate risk/impact assessment pilot activities in the agricultural sector, selecting priority actions relevant to adaptation to climate change based on the new sector strategy (e.g., with respect to olive-oil production, if applicable), to improve the knowledge on the subject matter and develop capacities.
- Overall coordination or addressing the lack of coordination amongst stakeholders has been identified as a continued problem and addressing the need for improved coordination through a functioning and operating NCCC is considered to be of the utmost importance (see also Tippmann et al. 2015).

5.2.5 ROADMAP

Taking into account the outcomes of this study the following overall roadmap crystallizes and is recommended, i.e., option 4 in the above Table 5-2 (see Figure 5-1 below).

1. **Build on and work the existing MCA and improve the overall database:** aside from improving the monetary assessments or cost figures for adaptation measures, such improved costing should be combined such improved costing should be combined with the determination or quantification of impacts with hard (local) data and related assessment approaches (see above) – selecting concrete localities and focusing on the three key sectors. For example, applying stochastic modelling and combining vulnerability indices for impacts with specific adaptation options and improved costing for such measures (engineering or management changes).

2. **Decide for which adaptation measures (a) CEA(s) or even (a) CBA(s) may be useful or even required:** focusing on the three priority sectors and the related list of priority adaptation actions identified in the NAP, CEAs or CBAs may be needed to arrive at the best or cost-effective, concrete adaptation options within a sector/subsector and a certain locality or at concrete ratios to convince the Palestinian government, other national stakeholders or stakeholder groups and/or international development partners to engage and/or invest in a measure. To what extent entire sector studies and/or individual subsectors or activities in certain localities are needed remains to be seen.

3. **Conduct CEA(s) or CBA(s) for selected options/measures:** Again, it is too early to know which options or measures may require CEA(s) or CBA(s) and more data on the

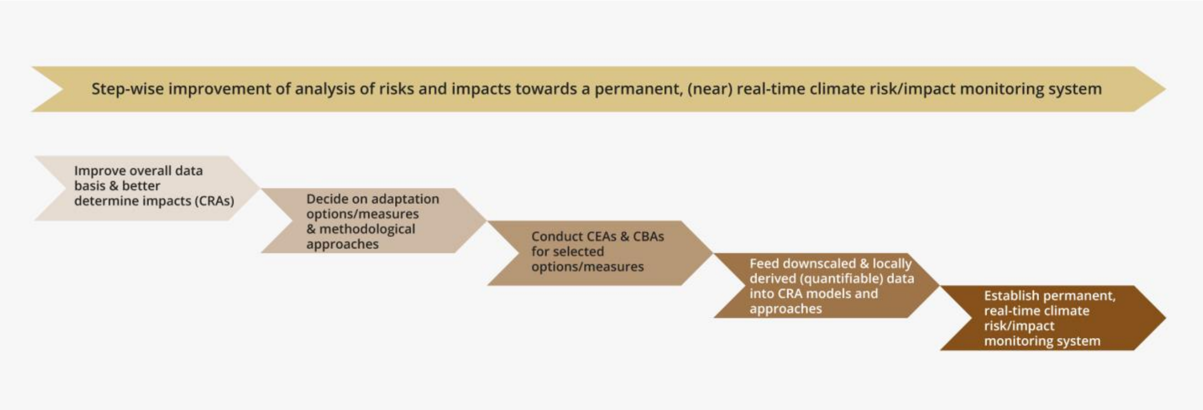
(economic) impacts and the quantification of the costs and benefits of adaptation measures is required. However, all three sectors are affected by climate change, are interlinked and are crucial to the Palestinian economy. Although, very little is known and there are no 360-degree economic-impact assessments beyond agri-production in the agri-food sector publicly available, yet,[31] an important agricultural or agri-food subsector in Palestine such as the olive oil industry, for example, could be a good starting point raising enough interest and critical stakeholder mass. That is with a view to conduct such a 360-degree impact assessment to gain first experiences in doing this and prepare (a) first CBA(s) for an important economic activity in Palestine.

4. **Feed outcomes of downscaled climate models and locally derived data into climate risk-assessment models and approaches:** Together with improved local climate data or related established trends from downscaled climate models, such climate and socio-economic data derived from CEAs or CBAs could be fed into climate risk-assessment models and approaches further improving them. Locally derived data and established national or even local trends – underpinning and improving or quantifying impact assessments and economic impacts country-wide and at the sector level as well as being able to drill down to the level of governorates all over the country – will allow for informed decision-making about the future course of action in Palestine using hard data.

5. **Establish permanent, (near) real-time climate risk/impact monitoring system for Palestine:** Assuming a parallel process of fully mainstreaming climate change into government structures and processes, horizontally at the sector level and vertically down to the governorates at some point, covering all 12 sectors or areas identified in the NAP as highly vulnerable to the impact of climate change will require the establishment of a permanent, real-time climate risk/impact monitoring system at the national level. Such a system should be integrated into the emerging climate-change governance and institutional framework and processes, whilst some activities or services may be outsourced to suitable non-governmental or research organisations. This in turn allows the proper integration of related climate action projects/programmes into the planning and budgeting processes of the Palestinian government, creating the planning and budget data, which is also needed with a view to track and MRV climate finance later on to be able to report under the UNFCCC and to the climate-finance donors.

[31] This area is still in its infancy. There are very few surveys on businesses and perception of risks or papers on climate change and supply chains from a risk management perspective. The big corporations in this sector, such as Nestle, Kraft and Syngenta, have only just become active in this area in recent years and are slowly moving forwards with pilots and studies on this matter.

Figure 5-1. Roadmap towards a permanent, (near) real-time climate risk/impact monitoring system



REFERENCES

Applied Research Institute – Jerusalem (ARIJ) (2015a) Status of the Environment in the State of Palestine -2015.

Applied Research Institute – Jerusalem (ARIJ) (2015a) The Food Industry Sector in the West Bank. Study summary.

Biewald, A., Lotze-Campen, H., Otto, I., Brinckmann, N., Bodirsky, B., Weindl, I., Popp, A., and Schellnhuber, H.J. (2015) The impact of climate change on costs of food and people exposed to hunger on a sub-national scale. Potsdam Institute for Climate Impact Research, Potsdam, Germany.

Bosello, F. and Eboli, F. (2013) Economic Impacts of Climate Change in the Southern Mediterranean. MEDPRO Technical Report No. 25.

Carbon Disclosure Project (CDP) (2013) Reducing Risk and Driving Business Value. CDP Supply Chain Report 2012-13.

Chenoweth, J., Hadjinicolaou, P., Bruggeman, A., Lelieveld, J., Levin, Z., Lange, M.A., Xoplaki, E., and Hadjikakou, M. (2011) Impact of climate change on the water resources of the eastern Mediterranean and Middle East region: Modelled 21st century changes and implications. *Water Resources Research*, 47(6).

Chiew, F. H. S., Kirono, D. G. C., Kent, D. M., Frost, A. J., Charles, S. P., Timbal, B., Nguyen, K. C., and Fu, G. (2010) Comparison of runoff modelled using rainfall from different downscaling methods for historical and future climates. *Journal of Hydrology*, 387, pp. 10–23

Dasaklis, T. K. and Pappis, C. P. (2013) Supply chain management in view of climate change: An overview of possible impacts and the road ahead. *Journal of Industrial Engineering and Management*, 6(4), pp. 1124-1138.

Elasha, B. O. (2010) Mapping of Climate Change Threats and Human Development Impacts in the Arab Region. Arab Human Development Report. Research Paper Series. United Nations Development Programme, Regional Bureau for Arab States.

Environment Agency (2013) Assessing and managing climate change risks in supply chains.

European Parliament Research Service (EPRS) (2016) Water in the Israeli-Palestinian conflict. Briefing Note PE 573.916.

European Union External Action Service (EEAS) (2016) European Union Commissioner Hahn visits the seawater desalination plant in Gaza and announces an additional funding of 10 million euros for the second phase. Available at: https://eeas.europa.eu/headquarters/headquarters-homepage/12442/the-european-union-commissioner-hahn-visits-the-seawater-desalination-plant-in-gaza-and-announces-an-additional-funding-of-10-million-euros-for-the-second-phase_en, accessed on 27 December 2016.

Evans, J.P. (2009) Twenty-first-century climate change in the Middle East. *Climatic Change*, 92(3), pp. 417-32.

Ferrise, R., Moriondo, M., Trombi, G., Miglietta, F., and Bindi, M. (2013) Climate-Change Impacts on Typical Mediterranean Crops and Evaluation of Adaptation Strategies to Cope With. In: Navarra, A. and Tubiana, L. (eds.) Regional Assessment of Climate Change in the Mediterranean. Volume 2: Agriculture, Forests and Ecosystem Services and People. Springer, Dordrecht, Netherlands.

Field, C. B., Barros, V. R., Mach, K., and Mastrandrea, M. (2014) Climate change 2014: impacts, adaptation, and vulnerability (Vol. 1). Cambridge University Press Cambridge, New York, NY.

Food and Agriculture Organisation (FAO) (2016a) The state of food and agriculture. Climate change, agriculture and food security. FAO, Rome, Italy.

GIZ (2012) Climate Change and Water in the Arab Region. Bonn, Germany.

Horizon and Climatekos (2013) Integrating Climate Change Finance into Sustainable Land Management Investment Strategies in Palestine - Assessment Report.

Impacts of climate change on olive crop evapotranspiration and irrigation requirements in the Mediterranean region

Intergovernmental Panel on Climate Change (IPCC) (2007) Climate Change 2007: Synthesis Report, Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland.

Jiménez Cisneros, B. E., Oki, T., Arnell, N. W., Benito, G., Cogley, J. G., Döll, P., Jiang, T., Mwakalila, S. S. (2014) Freshwater resources. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 229-270.

Jobbins, G., and Henley, G. (2015) Food in an uncertain future: the impacts of climate change on food security and nutrition in the Middle East and North Africa. Overseas Development Institute, London / World Food Programme, Rome.

Lelieveld, J., Hadjinicolaou, P., Kostopoulou, E., Chenoweth, J., El Maayar, M., Giannakopoulos, C., Hannides, C., Lange, M. A., Tanarhte, M., Tyrlis, E., and Xoplaki, E. (2012) Climate change and impacts in the Eastern Mediterranean and the Middle East. *Climatic Change*, 114, pp. 667–687.

