State of Palestine
Environment Quality Authority

National Adaptation Plan (NAP) to Climate Change

2016

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1 Background

1.1 UNFCCC Guidelines

The UNFCCC's *Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention* (Decision 17/CP.8) identify the following requirements in relation to "Programs containing measures to facilitate adequate adaptation to climate change":

28. *"Each Party shall, in accordance with Article 12, paragraph 1 (b) and (c), of the Convention, provide to the COP information on the general descriptions of steps taken or envisaged towards formulating, implementing, publishing and regularly updating national and, where appropriate, regional programs containing measures to facilitate adequate adaptation to climate change, and any other information they consider to be relevant to the achievement of the objective of the Convention and suitable for inclusion in their communications.*
29. *In doing so, non-Annex I Parties should provide information on their vulnerability to the adverse effects of climate change, and on adaptation measures being taken to meet their specific needs and concerns arising from these adverse effects.*
30. *Non-Annex I Parties may use appropriate methodologies and guidelines[1] they consider better able to reflect their national situation for assessing their vulnerability and adaptation to climate change, provided that these methodologies and guidelines are consistent, transparent and well documented.*
31. *Non-Annex I Parties are encouraged to use, for the evaluation of adaptation strategies and measures,[2]appropriate methodologies they consider better able to reflect their national situation, provided that these methodologies are consistent, transparent and well documented.*
32. *Non-Annex I Parties are encouraged to provide information on the scope of their vulnerability and adaptation assessment, including identification of vulnerable areas that are most critical.*
33. *Non-Annex I Parties are encouraged to include a description of approaches, methodologies and tools used, including scenarios for the assessment of impacts of, and vulnerability and adaptation to, climate change, as well as any uncertainties inherent in these methodologies.*
34. *Non-Annex I Parties are encouraged to provide information on their vulnerability to the impacts of, and their adaptation to, climate change in key vulnerable areas. Information should include key findings, and direct and indirect effects arising from climate change, allowing for an integrated analysis of the country's vulnerability to climate change.*
35. *Non-Annex I Parties are encouraged to provide information on and, to the extent possible, an evaluation of, strategies and measures for adapting to climate change, in key areas, including those which are of the highest priority.*
36. *Where relevant, Parties may report on the use of policy frameworks, such as national adaptation programs,[3] plans and policies for developing and implementing adaptation strategies and measures."*

[1] Such as the IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations (Carter, T.R., M.L. Parry, H. Harasawa, S. Nishioka, 1994), the UNEP Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies (Feenstra, J.F., I. Burton, J.B. Smith, R.S.J. Tol, 1998), and the International Handbook on Vulnerability and Adaptation Assessments (Benioff, R., S. Guill, J. Lee, 1996).
[2] Such as those contained in the Compendium of Decision Tools to Evaluate Strategies for Adaptation to Climate Change which is available from the UNFCCC web site, www.unfccc.int/issues/meth_tools.html
[3]For example, national adaptation programs of action (NAPAs) for least developed countries.

2 Introduction

The State of Palestine's National Adaptation Plan (NAP) provides:

- An assessment of historic trends in climate in relation to the State of Palestine
- Identification and prioritization of vulnerabilities
- Future climate-scenarios for the State of Palestine
- Identification and prioritization of adaptation options, including costings
- Future developments required for the State of Palestine's institutions to be able to participate in climate-modelling research
- An outline of the process for future monitoring and evaluation; and
- Next steps.

3 Methodology

3.1.1 Assessment of historic trends in climate

Historic trends in climate in relation to the State of Palestine have been assessed to provide a context for considering the climate sensitivity of potential vulnerabilities across the State of Palestine's various sectors in preparing the NAP.

The objectives of climate-trend analysis are not only to identify multi-year trends in climate parameters but also to distinguish between natural variability, on any timescale resulting from natural causes, and long-term trends resulting from the influence of human beings.

It was not intended that this historic trend analysis should be used as the basis for establishing a baseline for future climate projections that can be used to inform assessment of exposure and prioritization of adaptation actions in preparing the State of Palestine's NAP. It should also be noted that historic trends need not necessarily continue in the future under climate change.

Appendix 1 provides:

- A discussion of uncertainties in relation to estimating trends for the various parameters considered.
- Global analyses of observed trends in relation to the State of Palestine interpreted from the charts provided in the IPCC's Fifth Assessment Report, Working Group I, (IPCC AR5), published in 2013.
- A review of climate trends assessed at a national level in documents submitted to the UNFCCC for countries in the vicinity of the State of Palestine, namely Lebanon, Jordan, Israel and Egypt.
- A summary of a representative sample of numerous papers, identified from a literature search, that consider regional climate trends in and around the State of Palestine, assessing either trends in climate parameters themselves or trends in impacts of changes in these parameters. The geographical locations of the studies vary but, given the relative uniformity of the climate across the larger region, studies undertaken in climates similar to those in the State of Palestine were reviewed. Thus, studies for Lebanon, Jordan, Syria, Israel, Saudi Arabia and Egypt have been included.

Temperature is the most straightforward of all climate parameters to submit to trend analysis. This is because temperature tends towards statistically normal distributions and uniformity over large areas, and adheres to basic laws of physics. Analyses of combined temperature parameters, such as the length of heat waves, however, suffer from the relatively few occurrences within the data record with which to determine any trends.

Trends in rainfall are more difficult to analyse than those for temperature. Rainfall is not only non-normally distributed but is also spatially variable, with trends perhaps dependent on the location of a specific rainfall gauge. In the case of the State of Palestine, rainfall is often convective (i.e. When the land warms up, it heats the air causing it to expand and rise. As the air rises it cools and condenses leading to rainfall) and is controlled to an extent by landform. Thus, geographically-close rainfall gauges may provide very different recordings of any particular event and it is plausible that a slight change in predominant wind direction might result in a rainfall trend at particular locations in the country.

Calculated trends may critically depend on the length of the selected period of the record. This is particularly the case for rainfall for which there may be inherent cycles of some form that may appear as trends over specific intervals of analysis. Even where cyclical behaviour is not apparent, trends in rainfall may appear for a number of years for reasons that may be difficult to ascertain and may then reverse, equally without obvious cause. The issue of possible cycles in rainfall in the Levant is certainly a complicating factor that might affect not only the identification of trends in the rainfall itself, but also trends in combined parameters, such as drought frequency and intensity.

The issues summarised above variously affect calculation of trends in additional parameters, such as in specific humidity, wind, sunshine, etc.

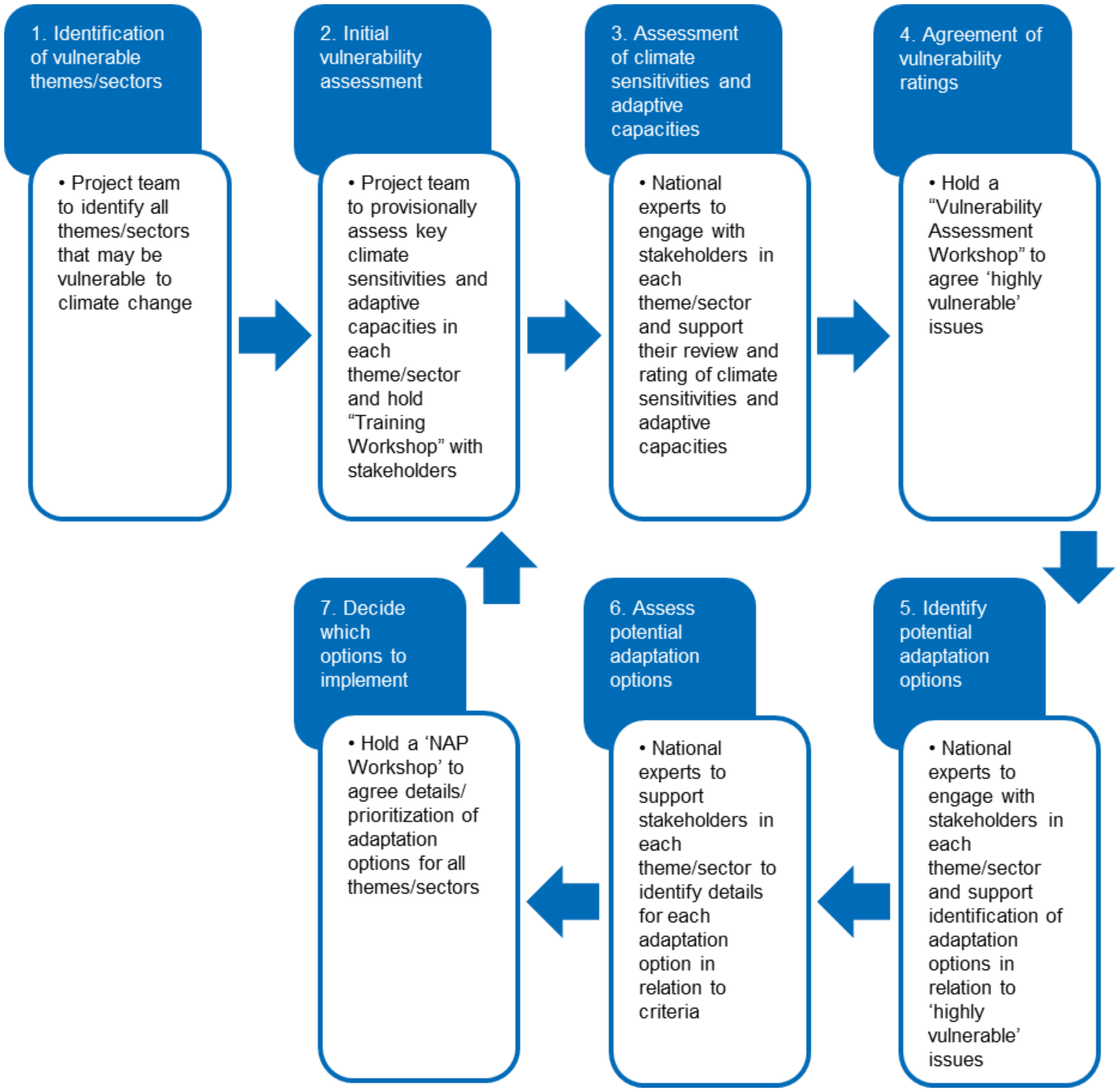
In order to embrace the difficulties and uncertainties related to identifying trends for the various parameters analysed, Appendix 1 uses the terminology for likelihood and confidence from the IPCC AR5 and offers mirror images of confidence statements in order to provide a balanced presentation.

3.1.2 Vulnerability assessment

The process for assessing vulnerabilities and identifying adaptation options (Figure 1) built on the UNFCCC's guidelines for least developed countries[4] and the Climate Change Adaptation Strategy and Program of Action for the Palestinian Government[5].

[4] Least Developed Countries Expert Group, 2012. National Adaptation Plans. Technical guidelines for the national adaptation plan process. UNFCCC.
[5] UNDP, 2010. Climate Change Adaptation Strategy and Program of Action for the Palestinian Authority.

Figure 1: The process agreed for assessing vulnerabilities and identifying adaptation options



Issues, in part revealed by the Climate Change Adaptation Strategy and Program of Action for the Palestinian Government, that helped to define the process include:

- Water and food security having previously been identified as the most vulnerable issues in the State of Palestine with knock-on implications for all other sectors
- Climatic vulnerability in the State of Palestine being dwarfed by existing non-climatic vulnerabilities
- The West Bank including East Jerusalem and the Gaza Strip facing similar and differing vulnerabilities
- A need to embrace climatic uncertainties
- A lack of quantitative data relevant to the identification and prioritization of vulnerabilities and adaptation options
- The need to ensure common understanding and commitment amongst key stakeholders.

The process was agreed at initial workshops with stakeholders in the West Bank and the Gaza Strip (Appendix 2) from across 12 themes/sectors (Box 1), which were identified as potentially vulnerable (Figure 1, Stage 1).

Box 1: Sectors or themes identified as potentially vulnerable to climate change

- Agriculture
- Coastal and marine
- Energy
- Food
- Gender
- Health
- Industry
- Terrestrial ecosystems
- Tourism
- Urban and infrastructure
- Waste and wastewater
- Water

It was agreed with stakeholders that an assessment of potential vulnerabilities (biophysical and/or socioeconomic) associated with each of the 12 themes/sectors should initially be drafted by a project team of national experts guided by an international expert. Definitions of terms used were consistent with the IPCC AR5, as follows:

Sensitivity – *'The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise)'.*

Adaptive capacity – *'The ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences'.*

Vulnerability – *'The propensity or predisposition [tendency] to be adversely affected'.*

The inter-relations between these terms are illustrated in (Figure 2below).

The draft assessments addressed the West Bank including East Jerusalem and the Gaza Strip separately. Climate sensitivities and adaptive capacities (with and without Israeli occupation) were identified and described in relation to each potential vulnerability. All relevant references were cited.

“Training Workshops” were then held in the West Bank and the Gaza Strip with stakeholders from each of the themes/sectors to familiarise them with the definitions of terms and the spreadsheet used for the assessment. Following the workshop, the draft vulnerability assessments were distributed to the stakeholders. They subsequently met in their thematic/sectoral groups in the West Bank and the Gaza Strip with a member of the project team. Each group reviewed and amended, where appropriate, the relevant list of potential vulnerabilities, the descriptions of climate sensitivities and adaptive capacities. They then rated each of them according to the scoring system set out in Table 1and Table 2 below.

Figure 2: Illustration of inter-relations between definitions of terms used in IPCC's 5th Assessment Report

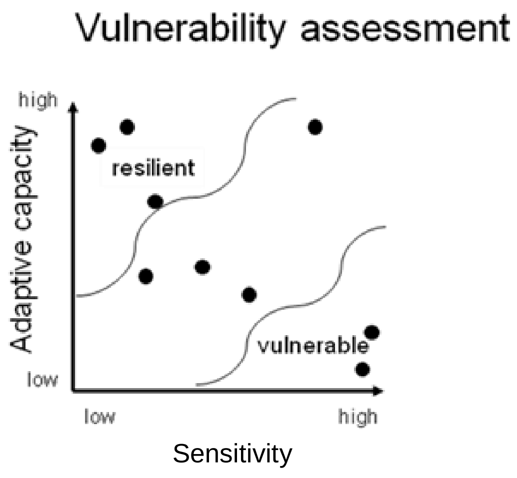


Table 1: Definitions for rating climate sensitivities

Rating	Definition
1	Will not be adversely affected
2	Unlikely to be adversely affected
3	Will be affected
4	Will be severely affected
5	Will become unmanageable

Table 2: Definitions for rating adaptive capacities

Rating	Definition
1	Unable to adapt without substantially increased support and resources
2	May be unable to adapt without increased support and resources
3	Should be able to adapt but will face challenges
4	Able to adapt but will face minor challenges
5	Able to adapt without problems

The ratings for climate sensitivity and adaptive capacities in relation to each of the potential vulnerabilities was then inter-related using the matrix in Figure 3to provide a vulnerability rating (with and without Israeli occupation).

Figure 3: Vulnerability ratings

Adaptive capacity					
5	1	1	2	2	2
4	1	2	3	3	3
3	2	3	3	4	4
2	2	3	4	4	5
1	2	3	4	5	5
	1	2	3	4	5
	Sensitivity				

Highly resilient	1
Resilient	2
Potentially vulnerable	3
Vulnerable	4
Highly vulnerable	5

The resultant vulnerability assessments for all themes/sectors in the West Bank including East Jerusalem and the Gaza Strip were quality assured by the project team's international expert. The stakeholders from across all 12 themes/sectors then reconvened for 'Vulnerability Assessment Workshops'(i.e. Figure 1 Stage 4) held in the West Bank and the Gaza Strip. Those issues rated as 'highly vulnerable' under Israeli occupation were reviewed and agreed at the workshops, as the focus for identification and prioritization of adaptation options. Securing agreement demanded recalibration of scores for a small number of issues to ensure parity across themes/sectors. Focusing the NAP solely on 'highly vulnerable issues makes the NAP more conservative and realistic, and reduces the effect of uncertainties in determining priorities.

3.1.3 Provision of future-climate scenarios for the State of Palestine

Future-climate scenarios for the State of Palestine have been developed by an international expert in order to aid identification and prioritization of adaptation options in relation to the 'highly vulnerable' issues. High-quality future-climate scenarios may be desired in order to ensure that adaptation planning is well-focused and to avoid maladaptation insofar as possible. However, developing such scenarios is not straightforward. The assessment of historic trends in climate demonstrates that it is not a simple process to determine changes in the climate from historical data, especially for parameters such as rainfall. When trying to establish future-climate scenarios such difficulties are compounded by the uncertainties inherent in climate models used for projections and uncertainties regarding future concentrations of greenhouse gases (GHGs) in the atmosphere, land-use change (particularly reduction in the area of tropical forests) and the future extent of mitigation actions taken by the international community.

In order to provide climate-change scenarios for the State of Palestine based on the latest science, relevant scenarios presented in the literature have been reviewed to provide context for an analysis of projections from models used in the IPCC AR5 (Appendix 3). The background review is presented in two parts:

1. A review of available official perspectives on future climate change submitted in National Communications (NCs) to the UNFCCC from countries in the vicinity of the State of Palestine (i.e. Lebanon, Jordan, Israel and Egypt)
2. A review of selected perspectives identified from a literature search of peer-reviewed journals and the grey literature.

The NCs perspectives of future climate change are consistent in expecting temperatures to increase. However, the range of temperature increase differs from less than 2°C to 4°C by the end of the century. These differences are to a major extent dependent upon the approaches taken. Most of the NCs anticipate reductions in rainfall; some by a few per cent, others by a substantial amount. Model results presented in the Egypt Second NC, albeit with relatively early generation climate models, illustrate the opposite possibility of substantial future increases in rainfall. There are some positions taken with respect to other aspects of rainfall, which would all lead to negative impacts, e.g. more droughts and floods, longer drought periods, and less daily rainfall but higher intensity falls leading to stronger floods.

The literature search of peer-reviewed journals and grey literature identified a range of perspectives on future climate change that are relevant to the State of Palestine. There is unanimity that temperatures will increase, although there is some disagreement by how much. Most analyses suggest future decreases in rainfall, although the amount of the decreases is somewhat uncertain. Nevertheless, one or two analyses suggest the possibility that rainfall may increase. In general, the contention is that the overall water situation will deteriorate, with more potential for drought and floods, increased evaporation, reduced river flow, etc., in line with the majority of positions in the NCs. However, where climate models are used, all analyses are based on limited numbers of projections, either one or just a few, rather than the much larger ensembles available to the IPCC.

The assessment of future-climate scenarios reviewed issues for climate projections of limited areas. The only viable approach available for assessing climate change is through the use of mathematical models, run on powerful computers, which simulate the climate over future decades. In order to run climate models, information is needed on future atmospheric GHG concentrations, which is provided through emissions scenarios or Representative Concentration Pathways (RCPs). However, no two models, or versions of a single model, will produce identical projections. Any differences in projections provided by the various climate models using a particular scenario or RCP can be traced predominantly to the way in which each model has been formulated. Relatively small changes to the structure of a model may have a disproportionately large impact on the projections produced. Thus, with numerous climate models, or their variants, being used to produce an ensemble of individual projections, none the same, there is an issue of how to interpret the broad spread of information produced. Several approaches have been used. At the simplest level a preferred model is used, however, there is no evidence to guide appropriate selection and predictability theory is clear in indicating the limitations of this approach. At the next level a small number of preferred models are used from the complete ensemble. However, there is no more justification in predictability theory for selecting a subset of models than there is for selecting a single model. Nevertheless, both approaches are used frequently in published papers, adaptation planning and NCs to the UNFCCC, including some reviewed here. The only approach that begins to satisfy predictability theory is to create and interpret as large an ensemble of models as possible. There are various ways of doing so. The main one used by the IPCC is to use all available models from the various climate modelling centres. Most of the NCs or documents reviewed in this assessment use much smaller ensembles than the IPCC.

The methodology used to provide climate-change scenarios for the State of Palestine incorporated two main steps:

- A background assessment of climate change projections for the State of Palestine, calculating ensemble means for the atmosphere/ocean models used in the main IPCC AR4 and AR5 assessments, repeated for the AR5 using the projections from Regional Climate Models (CORDEX[6]) covering the Levant
- A detailed assessment of projections using the AR5-set based on the technique of self-organizing maps (SOMs).

Appendix 3 notes that there are scientific issues still to be resolved with the regional models and, at this stage, it was considered appropriate only to use these as information rather than to exploit their enhanced temporal and spatial details.

Analyses have been prepared by year for 2016-2035 (summarised as 2025), 2046-2065 (2055) and 2081-2100 (2090) with changes calculated against simulations for each model for a historical period, 1986-2005. The assessment focused presentation of results on two of the four scenarios considered by IPCC AR5: RCP2.6 and RCP6.0 (the larger the value at the end of each ‘RCP’ the higher are the emissions and atmospheric GHG concentrations), although results for the other two RCPs (RCP4.5 and RCP8.5) are included in Appendix 3.3. Separate scenarios under all four of the (RCPs) for the State of Palestine are also presented in Appendix 3.4 for ease of comparison. The reasons for focusing on RCP2.6 and RCP6.0 were that:

- RCP2.6 is the only AR5 scenario that provides a high probability of achieving the UNFCCC target of a maximum average global temperature rise of 2.0°C, and
- RCP6.0 is a realistic option should UNFCCC processes fail given reasonable expectations of international mitigation activities.

A standard approach to interpreting the projections was used initially, i.e., an examination of ensemble means, their standard deviations, and ranges. However, the key additional step followed was to calculate SOMs. This is a technique to identify groupings within a dataset without assuming any statistical distributions (such as a normal distribution). Each grouping was then plotted on a scatter chart illustrating the complete temperature/rainfall projections, together with a companion chart showing the average temperature or changes associated at each time period with that particular group. Examination of the scatter charts typically suggests either a sequence of events in time, or, on occasions, individual groupings of models; the key aspect being that each model in each group is projecting similar future temperature and rainfall conditions. While this approach provides additional insight in comparison with the standard approach, both suffer from the same issues that lead to uncertainties:

- More outlying projections are taken into account only as components of the mean (or each group mean), and
- There is the possibility that the “answer” lies outside the entire range of the ensemble.

Thus, the interpretation of SOMs provided is not necessarily the final solution but is consistent with a realistic perspective of the complete spread provided by each full ensemble and resulted in a total of nine, somewhat overlapping, scenarios. From those nine scenarios, a summary of three scenarios that

[6]The results from the Mediterranean North Africa, MENA, CORDEX projections have been used.

are representative and cover the full range of options was provided to aid identification and prioritization of adaptation options in relation to the 'highly vulnerable' issues.

3.1.4 Identification and prioritization of adaptation options

It was agreed with stakeholders at the initial workshops that identification and prioritization of adaptation options (Figure 1; Stages 5-7) should be undertaken by them rather than by the project team, as it not only required stakeholders' understanding of specific operational details but also the buy-in of those stakeholders responsible for implementation of options selected. Members of the project team provided the stakeholders in each theme/sector in the West Bank and the Gaza Strip with active support in order to help guide them through the process. They also helped stakeholders, where necessary, to make an initial identification and prioritization of adaptation options for stakeholders' review and amendment.

Stakeholders were advised that adaptation options should seek to reduce vulnerabilities by reducing climate sensitivity or increasing adaptive capacity, and that options might include management and operational strategies, infrastructural changes, policy adjustments or capacity-building. They were also guided that some options might involve adjusting (climate-proofing) current activities, while other options might be new, or require major transformations in operations. In addition, it was suggested that some options might be ecosystem-based, i.e. helping people adapt to the impacts of climate change through the conservation, sustainable management, and restoration of ecosystems.

Stakeholders were encouraged to identify adaptation options that embrace all three future-climate scenarios for the State of Palestine that are representative of all projections considered in the IPCC AR5. Such options will be beneficial whichever of the scenarios comes to pass.

The State of Palestine's particular circumstances mean that stakeholders agreed that there was a need to focus on identification of immediate, near-future adaptation options that address the 'highly vulnerable' issues under Israeli occupation. However, limited consideration was also given to medium- and long-term adaptation options that could be taken if Israeli occupation was resolved.

3.1.4.1 Prioritizing adaptation options

An Excel tool, with associated guidance, was prepared by the project team's international expert in order to provide stakeholders with a simple framework for qualitatively comparing the relative merits of adaptation options[7]. More comprehensive tools (such as cost-benefit analysis) could be used in the future to analyse measures when more quantitative data become available. Stakeholders were introduced to the Excel tool at the 'Vulnerability Assessment Workshops'.

Stakeholders were requested to identify at least one adaptation option in relation to each of the 'highly vulnerable' issues relevant to their theme/sector. It was emphasised that the wording of the adaptation option should be as specific as possible. Stakeholders were directed that if they identified more than one adaptation option for the same 'highly vulnerable' issue then they should complete a separate row for each adaptation option. Furthermore, if the same adaptation option related to more than one 'highly vulnerable issue' then they were asked to complete a separate line for each 'highly vulnerable' issue.

The Excel tool required stakeholders to provide a short description in a 'Performance Matrix' of each adaptation option in relation to the criteria detailed below. Stakeholders were requested to make these descriptions as specific as possible in order to ensure subsequent prioritization of the adaptation options was adequately informed and in order to facilitate their translation into future outline funding proposals. In addition, the 'Performance Matrix' required that each adaptation option was screened in relation to the following questions:

- Would the adaptation action still be required if Israeli occupation was to be resolved?
- Could the adaptation action be taken only if Israeli occupation was to be resolved?

Stakeholders were directed that they should only seek to score the adaptation options in relation to each of the criteria using the Excel tool's 'Appraisal' sheet once the 'Performance Matrix' had been completed for all adaptation options in relation to a theme/sector for the West Bank or the Gaza Strip. This was to ensure that adaptation options across each theme/sector for the West Bank or the Gaza Strip could be scored relative to one another in a systematic, transparent and repeatable way.

[7] See also UNFCCC (2012): National Adaptation Plans. Technical guidelines for the national adaptation plan process. LDC Expert Group, 2012. Available at: https://unfccc.int/files/adaptation/cancun_adaptation_framework/application/pdf/naptechguidelines_eng_high__res.pdf

Criteria for describing and scoring each adaptation option

The criteria to which the 'Performance Matrix' and Appraisal' sheet related were as follows. Each criteria for each adaptation option within a theme/sector was given a relative score of 'Low' (1), 'Medium' (5) or 'High' (10). Criteria associated with co-benefits could also be scored as 'Negative' (-5).

- **Impact** (consequences or outcomes) – '*Effects on natural and human systems*'[8] – The magnitude of the potential 'impact' (i.e. if the adaptation option is not implemented), assessed by considering the nature of each 'vulnerability' in relation to its potential 'exposure' to climate change, i.e. as determined from consideration of the future-climate scenarios developed for the State of Palestine.
- **Efficacy** – The extent to which the adaptation option addresses all three climate change scenarios and their potential impact. 'No regrets' options have a positive impact even if climate change is not as anticipated.
- **Timing/urgency for action** – The most urgent actions are those where delay could lead to greater impact (due to the speed of impact and/or time for the adaptation option to become effective, e.g. tree planting to provide shade or shelter that will not be provided until the trees mature) 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** –The financial costs associated with design and implementation of the adaptation option, including operational costs (e.g. human resources) and investment costs, broken down into Years 1-5 and Years 6-10, where possible. High costs were scored as 'Low' whereas low costs were scored as 'High'. Table 3provides a list of prompts, which were intended to aid stakeholders' consideration of the scale of costs associated with each adaptation option.

Table 3: Prompts to aid consideration of the scale of costs

Issue	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 (N.B. 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?

- **Co-benefits for adaptation in other themes/sectors** –The extent to which the adaptation option delivers potential co-benefits for adaptation by other themes/sectors, including

[8] IPCC (2013) Fifth Assessment Report

contributing to National Development Plan goals. It was important when scoring this criterion to focus on the adaptation options most important implications for other themes/sectors (N.B. this criterion could have a negative score, i.e. some options could potentially increase other themes/sectors' vulnerabilities by increasing their climate sensitivity or reducing their adaptive capacity).

- **Co-benefits for mitigation** – The extent to which the adaptation action will reduce greenhouse gas (GHG) emissions (N.B. this criterion could have a negative score, i.e. some options could actually increase GHG emissions).

These criteria and associated scoring system were agreed with stakeholders at the 'Vulnerability Assessment Workshops'. A concern was expressed that inclusion of 'Costs' would unduly bias rankings and that they might be better considered separately. However, as 'Costs' contribute to only c.10% of the total possible score for each adaptation option, it was agreed to retain them within the scoring system. Consideration was also given to weighting each criterion to reflect the relative importance of its overall contribution to the ranking but this was not pursued, as unweighted scores were perceived to promotegreater transparency.

Ranking of adaptation options

Once the Excel tool was completed for each theme/sector, the 'Results' sheet then automatically provided a total score and ranking of all options in descending order of priority for each theme/sector in the West Bank and the Gaza Strip. Stakeholders were directed to use the total scores and ranking as a means of checking for consistency of scoring of all adaptation options within their theme/sector. In some instances, stakeholders had preconceived expectations of where particular adaptation options should appear in the rankings, which were inoculated by their prioritization in existing thematic/sectoral strategies or plans. Where such expectations were not met, stakeholders were directed not to simply amend the scores in the 'Appraisal' sheet but, first, to review descriptions systematically in the 'Performance Matrix and revise wording and subsequent scores in relation to individual criteria, if appropriate. Where this could not be justified, stakeholders were advised that this suggested that it was existing thematic/sectoral strategies or plans that needed to be updated to be aligned with the NAP rather than the other way around.

The resultant assessments of adaptation options for all themes/sectors in the West Bank and the Gaza Strip were quality assured by the project team's international expert. The stakeholders from across all 12 themes/sectors then reconvened for 'NAP Workshops' (i.e. Figure 1**Error! Reference source not found.**, Stage 7) held in the West Bank and the Gaza Strip at which it was agreed that:

1. All adaptation options identified in relation to 'highly vulnerable' issues should be included in the NAP, irrespective of their ranking
2. It would be inappropriate to compare the priority of adaptation options between the West Bank and the Gaza Strip or between themes/sectors, as relative scores have been used to rank options within each theme/sector.

3.1.5 Requirements for Palestinian institutions to participate in climate-change modelling research

The international expert who developed the future-climate scenarios for the State of Palestine, required in order to aid identification and prioritization of adaptation options in relation to the 'highly vulnerable' issues, also provided a review of requirements for the State of Palestine to have the capability to generate its own climate modelling inputs to its future NAPs and NCs (Appendix 5). The review assumed, for simplicity, that no resources to meet these requirements exist currently in the State of Palestine. Clearly that is not the case, however, a presentation in this form was intended to enable the State of Palestine to select the appropriate entry level in relation to each of the areas noted, which are.

- A comprehensive and readily accessible digitised database of ongoing weather and climate observations to World Meteorological Organization (WMO) standards
- Similar databases to fulfil requirements for hydrological parameters
- Appropriately-qualified staff
- Computer resources.

Resultant costings for inclusion in the NAP were provided by the Palestinian Meteorological Department.

3.2 Historic trends in climate

In summary, the assessment of historic trends in climate in relation to the State of Palestine, which was intended to provide a context for considering the climate sensitivity of potential vulnerabilities, reached the following conclusions in relation to climate variables:

- **Average temperature:** There is *very high* confidence that temperatures have risen over the past 100 years or so but less confidence in assessed 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°Cover the 19th century but also *medium* confidence that the rate of increase was highest in the final 20 years of the century
- **Maximum and minimum temperatures and diurnal temperature stage:** 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, only *low* confidence for any changes in diurnal temperature ranges.
- **Temperature extremes[9]:** The different signs in the trends of the two global analyses of warmest day of the year illustrate the difficulties in providing stable assessments for the State of Palestine. Otherwise the available, but rather limited, evidence does provide partial support the contention of longer warm spells and shorter cold spells but *high* confidence that warm days/nights and cold days/nights have increased/decreased respectively in frequency.
- **Rainfall totals:** Some regional authors have argued that rainfall has decreased, however, not all authors agree. Taking all of the evidence into account, the interpretation of local rainfall trends, and perhaps even more so of rainfall extremes, should be treated with caution, despite the substantial number of analyses available. Thus, 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. The IPCC AR5 notes that it is *very likely* that specific humidity has increased since the 1970s, a result reflected in the Jordanian and Egyptian National Communications. On a global scale, the IPCC AR5 states 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 presented for the Levant appear consistent with the statements of the IPCC, while others do not.
- **Oceanic parameters:** The only oceanic parameter for which any number of analyses has been obtained in the region of interest has been sea level. With the complexity of the Mediterranean system, sea level rises in the basin do not necessarily follow those of the global ocean and do appear to be variable in time. Equally, the limited evidence on sea-surface temperatures suggests variability in time.

Full conclusions from the assessment of historic trends in climate can be found at Appendix 1.

3.3 Vulnerabilities: 'Highly vulnerable' issues

Those issues rated as 'highly vulnerable', which stakeholders agreed should be the focus for identification, prioritization and implementation of adaptation options are listed in Table 4and are described below. The complete vulnerability assessments for all themes/sectors in relation to the West Bank and the Gaza Strip are available on request from EQA.

[9] IPCC AR5: "An extreme weather event is an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., drought or heavy rainfall over a season)."In this document the word "extreme" is used with caution, not to imply any impact but only within the context of the IPCC definitions listed in the NAP's Appendix 1.3.