Mason, M. and Mimi, Z. (2014) Trans-boundary climate security climate vulnerability and rural livelihoods in the Jordan river basin. Final project report.

Michael, D. and Crossley, R. (2012) Australian Food Security: Impact of Climate Change and Risk Management: How prepared are Australian food industry leaders? National Climate Change Adaptation Research Facility, Gold Coast, Australia.

Mimi, Z. A. and Jamous, S. A. (2010) Climate change and agricultural water demand: Impacts and adaptations. *African Journal of Environmental Science and Technology*, 4(4), pp. 183-191.

Mizyed, N. (2009) Impacts of Climate Change on Water Resources Availability and Agricultural Water Demand in the West Bank. *Water Resources Management*, 23(10), pp. 2015–2029.

National Round Table on the Environment and the Economy (2011) Paying the Price: The Economic Impacts of Climate Change for Canada. National Round Table on the Environment and the Economy, Ontario, Canada:

Önol, B. and Semazzi, F. H. M. (2009) Regionalisation of climate change simulations over the Eastern Mediterranean. *Journal of Climate*, 22, pp. 1944–1961.

Palestine Economic Policy Research Institute (MAS) (2016) Food Security Bulletin, Issue 14.

Palestinian Central Bureau of Statistics (PCBS) (2011) Agricultural Census 2010 – Final Results, Palestinian Territory. Ramallah, Palestine.

Palestinian Central Bureau of Statistics (PCBS) (2014) Number of Enterprises and Employed Persons and Main Economic Indicators in Palestine For Industrial Activities, 2014. Available at: http://www.pcbs.gov.ps/Portals/_Rainbow/Documents/Number%20of%20Enterprises%20and%20Employed%20Persons%20and%20Main%20Economic%20Indicators%20in%20Palestine%20For%20Industrial%20Activities%20,%202014.htm, accessed on 27 December 2016.

Palestinian Central Bureau of Statistics (PCBS) (2016) National Accounts at Current and Constant Prices, 2015. Ramallah, Palestine.

Palestinian Central Bureau of Statistics (PCBS) (undated), Variety tables of water, 2014. Available at: http://www.pcbs.gov.ps/site/lang__en/771/default.aspx#, accessed on 27 December 2016.

PCBS and Food Security Sector (2016) Socio-economic & Food Security Survey 2014. State of Palestine.

Peleg, N., Shamir, E., Georgakakos, K. P., and Morin, E. (2015) A framework for assessing hydrological regime sensitivity to climate change in a convective rainfall environment: a case study of two medium-sized eastern Mediterranean catchments, Israel. *Hydrology and Earth System Sciences*, 19(1), pp. 567–581.

Ponti, L., Gutierrez, A. P., Ruti, P. M., and Dell'Aquila, A. (2014) Fine-scale ecological and economic assessment of climate change on olive in the Mediterranean Basin reveals winners and losers. *Proceedings of the National Academy of Sciences* 111(15), pp. 5598–5603.

Porter, J. R., Xie, L., Challinor, A.J., Cochrane, K., Howden, S. M., Iqbal, M. M., Lobell, D. B., and Travasso, M. I. (2014) Food security and food production systems. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects.

Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 485-533.

Scholtz, A. and Von Bormann, T. (2016) Planning for uncertainty: developing scenarios for risk resilience in the South African agri-food value chain. WWF South Africa.

Selvaraju, R. (2013) Implications of climate change for agriculture and food security in the Western Asia and Northern Africa region. In: Climate change and food security in West Asia and North Africa. Springer, Dordrecht, The Netherlands, pp.27-51.

Smiatek, G., and Kunstmann, H. (2016) Expected future runoff of the Upper Jordan River simulated with a CORDEX climate data ensemble. *Journal of Hydrometeorology*, 17(3), pp. 865–879.

Smiatek, G., Kunstmann, H., and Heckl, A. (2014) High-Resolution Climate Change Impact Analysis on Expected Future Water Availability in the Upper Jordan Catchment and the Middle East. *Journal of Hydrometeorology*, 15(4), pp. 1517-1531.

Smithers, R., Harrison, M., Mimi, Z., Hardan, K., Abdelall, S. and Hasan, A. (2016) National Adaptation Plan (NAP) to Climate Change.

State of Palestine (2016) Initial National Communication Report (INCR) to the United Nations Framework Convention on Climate Change.

State of Palestine (2016b) Palestinian National Action Plan on Sustainable Consumption and Production 2016.

State of Palestine, Ministry of Agriculture (undated) National Agriculture Sector Strategy 2014-2016: Resilience and Development.

Tanasijevic, L., Todorovic, M., Pereira, L. S., Pizzigalli, C., and Lionello P. (2014) *Agricultural Water Management* 144, pp. 54–68.

Taylor, T., Markandya, A., Droogers, P., Rugumayo, A. (2014) Economic Assessment of the Impacts of Climate Change in Uganda. Water Sector Report.

Tippmann, R., Theodorie, H., Agoumi, A. and Stour, L. (2015) Assessment of National Capacities for Implementing Climate Change Adaptation and Mitigation Measures and Development of a National Capacity Development Program for the Palestinian Authority-Capacity Development Program Report. Report for UNDP/PAPP.

UNDP (2010) Climate Change Adaptation Strategy and Programme of Action for the Palestinian Authority. United Nations Development Programme of Assistance to the Palestinian People, Jerusalem.

UNFCCC (20114) Assessing the costs and benefits of adaptation options. An overview of approaches.

United Nations Conference on Trade and Development (UNCTAD) (2015) The Besieged Palestinian Agricultural Sector.

United Nations Development Programme (UNDP) (2010) Climate Change Adaptation Strategy and Programme of Action for the Palestinian Authority.

United Nations Development Programme (UNDP) (2015) Briefing note for countries on the 2015 Human Development Report. Palestine. Available at: http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/PSE.pdf, accessed on 27 December 2016.

United Nations Development Programme (UNDP) (2016) About the Occupied Palestinian Territory. Available at: http://www.ps.undp.org/content/papp/en/home/countryinfo/, accessed on 27 December 2016.

United Nations Statistics Division (2016) State of Palestine. Available at: http://data.un.org/CountryProfile.aspx?crName=State%20of%20Palestine, accessed on 27 December 2016.

Verner, D., Lee, D.R., Ashwill, M. and Wilby, R. (2013) Increasing Resilience to Climate Change in the Agricultural Sector of the Middle East: The Cases of Jordan and Lebanon. World Bank, Washington, DC.

World Bank (2009) Assessment of restrictions on Palestinian water development. Sector note.

World Bank (2014) Turn Down the Heat: Confronting the New Climate Normal. World Bank, Washington, DC.

World Bank (2016a) DataBank. Available at http://databank.worldbank.org/data/home.aspx, accessed on 27 December 2016.

World Bank (2016b) Palestine's Economic Outlook - Fall 2016. Available at: http://www.worldbank.org/en/country/westbankandgaza/publication/economic-outlook-fall-2016, accessed on 27 December 2016.

World Bank (2016c) High and Dry. Climate Change, Water, and the Economy. World Bank, Washington, DC.

World Food Programme and Applied Research Institute – Jerusalem (2010) Socio-economic and Food Security Atlas In the occupied Palestinian territory.

ANNEX I. SUMMARY FOR POLICY MAKERS: THE ECONOMIC IMPACTS OF CLIMATE CHANGE IN PALESTINE

Although significant uncertainties about the precise impacts of climate change in Palestine remain (given the lack of climate projections based on downscaling to the national and local levels, as well as the limited information on the economic impacts of climate change in the country), climate change is expected to negatively impact the three sectors studied. Impacts are likely to occur through a range of pathways and to compound the consequences of other drivers of vulnerability, such as population growth and the Israeli occupation.

Agriculture

Changes in temperature, precipitation, water availability, atmospheric composition, and extreme climate events are generally expected to negatively affect agricultural production, which may then translate into impacts on agricultural prices, incomes, and food security. Food insecurity is already a cause of concern in Palestine, with 28.6% of Palestinian households considered either severely or marginally food-insecure in 2014, according to the latest Socio-economic and Food Security Survey in Palestine. In the absence of adaptation, climate change may exacerbate these trends.

The potential consequences of climate change risks on agriculture in Palestine are summarised in the following table. Quantitative estimates of the effects of climate change on the Palestinian agricultural sector are, however, scarce and generally limited to particular localities.

Table 1. Potential climate-change impacts on agriculture in Palestine

Main climatic causes of risk	Consequences on the agricultural sector
Changes in monthly precipitation distribution	Crop area changes due to decrease in optimal farming conditions
Increased temperatures in critical periods	
Increased erosion	
Loss of soil water-retention capacity	
Increased soil salinity	
Sea level rise affecting coastal soil in the Gaza Strip	
Changes in monthly precipitation distribution	Decreased crop productivity
Increases in seasonal temperature variability	
Increased temperatures in critical periods (heat stress)	
Increased evapotranspiration (leading to water stress)	
Loss of soil water-retention capacity	
Increased incidence of agricultural pests and pathogens	
Decreasing livestock carrying capacity of grazing areas (due to changes in temperature and water availability)	Decreased livestock productivity
Increased temperatures (heat stress)	
Decreased water availability	

Increase of extreme events frequency/intensity	Increased risk of floods (affecting crops, livestock and agricultural infrastructure)
Loss of soil water-retention capacity	
Decreased annual and/or seasonal precipitation	Increased risk of drought and water scarcity
Increase in the frequency of extreme conditions (droughts and heat waves)	
Decreased groundwater availability/quality	
Sea water intrusion into groundwater in Gaza (which will add to its salinity and decrease its suitability for irrigation)	
Increased demand on aquifers leading to further depletion	
Conflicts amongst water users due to drought and water scarcity	
Increased average and extreme temperature	Increased irrigation requirements
Increased evapotranspiration in plants	
Increase of drought and heat stress conditions frequency	
Decreased precipitation	
Decreased water availability	

Source: Based on Mimi and Jamous (2010) and Horizon and Climatekos (2013)

Water

The water sector is particularly vulnerable to the effects of climate change since Palestine has one of the lowest per capita water availability in the world. The potential impacts of climate change on the water sector can be summarised as follows:

- declining rainfall, resulting in reduced water availability for rain-fed agriculture;
- increased evapotranspiration due to rising temperatures;
- reduced surface runoff and groundwater recharge;
- greater variability and more extremes decrease reliability of water resources and increase uncertainty in water management;
- sea level rise contributes to saltwater intrusion in coastal aquifers;
- increased irrigation requirements pose growing pressure on aquifers;
- temperature increases and extreme events may affect water quality.