Table 4: Issues ranked as "Highly vulnerable"

Theme/sector	Highly vulnerable – West Bank	Highly vulnerable – Gaza Strip
Agriculture	Olive production; Grape production; Stone fruits; Rain-fed vegetables; Field crops; Irrigated vegetables; Grazing area and soil erosion; Irrigation water; Livestock production	Livestock production; Cost of agricultural production; Employment; Vegetable production; Olive production, Citrus; Irrigation water
Coastal and marine	N/A	Fishing/fisheries; Coastal agriculture; Condition of beaches
Energy	Domestic/local energy production; Energy imports; Condition of infrastructure	Domestic energy production; Energy imports; Condition of infrastructure
Food	Domestic food prices; Imported food prices	Domestic food prices; Imported food prices
Gender	Major diseases related to water and sanitation	Employment and gender; Major diseases related to water and sanitation; Food security and gender
Health	Major diseases related to water, sanitation, and food	Major diseases related to water, sanitation, and food
Industry	Value of raw materials imported; Infrastructure; Energy supply; Energy demand	Value of industrial products exported; Value of raw materials exported; Employment; Energy supply; Energy demand
Terrestrial ecosystems	Habitat connectivity	Wadi Gaza – Habitat connectivity
Tourism	Condition of cultural heritage	N/A
Urban and infrastructure	Urbanization	Building conditions; Urban drainage
Waste and wastewater	Waste management	Waste management
Water	Ground water supply; Flood management; Condition of infrastructure	Groundwater supply; Groundwater quality; Flood management

3.3.1 Agriculture (West Bank) – 'Highly vulnerable' issues

General climate sensitivity and adaptive capacity

Agricultural production is sensitive to climate and local weather forecasts do not accurately predict heat waves, frosts or flash flood. Low rainfall postpones planting dates, and low temperatures delay maturation and harvesting. The Ministry of Agriculture (MOA) established an agricultural compensation fund, however, this is not yet active and compensation is limited to greenhouses and in some cases to irrigated vegetables, such as zucchini in the Jordan Valley, due to frost and/or hail storms. There is a lack of subsidies for farmers, as the State of Palestine is facing a fiscal crisis. Production of olives, grapes, stone fruits, rain-fed vegetables and field crops requires long-term water harvesting systems (and land management, including soil conservation practices, e.g. stone wall terracing etc). Technical solutions are available and applicable in the West Bank, although technical and technological support is needed and financial resources are restrictive. Agricultural extension, awareness-raising and training programs are being implemented by the MOA on farm management and the need to modify practices in order to address the adverse impacts of climate change, including how to cope during drought periods. The capacity of storm water drainage systems to drain excess water during flood events is limited. The amount of labour involved in harvesting, packing, and marketing, depends on the amount of production. Current post-harvesting storage techniques are inadequate, e.g. there is a lack of large-scale grading and refrigerated cold storage.

Israeli occupation reduces the ability of producers to respond to any consequences of climate change. Land continues to be confiscated for the benefit of the Israeli Illegal Settlements Regime and the Annexation and Expansion Wall impinges on land management. The Wall has a damming effect with consequent negative impacts on soil water content and consequent agricultural production. There are restrictions on digging new wells for irrigation purposes and Israel confiscates much of the State of Palestine's ground water in the West Bank. Land reclamation and rehabilitation is restricted, especially in Area C, including opening of new agricultural roads, construction of stone terraces to minimize erosion and digging new water wells for irrigation. Confiscation and closure of access to large swathes of land heightens pressures on the land to which Palestinians retain access, encouraging overgrazing and intensive farming practices, and making it difficult to plan and execute sustainable land management schemes. Access to the international market is limited, as there are restrictions on import of fertilizers (e.g. urea), basic agricultural inputs and spare parts, which increases the cost of agricultural production, as well as restrictions on exports of crops to neighbouring countries. The 2009 World Bank report on the State of Palestine's water sources indicates that removal of Israeli restrictions and provision of additional water would increase the agricultural sector's contribution to GDP by 10% and create approximately 110,000 new jobs.

Additional elements of climate sensitivity and/or adaptive capacity specific to individual 'highly vulnerable' issues are detailed below.

3.3.1.1 Production of olives, grapes, stone fruits, irrigated vegetables and field crops[10,11,12,13,14,15,16,17,18]

Climate sensitivity

The olive tree is a national symbol. Olive production is sensitive to frost, heat waves, drought, wind speed, amount and distribution of rainfall, and hail. In 2010, heat waves during the flowering season reduced olive production by 20%.Grape production is more climate sensitive than olive production, particularly to frost, hail, drought, and rainfall patterns (amount and distribution).In 2015, frost destroyed production of 170 hectares (3,825 tons), and partially destroyed 300 hectares (3,750 tons) in Hebron and Bethlehem Governorates. At Beit Umar (a town in Hebron Governorate), expected weather-related losses in grape production during 2015 were c.4,500 tons. Field crops are sensitive to drought, amount and distribution of rainfall, and heat waves. Irrigated vegetables are 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. In very low temperatures, crops will freeze and losses can result directly from damage or death of plants. Planting and harvesting dates of field crops and rain-fed vegetables are sensitive to climate. Low rainfall postpones the planting date, and low temperatures delay maturation.

Adaptive capacity

Olive trees in the State of Palestine comprise 71.6% of trees and c.15-19% of total agricultural production. Israeli settlers uproot, burn and destroy olive trees, as well as releasing wild pigs, which

[10] World Bank. (2013) Area C and the future of the Palestinian economy. Poverty reduction and economic management Department Middle East and North Africa Region, Report No. AUS2922.
https://openknowledge.worldbank.org/bitstream/handle/10986/16686/AUS29220REPLAC0EVISION0January02014.pdf?sequence=1
[11] Ma'an News Agency. (2010). Heat waves hit olive crops in Palestine (Arabic report).
www.maannews.net/arb/ViewDetails.aspx?ID=304225
[12] PCBS. (2011) Agricultural Statistics Survey, 2010/2011. Palestinian Central Bureau of Statistics, Arabic version. July 2012.
http://www.pcbs.gov.ps/PCBS-Metadata-en-v4.2/index.php/catalog/159/download/407
[13]Shaheen, H.; and Karim, R.A. (2007) Management of olive-mills wastewater in Palestine. An-Najah University Journal for Research (Natural Sciences) Vol. 21. P 63-83.
[14] Ma'an News Agency. (2015) Hebron grapes in danger, Arabic report.
https://www.maannews.net/Content.aspx?id=775427
[15] World Bank. (2015) Economic monitoring report to the Ad Hoc Liaison Committee.
http://documents.worldbank.org/curated/en/2015/05/24525116/economic-monitoring-report-ad-hoc-liaison-committee
[16] Hona alquds. (2015) Frost waves hurt crops in Jordan Valley. (Arabic report).
http://honaalquds.net/ar/article/8816/#.VVjOtPkirIU
[17] MOA. (2016) National Agriculture Sector Strategy, 2014-2016: Resilience and Development, Ministry of Agriculture, State of Palestine.
http://reliefweb.int/sites/reliefweb.int/files/resources/1417423273.pdf
[18] World Bank. (2009) Assessment of restrictions on Palestinian water sector development, West Bank and Gaza report. Report No. 47657-GZ.
http://siteresources.worldbank.org/INTWESTBANKGAZA/Resources/WaterRestrictionsReport18Apr2009.pdf

damage olive seedlings. Access to olive groves is restricted, where they are close to Israeli settlements and military bases. Olive oil degrades in quality while awaiting Israeli permission for export to the Arab Gulf and international markets. About 8,000 hectares is cultivated for grape production and contributes about 12% of total agricultural production. The MOA distributes seeds of field crops(e.g. wheat and barley) that are drought-tolerant. The Palestinian Government is trying to increase the number of jobs through establishing agro-industrial zones, such as Jericho and Jenin. USAID thankfully established several packing and grading houses in the Jordan Valley for high value cash crops (dates, cherry tomatoes, peppers, and herbs).

3.3.1.2 Grazing area and soil erosion[19,20,21,22,23]

Climate sensitivity

The grazing area on the eastern slopesis 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.

Adaptive capacity

While rangeland amounts to 2.02 million dunums (1 dunum = 0.1 ha), the area available for grazing is only 621,000 dunums. There is an absence of grazing regulations (open and close season). The MOA is undertaking several reforestation projects to protect soils from erosion.

3.3.1.3 Irrigation water[24,25,26]

Climate sensitivity

Irrigation water is sensitive to rainfall amount and distribution, and shifts in the rainy season. Drought decreases the quantity of water that can be allocated to agriculture yet at the same time increases crops' water requirement, increasing costs of production (inclusive of electricity for pumping).

Adaptive capacity

Irrigation water is supplied by groundwater wells and springs. In 2011, 60 million m^3 of water was available for agriculture. Irrigation infrastructure is old and inefficient, under-developed or undeveloped. Irrigation practices are outdated and there is a need to introduce precision agriculture and drip irrigation. Israeli occupation has led to inadequate infrastructure for treating Palestinian wastewater that could be used in irrigation, as: approval of plans for building treatment plants has been delayed (in some cases for more than a decade); Israel has demanded that the State of Palestine should connect settlements to the planned treatment plants (which has been rejected for political reasons); and Israel has forced Palestinians to employ treatment standards more advanced than those generally used in Israel, which has increased the cost of plant construction. Israel also places restrictions on Palestinians building power plants and desalination plants.

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[19] MOA. (2016) National Agriculture Sector Strategy, 2014-2016: Resilience and Development, Ministry of Agriculture, State of Palestine. http://reliefweb.int/sites/reliefweb.int/files/resources/1417423273.pdf

[20] Mason, M.; and Mimi, Z. (2014) Transboundary climate security: climate vulnerability and rural livelihoods in the Jordan River Basin, London School of Economics and Political Science Birzeit University. Final Project Report. http://www.lse.ac.uk/middleEastCentre/publications/Reports/TSCReport.pdf

[21] Abu Hammad, A. (2011) Watershed erosion risk assessment and management utilizing revised universal soil loss equation-geographic information systems in the Mediterranean environments. Water and Environment Journal, Vol 25, Issue 2, 149–162.

[22] Dudeen, B (2011) The soils of Palestine (The West Bank and Gaza Strip) current status and future perspectives. In, Soil resources of Southern and Eastern Mediterranean countries. CIHEAM, 203-225.

[23] World Bank. (2015) Economic monitoring report to the Ad Hoc Liaison Committee. http://documents.worldbank.org/curated/en/2015/05/24525116/economic-monitoring-report-ad-hoc-liaison-committee

[24] World Bank. (2013) Area C and the future of the Palestinian economy. Poverty reduction and economic management, department Middle East and North Africa Region, Report No. AUS2922. https://openknowledge.worldbank.org/bitstream/handle/10986/16686/AUS29220REPLAC0EVISION0January02014.pdf?sequence=1

[25] PCBS. (2011) Agricultural Statistics Survey, 2010/2011. Palestinian Central Bureau of Statistics, Arabic version. July 2012. http://www.pcbs.gov.ps/PCBS-Metadata-en-v4.2/index.php/catalog/159/download/407

[26] EQA. (2010) The impact of annexation and expansion wall on the Palestinian environment. Environment Quality Authority, Palestinian National Authority. http://www.lacs.ps/documentsShow.aspx?ATT_ID=6057

3.3.1.4 Livestock production[27,28,29]

Climate sensitivity

Heat and cold waves reduce productivity in cattle and poultry, 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 fertilization period). The cost of agricultural production increases in climatic extremes, for example, as a result of heat waves, there may be a requirement for more electricity for cooling in livestock barns.

Adaptive capacity

Most raw materials and fodder are imported, which increases the cost of production. Israel places restrictions on importing livestock, such as dairy cows for milk production and poultry (broilers and layers). Israel floods the State of Palestine's markets with Israeli products, such as chickens and eggs, which is destroying the country’s economy. There are limited financial resources to establish large-scale intensive livestock farms or to install large-scale granaries. The latter could reduce the cost of fodder production. Granaries are a government responsibility.

3.3.2 Agriculture (Gaza Strip) – ‘Highly vulnerable’ issues

Agriculture’s climate sensitivity in the Gaza Strip is often the same or similar to the West Bank, as is the adaptive capacity of systems, institutions, people, and ecosystems to respond. Hence, the two geographic areas share a number of ‘highly vulnerable’ issues in common for which details above are relevant: livestock production; production of olives and vegetables; irrigation water. However, fishing and fisheries is an additional ‘highly vulnerable’ issue in the Gaza Strip and there is greater concern than in the West Bank that the cost of agricultural production is ‘highly vulnerable’. The situation in Gaza is compounded by the high number of agricultural facilities (e.g. livestock barns and greenhouses)that have been destroyed by Israeli air strikes during the last three wars (2008, 2012, and 2014)[30].Further supplementary details specific to the Gaza Strip are provided below.

3.3.2.1 Livestock production[31,32,33]

Climate sensitivity

Livestock production’s sensitivity to climate is the same as in the West Bank (see above). In May 2015, 15% of chickens in the Gaza Strip died as a result of a heat wave (12ºC above the annual average).

Adaptive capacity

Issues in relation to adaptive capacity are the same as in the West Bank (see above). Notably, there is the potential to develop and enlarge slaughterhouses in the Gaza Strip.

3.3.2.2 Cost of agricultural production[34,35,36]

Climate sensitivity

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.

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[27] World Bank. (2009) Assessment of restrictions on Palestinian water sector development, West Bank and Gaza report. Report No. 47657-GZ. http://siteresources.worldbank.org/INTWESTBANKGAZA/Resources/WaterRestrictionsReport18Apr2009.pdf.
[28] PCBS. (2011) Agricultural Statistics Survey, 2010/2011. Palestinian Central Bureau of Statistics, Arabic version. July 2012. http://www.pcbs.gov.ps/PCBS-Metadata-en-v4.2/index.php/catalog/159/download/407
[29]Maan News Agency. (2015) Chickens death due to heat wave (Arabic report). https://www.maannews.net/Content.aspx?id=778289
[30]PASSIA Desk Diary (2015) Jerusalem: PASSIA, December 2014. http://www.passia.org/images/meetings/2015/Material%20for%20the%20Website/Economy%20%282015%29.pdf
[31] World Bank. (2009) Assessment of restrictions on Palestinian water sector development, West Bank and Gaza report. Report No. 47657-GZ. http://siteresources.worldbank.org/INTWESTBANKGAZA/Resources/WaterRestrictionsReport18Apr2009.pdf
[32] PCBS. (2011) Agricultural Statistics Survey, 2010/2011. Palestinian Central Bureau of Statistics, Arabic version. July 2012. http://www.pcbs.gov.ps/PCBS-Metadata-en-v4.2/index.php/catalog/159/download/407
[33]Maan News Agency. (2015) Chickens death due to heat wave (Arabic report). https://www.maannews.net/Content.aspx?id=778289
[34] World Bank. (2009) Assessment of restrictions on Palestinian water sector development, West Bank and Gaza report. Report No. 47657-GZ. http://siteresources.worldbank.org/INTWESTBANKGAZA/Resources/WaterRestrictionsReport18Apr2009.pdf
[35] PCBS. (2011) Agricultural Statistics Survey, 2010/2011. Palestinian Central Bureau of Statistics, Arabic version. July 2012. http://www.pcbs.gov.ps/PCBS-Metadata-en-v4.2/index.php/catalog/159/download/407
[36] Welfare Association (2009) Impact of Gaza crisis, Agricultural Sector Report. March 2, 2009 https://www.ochaopt.org/documents/opt_agri_fao_agrsect_impact_of_gaza_crisis_mar_09.pdf

Adaptive capacity

In 2008, the cost of agricultural production in the State of Palestine was USD490.4 million (25.1% for plant production; 74.9% for animal production). The cost of feed for livestock accounts for 58.9% of the total cost. There is a lack of agricultural subsidies due to the fiscal crisis that the Palestinian Government is facing. Currently, the MOA also has limited expertise to reduce the cost of agricultural production.

Adaptive capacity in relation to the cost of agricultural production is reduced by the State of Palestine's reliance on Israel for electricity and water and Israeli restrictions on: building Palestinian power plants and desalination plants; establishing a national fertilizer factory; and import of basic agricultural inputs and spare parts.

3.3.2.3 Production of Citrus, olives, and vegetables and employment[37,38,39,40,41]

Climate sensitivity

Citrus are sensitive to frost, which destroys the buds, young leaves, and flowers with consequent loss of fruit. Olives, rain-fed and irrigated vegetables are climate sensitive as described for the West Bank. Any shortage of rainfall will affect the area and type of agricultural production with likely resultant loss of employment.

Adaptive capacity

In 2009, the area of Citrus extended to 15,812 dunums (producing 36,028 tons of fruit), however, it has declined considerably from 72,000 dunums in 1980 and continues to do so for a wide range of reasons. Olive trees comprise 35% of all trees in the Gaza Strip and produce 5,000 tons of olive fruits per annum but are similarly in decline. Since 2000, Israel has bulldozed a large area of Citrus and olive trees and production costs have increased due to the Israeli siege. A dramatic increase in land values has also led to many Citrus farms and olive groves being converted to residential areas. In addition, there are restrictions on farming in the buffer zone parallel to the electrical fence. The shortage of agricultural land combined with a lack of regulation of what crops farmers choose to grow means that agricultural patterns have changed, and farmers are favouring high-value cash-crops, such as strawberries. There is also insufficient water to irrigate Citrus farms and olive groves during dry periods (see "Irrigation water" below).

In 2010/11, the area of rain-fed and irrigated vegetables in the Gaza Strip was 33,752 dunums producing 57,650 metric tonnes. It too has been hit by issues relating to the shortage of land and water.

Agriculture provides employment for 38,000 people in Gaza Strip. The Palestinian Government is trying to increase the number of jobs in the sector through establishing agro-industrial zones, such as the Gaza Industrial Estate. Currently, many donors and international agencies, in cooperation with the Palestinian Government, are implementing "work for food programs". Most of the issues limiting adaptive capacity in relation to other 'highly vulnerable' agricultural issues also directly or indirectly affect adaptive capacity in relation to the sector's level of employment.

3.3.2.4 Irrigation water[42,43]

Climate sensitivity

Drought reduces the amount of water available for irrigation and increases crops' requirements for water.

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[37] Al-Tabbaa, M. (2014) Gazan citrus disappeared from the market (Arabic report). March, 15, 2014. http://paltoday.ps/ar/post/187695.
[38] PCBS. (2009) Agricultural Statistics Survey for year 2007/2008. Palestinian Central Bureau of Statistics. http://www.pcbs.gov.ps/Downloads/book1620.pdf
[39] GNRD. (2011) Israeli enforcement of Buffer Zone Area in the Gaza Strip, "Most Important Violations Resulting from the Buffer Zone". Global network for rights and development (GNRD), Al-Dameer Association for Human Rights. http://www.gnrd.net/userfiles/cc/gaza.pdf
[40] World Bank. (2009) Assessment of restrictions on Palestinian water sector development, West Bank and Gaza report. Report No. 47657-GZ. http://siteresources.worldbank.org/INTWESTBANKGAZA/Resources/WaterRestrictionsReport18Apr2009.pdf
[41] PCBS. (2011) Agricultural Statistics Survey, 2010/2011. Palestinian Central Bureau of Statistics, Arabic version. July 2012. http://www.pcbs.gov.ps/PCBS-Metadata-en-v4.2/index.php/catalog/159/download/407
[42] Welfare Association (2009) Impact of Gaza crisis, Agricultural Sector Report. March 2, 2009 https://www.ochaopt.org/documents/opt_agri_fao_agrsect_impact_of_gaza_crisis_mar_09.pdf
[43] B'Tselem. (2009) Water crisis in Gaza Strip: over 90% of water un-potable. http://www.btselem.org/gaza_strip/gaza_water_crisis

Adaptive capacity

In 2011, 86 million m^3 of water was available for agriculture. Israel recognizes the State of Palestine's right to water but has reduced the quantity available for irrigation. Groundwater wells are the main source of water for irrigation in the Gaza Strip. Limited use is made of treated wastewater. Israel's refusal to allow Palestinians to import and install wastewater treatment or desalination plants means that there is insufficient freshwater for irrigation during dry periods, and the ability of irrigation engineering to manage irrigation water resources is limited. Due to the Israeli siege, the power supply is frequently interrupted, which also impedes irrigation.

3.3.3 Coastal and marine (Gaza Strip) – "Highly vulnerable" issues

3.3.3.1 Fishing and fisheries, and fish catch[44,45,46,47]

Climate sensitivity

Most fish are found between 20m and 200m from shore, with the highest rate of abundance between 100m and 200m. However, as noted in relation to fishing and fisheries, higher temperatures encourage fish to move from warm, shallow coastal waters into cooler, deeper waters with potentially negative implications for the quantity and quality of the fish catch. Increasing levels of carbon dioxide in the atmosphere will also lead to acidification of seawater, which will dissolve the shells of some animals, and reduce the rate of survival and affect the behaviour of fish, with consequences for the fish catch.

Adaptive capacity

According to the UN, at least 95% of fishermen in the Gaza Strip rely on international aid to survive. The MOA estimates that the people of the Gaza Strip require around 10,000 metric tonnes of fish annually. However, the annual fish catch from all types of vessel is less than 2,000 metric tonnes. Approximately two-thirds of fish are landed in Gaza Governorate. There are no fish-processing plants, so if the amount of fish caught exceeds demand then fish prices are usually reduced. Fishing and fisheries also suffer from a lack of government subsidies and insurance.

According to the UN, Palestinian fishermen lost 1,300 metric tonnes of fish annually between 2000 and 2012, as a result of Israeli restrictions. Most notably, the fishing area has been reduced from the 20 nautical miles stipulated by the Oslo Agreement to 6 nautical miles, which is enforced by Israel. With 935 boats concentrated in 660km^2, resultant overfishing has led to diminishing populations of pelagic and, especially, demersal fish. The cost of fishing has been increased by Israeli restrictions on importing: fuel for vessels and cold storage basic; spare parts; and fishing inputs. Israeli restrictions on installation of wastewater treatment plants along the Gaza Strip mean that more than 50% of all wastewater (70-80,000m^3) is discharged from 16 sewage outfalls directly into the sea. This is polluting the fishing area and destroying the sector. Fishermen are also often intimidated and displaced by Israeli armed forces.

If Israel would agree to the State of Palestine's area of fishing being extended and to rehabilitation of Gaza's fishing port, then the latter could have the potential to be developed. However, there has been a decline in the number of people involved in fishing from approximately 10,000 in 2000 to 3,500 in July 2013.

[44] PCBS (2012) Agriculture Statistics Survey, 2010/2011. Palestinian Central Bureau of Statistics - www.pcbs.gov.ps/PCBS-Metadata-en-v4.2/index.php/catalog/159/download/407
[45] Omer, M., (2014) Gaza fishermen demand end to blockade. Al Jazeera English report http://www.aljazeera.com/news/middleeast/2014/08/gaza-palestinian-fishermen-israel-blockade-201489131718364341.html
[46] Maannews (2015) First Shrimp Farm in Gaza - Arabic report. Ma'an News Agency https://www.maannews.net/Content.aspx?id=780137
[47] OCHA (2009) Agriculture Sector Report - Impact of Gaza Crisis. United Nations Office for the Coordination of Humanitarian Affairs https://www.ochaopt.org/documents/opt_agri_fao_agrsect_impact_of_gaza_crisis_mar_09.pdf

3.3.3.2 Coastal agriculture[48,49,50,51]

Climate sensitivity

Agricultural land amounts to about 43% of the coastal area and contributes 31% of the Gaza Strip's total agricultural production. Sea-level rise (currently 1.5mm per annum) will accelerate coastal erosion and increase saltwater intrusion affecting the nearest agriculture farms, especially on low-lying land.

Adaptive capacity

There is scope to use saline-tolerant crops that are able to cope with the conditions.

3.3.3.3 Condition of beaches[52,53,54,55]

Climate sensitivity

As noted above, sea-level rise will increase wave impact and accelerate coastal erosion thereby reducing the quality of tourist beaches, damaging harbors and other coastal structures, and potentially leading to collapse of the coastal beach cliff.

Adaptive capacity

Sensitivity to climate has been exacerbated by excavation of sand from coastal dunes. A total of 25 million m^3 is estimated to have been removed. This has reduced the dunes' functions to protect the coast from erosion, to purify water reaching the subsoil, and to provide wildlife habitat. Rocks have also been removed for construction. Israel restricts import of sand, rocks, and cement, which are required for implementation of beach protection measures.

3.3.4 Energy (West Bank) – "Highly vulnerable" issues

3.3.4.1 Domestic energy production[56,57]

Climate sensitivity

Domestic electricity production currently fulfils only 2% of demand (annual per capita electricity consumption 700kWh). Temperature extremes increase energy demands for heating and/or cooling. Currently, 70% of households use solar water heaters. The performance of such systems is climate-sensitive. Most feedstocks are imported, subject to Israeli permission. Small amounts of biomass from wood and waste, produced locally and used primarily for heating, are affected by the climate.

As there are no facilities to store feedstocks, the ability to produce domestic energy from feedstocks is sensitive to climate and is seasonally affected or if demand suddenly increases due to climate. There is limited ability to import large volumes of feed stocks in order to maintain a continuous energy supply when electricity from Israel is interrupted. In addition, systems for distributing feedstocks are inefficient and are affected by extreme climate events. Notably, interruptions in electricity supply affect water pumping and wastewater treatment, especially during extreme weather events.

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[48] EQA (2010). Environment Sector Strategy. Environment Quality Authority
http://www.lacs.ps/documentsShow.aspx?ATT_ID=6056
[49] UNDP (2010), Climate Change Adaptation Strategy and Programme of Action for the Palestinian Authority. United Nations Development Programme - Programme of Assistance to the Palestinian People
http://www.lacs.ps/documentsShow.aspx?ATT_ID=6054
[50] UNDP (2010), Climate Change Adaptation Strategy and Programme of Action for the Palestinian Authority. United Nations Development Programme - Programme of Assistance to the Palestinian People
http://www.lacs.ps/documentsShow.aspx?ATT_ID=6054
[51] MEnA (2001), Gaza Coastal and Marine Environmental Protection and Management Action Plan prepared by Ministry of Environmental affairs, Palestinian National Authority.
http://s3.amazonaws.com/zanran_storage/smap.ew.eea.europa.eu/ContentPages/723959522.pdf
[52] EQA (2010). Environment Sector Strategy. Environment Quality Authority
http://www.lacs.ps/documentsShow.aspx?ATT_ID=6056
[53] UNDP (2010), Climate Change Adaptation Strategy and Programme of Action for the Palestinian Authority. United Nations Development Programme - Programme of Assistance to the Palestinian People
http://www.lacs.ps/documentsShow.aspx?ATT_ID=6054
[54] UNDP (2010), Climate Change Adaptation Strategy and Programme of Action for the Palestinian Authority. United Nations Development Programme - Programme of Assistance to the Palestinian People
http://www.lacs.ps/documentsShow.aspx?ATT_ID=6054
[55] MEnA (2001), Gaza Coastal and Marine Environmental Protection and Management Action Plan prepared by Ministry of Environmental affairs, Palestinian National Authority.
http://s3.amazonaws.com/zanran_storage/smap.ew.eea.europa.eu/ContentPages/723959522.pdf
[56] Yasin, B. (2013) Energy Efficiency Country Profile –Palestine 2012.Regional Centre for Renewable Energy and Energy Efficiency.
http://www.rcreee.org/sites/default/files/palestine_ee_fact_sheet_print.pdf
[57] Palestinian Central Bureau of Statistics, Statistics – Energy. http://www.pcbs.gov.ps/site/lang__en/886/Default.aspx

Adaptive capacity

The State of Palestine's energy strategy is to generate 50% of electricity consumed by 2020 and two 200MW power stations are planned in the North and South of the West Bank. The strategy also specifically sets a target of 20% from renewables by 2020. Solar energy has the greatest potential with daily average insolation of 5.4kWh/m^2/day for both heat and electricity generation. However, other renewable energy sources, such as wind, geothermal and biomass are expected to play a role. It is estimated that there is potential to generate 20MW from energy-from-waste (e.g. municipality solid waste, agriculture and some industrial waste), with high potential for gasification. There has also been a recent possible discovery of natural gas in West Bank.

The State of Palestine encourages import of feedstocks through Jordan whenever it is possible and can be offered feedstocks at reduced prices from Arab and other countries. Legislation and regulations (e.g. building standards and codes) are being adopted and energy conservation measures (e.g. green-building concepts) are being introduced to enforce and encourage energy efficiency and use of renewable energy.

Israel controls all energy resources in the West Bank and Israeli restrictions (e.g. on people's movement, and import of goods, technology and fuel) limit:

- Upgrading of the State of Palestine's electricity grid and establishing a national transmission line
- Building power stations in the West Bank
- The State of Palestine's ability to extract any natural gas
- The amount of renewable electricity that can be fed into the grid (at medium voltage)
- Import of feedstocks, including only granting import through Israeli agents and companies, and causing delays as a result of security, customs, standards and quality checking, with resultant impact on availability
- Importing of photovoltaics (PV) and other renewable energy systems hampering the rate of installation.

3.3.4.2 Energy imports[58]

Climate sensitivity

Changes to climate may increase energy demands for heating and/or cooling (e.g. as result of frosts or heatwaves). In order to fulfil domestic demand, 93% of electricity is imported currently; 89% from Israel and 4% from Jordan and Egypt. All required petroleum products are imported through Israel.

Adaptive capacity

There is no security of electricity supply as Israel can and does cut it off. The State of Palestine's ability to adapt is limited because the electricity transferred, voltage type, and number of connecting points (feeders) are all determined by Israel. Upgrading of the State of Palestine's grid is subject to Israeli approval. Import of fuel from Jordan or other Arab countries is subject to permission from Israel. Israel also prevents storage of large amounts of petroleum and liquid petroleum gas (LPG) and development of a distribution system (pipe network) in the West Bank. Despite all of these restrictions, the electricity grid is being connected with Jordan in the Jericho region, so that electricity can be imported from Jordan, and a range of measures are being taken to promote domestic energy production (see above).

3.3.4.3 Condition of infrastructure

Climate sensitivity

The electricity high-voltage grid is weak and needs rehabilitation, so could be easily damaged during extreme weather conditions, for example, by storms. There are no national fuel pipelines and no power stations in the West Bank. Fuel tankers are affected by weather and road conditions.

Adaptive capacity

There is a need to: establish a national high-voltage grid and upgrade the connection with Jordan; rehabilitate and update the existing electricity distribution systems to cope with additional electricity

[58] Regional Centre for Renewable Energy and Energy Efficiency (2009) Provision of technical support/services for an economical, technological and environmental impact assessment of national regulations and incentives for renewable energy and energy efficiency. Country report: Palestine. http://www.rcreee.org/content/country-report-palestine.

generated from renewables; build power stations; and develop fuel-storage facilities for diesel, gasoline and LPG. However, all are subject to Israeli approval and are usually prevented or delayed.

3.3.5 Energy (Gaza Strip) – "Highly vulnerable" issues

3.3.5.1 Domestic energy production[59,60,61,62,63]

Climate sensitivity

Climate changes may increase energy demand for heating, cooling, or desalination. Hence, as almost all houses are connected to weak electricity grids, any changes in the climate that increase the load on the grids could cause interruption in the electricity supply.

Adaptive capacity

The Gaza Power Plant (GPP) is the primary source of domestic energy production. Israel restricted the GPP's maximum generation capacity from 135 MW to approximately 90MW, which was further reduced to about 50MW (30% of total energy consumed) by an Israeli air strike in June 2006. Israel neither allows expansion of the GPP nor upgrading of the current equipment. Current use of renewable energy to meet any increased demand is limited due to the high investment costs, although approximately two-thirds of houses use solar water heaters. Many homes have their own electricity generators and households purchase fuel to run them, which is expensive. Lots of households own batteries to store electricity for lighting.

3.3.5.2 Energy imports[64]

Climate sensitivity

The State of Palestine is reliant on energy imports from Israel, which is an unreliable source, especially if climate changes lead to increased energy demands. Most electricity consumed is imported from Israel through the Israeli electricity company. The GPP requires 550,000 liters of fuel per day to maximise its generation of electricity and households purchase fuel to run their own generators. All petroleum products are imported through Israeli petroleum companies. This fuel is transported by tankers and, hence, the reliability of the supply is very sensitive to weather and road conditions.

Adaptive capacity

Most of the sources of energy required to fulfil demand are imported (currently, 121MW from Israel and33 MW from Egypt out of current total of 220 MW[65])and, hence, subjected to strict Israeli regulation. The diversity of sources is restricted by Israel. Electricity is supplied and cut off by the Gaza Electricity Distribution Corporation at 6- to 8-hourly intervals. Israel restricts the regular supply and storage of fuel for running the GPP. It also prevents construction of the seaport, which could otherwise facilitate import of fuel.

3.3.5.3 Condition of infrastructure[66]

Climate sensitivity

The destruction of the GPP and associated infrastructure by the Israeli military in 2006 and 2014 leaves its electricity generation sensitive to climate, as there are no fuel pipelines and fuel tankers are affected by weather and road conditions. As noted with regard to domestic energy production, the electricity

[59] PCBS (2010), Palestine - Household Energy Survey January 2010, Palestinian Central Bureau of Statistics, Palestinian National Authority, Reference ID: PSE-PCBS-HES-2010jan-V1.0
http://www.pcbs.gov.ps/PCBS-Metadata-en-v4.2/index.php/catalog/57
[60] PCBS (2009), Energy Balance in the Palestinian Territory 2007, Palestinian Central Bureau of Statistics, Palestinian National Authority.
http://www.pcbs.gov.ps/Downloads/book1532.pdf
[61] Ouda, M. (2006), Energy Analysis Of Gaza Strip's Residential Sector, Islamic University of Gaza, Palestine.
http://site.iugaza.edu.ps/mouda/files/2010/02/ENERGY_ANALYSIS__GS_RESIDENTIAL.pdf
[62] PCBS (2010), Palestine - Household Energy Survey January 2010, Palestinian Central Bureau of Statistics, Palestinian National Authority, Reference ID: PSE-PCBS-HES-2010jan-V1.0
http://www.pcbs.gov.ps/PCBS-Metadata-en-v4.2/index.php/catalog/57
[63] GISHA (2013), Restricted Import List Gaza Strip 2013
http://www.gisha.org/userfiles/file/LegalDocuments/procedures/merchandise/55en.pdf
[64] OCHA (2014), The Humanitarian Impact of Gaza's Electricity And Fuel Crisis, United Nations, Office For The Coordination Of Humanitarian Affairs, Occupied Palestinian Territory.
https://www.ochaopt.org/documents/ocha_opt_electricity_factsheet_march_2014_english.pdf
[65]Dmeri, F., PENRA, pers. comm.
[66] OCHA (2014), The Humanitarian Impact of Gaza's Electricity And Fuel Crisis, United Nations, Office For The Coordination Of Humanitarian Affairs, Occupied Palestinian Territory.
https://www.ochaopt.org/documents/ocha_opt_electricity_factsheet_march_2014_english.pdf

grids are weak and any changes in the climate that increase the load on the grids could cause interruption in the electricity supply.