Whilst some quantitative estimates (based on modelling) of the physical impacts of climate change on Palestine's water resources exist, the *economic* impacts have not yet been quantitatively assessed.

Food security and the agri-food sector

Data on the impacts of climate change on the agri-food sector, beyond impacts on agricultural output, is more limited compared to the first two sectors analysed, both globally and in Palestine. In general terms, climate change may affect multiple links of the agri-food supply chain, from manufacturing to distribution and consumption. Key potential impacts include:

- reduced availability/quality of input (agricultural production and water resources): the Palestinian food processing industry relies on locally produced agricultural products for 50% of the raw materials used, hence a reduction in domestic yields due to increased temperatures and reduced water availability could significantly affect the sector;
- impacts on domestic and imported food prices, which may aggravate food insecurity;
- temperature increases may increase post-harvest losses by causing food to spoil more rapidly or by increasing the risk of pathogen or pest infection – particularly given the lack of large-scale cold-storage facilities in Palestine - whilst transport disruptions caused by extreme events may affect the supply chain.

Overall, very little information exists on the economic impacts of climate change on the Palestinian agri-food sector, and quantified (monetary) estimates are entirely lacking.

Recommendations

Through the development of the National Adaptation Plan to Climate Change, Palestine has made significant progress towards identifying and ranking adaptation measures on the basis of a multi-criteria analysis, including ballpark quantitative estimates of the costs associated with each measure and broad qualitative assessments of the benefits. To build on this work and further improve the knowledge base on the impacts of climate change in Palestine and the costs and benefits of adaptation, the following recommendations emerge from our analysis.

- The Department of Meteorology should be enabled to conduct downscaling of global and regional climate models to the national and local/governorate level and to collect local level climate data.
- The Palestinian government (or the relevant ministries or agencies) should conduct or contract out detailed climate risk and economic-impact assessments in the sectors highly vulnerable to climate change, as identified in the NAP.
- Further analysis of the costs and benefits of adaptation measures in the three sectors should be conducted. Several options exist in this regard, as outlined in the following table.

Table 2. Options for the further analysis of the costs and benefits of climate change adaptation in the Palestinian context

Option	Pros	Cons
1. Full-fledged Cost-Benefit Analysis (CBA) for the 3 sectors, or selected priority NAP actions from the 3 sectors	Arrive at or support decision-making with respect to a policy, project or measure based on quantifiable data and cost-benefit ratio	Most (monetary) data intensive, requiring quantifiable data on costs of adaptation and benefits Rather lengthy implementation process
2. Cost-effectiveness Analysis (CEA) (same features as	Identify the least costly adaptation option(s), if needed, based on (improved) costs of adaptation measures	Cost-benefit ratio cannot be determined

above for the CBA)		
3. Multi-criteria Analysis (MCA)	Already implemented (to some extent) and makes it possible to arrive at the identification of (no-regrets) adaptation option(s) to support decision-making	Cost-benefit ratio cannot be determined
4. Step-wise approach – improving MCA whilst conducting CEA(s) or CBA(s) over time as well	Thorough data collection and analysis process – allowing one to arrive at full-fledged CBA over time (if and where needed), whilst providing interim results the different stakeholder groups can work with/make use of	Rather lengthy implementation process

A roadmap suggesting the broad approach over a longer period of time is presented below.

6. **Build on and work the existing MCA and improve the overall database:** aside from improving the monetary assessments or cost figures for adaptation measures, such improved costing should be combined such improved costing should be combined with the determination or quantification of impacts with hard (local) data and related assessment approaches (see above) – selecting concrete localities and focusing on the three key sectors. For example, applying stochastic modelling and combining vulnerability indices for impacts with specific adaptation options and improved costing for such measures (engineering or management changes).

7. **Decide for which adaptation measures (a) CEA(s) or even (a) CBA(s) may be useful or even required:** focusing on the three priority sectors and the related list of priority adaptation actions identified in the NAP, CEAs or CBAs may be needed to arrive at the best or cost-effective, concrete adaptation options within a sector/subsector and a certain locality or at concrete ratios to convince the Palestinian government, other national stakeholders or stakeholder groups and/or international development partners to engage and/or invest in a measure. To what extent entire sector studies and/or individual subsectors or activities in certain localities are needed remains to be seen.

8. **Conduct CEA(s) or CBA(s) for selected options/measures:** Again, it is too early to know which options or measures may require CEA(s) or CBA(s) and more data on the (economic) impacts and the quantification of the costs and benefits of adaptation measures is required. However, all three sectors are affected by climate change, are interlinked and are crucial to the Palestinian economy. Although, very little is known and there are no 360-degree economic-impact assessments beyond agri-production in the agri-food sector publicly available, yet,[32] an important agricultural or agri-food subsector in Palestine such as the olive oil industry, for example, could be a good starting point

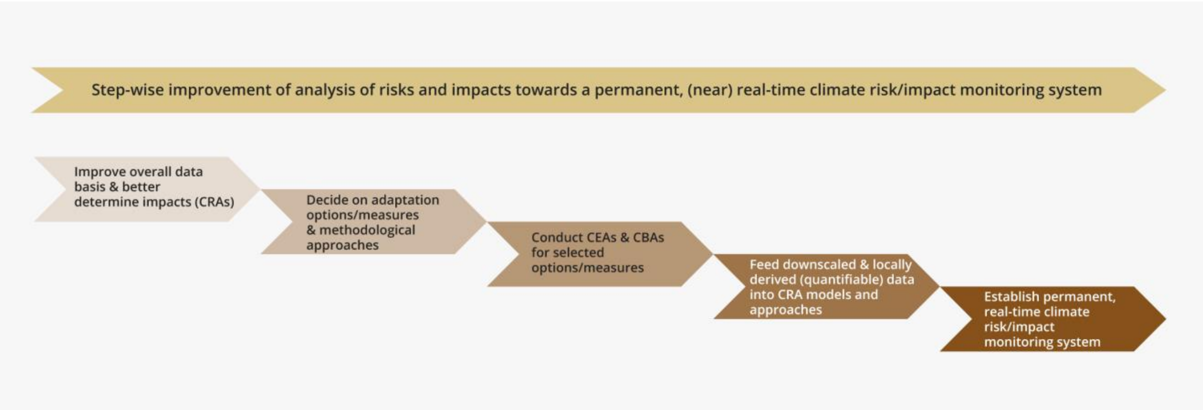
[32] This area is still in its infancy. There are very few surveys on businesses and perception of risks or papers on climate change and supply chains from a risk management perspective. The big corporations in this sector, such as Nestle, Kraft and Syngenta, have only just become active in this area in recent years and are slowly moving forwards with pilots and studies on this matter.

raising enough interest and critical stakeholder mass. That is with a view to conduct such a 360-degree impact assessment to gain first experiences in doing this and prepare (a) first CBA(s) for an important economic activity in Palestine.

9. **Feed outcomes of downscaled climate models and locally derived data into climate risk-assessment models and approaches:** Together with improved local climate data or related established trends from downscaled climate models, such climate and socio-economic data derived from CEAs or CBAs could be fed into climate risk-assessment models and approaches further improving them. Locally derived data and established national or even local trends – underpinning and improving or quantifying impact assessments and economic impacts country-wide and at the sector level as well as being able to drill down to the level of governorates all over the country – will allow for informed decision-making about the future course of action in Palestine using hard data.

10. **Establish permanent, (near) real-time climate risk/impact monitoring system for Palestine:** Assuming a parallel process of fully mainstreaming climate change into government structures and processes, horizontally at the sector level and vertically down to the governorates at some point, covering all 12 sectors or areas identified in the NAP as highly vulnerable to the impact of climate change will require the establishment of a permanent, real-time climate risk/impact monitoring system at the national level. Such a system should be integrated into the emerging climate-change governance and institutional framework and processes, whilst some activities or services may be outsourced to suitable non-governmental or research organisations. This in turn allows the proper integration of related climate action projects/programmes into the planning and budgeting processes of the Palestinian government, creating the planning and budget data, which is also needed with a view to track and MRV climate finance later on to be able to report under the UNFCCC and to the climate-finance donors.

Roadmap towards a permanent, (near) real-time climate risk/impact monitoring system



ANNEX II. THE IMPACTS OF CLIMATE CHANGE ON AGRICULTURE

Several studies document the biophysical impacts of climate change on agricultural systems (for comprehensive reviews, see Verner et al. 2013, pp. 36-39; Porter et al. 2014). The impacts of different climate parameters are outlined below.

Temperature changes

Firstly, climate change affects crop yields and livestock production through changes in temperature. Key developmental stages in plants, such as germination, tillering and fruit ripening are triggered by temperature cues; hence temperature increases could affect the start and/or duration of these physiological processes (Fuhrer, 2003, cited in Verner et al. 2013, p. 36). For example, increased temperatures during the colder winter months could shorten the time to maturity of crops grown during these seasons. Whilst this could be beneficial in areas with a limited growing season, it may on the contrary result in reduced yields in others by shortening the grain-filling stage of crops such as wheat or barley, which leads to smaller harvests (Khresat 2010, cited in Verner et al. 2013, p. 36). High temperatures pre- and post-harvest can also affect the nutritional quality of many fruit and vegetable crops (Moretti et al. 2009, cited in Verner et al. 2013, p. 36). However, the effects of temperature changes on crops are generally well understood up to the optimal temperature for crop development, but less is known in regards to effects beyond these optimal temperatures (Porter et al. 2014, p. 497).

Increased temperatures are also likely to result in reduced soil carbon levels, due to greater evaporation and transpiration by plants, and may affect organic matter cycling rates and increase soil salinity (Verner et al. 2013, p.38).

The effects of climate change on crop production have already been observed in several regions of the world, with negative impacts being more common than positive ones (Porter et al. 2014; FAO 2016a). For example, it is estimated that global wheat and maize yields dropped by 5.5% and 3.8% respectively over the period between 1980 and 2008, compared to what they would have been had climate remained stable (Lobell, Schlenker and Costa-Roberts 2011, cited in FAO 2016a, p. 22).