Adaptive capacity

There is a need to: connect the GPP with fuel pipelines to reduce use of fuel tankers; rehabilitate existing electricity distribution systems; develop fuel-storage facilities; and import equipment and spare parts required to construct and maintain the infrastructure. However, all are subject to Israeli approval and are usually prevented or delayed.

3.3.6 Food (West Bank) – "Highly vulnerable issues"

3.3.6.1 Domestic food prices[67,68,69,70,71,72]

Climate sensitivity

As explained in relation to the agricultural sector, domestic food production is sensitive to climate. This can lead to food shortages and price instability. The Consumer Price Index (CPI) increased by 1.67% between April 2014 and April 2015, which was attributed to the increase in prices of fresh fruits, vegetables, and poultry. Fresh food prices in Palestinian markets broke historic records in 2013, making nutritious foods unaffordable for low-income households. Increases in prices of fresh vegetables, poultry, and dairy production were attributed mainly to adverse weather conditions (frost and heat waves).

Adaptive capacity

The climate sensitivity of domestic food prices is compounded by limited adaptive capacity. There is a lack of large-scale cold-storage facilities and restrictions on trade in food between West Bank and the Gaza Strip.

3.3.6.2 Imported food prices[73,74,75,76]

Climate sensitivity

Global food prices increased by 8% from December 2011 to March 2012 due to higher oil prices, adverse weather conditions (e.g. Russia banned wheat and grain exports after a heatwave), and Asia's strong demand for food imports. When global food prices rise, local prices also rise. The West Bank imports a significant amount of food for domestic consumption, for example, in 2010, live animals and animal products worth USD171 million and vegetable products worth USD273 million.

Adaptive capacity

Due to the financial crisis, the State of Palestine is not able to construct large-scale storage facilities and grain silos to import and store food and grain when prices are low during periods of low demand in the international markets. 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.

[67] Palestinian News & Info Agency (2015) Consumer Price Index up in April 2015. http://english.wafa.ps/index.php?action=detail&id=28494
[68] Palestinian Central Bureau of Statistics (2007) The Household Expenditure and Consumption Survey (PECS), 2007.
[69] MAS. (2012) Food Security Bulletin. Biannual Bulletin Published by Palestine Economic Policy Research Institute (MAS): Issue 7, Summer 2012. http://www.mas.ps/files/server/20141911181819-1.pdf
[70] Baert, R.; Skoczylas, P.; and Grove, N. (2013) Food Security Watch, West Bank and Gaza Strip, State of Palestine. Issued by UN, WFP, and FAO. October 2013. www.lacs.ps/documentsShow.aspx?ATT_ID=7839
[71] World Bank. (2013) Area C and the future of the Palestinian economy. Poverty Reduction and Economic Management, Department Middle East and North Africa Region, Report No. AUS2922. https://openknowledge.worldbank.org/bitstream/handle/10986/16686/AUS29220REPLAC0EVISION0January02014.pdf?sequence=1
[72] EQA. (2010) The impact of annexation and expansion wall on the Palestinian environment. Environment Quality Authority, Palestinian National Authority. http://www.lacs.ps/documentsShow.aspx?ATT_ID=6057
[73] World Bank. (2012) Food prices rise again on higher oil prices and adverse weather. News Release No: 2012/411/PREM. http://web.worldbank.org/WBSITE/EXTERNAL/EXTABOUTUS/ORGANIZATION/BODEXT/EXTEDS03/0,,contentMDK:23180612~menuPK:380567~pagePK:64099144~piPK:64099061~theSitePK:380554,00.html
[74] PCBS. (2010) Registered Foreign Trade Statistics Goods and Services, Palestinian Central Bureau of Statistics. http://www.pcbs.gov.ps/Downloads/book1817.pdf
[75] Vidal, J. (2013) Climate change: how a warming world is a threat to our food supplies. The impact of climate on food. http://www.theguardian.com/environment/2013/apr/13/climate-change-threat-food-supplies
[76] B'Tselem. (2015) The Tightened siege and intensified economic sanctions, B'Tselem - The Israeli Information Center for Human Rights in the Occupied Territories. http://www.btselem.org/gaza_strip/siege_tightening

3.3.7 Food (Gaza Strip) – "Highly vulnerable issues"

3.3.7.1 Domestic food prices[77,78,79,80]

Climate sensitivity

The sensitivity of domestic food prices in relation to climate is the same as in the West Bank. The Consumer Price Index (CPI) increased by 4.18% between April 2014 and April 2015 and was also attributed to the increase in prices of fresh fruits, vegetables, and poultry.

Adaptive capacity

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 is 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 (2008, 2012, and 2014). People are also more financially insecure and less able to cope with price volatility.

3.3.7.2 Imported food prices[81,82,83,84]

Climate sensitivity

Imported food prices are sensitive to climate for the same reasons as in the West Bank

Adaptive capacity

Adaptive capacity is limited in the similar ways to the West Bank. 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.

3.3.8 Gender (West Bank) – "Highly vulnerable" issues

3.3.8.1 Major diseases related to water and sanitation[85]

Climate sensitivity

In general, women lack access to resources and opportunities for improving and diversifying their livelihoods. They are the primary care-givers in rural families. Drought or flooding, as well as long-term incremental changes in rainfall patterns and temperatures that also lead to changes in ecosystems, have important gender-differentiated impacts on all aspects of human livelihoods, activities and health. Due to a lack of safe drinking water and sanitation services, the health of women and children, in particular, is being adversely affected. Water shortages and sanitation problems cause particularly acute problems for women, increasing domestic work burdens and the incidence of water-borne diseases among family members.

Adaptive capacity

The State of Palestine has launched many projects from a gender perspective, with help from international donors, to decrease major diseases related to water and sanitation. However, major issues limiting adaptive capacity are: increasing poverty and unemployment rates; lack of alternative plans for emergency situations, including financial shortages; and insufficient resources to develop the water and

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[77] Wafa News Agency. (2015) Consumer Price Index up in April 2015. Palestinian News & Info Agency http://english.wafa.ps/index.php?action=detail&id=284 94

[78] PECS (2007) The Household Expenditure and Consumption Survey, Stat of Palestine, Palestinian Central Bureau of Statistics, 2007. http://www.pcbs.gov.ps/PCBS-Metadata-en-v4.2/index.php/catalog/33

[79] MAS. (2012) Food Security Bulletin. Biannual Bulletin Published by Palestine Economic Policy Research Institute (MAS): Issue 7. http://www.mas.ps/files/server/20141911181819-1.pdf

[80] Baert, R.; Skoczylas, P.; and Grove, N. (2013) Food Security Watch, West Bank and Gaza Strip, State of Palestine. Issued by UN, WFP, and FAO. October 2013. www.lacs.ps/documentsShow.aspx?ATT_ID=7839

[81] World Bank. (2012) Food prices rise again on higher oil prices and adverse weather. News Release No: 2012/411/PREM. http://web.worldbank.org/WBSITE/EXTERNAL/EXTABOUTUS/ORGANIZATION/BODEXT/EXTEDS03/0,,contentMDK:23180612~menuPK:380567~pagePK:64099144~piPK:64099061~theSitePK:380554,00.html

[82] PCBS. (2010) Registered Foreign Trade Statistics Goods and Services, Palestinian Central Bureau of Statistics. http://www.pcbs.gov.ps/Downloads/book1817.pdf

[83] Vidal, J. (2013) Climate change: how a warming world is a threat to our food supplies – The impact of climate on food. http://www.theguardian.com/environment/2013/apr/13/climate-change-threat-food-supplies

[84] B'Tselem. (2015) The tightened siege and intensified economic sanctions, B'Tselem - The Israeli Information Center for Human Rights in the Occupied Territories. http://www.btselem.org/gaza_strip/siege_tightening

[85] Palestinian Women Research and Documentation Center (2010)Women's health surveillance report: towards a multi-dimensional look at the health of Palestinian women.UNESCO, Palestine.

sanitation infrastructure, and to expand community-based behaviour-centered programmes that promote improved hygiene practices at the community and household level. Restrictions on movement imposed by Israel continue to impede access to health care, more particularly for women and children in Area C.

3.3.9 Gender (Gaza Strip) – “Highly vulnerable” issues

3.3.9.1 Employment and gender[86,87]

Climate sensitivity

As noted for the West Bank (above), climate variability has important gender-differentiated impacts on all aspects of human livelihoods. In this context, employment is a significant issue in the Gaza Strip, where only 14.9% of women are employed, as compared with 65.9% of men. Women’s access to the labour market is difficult and salary inequality is a major issue. Refugee women are more affected by unemployment than non-refugee women, as the latter work in agriculture and, so, have greater employment opportunities. The political situation together with local traditions are the main factors affecting women’s livelihood choices and their economic independence. The main sectors of women’s employment are agriculture, services, and the informal (non-governmental) sector. Women face difficulties in marketing handicrafts and food-processed products. Women`s roles in agriculture and environmental projects are unique in the Gaza Strip, as the occupation forces women to perform a variety of male tasks. Women’s work (e.g. in the agricultural sector) is often invisible and unrecognized, so their innovative practices are not given due attention. Women are major contributors to water management, while at the same time suffering disproportionately from the impacts of water shortages or changes in agriculture. Men benefit from a majority of agricultural projects, especially training and extension services, although women perform most of the work. Unfortunately, there is a lack of disaggregated and verifiable data on gender in relation to water and agriculture.

Adaptive capacity

The Palestinian Government, with help from international donors, has launched many important projects to increase the rate of women’s employment. However, the following major issues limit adaptive capacity in this regard: the continuing presence of patriarchal social roles; long-standing legislative uncertainty; Palestinian institutions’ lack of formal gender policies; discrimination against women and workers with family responsibilities; continuing perceptions that employing women threatens men’s work opportunities, and is more expensive for the employer because of the potential need to provide maternity leave; and insufficient women in management and, particularly, senior management positions. As a result donor-led gender units may not be sustainable. More specifically, there is lack of conceptual understanding of relations between gender issues and integrated water resources management.

3.3.9.2 Major diseases related to water and sanitation[88]

Climate sensitivity

Major diseases related to water and sanitation are a climate-sensitive gender-related issue in the Gaza Strip for the same reasons identified for the West Bank.

Adaptive capacity

Important issues which limiting adaptive capacity are the also the same as in the West Bank.

3.3.9.3 Food security and gender[89,90]

Climate sensitivity

The level of food insecurity among female-headed households is 17% higher than among male-headed households.

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[86] Water and Solid Waste Management Programmes (2011) Situation analysis for women in the water and solid waste management sectors. GIZ, Palestine.
[87] UNICEF (2011) Occupied Palestinian Territory – MENA Gender Equality Profile: status of girls and women in the Middle East and North Africa.
[88]Palestinian Women Research and Documentation Center (2010) Women’s health surveillance report: towards a multi-dimensional look at the health of Palestinian women. UNESCO, Palestine.
[89] Water and solid waste management programmes (2011) Situation analysis for women in the water and solid waste management sectors. GIZ, Palestine.
[90] UNICEF (2011) Occupied Palestinian Territory – MENA Gender Equality Profile: status of girls and women in the Middle East and North Africa.

Adaptive capacity

Adaptive capacity is defined by the same issues identified in relation to employment and gender.

3.3.10 Health (West Bank) – "Highly vulnerable" issues

3.3.10.1 Major diseases related to water, sanitation and food[91],[92]

Climate sensitivity

Changes in temperature, humidity and rainfall directly influence the likelihood of water-borne, food-borne, and vector-borne disease transmission as well as disease. However, the impact of climate on water and food supplies also indirectly affects the likelihood of such diseases.

Inadequate water supplies, either in quantity or quality, may increase risk of waterborne illnesses, such as diarrhoea, typhoid, hepatitis, dysentery, giardiasis, bilharzia, and cholera. Communicable diseases, such as hepatitis, are the most prevalent and most serious. Although epidemiological data in the West Bank is patchy, anecdotal evidence suggests that there is a high-incidence of water-borne diseases leading to substantial costs and losses. In a Palestinian Hydrology Group (PHG) survey, more than 20% of all communities reported that at least 1% of the population had water-related health problems. Diarrheal diseases are significant causes of morbidity in infants and children in the State of Palestine. 44% of children from herder and Bedouin communities in Area C suffer from diarrhoea. Lack of water and highly saline water can also result in kidney dysfunction or failure; a situation exacerbated by hot weather. Reduced dilution of contaminants in water ingested can have long-term consequences for health, e.g. nitrate concentrations can increase anaemia and induce spontaneous abortion.

Floods can disrupt basic sanitation systems, promoting disease outbreaks via the faecal-oral route and the likelihood of vector-borne diseases through expansion of the number and range of vector habitats.

The climate sensitivity of domestic food production can lead to food shortages and resultant malnutrition amongst low-income households. Mounting pressure on freshwater resources is leading to increased use of wastewater for irrigation in the West Bank, which if improperly treated can present health risks to farmers and consumers.

Weather conditions, including temperature, humidity, and wind, affect the impact of anthropogenic sources of pollutants on ambient air quality and increase ambient concentrations of allergens and suspended particulate matter (including pollen and dust), and ground-level ozone, all of which can exacerbate respiratory illnesses.

Extreme weather events can also lead to a range of psychological impacts due to loss, social disruption, displacement, and repeated exposure to natural disasters.

Adaptive capacity

The State of Palestine is aware of the level of health problems, and has developed national strategies and implemented many important projects. However, the following factors limit adaptive capacity:

- Insufficient resources to develop adequate water and sanitation infrastructure, and to expand community-based behaviour-centred programmes that promote improved hygiene practices at the community and household level
- A shortage of specialized health workers and emigration of qualified personnel
- Increasing poverty and unemployment rates
- Lack of alternative plans and funding for emergency situations
- Israel's occupation, blockade and restrictions on movement and access restrictions, which impede effective action on inter-related crises, e.g. in relation to water supplies or food production
- Disposal of Israeli waste and food waste from Israeli settlements' food industries, including hazardous waste (most unidentified and from unknown sources), in the State of Palestine.

[91] Palestinian Hydrology Group (2003) Water and Sanitation Hygiene Monitoring Project. Ramallah, Palestine.
[92] Ministry of Health (2013) National Health Strategy, 2014-2016. Ramallah, Palestine.

3.3.11 Health (Gaza Strip) – "Highly vulnerable" issues

3.3.11.1 Major diseases related to water, sanitation and food[93]

Climate sensitivity

General issues concerning the climate sensitivity of major diseases in relation to water, sanitation and food identified in relation to the West Bank also apply to the Gaza Strip.

The Coastal Aquifer is the Gaza Strip's sole source of freshwater and is currently facing a serious challenge in terms of quantity and quality. Only 3.8% of domestic water meets World Health Organization (WHO) standards. Between 90% and 95% of drinking water is contaminated by sewage, and there is increasing incidence of water-borne diseases, particularly hepatitis, meningitis, and typhoid. Contamination of water by microbes (including faecal coliforms and faecal streptococcus) increases at each point the process of water supply. Inadequate water for hygiene purposes is also known to be a significant cause of diarrhoea in children under five. Intestinal parasites, both helminths (worms) and protozoa, infect children throughout the Gaza Strip. The level of infestation is still high in some locations, particularly in agricultural communities and near sewage-treatment ponds, despite implementation of control measures many decades ago. Other sanitary-related diseases, such as skin diseases, are increasing, especially in areas with inadequate water supply. Water-related diseases account for approximately 26% of disease in the Gaza Strip and are the primary cause of child morbidity. In 2009, diarrhoea was the cause of 12% of infant and young child deaths in the Gaza strip, despite being preventable and easily treated.

A range of chemicals are found in drinking water at concentrations that far exceed WHO and Palestinian Water Authority Guidelines. Nitrate and chloride levels are as much as six times the levels set by WHO. Elevated nitrate levels risk poisoning infants under six months old. High concentrations of fluoride are also toxic and may result in gastroenteritis, acute kidney poisoning, and various degrees of liver and heart damage.

Adaptive capacity

The Palestinian government is aware of the extent of health problems, and has developed national strategies and implemented many important projects, however, the following factors continue to limit adaptive capacity:

- The need to strengthen policies, strategies, responses, coordination, sustained community-based programming, and donor support in relation to water, sanitation and nutrition, as well as maladapted behaviour inevitably result in increasing child mortality, morbidity and impaired intellectual development inevitable.
- High levels of poverty in the Gaza Strip result in households making use of unsafe water supplies.
- The need for long-term funding to help prevent or reverse a decline in children's health linked with unsafe water, a contaminated environment, and deteriorating community health services and hospitals.
- Hygiene practices in the Gaza Strip are not adapted to chronic conditions of unsafe and inadequate water, poor sanitation and a contaminated environment.
- Worming treatments administered to school children do not reach young children who are most vulnerable to being affected by parasites
- Major investments need to target long-term infrastructure rather than small emergency projects
- To an even greater extent than in the West Bank, Israel's occupation, blockade and restrictions on movement and access restrictions impede effective action on inter-related crises, e.g. in relation to water supplies or food production.