Changes in precipitation and reduced water availability

Climate change also impacts the agricultural sector through changes in precipitation and reduced water availability. The MENA region is amongst the most water-scarce regions of the world, and climate change is expected to exacerbate existing water challenges (GIZ, 2012). Firstly, precipitation changes have a direct impact on rain-fed agriculture. Evans (2009) predicts that rain-fed agriculture in the Eastern Mediterranean will decline by more than 170,000 km^2 by the end of the century due to declining means and increasing variability of precipitation. Higher temperatures and less rainfall are also predicted to reduce river flow, slow the rate of aquifer recharge, and increase aridity in the region (Elasha 2010). Consequently, whilst water demand will increase due to high temperatures and increased evapotranspiration, water supply for irrigation is likely to decrease. Climate change is also expected to exacerbate desertification in the region, with longer dry periods degrading soil quality and reducing the length of time rangelands can be grazed (GIZ 2012).

Plants experience drought stress if they cannot access sufficient water through their roots and when water loss through the stomata in leaves is too high due to high air temperatures or low humidity levels (Verner et al. 2013, p. 36). Water stress through drought reduces a plant's ability to integrate carbon from the atmosphere during photosynthesis, decreasing the plant's capacity to grow (Verner et al. 2013, p. 36). Severe drought stress can disrupt plant cell membranes and inhibit enzyme functioning, disrupting photosynthesis and respiration (Verner et al. 2013, pp. 36-37). Water losses can be limited through management strategies such as weed management, drip irrigation or deficit irrigation. A complementary approach is the development of drought-tolerant crops. Several local crop varieties in the Arab region are well adapted to conditions of water scarcity and display traits leading to high water-use efficiency (Verner et al. 2013, p. 37).

Effects on livestock

High temperatures and dry conditions also have negative impacts on livestock by directly affecting physiological processes and through effects on livestock feed and water supplies (Verner et al. 2013, p. 39; Porter et al. 2014, p. 502). For example, extreme or prolonged high temperatures can reduce milk yields even in animals such as sheep and goats, which are relatively heat-resistant by comparison to other livestock (Nardone et al. 2010, cited in Verner et al. 2013, p. 39).

Changes in atmospheric composition

In addition to the effects of changes in temperature and water availability, plant growth is also affected by increases in carbon dioxide (CO_2) and ozone (O_3) concentrations. Elevated levels of atmospheric CO_2 increase plants' water-use efficiency (or the ratio of carbon gain to water lost when opening stomata to take in CO_2) during photosynthesis. This fertilisation effect is particularly relevant for the 'C3 plants' which use this pathway for photosynthesis, including certain vegetables, fruit trees, wheat and barley (Verner et al. 2013). Recent studies confirm the stimulatory effects of CO_2 on crop yields, although these benefits have played only a minor role in driving overall yield trends (Porter et al., 2014, p. 493). In fact, the degree to which the CO_2 fertilisation effect can increase crop yields and compensate for the negative effects of climate change is uncertain, as is shown by different experimental designs (World Bank 2014).

CO_2 emissions are often accompanied by O_3 precursors. There is robust evidence (and high agreement) that tropospheric ozone and its secondary by-products damage vegetation by reducing photosynthesis and other physiological functions, which decreases the quality and quantity of yields, posing a growing threat to global food security (Porter et al. 2014). In fact, elevated O_3 levels since preindustrial times have very likely suppressed global production of major crops compared to what they would have been without O_3 increases (Van Dingenen et al. 2009, cited in Porter et al. 2014). Global estimates of yield losses due to increased O_3 in soybeans, wheat, and maize in 2000 ranged from 8.5 to 14%, 3.9 to 15%, and 2.2 to 5.5%, respectively, amounting to economic losses of US$11 to 18 billion (Avnery et al., 2011, cited in Porter et al. 2014). Interactions between O_3 and other environmental factors such as CO2, temperature, moisture and light also influence yields, but these interactive effects are less well understood (Porter et al. 2014).

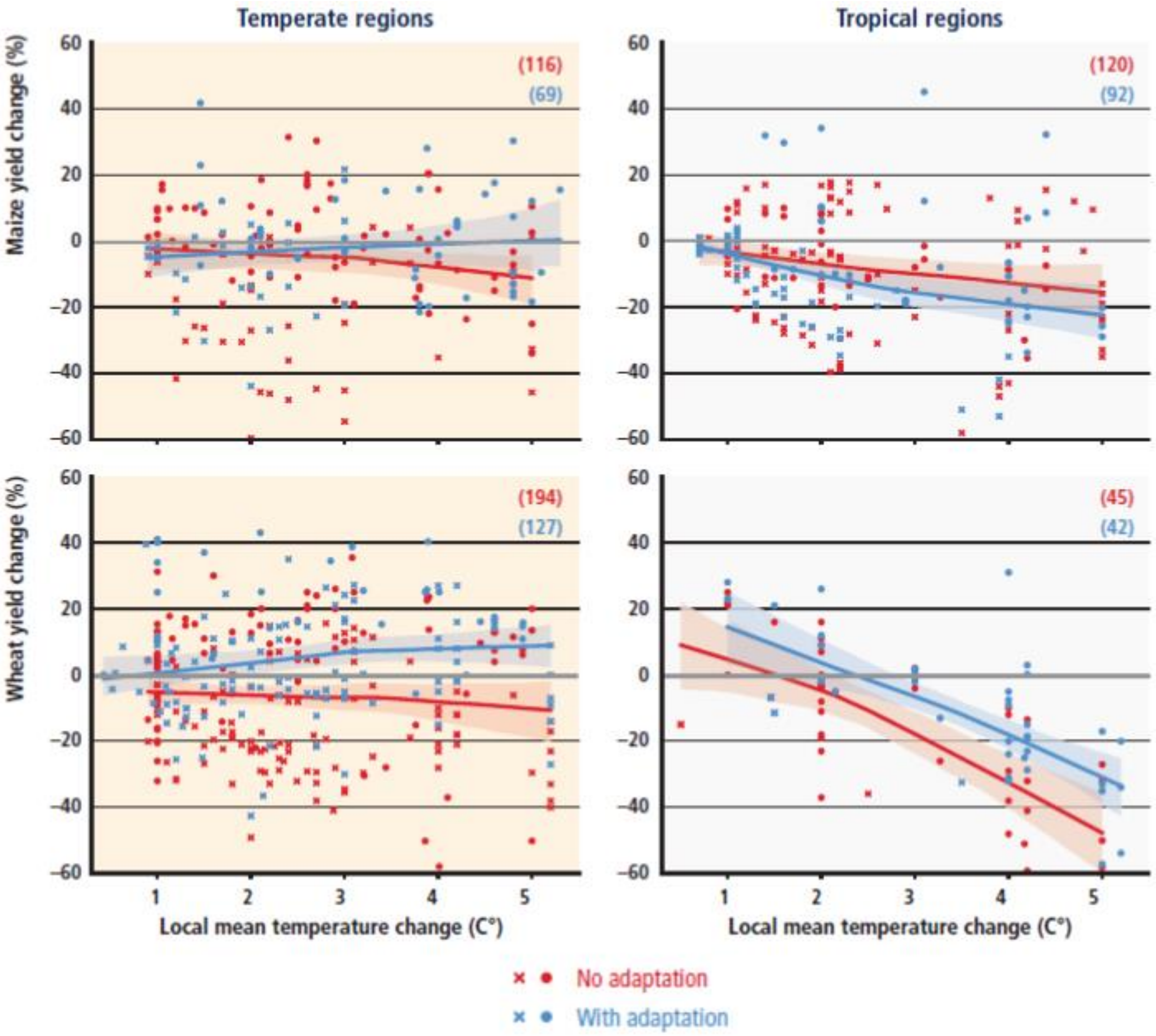
Pests and pathogens

Climate change may also affect agricultural production through its impacts on pests and pathogens. Temperature changes may alter the geographical ranges as well as the intensity of pests and diseases, whilst extreme events such as droughts and floods can trigger outbreaks of insect pests (Verner et al. 2013). Moreover, rising temperatures and CO_2 levels may hamper the effectiveness of some pesticides (Juroszek and Tiedemann 2011, cited in Verner et al. 2013, pp. 38-39).

Global quantitative estimates of impacts

A meta-analysis of 66 yield impact studies for major cereal crops conducted as part of the IPCC Fifth Assessment Report shows that yields of maize and wheat begin to decline with even slight local warming of 1°C to 2°C in tropical regions. Beyond 3°C of local warming, negative impacts on yields are expected at both low and high latitudes in the absence of adaptation measures (Porter et al. 2014, pp. 497-498). Figure A-1 schematically presents the results of this meta-analysis.

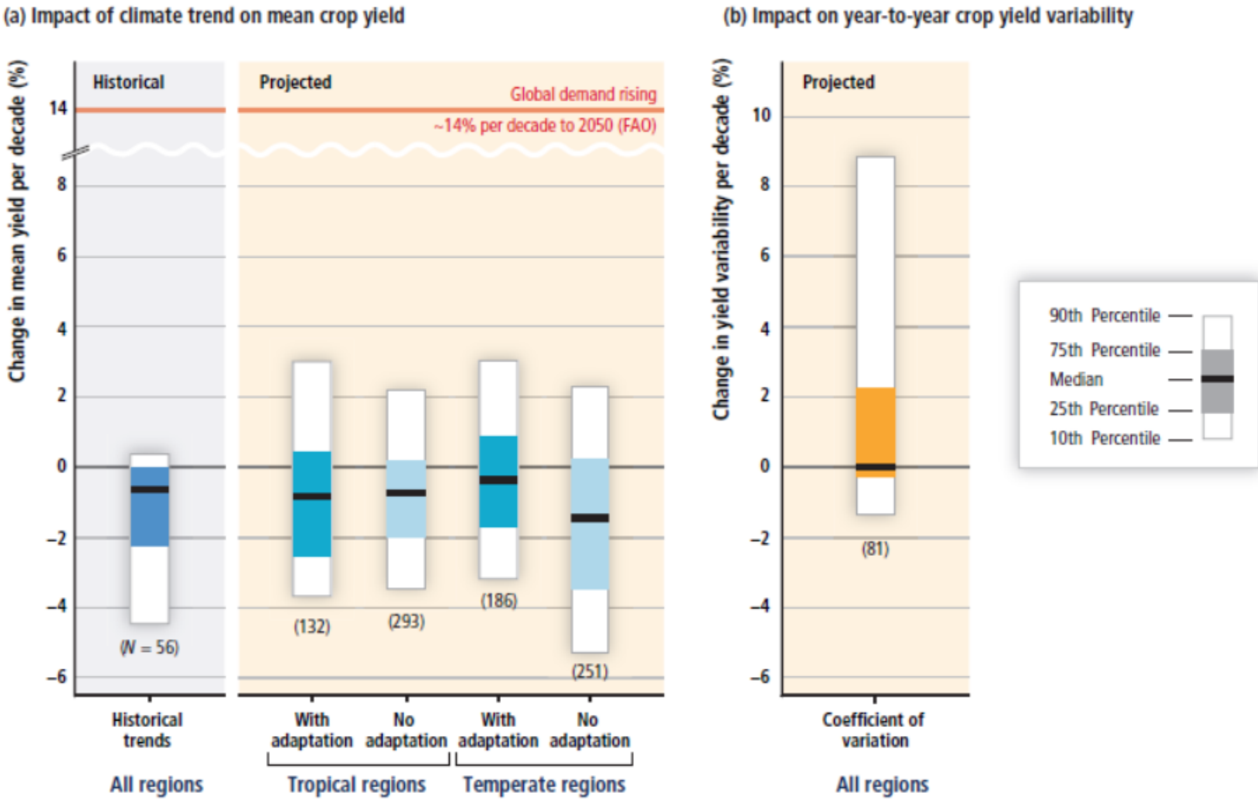
Figure A-1.. Percentage simulated yield change as a function of local temperature change for maize and wheat, in temperate and tropical regions



Note: the dots indicate where a known change in atmospheric CO2 was used in the study; remaining data are indicated by x. The numbers in the top-right corner of the graphs indicate the number of observations.

Source: Porter et al. (2014) Food Security and Food Production Systems. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, p. 498.

Figure A-2. Box-plot summary of studies that quantify impact of climate and CO_2 changes on mean crop yields and variability



Source: Porter et al. (2014) Food Security and Food Production Systems. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, p. 506.

ANNEX III. NAP APPROACH TO THE IDENTIFICATION AND PRIORITISATION OF ADAPTATION OPTIONS

The process of developing Palestine's National Adaptation Plan to Climate Change included a stakeholder consultation process aimed at the identification and prioritisation of adaptation options on the basis of Multi-criteria Analysis. For each vulnerable sector, a range of adaptation options were identified which seek to reduce vulnerabilities by decreasing climate sensitivity or increasing adaptive capacity, and which are relevant to all three future-climate scenarios established in the NAP (see Section 2.3).

The stakeholder consultation undertaken during the NAP's preparation also served to identify the scale of the costs associated with the design and implementation of each adaptation option, including operational costs (e.g., human resources) and investment costs. Stakeholders were presented with a series of prompts to aid consideration of the scale of costs (as shown in Table A-1).

Table A-1. Prompts to aid consideration of the scale of costs when assessing NAP adaptation options

	Prompt
Scope	What is the nature of the adaptation option (e.g., does it require implementation of management and operational strategies, infrastructural changes, policy adjustments or capacity-building)? Who or what does the adaptation option focus on (e.g., if it is focused on farmers, how many does it target, all farmers or only in one geographic area)? Are there any existing related projects with established budgets that might inform an estimate of costs?
Type	Does the adaptation option need to be preceded by a feasibility study? Will the adaptation option require a one-off capital investment and/or a series of investments, e.g., annually (note: some adaptation options will not involve capital costs, e.g., an awareness-raising campaign might only involve operational costs)? What are the operational costs associated with the adaptation option, including maintenance and human resources?
Timing	How does the time horizon for the adaptation option impact on its costs?

Source: Smithers et al. (2016), p.18.

In addition to cost estimates, the NAP also provides a multi-criteria analysis of the various adaptation options in order to derive a ranking of options. Stakeholders were presented with a "Performance matrix" and asked to qualitatively evaluate each adaptation option – by giving it a score of "Low" (1), "Medium" (5) or "High" (10) - on each of the following criteria.

- **Impact** – The magnitude of the potential impact if the adaptation option is *not* implemented, as assessed by considering the nature of each "vulnerability" in regards to its potential "exposure" to climate change.
- **Efficacy** – The extent to which the adaptation option addresses all three climate-change scenarios and their potential impact.
- **Timing/urgency for action** – The most urgent actions are those where delay could lead to greater impact and/or increased costs.
- **Social acceptance –** The extent to which Palestinians will support and/or implement the adaptation option.
- **Technology –** The extent to which the technology to implement the adaptation option is readily available.
- **Knowledge and skills –** The extent to which the skills and knowledge to implement the adaptation option are readily available.
- **Costs** – High costs were scored as "Low", whereas low costs were scored as "High".
- **Co-benefits for adaptation in other sectors**
- **Co-benefits for mitigation**

For each adaptation option stakeholders were also asked to consider whether the measure would still be required if Israeli occupation was to be resolved, and whether it could be taken only if Israeli occupation was to be resolved.

ANNEX IV. QUESTIONNAIRE ADDRESSED TO RELEVANT PALESTINIAN INSTITUTIONS WITH A VIEW TO COLLECTING DATA ON THE COSTS AND BENEFITS OF ADAPTATION MEASURES

Adding value in relation to costs and benefits in the context of addressing economic impacts of climate change, with focus on Palestinian data

Approach and methodology

We use the relevant adaptation options identified through the national stakeholder consultation process as part of the NAP development and add an additional layer - underpinning with better figures, where possible, using project budgets and data from relevant past, ongoing or recently planned projects.

Below is a preliminary list of projects/programmes related to the adaptation options identified in the NAP and relevant to the 3 sectors (agriculture, water and agri-food industry) of concern for the study at hand, drawing on a list that was prepared during an assignment and a related report on "Integrating Climate Change Finance into Sustainable Land Management Investment Strategies in Palestine - Assessment Report", prepared for the PA in 2013 by Climatekos and Horizon on behalf of the Global Mechanism to the UNCCD.

The below list is shared with MoA and PWA in order to:

1. determine whether a project/programme is relevant to the identified adaptation option(s) (directly or indirectly related to climate change and addressing impacts/adaptation to climate change)? Please review and amend column 3;

2. determine whether climate change is mainstreamed in a project/programme. Are any relevant information on impacts and adaptation measures and costs available? See columns 7, 8 and 9;

3. any new, recent project/programme not yet included in the list should be added and relevant information be provided;

4. a pre-selection of the most relevant project/programme should be made by the assigned officers based on 1. and 2. above. Relevant information in the form of (summary) reports or proposals etc. should be made available.

The third column (no. 3) in the tables below indicates the adaptation option(s) to which we believe the project/programme corresponds. Please note that we can only provide indicative suggestions and that they are incomplete as we do not have any more information about the projects at this stage. They need to be reviewed and potentially amended by the respective officers. The adaptation options identified in the NAP in regards to the three sectors are shown below.

Agriculture

1) Improve water-use efficiency and using alternative water resources

2) Enhance sustainable community-level irrigation schemes and infrastructure

3) Increase the availability of animal feed (including plant and organic residues) at an affordable price

4) Improve livestock production pens

5) Climate-smart agriculture

6) Agricultural disaster risk reduction and management (DRR/M)

7) Establishment of farmers' support (subsidies, awareness training programs)

8) Introduction of new saline-tolerant crops (Gaza)

9) Supporting improvements in efficient use of water in women's private small-scale agricultural projects (Gaza)

10) Encouraging women to use their home gardens to produce food (Gaza)

Food

11) Enhancing agricultural value chain by improving infrastructure for livestock production

12) Greenhouse management

13) Construction of large-scale cold storage

14) Construct large-scale steel silos for grain to enable import and storage during periods when prices on the international markets are low

Water

15) Enhance the use of additional and alternative water resources for non-domestic purposes

16) Allocate trans-boundary water resources equitably and reasonably between Israel and Palestine

17) Rehabilitate water sources: wells, canals and springs

18) Control of leakage from distribution systems

19) Develop and improve storm water systems and drainage infrastructure

20) Build a large desalination plant for Gaza

21) Increase share of imported water (Gaza)

22) Rain-water harvesting (for coastal agriculture in Gaza)

23) Improve water supply through wastewater collection and treatment systems

24) Training health professionals and increasing the awareness of people, particularly women, in water-poor areas about measures they can take to help prevent major diseases related to water, sanitation, and food

25) Development of water, food and sanitation monitoring and safety systems using high technology

A) Agriculture Projects:

#	Title	NAP adaptation option(s)	Period	Funding Agencies	Implementing Agencies	Budget (000) US $	Project/programme relevant to the adaptation option(s) (directly or indirectly related to climate change and addressing impacts/adaptation to climate change) (Y/N)[33]	Climate change mainstreamed in this project/programme, i.e., any relevant information on impacts and adaptation measures and costs available? (Y/N)	Relevant information in the form of (summary) reports or proposals provided (Y/N)
1	Protecting Livelihoods of the Marginalised Palestinian Farmer Through Enhanced Agro-Marketing Potential		2010-2011	ACDI/VOCA	Action Against Hunger - Spain	313			
2	Development of Agriculture Irrigation Water Use	1? 2? 15?	2010-2012	Arab and Islamic Fund		995			
3	Control of Small Ruminants New Born Mortalities		2010-2013	Arab and Islamic Fund	MoA	1,470			
4	Water Harvesting	1? 22?	2010-2013	Arab and Islamic Fund	MoA	2,000			
5	Development of Community Seed Production of Non-Formal to Encourage Conservation of Field Crops in Palestine		2010-2013	Islamic Fund	MoA+ ICARDA	276			
6	Protection Agriculture Based Livelihood in Palestine		2012-2014	Islamic Fund	MoA	940			
7	Establishment of Desalination Plant in Jordan Valley/ Marj Na'jeh	20	2011-2012	AOAD	MoA	100			
8	Support Endangered Farmers in GS	7	2009	Austria	FAO	280			
9	Emergency Support to Poor Families in the Gaza Strip to Restart Open Field Vegetable Production.	7	2009-2011	Austria	FAO	415			
10	Sustainable Rangeland	5?	2009-	Brazil Rep.	MoA	1,300			

[33] If yes, proceed to the next question.