[93]UNICEF (2011) Protecting Children from Water Unsafe in Gaza Strategy, Action Plan and Project Resources. Gaza, Palestine.

3.3.12 Industry (West Bank) – "Highly vulnerable" issues

3.3.12.1 Value of raw materials imported

Climate sensitivity

The amount and, therefore, value of raw materials imported by a wide range of industries is potentially sensitive to changes in climate. For example, more raw materials may be imported for:

- Producing medicine to treat illnesses resulting from extreme climate conditions
- Manufacturing beverages and drinks in hot weather
- Producing sweets (e.g. flour and sugar) during cold weather
- Producing building insulation in response to extreme climate changes.

Adaptive capacity

There is a need to encourage and support direct import of materials by Palestinian companies, whenever possible, to reduce import costs. Reducing customs and taxes on imported materials for industry could be a possibility. Establishment of an investment promotion body could encourage new industries that could make greater use of locally-available raw materials. It would be beneficial to import materials directly rather than through Israeli agents and to establish a Palestinian certifying body and laboratories to avoid need to secure certifications and approval from the Israeli Institute of Standards. It would also be securing importation of a larger share of raw materials from countries other than Israel (e.g. China, Turkey, EU, and USA).

3.3.12.2 Infrastructure[94]

Climate sensitivity

Storms can damage factories and lead to their collapse. There are irregularities in water supplies needed for manufacturing, which may be exacerbated by the sensitivity of the condition of the water infrastructure to climate, described below. The wastewater collection system is weak in most locations in Palestine and industrial wastewater is not separated from domestic wastewater. The situation would be exacerbated by increased rainfall and could lead to industrial production being interrupted due to water being cut-off or unavailable or to industrial workers suffering health problems. The climate sensitivity of infrastructure associated with domestic energy production and energy imports, described above, may mean that required fuel and electricity may be unavailable or infrastructure not adequate. Factories may not provide a suitable working environment in factories during extremely hot or cold weather (e.g. due to lack of adequate air-conditioning or heating).

Adaptive capacity

Industrial Free Zones and promising laws encourage investors to establish new enterprises. Work progresses to provide energy infrastructure, such as high-voltage electricity, and LPG supply for industry. Internet access and computers, as well as other advanced technologies, are available in the State of Palestine. However, Israeli permits are required for West Bank factories and there are Israeli restrictions on: developing new industries; constructing and rehabilitating roads between cities; import of new equipment and machinery, especially high technology; and internet access and wireless communication systems.

3.3.12.3 Energy supply

Climate sensitivity

The condition of the electricity grid makes it vulnerable to interruption as a result of overloading (a situation made worse by electricity losses from the grid) and extreme weather conditions. Lack of fuel pipelines and fuel-storage facilities means that fuel supplies required by industry need to be transported by tanker and are, thus, sensitive to extreme weather conditions compounded by the condition of the roads.

Adaptive capacity

There is a need to provide a reliable electricity supply by rehabilitating the electricity grid and establishing a national high-voltage transmission line. The electricity grid is being connected with Jordan

[94] Union of Stone and Marble Industry (2011) Stone and marble in Palestine: developing a strategy for the future. http://blair.3cdn.net/328bd530dca6a02f4c_kum6b6dhi.pdf

in the Jericho region, so that electricity can be imported from Jordan, two new power stations are proposed and a range of measures are being taken to promote production of renewable energy. However, Israeli restrictions hamper progress with many issues relating to improving energy supply for industry, including: establishment of national storage facilities for fuel and LPG in order to avoid interruptions in supply; exploration of the possible discovery of natural gas in the West Bank; import of fuel through Jordan as well as Israel; use of natural gas from the Gaza Strip rather than from Israel; and long-term agreements or contracts with Israeli electricity and fuel companies to supply the West Bank.

3.3.12.4 Energy demand

Climate sensitivity

Industrial demand for electricity and fuel exceeds supply during extreme cold or hot weather, as it is required for heating and/or cooling (e.g. as result of frosts or heatwaves). Hence, in general, longer winters or longer summers would increase energy demands. However, industrial production is sensitive to climate in ways that can lead to an increase in energy demand. For example, less heavy rainfall or snow can lead to: fewer interruptions in the electricity supply; fewer delays to delivery of raw materials; and fewer interruptions in operation of machinery, such as stone crushers at quarries.

Adaptive capacity

The Palestinian Government needs to establish electricity tariffs that better manage demand and consumption. Energy demand needs to be reduced by further encouraging energy efficiency measures in industrial production, including through introduction of modern production technologies.

3.3.13 Industry (Gaza Strip) – "Highly vulnerable" issues[95,96,97]

3.3.13.1 Value of industrial products exported

Climate sensitivity

Many industries are highly dependent on the Israeli market. Closure of the border and seaport make it difficult to import raw materials and export products. The length of time that products destined for export can be kept waiting at the border inevitably means that many are sensitive to climate, which affects their quality and, therefore, value.

Adaptive capacity

Lack of suitable storage facilities means that those products that are likely to be most negatively affected by climate include food (particularly frozen and refrigerated products), textiles, furniture, cosmetics, and cleaning products.

3.3.13.2 Value of raw materials exported

Climate sensitivity

Issues in relation to the value of industrial products exported also apply to the value of raw materials exported.

Adaptive capacity

The situation is compounded by inadequate handling, fumigation, packaging and storage techniques.

3.3.13.3 Employment

Climate sensitivity

More than 120,000 people are employed by industry in the Gaza Strip, around 20% of the total workforce. Approximately 90% of all industrial enterprises have fewer than 10 employees. However, a few mining and construction companies have more than 100 employees. Industrial supply chains are sensitive to climate in a range of ways that have consequences for employment.

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[95] Palestinian Federation of Industries
http://www.wafainfo.ps/atemplate.aspx?id=3107
[96]Hanieh, A. A., AbdElall, S. and Hasan, A. (2013). "Sustainable Development of Stone and Marble Sector in Palestine." Journal of Cleaner Production, Volume 84, Pages 581-588
[97] GISHA (2010), Partial List of Items Prohibited/Permitted into the Gaza Strip, May 2010
http://gisha.org/UserFiles/File/HiddenMessages/ItemsGazaStrip060510.pdf

Adaptive capacity

Actions by Israel have led to stagnation of the Palestinian economy. The list of raw materials and industrial products prohibited by Israel for import and export severely affects many production processes and several industries in the Gaza Strip are no longer viable.

3.3.13.4 Energy supply

Climate sensitivity

Energy consumption by industry is around 1,438TJ, which accounts for around 6.5% of the total energy consumed in the Gaza Strip, and is liable to increase in response to increasing temperatures and heatwaves due to the need for more air-conditioning and cold storage. This would not only have implications for the security of the electricity supply but also for industries' competitiveness

Adaptive capacity

In order to avoid having to reschedule production according to when electricity is available, some industries make use of private electricity generators but this has to be balanced with the potential for any associated increase in production costs to reduce their competitiveness.

3.3.13.5 Energy demand

Climate sensitivity

Industrial demand for energy is sensitive to climate, as described in relation to energy supply above.

Adaptive capacity

Any increase in energy demand will be compounded by the outdated energy inefficient equipment used by many industries. Hence, it would be beneficial to conduct energy audits in order to increase industries' use of energy efficiency measures and rehabilitate and maintain industrial equipment. Reducing energy consumption through introducing modern production technologies is not a viable option due to Israeli restrictions on imports into the Gaza Strip.

3.3.14 Terrestrial ecosystems (West Bank) – "Highly vulnerable" issues

3.3.14.1 Habitat connectivity[98,99,100]

Climate sensitivity

The State of Palestine's strategic position at the meeting point between Eurasia and Africa enriches the country's biodiversity. Species will need to shift their ranges in response to changes in climate. However, the extreme climatic conditions and human activities limit species' abilities to move between terrestrial ecosystems.

Adaptive capacity

There is insufficient environmental awareness in the West Bank and application of land-use policies is inadequate. The Annexation and Expansion Wall and associated fencing and removal of vegetation has degraded the natural habitat, reduced habitat connectivity and limits species movement. This has had a significant impact on gazelle, ibex, fox, porcupine and badger, which have large home ranges, resulting in inbreeding. Pressures on wildlife, loss of habitat and a reduction in habitat connectivity have also resulted from confiscation of land for the Israeli Illegal Settlements Regime, bypass roads and Israeli Occupation military areas.

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[98] ARIJ. (1997) The status of the environment in the West Bank, Applied Research Institute. Jerusalem. http://www.arij.org/files/admin/1997-3_The_Status_of_the_Environment_in_the_West_Bank.pdf

[99] Al Qutob, M.A. (2014) Floral diversity in Palestine. http://www.fatehmofr.ps/book-of-the-month-the-fauna-and-flora-of-palestine

[100] EQA. (2010) The impact of Annexation and Expansion Wall on the Palestinian environment. Environment Quality Authority, Palestinian National Authority.http://www.lacs.ps/documentsShow.aspx?ATT_ID=6057

3.3.15 Terrestrial ecosystems (Gaza Strip) – "Highly vulnerable" issues

3.3.15.1 Wadi Gaza – Habitat connectivity[101,102,103]

Climate sensitivity

Wadi Gaza Nature Reserve is home to at least 154 terrestrial vertebrate species, most notably birds. It also supports a diverse flora with 70 species (32 families and 24 orders) recorded, including some crop wild-relatives, such as barley (*Hordeum sp.*), parsley (*Petroselinum sativum*), common sage (*Salvia sp.*), peppermint (*Mentha sp.*) and sweet basil (*Ocimum sp.*). As elsewhere, species will need to shift their ranges in response to changes in climate.

Adaptive capacity

Ongoing loss of habitat is increasing habitat fragmentation and reducing habitat connectivity, as a result of: creeping urban development; alteration and destruction of habitats; environmental pollution; intensive use of herbicides and pesticides; and human disturbance. Israel has destroyed the Gaza Valley, which is the main natural feature of the Gaza Strip, by inundating it with untreated wastewater.

3.3.16 Tourism (West Bank) – "Highly vulnerable" issues

3.3.16.1 Condition of cultural heritage[104,105,106]

Climate sensitivity

The State of Palestine is known worldwide as the "Holy Land", as it is the focus of three major monotheistic religions It embraces a large number of historical, cultural, and religious sites, which are potentially major tourist attractions. The condition of these sites is sensitive to climate extremes.

Adaptive capacity

The State of Palestine has launched a few projects to maintain and improve the condition of the cultural heritage with help from international donors, however, major needs to enhance adaptive capacity are:

- Stronger regulations to prevent construction of new buildings in very sensitive areas (e.g. along wadis), which potentially increases the sensitivity of the local cultural heritage, e.g. in relation to flooding
- Better enforcement of legislation to avoid cultural heritage sites being left open to assault
- Greater maintenance of cultural heritage sites
- More coordination between relevant institutions
- Stronger national registration and classification of cultural heritage sites
- Enhanced city and regional plans and related by-laws, including conservation guidelines
- Increased awareness of the importance of conserving and restoring cultural heritage sites.

Israeli measures in the State of Palestine explicitly target religious and cultural heritage sites, and have led to damage and demolition of mosques and ancient sites. Constant military incursions and unilateral actions taken by Israel in the State of Palestine threaten development of, or investment in, conservation measures.

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[101] Rabou, A.F.N.A.; Yassin, M.M.; Al-Agha, M.R.; Hamad, D.M. and Ali, A.K.S. (2007) The avifauna of Wadi Gaza Nature Reserve, Gaza Strip, Palestine. The Islamic University Journal (Series of Natural Studies and Engineering) 15:1, 39-85.
http// www.iugaza.edu.ps/ara/research
[102]Rabou, A.F.N.A.; Yassin, M.M.; Al- Agha, M.R.; Madi, M.I.; Al-Wali, M.M.; Ali, A.K.S. and Hamad, D.M. (2008) Notes on some common flora and its uses in Wadi Gaza, Gaza Strip. The Islamic University Journal (Series of Natural Studies and Engineering), 16:1, 31-63.
http://www.iugaza.edu.ps/ara/research//
[103] Jalal, R.A. (2013) Gaza Valley Faces Environmental Disaster. Al-monitor.
http://www.al-monitor.com/pulse/originals/2013/08/wadi-gaza-valley-environment-sewage.html
[104]International Chamber of Commerce (2013) Palestine tourism sector. Ramallah, Palestine.
[105]Palestinian Central Bureau of Statistics (2011) Tourism activities report, 2010: main results. Ramallah, Palestine.
[106]World Tourism Organization (UNWTO), the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) (2008) Climate Change and Tourism Responding to Global Challenges.

3.3.17 Urban and infrastructure (West Bank) – "Highly vulnerable" issues

3.3.17.1 Urbanization[107]

Climate sensitivity

Urban areas are sensitive to floods, heat waves, droughts, and other extreme events. Rapid population growth and urbanization are contributing to the sensitivity of cities to climate. The average population density is 468 people per km², which is higher than neighbouring countries. In 2007, 73.7% of the total population lived in urban areas, with 17% living in rural areas and the remainder, c.10%, resident in refugee camps. Rapid urbanization is occurring because of high fertility rates, substantial rural-urban immigration, and the concentration of economic activity in urban areas. The road infrastructure is in a poor condition and heavy rainfall can lead to their erosion, collapse and closure, and to accidents due to the presence of dangerous curves and slopes coupled with a lack of retaining walls, traffic signals and pedestrian bridges.

Adaptive capacity

The State of Palestine has launched a vital project to enhance urban planning but major needs to enhance adaptive capacity include:

- Better policies and administration in relation to urban planning
- Management of the growth of cities, so that they are able to provide basic services and infrastructure to their existing populations
- Regional planning and connectivity between population centres to be within the State of Palestine's control and not subject to physical disruption from Israeli settlement activity
- Open spaces between rural and urban communities in the State of Palestine to be within the Palestinian Government's control
- Lifting of restrictions on movement, development and growth of major urban centres; rural communities maintain much of their rural character but have been "urbanized".

3.3.18 Urban and infrastructure (Gaza Strip) – "Highly vulnerable" issues

3.3.18.1 Building conditions[108,109,110]

Climate sensitivity

Recent developments have used imported western styles of architecture and techniques that are ill-suited to Palestinian climatic conditions. New urban centers include modern high-rise buildings with glass facades; the antithesis of thermal massing. These towers feature inoperable windows and create a huge energy demand to power air conditioning systems. As described for the West Bank, roads are in poor condition.

Adaptive capacity

Green buildings reduce climate sensitivity and provide many benefits, including: increased return on investment; reduced energy, operating, and maintenance costs; better occupant health and productivity; and reduced use of natural resources. However currently, there are only a few green buildings in the Gaza Strip. The State of Palestine has developed guidelines for green buildings and there are many Palestinian institutions that are promoting their construction.

3.3.19 Waste and wastewater (West Bank) – "Highly vulnerable" issues

3.3.19.1 Waste management[111]

Climate sensitivity

Waste management operations are sensitive to temperatures, rainfall patterns, wind speeds, and storms. Temperature affects the biological activities within treatment systems, while storms affect the leaching process within solid treatment plants. In 2009, about 1,710 tons/day of residential solid waste was generated. The average daily residential solid waste generated per dwelling is 3.9 kg/day at an

[107] UN-Habitat (2014) National Report. Ramallah, Palestine.
[108] UN-Habitat (2014) National Report. Ramallah, Palestine.
[109] Engineering Association (2013)Green Buildings Guidelines. Ramallah, Palestine.
[110] Palestinian Central Bureau of Statistics (2011) Housing Conditions Survey 2010. Ramallah, Palestine.
[111] Palestinian National Authority (2010) National Strategy for Solid Waste Management in the Palestinian Territory (2010-2014).

average rate of 0.7 kg/capita/day. In 2009, healthcare centres generated an estimated 472 tons/month of solid waste, while industrial establishments generated an estimated 6,308 tons/month. About 95% of the West Bank is served by solid collection and transport services. Efforts to promote recycling and reuse of solid waste are largely limited to initiatives by individuals or the voluntary sector. There are unsafe approaches to dealing with solid waste, including use of random dumpsites, open waste burning, and partial mismanagement of medical and hazardous waste. Solid waste collection and transport operations are moderately efficient.

Adaptive capacity

The State of Palestine has constructed a number of regional sanitary landfills (Zahrat Al-Funjan landfill, Jericho landfill and AL-Minya), which help to reduce risks to health and the environment caused by random dumpsites, which are commonly spread throughout the districts. The State of Palestine is aware of the extent of the solid waste problem, and has passed new laws and developed national strategies to address it. However, major needs to enhance adaptive capacity are:

- More attention to be paid to relevant social, economic, environmental, technical, and legislative issues
- Enhanced legal, organizational, and institutional frameworks in order to address handling of hazardous waste
- Greater experience in minimizing or recycling greenhouse-gas emissions from landfill sites, which could gain credits from carbon trading mechanisms
- Comprehensive systems for authentication and analysis of data and monitoring and evaluation
- Increased participation of the private sector in solid waste management.
- Discontinuation of Israel’s disposal of waste, including hazardous waste (most of which is unidentified from unknown sources), in the State of Palestine.
- Cessation of Israel’s relocation of internationally-forbidden industries to the West Bank and disposal of toxic effluents without treatment in the State of Palestine
- The State of Palestine to have jurisdiction and control over resources (including within Area C)
- Land availability to implement several projects and construction of regional facilities.