	Management in Communal Land		2013	Office					
11	Establishing a Pilot Fish Farming in the West Bank		2009-2013	Brazil Rep. Office	MoA	785			
12	Emergency Food Production Support to Poor Families in the Gaza Strip Phase II	7	2011-2012	Belgium Technical Cooperation	FAO	400			
13	Rapid mitigation of the livelihood crisis in the Gaza Strip	7	2011-2012	Belgium Technical Cooperation	FAO	686			
14	Support Small Farmers, Poor Families, Women and Youth in the Agricultural Sector, Including Aquaculture in the Gaza Strip	7		Belgium Technical Cooperation	Oxfam GB+FAO	3,400			
15	Small Ruminants		2010-2011	CIDA	FAO+ Agency for Technical Cooperation and Development +UAWC	100			
16	Emergency support to vulnerable herding communities in Area C of the West Bank	7	2012-2013	CIDA	FAO	6,000			
17	The Safe Use of Wastewater and Grey water in Agriculture	1 15 23	2010-2013	Coca Cola Co	MoA/ NARC	10			
18	Improve Living Conditions of the Most Vulnerable Rural Population of the Al Mawasi Region, governorates of Khan Yunis and Rafah, Gaza Strip	7?	2010-2011	Consulate General de France	Premiere Urgence	482			
19	Rehabilitation of Fifty One (51) Ancient Cisterns Systems to Collect Seasonal Rain Water in The Eastern Slopes of Bethlehem	22	2011	DanChurchAid	DanChurchAid	918			
20	MERAP_ Phase III		2012-2015	Government of Denmark	MoA	2,900			
21	Rural Microfinance : Pilot Project for Agricultural Production in Palestine		2009-2012	EC	Reef Finance Company Private Stock company/	1,253			
22	Enhancing Marginalised People's Income and Food Security in the Occupied Palestinian Territory		2010-2011	EC	Oxfam GB+Economic & Social Development Centre of Palestine	501			
23	Food Security Support for Vulnerable Households in		2010-2011	EC	Action Against Hunger - Spain	6,051			

	Gaza Strip Through Backyard Animal Production								
24	Food Assistance Intervention to Support the Recovery of Bedouins' Livelihood		2010-2011	EC	CISP +Palestinian Association Farmers Union	483			
25	Livelihood Enhancement Project in West Bank and Gaza Strip – Occupied Palestinian Territories (Opt).		2010-2011	EC	COOPI	16,003			
26	Raptor pest control as a sustainable resource management model in the Jordan valley in support of the middle east peace		2009-2012	EC	NGOs	461			
27	Livelihood Security in Income Generation	7?	2012	EC	Palestine Association for Education and Environmental Protection	146			
28	Beit Dajan and Anzah villages-North West Bank- produce more food through sustainable and safe use of reclaimed wastewater in agriculture	1 15 23	2011-2014	EC	ADA/ Birzeit University+ EcoSan Club	3,758			
29	Ensuring a better future for small scale farmers and rural women in the olive sector		2012-2015	EC	ADA	1,033			
30	Enhancement of Food Security in Taybeh and Ramoun through Rural Development and Agricultural Extension		2010-2013	EC	Palestinian Waste Water Engineers Group Association+ UAWC	3,479			
31	'From Grove to Market - Developing the Value Chain for Subsistence and Small Farmers in the oPt"		2012-2015	EC	Oxfam GB	1,379			
32	Making wastewater an asset: increasing agricultural production introducing irrigation from non-conventional water sources	1 15 23	2011-2014	EC	GVC/ UAWC+PHG	3,309			
33	Pest Management Sans Frontieres: Palestinian-Israeli-Jordanian Cooperation for Environmentally Friendly Pest Management		2010-2013	EC	NGOs	477			
34	Strengthening cooperatives in Salfit and Qalqilya governorates, West Bank		2010-2014	EC	NGOs	501			

35	Support livestock based livelihoods		2012	EC	ECHO	14,000			
36	Treated waste water for agricultural purposes	1 15 23	2011-2014	EC	NGOs	11000			
37	Support rain water harvesting and water demand management	1 22	2011-2013	EC	FAO	2000			
38	Support to the olive and olive oil value-chain		2012	EC	NGOs	18,800			
39	Support to affected farmers in West Bank	7		EC	MoA+MoF	6,250			
40	Support to affected farmers in Gaza Strip	7		EC	MoA+MoF	4,375			
41	Land and Infrastructure Development in Area C			EC	NGOs	4,500			
42	Capacity Building of MoA for Livestock Support		2013-2016	EC	MoA	4,441			
43	Support to Vulnerable Households Affected By Limited Livelihood Opportunities in West Bank and Gaza Strip – Occupied Palestinian Territories	7?	2012	ECHO	COOPI	2,700			
44	Emergent Support for Herders and Poor Families in WBGS	7		ECHO	ACF, ACTED, CISP, CRIC, OXFAM GB, OXFAM IT, PU	11,780			
45	Humanitarian Assistance to Vulnerable Palestinian Households Having a Limited Access to the Most Basic Needs in Protection Prone Areas of the West Bank And of the Gaza Strip	7	2012-2013	ECHO	Action Against Hunger - Spain	1,320			
46	Development of Monitoring and Evaluation System for the Agriculture Sector		2010-2011	Germany/ GIZ	MoA	200			
47	Support Small Farmers in GS	7?		Germany/ GIZ	CARE International	700			
48	Emergency Assistance projects for Farmers and Herders affected by the Emergency Weather Conditions as well as the Practices of the Occupation and the Settlers, Specifically in Area C	7		HRF/ CERF	NGOs, UAWC, SDC, Oxfam, IT, Near East Foundation, APY, ESDC, Development of Palestinian Farmer Association - Deir Albalah, Agricultural and Environmental Development Society, ACTED, FAO	4,000			

49	Natural Resources Management Project IFAD	5?	2009-2015	IFAD	MoA/ NGOs	8,000			
50	Water Livelihood Initiative		2011-2012	ICARDA	MoA	52			
51	Adaptation to Climate Change in Marginal Area (ICBA/Phase II)	5?	2010-2013	ICBA	MoA	30			
52	Green House - Nursery in Bethlehem	12	2010-2011	ICRC	ICRC				
53	Land Development		2010-2012	IRW	IRW - West Bank	882			
54	Rehabilitation of Agricultural Wells in Gaza Strip - Belgium	17	2010-2011	IRW	IRW - Palestine Office	100			
55	Small Enterprise for Rural Women Phase3		2012-2013	IRW	IRW - West Bank	892			
56	Emergency Support to Protect Agriculture-Based Livelihoods in the Pastoral Areas of the West Bank	7	2010-2012	Italian Cooperation	FAO	2,196			
57	Emergency Support to Small Ruminant Herders and Vulnerable Farming Households in the West Bank and Gaza Strip (WBGS)	7	2010-2011	Italian Cooperation	FAO	1,000			
58	Improving Lives of Farmers in Jordan Valley		2011-2012	Italian Cooperation	FAO	1,900			
59	Pilot Project for the Production of Quality Olive oil		2009-2011	Italian Cooperation		1,400			
60	Intervention of Home Gardens for Vulnerable Families in Gaza Strip		2012	Italian Cooperation	ACS	60			
61	Agriculture Revitalisation Program Phase II	5?	2011-2013	Italian Cooperation	FAO	2,720			
62	Land Development Project Phase II			Italian Cooperation	UNDP/PAPP	3,000			
63	Agricultural Credits	7?		Italian Cooperation	MoF+ Banks	11,250			
64	Capacity Building Reinforcement for the Ministry of Agriculture and Development of the Agro-industrial Sector		2010-2013	Italian Cooperation	MoA	1,800			
65	Supporting Affected Beekeepers	7	2011	JICA	UNDP	730			

66	Improved Extension for Value-Added Agriculture in the Jordan River Rift Valley	5?	2011-2015	JICA	MoA	4,400			
67	Livelihood Protection and Sustainable Empowerment of Vulnerable Rural Refugee Families in the Jordan Valley	7?	2010-2013	JICA	FAO+ MoA	2,028			
68	Olive Insect Control and Poverty Alleviation for Women Groups			JICA	NICCOD	371			
69	Improvement the Quality and Marketing of Olive Oil in Tubas			JICA	MoA+ JICA	385			
70	Empowering the Agricultural Sector, Training, Promotion Methods for Environment and Sustainable Development in GS	5?		JICA	NGO/Japan	572			
71	Establishment of Compost Plant for Agricultural Production in the Jericho Region			JICA	AEHS+ Local NGOs	220			
72	Create Herb Bags for Agricultural Production to Reduce Local Poverty			JICA	Aqaba Rural Women Society	1,000			
73	Beekeeping Project			JICA	JICA	102			
74	Support the National Industry through Drying Agricultural Products			JICA	JICA	104			
75	Early Recovery Programme II – Gaza Strip	7?	2009-2012	Netherlands Representative Office	Palestinian Agricultural Relief Committees(PARC)+Agricultural Development Association	10,828			
76	Improving Farmers Capabilities in Production of Export Crops Global gap (RAM Global Gap)		2009-2012	Netherlands Representative Office	Palestinian Agricultural Relief Committees (PARC)+MoA	7,500			
77	RAM Cash Crops 2011-2012		2011-2012	Netherlands Representative Office	Palestinian Agricultural Relief Committees (PARC)	2,063			
78	RAM Gaza Cash Crops 10-11		2010-2011	Netherlands Representative Office	Palestinian Agricultural Relief Committees (PARC)	2,418			
79	Improving Livelihood in Occupied Palestinian Territories West Bank	7?	2009-2012	Netherlands Representative Office	MoA+ PARC	820			
80	RAM Reef Finance Co.		2010-2012	Netherlands Representative	Reef Finance Company Private Stock company/	3,262			

				Office					
81	Increase the Productivity and Sustainability of Rain-Fed Food Crops and Improve the Efficiency of Seed Production	5	2010-2013	Netherlands Representative Office	MoA	400			
82	Enhancing Food Security and Livelihoods of Poor Rural Communities in Palestine	7?	2010-2013	Netherlands Representative Office	MoA+ ICARDA	1,470			
83	Improving Livelihood (Land Development) _Phase III			Netherlands Representative Office	PARC	12,900			
84	Marketing and Export Crops		2013-2017	Netherlands Representative Office	NGOs/FAO/MoA	6,200			
85	Enhancing the Farmers Production Capabilities in Rafah and Khanyounis Rural Areas- Second Phase	7?	2010-2011	NPA	PEF	153			
86	Income Generation through Sheep Fattening		2010-2011	NPA	Aqaba Rural Women Society	129			
87	Revitalisation of Olive Production in the Damaged Areas and Home Gardens		2010-2011	NPA	Improvement and Development for Communities	180			
88	Support and Rehabilitation of Poor Farmers in Middle Area	7?	2010-2011	NPA	ASDPD				
89	Support to Reduce the Impact of Food Insecurity for Palestinians in the West Bank and Gaza Strip	7?	2010-2011	NPA	FAO	777			
90	Support Agricultural Development and Woman in WBGS			NPA	NPA	5,830			
91	Emergency support to livestock herders in the southern part of the West Bank	7	2011	OCHA	FAO	200			
92	Emergency Intervention to Mitigate the Effect of Extreme Weather Conditions to Families in Southern West Bank	6 7	2012	OCHA	UAWC	249			
93	Development of Irrigation Systems and Water Resources in the Jordan Valley and the North Western Districts of West Bank	1 2 15?	2011-2013	The OPEC Fund for International Development	MoA +UNDP	2,000			
94	Cooperative Growth and		2012	Oxfam GB	Oxfam GB	131			

	Marketing in the Jordan Valley-(Pilot)								
95	Improvement of the Access to Water through the Restoration of Water Agricultural Cisterns in the South Hebron District.	17?	2012	Poland	PAH	263			
96	Support Livestock Herders in Area C	7?		Poland	PCPM	370			
97	Agricultural Rehabilitation and Aquaculture Support in GS			Qatar Charity	Qatar Charity	342			
98	Food Security and Job Creation in the Gaza Strip - (BALEAR 7)		2010-2011	Spanish Agency for International Cooperation	JCP - Office of the President+ MoA+ PWA	137			
99	Improvement of Food Security Conditions and Water Saving Measures in the Gaza Strip (FS&WS)-Phase II	1	2010-2011	Spanish Agency for International Cooperation	JCP - Office of the President+ MoA+ PWA+ UAWC+PARC	1,723			
100	Pilot Demonstrations of Alternative Water and Natural Resources Catalonia III	1 15	2010-2011	Spanish Agency for International Cooperation	JCP - Office of the President+ PWA+ Al-Ahlyia Association for the Development of Palm & Dates+ Safe Agriculture Producers Society	172			
101	Improvement of family income and food security in five Nablus area communities through productive projects and women training	7?	2010-2011	Spanish Agency for International Cooperation	UAWC	296			
102	Emergency assistance to protect the livelihoods of vulnerable farming families and rural women through restoration of horticultural production and household food production in the West Bank and Gaza Strip	7?	2010-2012	Spanish Agency for International Cooperation	FAO	1,526			
103	Production systems and trade improvement for six agricultural women cooperatives in Gaza and the West Bank		2010-2012	Spanish Agency for International Cooperation	Rural Women Development Society	438			
104	Building of greenhouses in ten Palestinian villages	12	2010-2012	Spanish Agency for International Cooperation	Association for Environmental Resources Protection	479			
105	Improvement of employment conditions in Bani Naim, oPT, through the building and management of agricultural	12	2010-2012	Spanish Agency for International Cooperation	NGOs	79			

	greenhouses								
106	Improvement in the livelihoods of Palestinian rural communities by developing water uses for agriculture	1 2? 15	2010-2012	Spanish Agency for International Cooperation	PHG	315			
107	Improving the Access to Water and Food Security Conditions of Vulnerable Households in Surif, Hebron District, West Bank, Opt		2010-2011	Spanish Agency for International Cooperation	ACPP+PHG				
108	Improving the Food Security Conditions of 86 Vulnerable Families in the Villages of Qaffin, An Nazla The Gharbiya, Zeita And Nazla An Ash Sharqiya, West Bank, Palestine		2010-2011	Spanish Agency for International Cooperation	ACPP+PARC				
109	Protection of Agricultural Livelihoods in Area C and the Seam Zone Through Improved Access to Water for Agricultural Use, Qalqiliya District, West Bank		2010-2011	Spanish Agency for International Cooperation	ACPP+PHG				
110	Institutional Capacity Building of the Ministry of Agriculture		2010-2011	Spanish Agency for International Cooperation	MoA	374			
111	Support for horticultural production for vulnerable families		2010-2012	Spanish Agency for International Cooperation	MoA	1,566			
112	Culture and Development - (MDGF-1841)		2009-2012	Spanish Agency for International Cooperation	FAO	392			
113	Supporting Food Security in Gaza Strip by Utilisation of Alternative Agricultural and Water Resources Catalonia IV	1 15	2012	Spanish Agency for International Cooperation	JCP - Office of the President	100			
114	Job Creation Programme Gaza	7?	2009-2012	Spanish Agency for International Cooperation	JCP of the PNA (Gaza)+PWA	5,640			
115	Promotion of sustainable production and associations through the strengthening of four agricultural cooperatives in Northern WB		2010-2012	Spanish Agency for International Cooperation	PARC	381			
116	Develop and Raise the Efficiency of Food Inspection		2012-2014	Spanish Agency for International	MoA	962			

	Section of the Central Veterinary Laboratory			Cooperation					
117	Improvement of livelihoods in the most vulnerable communities in the West Bank	7?	2010-2014	Spanish Agency for International Cooperation	UAWC/ESDC	3,008			
118	Support Small Farmers, Poor families and Women in Agri. Sector	7?		Spanish Agency for International Cooperation	ACPP	25,000			
119	Food Safety	24? 25?		Spanish Agency for International Cooperation	ACPP				
120	Institutional Capacity Development (financial and administrative) in MoA			Spanish Agency for International Cooperation	ACPP				
121	Support Sector Coordination and Policy-Making			Spanish Agency for International Cooperation	ACPP				
122	Support to FAO Programme Coordination, Jerusalem			Spanish Agency for International Cooperation	FAO	355			
123	Improvement of water resources management in the agricultural sector to ensure food security in the Palestinian Territories	1		Spanish Agency for International Cooperation	PARC	1,175			
124	Support to Olive Oil Producers	7?	2010-2014	SDC	Bethlehem University / PARC	3,641			
125	Applied Research Institute Jerusalem (ARIJ) Program Contribution		2010-2014	SDC	ARIJ	1,508			
126	Making the Olive Market Work for the Poor		2011-2014	SDC	Oxfam GB	3,200			
127	Support the Olives Sector	7?		SDC	ARIJ+PARC	3,120			
128	Support Poor Families and Woman in WBGS	7?		SCC	SCC	4,000			
129	Immediate Support for Endangered Livelihoods of Food Insecure Farmers, Herders and Fisher Folks in the Gaza Strip	7	2010-2011	DFID	FAO	1,250			
130	Supporting farmers and rural communities and refugees in the Jordan Valley	7		UNTFHS	UNRWA, FAO, UNESCO, UN Women	2,000			
131	Investment Climate Improvement (ICI)	5?	2010-2013	USAID	Chemonics International	24,933			
132	Enterprise Development for		2011-	USAID	Ministry of Tourism and	97,633			

	Global Competitiveness Project		2014		Antiquitie+MoA				
133	Early Warning System for Agricultural Drought	6	2010-2013	WFP	MoA	145			
134	Improving the Standard of Living for Vulnerable Farmers and Women in Palestine		2012-2013		PAEEP	221			
135	Rehabilitation and Planting of Greenhouses in Rafah Governorate	12	2012-2013		AGAS	255			
136	Promoting Sustainable Fisheries Resources in Gaza Strip through Fishermen Capabilities Development - Phase II	7?	2012-2013		PEF	181			
137	Improve Women's Economic Situation in 4 Villages of Nablus District		2012-2013		BWDS	149			
	Total (without USAID projects)					314,817			

(B) Water Projects:

#	Title	NAP adaptation option(s)	Status	Funding agencies	Implementing agencies	Budget	Project/programme relevant to the adaptation option(s) (directly or indirectly related to climate change and addressing impacts/adaptation to climate change) (Y/N)[34]	Climate change mainstreamed in this project/programme, i.e., any relevant information on impacts and adaptation measures and costs available? (Y/N)	Relevant information in the form of (summary) reports or proposals provided (Y/N)
1	North Gaza Emergency Sewage Treatment (NGEST) Project	23	Ongoing	Agence Française de Développement	Palestinian Water Authority	12,000,000.00 EUR			
2	North UXOs Clearance and Rubble Removal		Ongoing	Swedish International Development Cooperation Agency	Ministry of Public Works and Housing (MoPWH)	5,598,105.00 USD			
3	Al Yamoun Water		Ongoing	Agence Française de Développement	Palestinian Water Authority	10,500,000.00 EUR			
4	Water Programme in the Palestinian Territories		Ongoing	Gesellschaft fuer Internationale Zusammenarbeit/	Palestinian Water Authority	5,685,916.00 EUR			
5	Water well and carrier line project in Khan Yunis		Ongoing	Turkish International Cooperation & Development Agency	Coastal Municipalities Water Utility	1,650,600.00 USD			
6	Construction of Khan Younis Waste Water Treatment Plant.	23	Ongoing	Japanese Government- Japanese Representative Office	Coastal Municipalities Water Utility / Palestinian Water Authority /	14,830,000.00 USD			
7	The supply of solid waste equipment and tools		Ongoing	Islamic Development Bank	Palestinian Environment Quality Authority /	2,035,038.00 USD			
8	Infrastucture Needs Program	23?	Ongoing	United States Agency for International Development	Ministry of Education and Higher Education / Ministry	223,415,318.00 USD			

[34] If yes, proceed to the next question.