3.3.20 Waste and wastewater (Gaza Strip) – “Highly vulnerable” issues

3.3.20.1 Waste management[112,113]

Climate sensitivity

Issues in relation to the climate sensitivity of waste management are the same in the Gaza Strip as described for the West Bank. In 2015, about 716 tons/day of residential solid waste was generated, which comprised approximately 67% organic matter, 11% plastics, and 12% paper with the remainder being metals, glass and other waste materials. The average daily residential solid waste generated per dwelling in 2009 was2.7 kg/day at an average rate of 0.4 kg/capita/day. In 2009, healthcare centres generated an estimated 730 tons/month of solid waste, while industrial establishments generated an estimated 14,996 tons/month.

Adaptive capacity

The Palestinian government has launched a regional sanitary landfill (Deir-El-Balah),which helps to reduce risks to health and the environment caused by random dumpsites, which are commonly spread throughout the Gaza Strip. Major needs limiting adaptive capacity are very similar to those in the West Bank. In addition, Israel needs to allow entry of materials for construction, repair and rehabilitation of infrastructure that would enable improved waste management.

[112]Palestinian National Authority (2010) National Strategy for Solid Waste Management in the Palestinian Territory (2010-2014).
[113]Palestinian Central Bureau of Statistics (2015) Press Release on Household Environmental Survey, 2015.
http://www.pcbs.gov.ps/site/512/default.aspx?tabID=512&lang=en&ItemID=1454&mid=3171&wversion=Staging

3.3.21 Water (West Bank) – "Highly vulnerable" issues

3.3.21.1 Groundwater supply[114],[115],[116],[117]

Climate sensitivity

Water resources in the West Bank are limited. The groundwater aquifer is the major source of freshwater supply and is shared between Palestine and Israel. There is excessive pumping or mining of shared aquifers by Israeli occupation and some West Bank communities are resorting to unlicensed drilling to obtain drinking water. Reduced rainfall results in lower groundwater recharge, as does high-intensity rainfall due to increased run-off. High temperatures increase demand for water and increase the amount of water discharged from aquifers. Drought conditions lead to ever-decreasing amounts of available groundwater.

Adaptive capacity

The State of Palestine has launched many projects related to use of groundwater, including protection of springs and rehabilitation of wells in different districts. However, the State of Palestine is struggling to attain the most basic level of infrastructure and services of a low-income country. Its agencies are suffering from resource deficiencies and managerial weaknesses. Investment (and investment efficiency) in the West Bank's groundwater supply has dropped to very low levels. The prevailing economic, water resource and institutional constraints mean that the performance of the water utilities is deteriorating. The institutional architecture proposed for the water sector has not been fully implemented. Water harvesting projects are limited and there is an absence of institutional arrangements for shared aquifer systems. There is limited deepening and rehabilitation of wells, protection of springs, and implementation of small-scale desalination units (mostly only as pilot projects).

Since 1967, Israel's policy and practice in the State of Palestine has been to expropriate and assert control over water resources, maintain an unequal and discriminatory allocation of water resources to benefit both Israeli citizens and settlers, and prevent the State of Palestine from developing its resources. The Palestinian Water Authority (PWA) is unable to conduct an integrated water management scheme in the West Bank within the current governance framework. The governance system established by Article 40 of the Oslo Agreement requires the approval by Israeli authorities of any proposed PWA management measure or infrastructure project within the West Bank. This arrangement and its implementation, gives Israeli authorities control over the allocation and management of the West Bank's water resources.

A permit is required from the Israeli Civil Administration within Area C, which covers 61% of the West Bank, for any construction, including water and sanitation projects.. The vast majority of permit applications are denied, and any structure built without a permit may be demolished by the Israeli authorities. Following the 1967 War, Israel took control of the State of Palestine's water resources and developed wells throughout the West Bank together with a water supply network serving settlements that link into the Israel National Water Company (Mekorot) network. The amount of water that Mekorot supplies to the settlements is unofficially estimated at some 75 million m^3, of which 44 million m^3 is produced from wells controlled by Israeli occupation or settlers within the West Bank.

The State of Palestine has access to 20% of the resources of the Mountain Aquifer. Water withdrawals per capita for Palestinians in the West Bank are about 25% of those available to Israelis, and have declined over the last decade. Palestinian abstractions have actually declined over the last ten years, under the combined effect of dropping water tables and restricted drilling to deepen and rehabilitate wells. Over-extraction from deep wells by Israel, combined with reduced groundwater recharge, has created risks for the aquifers and a decline in water available to Palestinians through shallower wells. The construction of the Annexation and Expansion Wall has also resulted in the isolation of several Palestinian groundwater wells and springs previously used for domestic and agricultural purposes.

[114] Amnesty International (2009)Troubled waters: Palestinians denied their fair share of water. London, UK.
[115] Centre on Housing Rights & Evictions (2008)Policies of denial: lack of access to water in the West Bank. Geneva, Switzerland.
[116] PWA (2013)Status report of water resources in the Occupied State of Palestine – 2012. Ramallah, Palestine.
[117]World Bank (2009)Assessment of restrictions on Palestinian water sector development. Middle East and North Africa Region Sustainable Development, Report No. 47657-GZ. Ramallah, Palestine.

3.3.21.2 Flood management[118,119,120]

Climate sensitivity

Urban development increases the amount of water runoff. Storm-water systems in the West Bank are under-designed and poorly managed. Localized flooding occurs in urban areas where there are too few drains, or where their capacity is insufficient to deal with heavy precipitation. Drought allows build-up of solid waste and sediments that can block storm-water drains, impeding the flow of water from the impacted area and polluting a wider area. The overstretched infrastructure is further pressured by increasing urban growth and rural to urban migration.

Adaptive capacity

Palestinians have the necessary technology and skills to match urban-drainage systems to the demands made by heavy precipitation. However, adaptive capacity is limited by the scale of required investments in flood management, and the municipalities' and village councils' lack of resources and managerial weaknesses. The State of Palestine faces the challenge of compulsory connection with Israel's infrastructure. Israel has blocked every possible means by which the Palestinians might manage flooding.

3.3.21.3 Condition of infrastructure[121,122,123]

Climate sensitivity

The condition of urban drainage systems is sensitive to climate for reasons described in relation to flood management. Water losses from open canals, dams and agricultural ponds are considerable due to high evaporation and the presence of cracks and leaks.

Adaptive capacity

Adaptive capacity in relation to the condition of urban drainage systems is as described for flood management. Many of the issues limiting the State of Palestine's adaptive capacity in relation to groundwater supply, described above, are also relevant in relation to the condition of the water infrastructure. Many Palestinian families, especially in rural areas, use cisterns and rainwater harvesting tanks, some of which are centuries old, to gather and store rainwater. Lots of agricultural ponds have been constructed, which are rainwater-fed. Water is conveyed through open channels or pipes. Surface-water harvesting of wadis is still not much developed by the PWA despite significant interest, mainly as a result of Israeli restrictions.

Israeli policy and practice to expropriate and assert control over water resources limits adaptive capacity with regard to the condition of the infrastructure, as does the PWA's inability to conduct integrated water management schemes in the West Bank within the current governance framework. Israel imposes severe restrictions on permits for construction of dam and water harvesting projects.

3.3.22 Water (Gaza Strip) – "Highly vulnerable" issues

Water resources are limited and water demand exceeds the available water supply. The Palestinian government has launched many projects related to water management. However, the State of Palestine is struggling to attain the most basic level of infrastructure and services of a low-income country and its agencies are suffering from resource deficiencies and managerial weaknesses. The Gaza Strip has a well-designed Master Plan for water and sanitation, however, less than 2% of the Gaza Strip's investment plan has been implemented. PWA's operations and water resource management in the Gaza Strip have been affected by political instability. PWA has not progressed development of seawater desalination facilities, although there is an urgent need.

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[118] Centre on Housing Rights & Evictions (2008) Policies of denial: lack of access to water in the West Bank. Geneva, Switzerland.
[119] PWA (2013) Status report of water resources in the Occupied State of Palestine – 2012. Ramallah, Palestine.
[120]World Bank (2009)Assessment of restrictions on Palestinian water sector development. Middle East and North Africa Region Sustainable Development Report No. 47657-GZ. Ramallah, Palestine.
[121] PWA (2013) Status report of water resources in the Occupied State of Palestine – 2012. Ramallah, Palestine.
[122]World Bank (2009) Assessment of restrictions on Palestinian water sector development. Middle East and North Africa Region Sustainable Development Report No. 47657-GZ. Ramallah, Palestine.
[123] Palestinian National Authority (2014) National Development Plan (2014-2016). Ramallah, Palestine.

3.3.22.1 Groundwater supply[124,125,126,127]

Climate sensitivity

Water resources are limited and water demand exceeds the available water supply. The coastal aquifer is the main source of groundwater in the Gaza Strip and is a shared aquifer that also underlies Israel and Egypt. The aquifer provides a sustainable yield in the Gaza Strip of around 55 million m^3/year. More than 1.8 million Palestinians in Gaza consume in excess of 200 million m^3/year from the aquifer, thus, taking approximately four times as much water as the aquifer can sustain. Palestinians have drilled a very large number of unlicensed wells due to the lack of secure access to water. Over-pumping of groundwater has damaged the Gaza aquifer.

Adaptive capacity

Projects launched by the Palestinian government in relation to the use of groundwater, including securing additional water resources and rehabilitating wells in different districts.

There is an absence of institutional arrangements for managing the shared aquifer systems. The private sector and households are coping through implementing unlicensed wells and small-scale desalination. There are also external risks to the coastal aquifer. Network coverage rates are high but closures and conflict have led to a near collapse in the reliability of the water supply. Israel limits the entry of construction materials for construction, repair and rehabilitation of infrastructure that would allow for improved management of the groundwater supply.

Water supply has become very intermittent and has fallen to crisis levels, largely due to the deteriorating political and security situation, which curtails access to power, fuel and spare parts. Mass desalination of sea water as an alternative, which is under consideration by the Palestinian Government even if it is costly and constrained within the current context, given that there are frequent electricity shortages in the Gaza Strip associated with Israel's blockade.

3.3.22.2 Groundwater quality[128,129,130,131]

Climate sensitivity

The water quality of the coastal aquifer has deteriorated to crisis levels, due to the imbalance between groundwater recharge and pumping. The salinity of the coastal aquifer is a major concern. 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 has a shallow water table with high permeability making it susceptible to all sources of pollution. The aquifer is unconfined in many places in the Gaza Strip, thus, contaminants readily infiltrate through the surface soil layer. Intensive agricultural practices have increased the levels of nitrates. Most sewage is either returned raw to lagoons, wadis and the sea, or seeps through the soil ultimately reaching the aquifer.

Adaptive capacity

Issues limiting adaptive capacity in relation to groundwater quality are the same as those described for groundwater supply.

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[124] Husseini, H. (2000) Protection of Wadi Gaza: an environmental challenge. http://www.husseini1.com/resources/file/publications/127374358904/Protection%20of%20Wadi%20Gaza,%20An%20Environmental%20Challenge,%202000.pdf
[125] Centre on Housing Rights & Evictions (2008) Policies of denial: lack of access to water in the West Bank. Geneva, Switzerland.
[126] PWA (2013) Status report of water resources in the Occupied State of Palestine – 2012. Ramallah, Palestine.
[127] World Bank (2009)Assessment of restrictions on Palestinian water sector development. Middle East and North Africa Region Sustainable Development Report No. 47657-GZ. Ramallah, Palestine.
[128] Husseini, H. (2000) Protection of Wadi Gaza: an environmental challenge.
[129] Centre on Housing Rights & Evictions (2008) Policies of denial: lack of access to water in the West Bank. Geneva, Switzerland.
[130] PWA (2013) Status report of water resources in the Occupied State of Palestine – 2012. Ramallah, Palestine.
[131] World Bank (2009)Assessment of restrictions on Palestinian water sector development. Middle East and North Africa Region Sustainable Development Report No. 47657-GZ. Ramallah, Palestine.

3.3.22.3 Flood management[132,133,134,135,136]

Climate sensitivity

Flood management is climate sensitive in the Gaza Strip for the same reasons as in the West Bank

Adaptive capacity

Adaptive capacity is limited in the same ways as in the West Bank. However, Israel limits import of construction materials for construction, repair and rehabilitation of storm-water systems that would provide improved flood management. Israeli occupation have opened a number of dams near the border of the Gaza Strip, which causes the Gaza Valley to flood in severe winter storms.

3.3.23 'Vulnerable' issues

Notably, a substantial number of issues were also identified as 'vulnerable' as a result of Israeli occupation, which were otherwise often rated only as 'Potentially vulnerable'. These issues are listed in Table 5but have not been prioritized for further consideration in terms of adaptation.

Table 5: Issues ranked as "vulnerable"

Theme/sector	Vulnerable – West Bank	Vulnerable – Gaza Strip
Agriculture		Watermelon production; Greenhouses; Soil erosion; Cut-flower production
Coastal and marine		Coastal agriculture
Energy	Domestic/local energy and prices	Environmental impacts; Social impacts; Imported energy prices; Cost of domestic feedstocks
Food	Food processing sector; Food storage	Exported food prices; Food storage; Food waste
Gender	Employment and gender; Maternal mortality and life expectancy; Food security and gender	Maternal mortality and life expectancy
Health	Mortality morbidity and life expectancy; Infrastructure; Health costs.	Mortality, morbidity and life expectancy; Infrastructure; Health costs
Industry	Industrial production; Value of industrial products imported and exported; Production of raw materials; Value of raw materials exported; Employment; Waste management	Industrial production; Value of industrial products imported; Production of raw materials; Value of raw materials imported; Infrastructure; Waste management
Terrestrial ecosystems	Biodiversity; Invasive species; Forest shrublands and grasslands; Nature reserves; Birds, mammals, reptile and amphibians; Habitat area; Habitat quality	Biodiversity; Habitat – birds; Wadi Gaza – fauna; Wadi Gaza – flora
Tourism	Infrastructure of the tourism sector; Income from tourism	

132 UN-Habitat (2014)National Report. Ramallah, Palestine.
133 Husseini, H. (2000) Protection of Wadi Gaza: an environmental challenge.
134 Centre on Housing Rights & Evictions (2008)Policies of denial: lack of access to water in the West Bank. Geneva, Switzerland.
135 PWA (2013) Status report of water resources in the Occupied State of Palestine – 2012. Ramallah, Palestine.
136 World Bank (2009)Assessment of restrictions on Palestinian water sector development. Middle East and North Africa Region Sustainable Development Report No. 47657-GZ. Ramallah, Palestine.

Theme/sector	Vulnerable – West Bank	Vulnerable – Gaza Strip
Urban and infrastructure	Urban economy; Urban drainage	Urbanization; Urban economy; Urban air pollution;
Waste/wastewater	Management of wastewater	Cost of waste management; Sewerage; Management of wastewater
Water	Surface water supply; Water quality (surface and groundwater water); Water prices; Volume of water imported	Surface water supply; Surface water quality; Condition of infrastructure; Volume of water imported

3.4 Future-climate scenarios for the State of Palestine

The three future-climate scenarios for the State of Palestine that have been developed to be representative of all projections considered by the IPCC AR5 are summarised below. Further technical details can be found in the NAP's Appendices 4 and 5.

3.4.1 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 warmer periods, both becoming more prominent in 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.

3.4.2 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 warmer periods, both becoming more prominent in time; more so than under Scenario 1.
Rainfall	Decreases by ~10% by 2025, by ~15% by 2055, 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.

3.4.3 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 warmer periods, both becoming more prominent in time; perhaps moderated slightly in the Gaza Strip.
Rainfall	Decreases by ~20% throughout until 2055, and to ~30% by 2090.

Rainfall-related	In general, 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, especially in the West Bank, thus, raising a possibility of an increased flood risk.

3.5 Adaptation measures

The identity and summary ranking of adaptation options in relation to 'highly vulnerable' issues for each theme/sector in the West Bank and the Gaza Strip are provided below together with the total costs of each option and summaries of specific technical and capacity needs. All completed 'Performance Matrices' and 'Appraisal' sheets are available on request from EQA and a summary of the costs of each adaptation option for Years 1-5 and 5-10 can be found at Appendix 4.