	(INP) (multiple recipients)				of Public Works and Housing (MoPWH) / Palestinian Water Authority				
9	Desalination units establishment project for Gaza schools	20	Ongoing	Turkish International Cooperation & Development Agency	Coastal Municipalities Water Utility	1,582,000.00 USD			
10	Safe water and safe sanitation		Ongoing	United Nations International Children's Emergency Fund	Palestinian Water Authority	14,617,193.00 USD			
11	Infrastructure Needs Program - Construction Phase II (INP II)	23?	Ongoing	United States Agency for International Development	Ministry of Public Works and Housing (MoPWH) / Palestinian Water Authority	450,000.00 USD			
12	Promote peace building through cross boundary wastewater management in the oPt	23	Ongoing	Japanese Government- Japanese Representative Office	Palestinian Water Authority	5,787,321.00 USD			
13	Program for the support of Water and Solid Waste Management DED	23	Ongoing	German Representative Office / German Ministry for Economic Cooperation and Development	Municipality of Al-Bireh /	202,000.00 EUR			
14	Design and implementation of an integral system of wastewater treatment and reuse in the Wadi Al-Aroub area (Hebron)	23	Ongoing	Spanish Cooperation - Spanish Agency for International Cooperation	Applied Research Institute - Jerusalem (ARIJ)	450,488.00 EUR			
15	Improving access to safe drinking water for Palestinian children in the West Bank		Ongoing	Spanish Cooperation - Spanish Agency for International Cooperation	Palestinian Water Authority	500,000.00 EUR			
16	Maythalun Water		Ongoing	Agence Française de Développement	Palestinian Water Authority	10,600,000.00 EUR			
17	Capacity building of Water Authorities		Ongoing	United Nations International Children's Emergency Fund	Palestinian Water Authority	1,828,021.00 USD			
18	Re-activation and Upgrading of the Deir Al Balah Sea	20	Ongoing	Italian Development Cooperation	Palestinian Water Authority / Coastal Municipalities Water Utility /	356,786.00 USD			

	Water Desalination Plant								
19	Sewage pumping station construction project in Gaza Strip	23?	Ongoing	Turkish International Cooperation & Development Agency	Coastal Municipalities Water Utility	695,800.00 USD			
20	Engineering & Construction Management for INP		Ongoing	United States Agency for International Development	Palestinian Water Authority	58,000,000.00 USD			
21	Al Bireh Sewerage	23?	Ongoing	Kreditanstalt fr Wiederaufbau	Ministry of Planning and Administrative Development	10,992,775.00 EUR			
22	Emergency Water and Sanitation II (EWAS II)		Ongoing	United States Agency for International Development	Palestinian Water Authority / Ministry of Health / Ministry of Education and Higher Education	64,800,000.00 USD			
23	AEP 5 Tammoun Tubas		Ongoing	Agence Française de Développement	Palestinian Water Authority	15,000,000.00 EUR			
24	Upgrading of Water Systems in Jericho and Hebron Cities		Ongoing	Italian Development Cooperation / United Nations Development Programme	Jericho Municipality	3,275,880.00 USD			
25	Construction project of storm water network in Rafah municipal area	19	Ongoing	Turkish International Cooperation & Development Agency	Municipality of Rafah	2,058,000.00 USD			
26	PWA PMU Storm & sewage cont.	19	Ongoing	Swedish International Development Cooperation Agency	Palestinian Water Authority	25,000,000.00 SEK			
27	Upgrading project of Gaza wells	17	Ongoing	Turkish International Cooperation & Development Agency	Coastal Municipalities Water Utility	345,800.00 USD			
28	Water Sanitation Program Palestinian Territory		Ongoing	Kreditanstalt fr Wiederaufbau	Ministry of Planning and Administrative Development / Palestinian Water Authority	15,000,000.00 EUR			
29	Re-formulation of the project `Fostering co-operation on water management between the		Ongoing	European Commission	Palestinian National Authority	58,002.00 EUR			

	Israeli, Palestinian and Jordanian								
30	Bethlehem Water and Sanitation Project		Ongoing	Agence Française de Développement	Palestinian Water Authority	10,000,000.00 EUR			
31	Assessment of Water Supply Gaza		Ongoing	Norwegian Ministry of Foreign Affairs	Palestinian Water Authority / Ministry of Planning and Administrative Development	600,000.00 NOK			
32	Improvement of livelihoods in the most vulnerable communities in the West Bank		Ongoing	Spanish Cooperation - Spanish Agency for International Cooperation	Union of Agricultural Work Committees / Economic and Social Development Centre	2,400,000.00 EUR			
33	Additional financing for the NGEST project		Ongoing	Agence Française de Développement	Palestinian Water Authority	4,000,000.00 EUR			
34	WASH in School		Ongoing	United Nations International Children's Emergency Fund	Palestinian Water Authority	8,777,695.00 USD			
35	Emergency Water Supply and Rehabilitation in Rafah		Ongoing	Japanese Government- Japanese Representative Office	Palestinian Water Authority	5,424,106.00 USD			
36	GZ- SOUTHERN WEST BANK SOLID WASTE MANAGEMENT		Ongoing	World Bank	Municipality of Hebron	12,000,000.00 USD			
37	Extension of a Water Network to Service the Future Jericho Agro-Industrial Park (JAIP)		Ongoing	Japanese Government- Japanese Representative Office	Palestinian Industrial Estates and Free Zone Area	859,531.00 USD			
38	UXOs Clearance, and Improvement of Solid Waste Services in the Gaza Strip		Ongoing	Japanese Government- Japanese Representative Office	Palestinian Environment Quality Authority / Municipality of Gaza / Municipality of Rafah / NGOs	18,262,654.00 USD			
39	Improve the capacity of CMWU for Monitoring the Quality of Water Supply		Ongoing	Austrian Development Agency	Palestinian Water Authority	635,324.00 USD			

ANNEX V. DATA NEEDS, APPROACHES, AND MAIN STEPS IN APPLYING COST-BENEFIT ANALYSIS

The assessment of benefits for a CBA of proposed adaptation measures would require further information on:

1. the economic impact (or cost) of climate change (ideally, monetised) in each sector of interest, in order to estimate the cost of inaction, or the damage that could be avoided by implementing adaptation measures;
2. the effectiveness of each adaptation option in reducing the impacts of climate change in that sector (i.e., the extent to which the costs of climate change identified in point 1) above would be reduced through the adaptation measure);
3. any additional benefits resulting from the option's implementation, ideally expressed in monetary terms.

To gather information in regards to these three points, the following approaches could be used (individually or in combination):

- benefit transfer, i.e., transferring available information from studies conducted in another location and/or context (while making the necessary adjustments to reflect the benefits for Palestine/the particular site under consideration);
- up-scaling or extrapolating information from projects/measures already implemented in Palestine and for which the benefits have already been assessed; and
- conducting primary analysis (e.g., modelling, experiments, contingent valuation studies) to assess the impacts of adaptation measures in Palestine.

Finally, the aggregated costs and benefits of each adaptation measure would have to be compared (e.g., on the basis of their net present value, benefit-cost ratio, or internal rate of return), in order to identify the most efficient adaptation options.

The main steps in applying CBA are (based on UNFCCC 2011 and FAO 2016b):

- agree on the adaptation objective and identify potential adaptation options;
- establish a baseline;
- define the boundaries of the analysis;
- identify, quantify and aggregate the costs over specific time periods;
- identify, quantify and aggregate the benefits over specific time periods;
- discount benefits and costs to estimate present value; and
- compare the aggregated costs and benefits.

ANNEX VI. THE CONFLICT-RIDDEN ENVIRONMENT OF PALESTINE AND ITS ECONOMIC IMPACTS

The permanent conflict situation together with increasing environmental problems and climate-change impacts as main risks to Palestine's development ambitions. Israel has control over most of the important natural resources of the occupied Palestinian territory, access to Palestinian territory and destroyed Palestinian infrastructure several times in the course of situations with heightened tensions. Some of the limiting factors in the three examined sectors stem from - or are compounded by - the restrictions imposed by Israel. For example restrictions on fertilizer imports result in decreased productivity and increased costs, whilst restrictions on water use, the movement of farmers and trade impose financial and time costs on Palestinian producers (UNCTAD 2015). In addition, severe impacts on the Palestinian economy by controlling the free movement of goods, agricultural products and people are felt.

Agriculture

The occupation and full control of Area C (covering 63% of the agricultural resources of the West Bank), the construction of the separation barrier, and the expansion of Israeli settlements have reduced the area available for agriculture (UNCTAD 2015). A report by the World Bank on Palestine's water resources indicates that removal of Israeli restrictions and provision of additional water could increase the agricultural sector's contribution to the GDP by as much as 10% and create approximately 110,000 new jobs (World Bank 2009).

Water

Israeli control over the key sectors and areas in Palestine is reflected in using licensing, permits and access rights to control vast amounts of ground water and aquifers, for example. Due to the allocation of trans-boundary water resources agreed upon under the Oslo II Interim Accord concluded in 1995, Israel controls approximately 80% of water reserves in the West Bank (EPRS 2016). The Accord was intended to regulate the matter for an interim period of five years, but is still in place as parties have not reached a final agreement. The quantitative approach followed by the Oslo Accord has been criticised for failing to consider adjustments to natural changes and socio-economic developments, such as population increases (EPRS 2016). In fact, Israel controls the water sector in Palestine to a very large extent through the Joint Water Committee (JWC) which does not allow any major water-related supply or access decision without Israeli approval. Since 1967, Palestinians have been denied the right to access and utilize the water resources of the Jordan River, for example. The long-term average annual flow of flood water through wadis in the West Bank was estimated at about 165 MCM/year, but runoff has not been utilised or controlled on a large scale in the West Bank due to the high investments required and the Israeli restrictions on permits for the construction of dams (ARIJ 2015a).

Agri-food

The climate sensitivity of domestic food production and prices is compounded by restrictions on trade in food between the West Bank and Gaza Strip. Logistical problems drive up food prices, as there is no airport, which means low-income households cannot afford to purchase imported foods. Most food is imported through Israel, increasing costs and, therefore, prices. Israel refuses to allow use of Qalandia Airport for importing food or the establishment of a new airport. Israeli occupation delays issuing of import licences. Barriers to imports increase the cost of trade and, thus, food prices. Issues limiting adaptive capacity to contend with the climate sensitivity of domestic food prices are similar but even more profound in the Gaza Strip than in the West Bank. Not only is there a similar lack of large-scale cold-storage facilities but, furthermore, many food-processing facilities have been destroyed by Israeli air strikes during the last three wars on Gaza (2008, 2012, and 2014). Israel destroyed the Gaza Strip's airport, prevents construction of the seaport and does not usually allow import of food. Hence, stocks of imported food products in the Gaza Strip are dwindling, driving their prices sky-high. (Smithers et al. 2016).

Last but not least, there is the ongoing and continued expansion of areas occupied by Jewish settlements, often in key strategic locations in the West Bank, taking over more and more land in Area C and encroaching on Area B land. Area C contains most of the West Bank's natural resources and open spaces. Full control over Areas B and C and its resources, that should have no Israeli settlements since Oslo II, with the Israeli government not intervening, are a key issue in this process.

Due to the Israeli control over the infrastructure and access to the Palestinian territory and water resources, combined with restrictions on movement of individuals, services and trade, the Palestinian Government does not have *full control over a larger area of its territory.*