3.5.1 Agriculture

3.5.1.1 West Bank

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Enhance sustainable community-level irrigation schemes and infrastructure	Irrigated vegetables	76	19,400,000
2	Climate-smart agriculture	Production of olives, grapes, stone fruits, rain-fed vegetables and field crops	71	146,000,000
3	Improve water-use efficiency and using alternatives water resources	Irrigation water	66	140,000,000
3	Land-use planning and management - greening, afforestation, and rangeland development	Grazing area and soil erosion	66	600,000,000
5	Agricultural disaster risk reduction and management (DRR/M)	Production of olives, grapes, stone fruits, rain-fed vegetables, field crops and livestock	61	88,000,000
6	Increase the availability of animal feed (including plant and organic residues) at an affordable price	Livestock production	60	16,000,000
6	Improve livestock-production pens	Livestock production	60	15,000,000

Specific technical needs

Technologies are readily available in the West Bank to implement most of the selected adaptation options for the agriculture sector with one notable exception. The basket of measures identified for increasing the availability of animal feed at an affordable price includes the need to build large-scale grain-storage silos in order to enable import during periods when prices on the international markets are low. There are currently no such facilities in the West Bank despite the existing presence of fodder factories.

Specific capacity needs

While farmers are familiar with many of the concepts and techniques associated with many of the selected adaptation options for agriculture in the West Bank, there is a need to reinforce and develop capacities in relation to each of them.

Enhancing sustainable community-level irrigation schemes and infrastructure in relation to irrigated vegetables will need to build upon existing capacities in community-based, water-resource management through the establishment of water-user associations.

Knowledge and skills exist within the MOA, FAO, NGOs, and universities with regard to climate-smart agriculture and the production of olives, grapes, stone fruits, rain-fed vegetables and field crops. Additional expertise is required in soil management, water conservation, and agricultural extension. Capacity to adopt and utilize drought-tolerant varieties effectively in the State of Palestine is limited and needs to be developed. Capacities also need to be developed in intercropping, crop rotation and minimum/zero tillage techniques.

Improving water-use efficiency and using alternatives water resources in irrigation will demand training programs to operate the desalination and wastewater treatment plants and to monitor and assure the quality of effluent. Concentrations of salt in treated wastewater for reuse and its biochemical oxygen demand need to be reduced and health risks need to be totally eliminated. Professional irrigation engineers and sustainable water management experts need to be involved. Farmers' capacities to safely and sustainably irrigate with treated wastewater need to be developed.

The Ministry of Agriculture, ICARDA, PARC, UAWC, Palestinian universities and others all possess some relevant knowledge and skills in relation to managing the grazing area and soil erosion through land-use planning and management (greening, afforestation, and rangeland development). However, additional expertise is required in soil and water conservation, and large-scale land management.

Production of olives, grapes, stone fruits, rain-fed vegetables, field crops and livestock are all 'highly vulnerable' but a functioning agricultural disaster-risk reduction and management (DRR/M) system has not yet been established in the State of Palestine. Institutional capacities are needed to perform climate change-related vulnerability assessments at national and governorate level with a special focus on the most vulnerable communities. There is a need to enhance multi-stakeholder information sharing and coordination of preparedness and emergency response activities (including MOA, Palestinian Civil Defense – PCD), PMD, National Spatial Plan – NSP, PWA, food security sector etc.). There is also a need to develop institutional capacities for agricultural insurance and compensation. A structure is already in place (Palestinian Disaster Risk Reduction and Insurance Fund - PADRRIF) but capacities to operate it need to be developed.

The wide range of measures to increase the availability of animal feed at an affordable price include: establishing feed factories; increasing the agricultural area; concentrating on drought-tolerant species, such as barley; as well as building large-scale grain-storage silos. However, there is a shortage of knowledge and skills. For example, large farms usually purchase dairy-cattle food from Israel.

Many farmers do not have the necessary knowledge and skills to improve livestock-production pens. Hence, when companies install modern pens and hangars, people usually receive operational training.

3.5.1.2 Gaza Strip

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Climate-smart agriculture: Management of crop production systems including soil and water resources for better environmental sustainability along with improved economic profitability for farmers	Citrus, Olive production, Vegetable production, Employment	80	40,400,000

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
2	Improve water-use efficiency and using alternatives water resources	Irrigation water	71	14,270,000
3	Establishment of farmers' support (subsidies, awareness training programs)	Cost of agricultural production	62	85,000,000
4	Agricultural disaster risk reduction and management (DRR/M)	Cost of agricultural production	61	44,000,000
5	Improve livestock-production pens	Livestock production	60	15,000,000

Specific technical needs

Technical needs with regard to the selected adaptation options for the agriculture sector in the Gaza Strip relate primarily to addressing potential impacts on the cost of agricultural production. Establishment of an approach for farmers' support, including subsidies, needs to be informed by schemes in other countries but be tailored to the Gaza Strip's unique circumstances. There is a need to set up an Early Warning System (EWS) to monitor drought, flood, plant pests and transboundary animal diseases through a combination of remote sensing and indicators collected on the ground. Data and information management is in place, but improvements are needed to facilitate quick and targeted post-disaster response.

Specific capacity needs

While the knowledge and skills exist in the State of Palestine to develop and implement an approach for farmers' support in relation to the cost of agricultural production, there is a need to build upon and develop capacities in relation to all of the other adaptation options.

Knowledge and skills exist within the MOA, FAO, NGOs, and universities in relation to climate-smart agriculture but additional expertise is required in soil management, water conservation, and agricultural extension. There is also a need for capacity-building to enable adoption and effective utilization of drought and salt-tolerant varieties.

In the same way as in the West Bank, there is a need to develop and reinforce existing capacities in community-based, water-resource management through the establishment of water-user associations, and to improve knowledge and skills in relation to use of alternative water resources through training programs and the involvement of professional irrigation engineers and sustainable water management experts.

Establishment of a functioning agricultural DRR/M system that addresses potential impacts on the cost of agricultural production and improvement of livestock-production pens will both demand the same range of capacity-building activities as described for the West Bank (above).

3.5.2 Coastal and marine

3.5.2.1 Gaza Strip

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Rain-water harvesting	Coastal agriculture	75	500,000

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
2	Construction of detached breakwaters	Condition of beaches	66	10,000,000
3	Introduction of new saline-tolerant crops	Coastal agriculture	61	500,000
4	Enlargement of the fishing area and improve fishing equipment	Fishing/fisheries	57	90,000,000
5	Provision of beach nourishment, reclamation and beach drift rehabilitation	Condition of beaches	56	10,000,000
5	Provision of laboratories and equipment for data collection and analysis	Condition of beaches	56	2,000,000
7	Fish packaging/preservation industry	Fish catch	20	1,000,000

Specific technical needs

With the exception of the construction of detached breakwaters to maintain the condition of beaches, all other adaptation options identified in relation to the coastal and marine sector have specific technical needs, which may be difficult to fulfil due to Israeli import restrictions. At least some of the necessary equipment and technology for rain-water harvesting to sustain coastal agriculture is available in the Gaza Strip. Introduction of new saline-tolerant crops would require applied research to determine the likely extent of saltwater intrusion and appropriate crops suited to the soil-type but this could be hampered by Israeli import restrictions. There are restrictions on importing basic fishing equipment and fuel for vessels and cold storage, which would be required to sustain fishing and fisheries. The sand needed for beach nourishment, reclamation and beach drift rehabilitation and the technology required to transport it are available in the Gaza Strip, but more advanced technologies are needed to pump sand from the sea bed. There is limited availability of equipment at the universities and some governmental offices relevant to provision of laboratories and equipment for data collection and analysis in order to increase understanding of the vulnerability of beaches and the efficacy of adaptation options. Most notably, establishment of a fish packaging and fish preservation industry could only happen if relevant machinery and equipment could be imported, although, unless the fishing area is increased, the fish catch is unlikely to be sufficient to sustain the industry.

Specific capacity needs

Knowledge and skills exist in the State of Palestine to construct detached breakwaters to maintain the condition of beaches, but to a greater or lesser extent there is a need to reinforce and develop capacities in relation to all of the other adaptation options. Farmers have knowledge and skills associated with small-scale rain-water harvesting on which to build. There is a need to increase awareness of the benefits of introducing new saline-tolerant crops and to provide training in their cultivation, as appropriate. Academic and professional knowledge and skills are limited in relation to use of advanced technologies for beach nourishment, reclamation and beach drift rehabilitation, so some training is required. Training would also be needed in use of more advanced equipment for data collection and analysis intended to increase understanding of the vulnerability of beaches. Finally, if equipment for fish packaging and preservation were to be successfully imported then operational training would be needed to make use of it.

3.5.3 Energy

3.5.3.1 West Bank

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Generation of solar electricity for medium-large scale commercial and industrial application	Domestic/local energy production	76	99,548,000
1	Use of renewable energy such as solar to reduce imported energy.	Energy imports	76	106,048,000
3	Implement energy efficiency measures to reduce consumption, mainly for commercial and industrial application	Domestic/local energy production	75	10,500,000
3	Implement energy efficiency measures to reduce consumption and hence imported energy	Energy imports	75	13,500,000
5	Electricity grid upgrading	Condition of infrastructure	65	16,250,000
6	Building fossil-fuel storage facilities	Condition of infrastructure	24	21,200,000

Specific technical needs

Technical needs relate primarily to implementation of energy efficiency measures and to building fossil-fuel storage facilities, as the other adaptation options make use of existing technologies available within the West Bank. Suitable technologies are available for small projects and household applications that reduce energy consumption but technologies for industrial or commercial application would need to be imported. The technology to build small-scale, fossil-fuel storage facilities is available in the State of Palestine but technology associated with large-scale facilities would also need to be imported.

Specific capacity needs

While the knowledge and skills exist in the State of Palestine to upgrade the electricity grid, there is a need to build upon and develop capacities in relation to all of the other adaptation options. Existing knowledge and skills with regard to solar energy relate primarily to small-scale applications. Larger-scale installations (> 1MW) demand development of new knowledge and skills. Existing knowledge and skills in relation to energy efficiency relate to household applications. However, capacity building and training is needed for commercial and industrial applications. Palestinians possess the necessary knowledge and skills to build small-scale, fossil-fuel storage facilities, however, will require training to build larger storage facilities and to manage accidents associated with fuel storage.

3.5.3.2 Gaza Strip

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Additional supply of energy from neighbouring countries	Total energy imports	81	10,000,000
2	Enhancing the equipment and efficiency of the Gaza Power Plant (GPP)	Total domestic energy production	80	10,000,000
3	Use of renewable energy, such as solar, to reduce imported energy.	Total energy imports	76	50,000,000
4	Implement energy efficiency measures to reduce consumption and hence imported energy	Total domestic energy production	75	6,000,000
5	Electricity grid upgrading	Condition of infrastructure	71	100,000,000

Specific technical needs

All of the selected adaptation options are able to make use of existing technologies available in the Gaza Strip with the exception of implementation of energy efficiency measures, where specific technical needs are the same as for the West Bank.

Specific capacity needs

With the exception of negotiating additional supply of energy from neighbouring countries, there is a need to reinforce and develop capacities in relation to each of the selected adaptation options. Local electricity companies have the knowledge and skills to operate the GPP, but some technical or managerial training could be needed to install and operate the new equipment. Specific capacity needs in relation to solar energy and implementation of energy efficiency measures are the same as for the West Bank. Local electricity companies have the knowledge and skills to upgrade the grid. However, more training would improve their emergency response to interruption of the electricity grid, during extreme weather conditions

3.5.4 Food

3.5.4.1 West Bank

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Enhancing agricultural value chain and improving infrastructure for livestock-production	Domestic food prices	66	227,500,000
2	Greenhouse management	Domestic food prices	60	25,000,000
3	Construction of large-scale cold storage	Domestic food prices	55	33,000,000
4	Construct large-scale steel silos for grain to enable import and storage during	Imported food prices	47	4,000,000

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
	periods when prices on the international markets are low			

Specific technical needs

Suitable technologies are available and accessible for improving infrastructure for livestock production, e.g. large-scale poultry-production pens in the Northern part of the West Bank, and for greenhouse management, e.g. irrigation techniques, tensiometer, and shading systems. Construction of large-scale cold storage would be able to draw upon some relevant existing technologies available in the State of Palestine, as there are a few existing private cold-storage facilities. However, there are no up-to-date, large-scale grain silos in the State of Palestine, so suitable technology would need to be imported.

Specific capacity needs

Many of the technologies and techniques in relation to improving infrastructure for livestock production and to greenhouse management are already familiar to large private companies. The same is true of cold storage, although techniques need to be improved, especially if facilities are to be enlarged. Lack of experience of constructing large-scale steel silos for grain, means that associated knowledge and skills either need to be developed or outsourced.

3.5.4.2 Gaza Strip

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Enhancing agricultural value chain and improving infrastructure for livestock-production	Domestic food prices	66	121,250,000
2	Greenhouse management	Domestic food prices	65	12,500,000
3	Construction large-scale cold storage	Domestic food prices	60	15,000,000
4	Construct large-scale steel silos for grain to enable import and storage during periods when prices on the international markets are low	Imported food prices	47	5,000,000

Specific technical needs

As the same suite of adaptation options have been selected as in the West Bank, the specific technical needs are also identical.

Specific capacity needs

Specific capacity needs also reflect those in the West Bank.

3.5.5 Gender

3.5.5.1 West Bank

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Increasing the awareness of people, particularly women, in water-poor areas of measures they can take to help prevent major diseases related to water, sanitation, and food	Major diseases related to water, sanitation, and food	76	2,200,000

Specific technical needs

Awareness campaigns need only promote measures associated with existing regulations and technologies in the State of Palestine.

Specific capacity needs

Although the necessary knowledge and skills to develop and implement the awareness campaigns are available in the State of Palestine, there are two Departments at the Palestinian Ministry of Health that would benefit from training.

3.5.5.2 Gaza Strip

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Increasing the awareness of people, particularly women, in water-poor areas of measures they can take to help prevent major diseases related to water, sanitation, and food	Major diseases related to water and sanitation	71	3,200,000
2	Supporting improvements in efficient use of water in women's private small-scale agricultural projects	Employment and gender	62	3,000,000
3	Encouraging women to use their house gardens to produce food	Food security and gender	61	3,200,000

Specific technical needs

As with the West Bank, awareness campaigns need only promote measures associated with existing regulations and accessible technologies. Supporting improvements in efficient use of water in women's private small-scale agricultural projects could be achieved through measures already deployed in the Gaza Strip, such as modern irrigation techniques and plastic houses. Using house gardens to produce food could be also informed by readily accessible techniques.

Specific capacity needs

Specific capacity needs in relation to awareness campaigns mirror those in the West Bank. Women require training in how to make more efficient use of water in their small-scale agricultural projects but have adequate existing knowledge and skills to use their house gardens to produce food.

3.5.6 Health

3.5.6.1 West Bank

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Development of water, food and sanitation monitoring and safety systems using high technology	Major diseases related to water, sanitation, and food	66	5,850,000
2	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	Major diseases related to water, sanitation, and food	65	2,680,000

Specific technical needs

Development of water monitoring and safety systems using high technology can be implemented by reviewing available technologies in other countries and importing the best available suited to the West Bank. Training programs and awareness campaigns need only promote measures associated with existing regulations and technologies in the State of Palestine.

Specific capacity needs

Health professionals would need to be trained in use of the monitoring and safety systems. Specific capacity needs in relation to awareness campaigns mirror those in the West Bank with regard to gender (above).

3.5.6.2 Gaza Strip

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	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	Major diseases related to water, sanitation, and food	70	850,000
2	Development of water, food and sanitation monitoring and safety systems using high technology	Major diseases related to water, sanitation, and food	66	2,900,000

Specific technical needs

Technical needs in relation to the selected adaptation options are the same as identified for the West Bank

Specific capacity needs

Capacity needs are also the same as in the West Bank.

3.5.7 Industry

3.5.7.1 West Bank

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Providing reliable electricity supply	Energy supply	71	29,400,000
2	Replace imported raw materials with local materials whenever possible	Value of raw materials imported	61	28,000,000
3	Improve water supply through wastewater collection and treatment systems	Infrastructure	52	58,000,000
4	Reducing energy consumption through introduction of modern production technologies	Energy demand	44	31,000,000
5	Building fossil-fuel storage facilities	Energy supply	32	25,400,000

Specific technical needs

Local electricity companies have access to the necessary technology for upgrading the grid to increase the reliability of the energy supply. However, there are specific technical needs in relation to all of the other adaptation options. Replacing imported raw materials with local materials demands research and potential changes in production processes. Some suitable technologies to enable greater use of local materials will be available in the State of Palestine but some would need to be imported. The necessary technology to improve wastewater collection is available, however, technologies to deal with treatment of industrial wastewater would need to be imported. Modern production technologies that have the potential to reduce energy consumption are not available and would also need to be imported, as would technology associated with large-scale, fossil-fuel storage facilities (see energy sector above).

Specific capacity needs

There is a general lack of knowledge and skills in relation to the various adaptation options selected for this sector and consequent training needs. As noted for the energy sector (above), local electricity companies would benefit from training to improve their emergency response to interruption of the electricity grid, especially the high voltage network, during extreme weather conditions. Lack of relevant knowledge and skills regarding replacement of imported raw materials with local materials inhibits progress and specialized and professional training is required. Training and capacity building is needed to deal with industrial waste water; its collection and treatment. Palestinians also need training to fill gaps in knowledge and skills with regard to advanced energy efficient technologies that have potential to reduce energy consumption. Training needs in relation to building fossil-fuel storage facilities have already been described for the energy sector (above).

3.5.7.2 Gaza Strip

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Improve handling, fumigation, packaging, and storage techniques for raw materials intended for export	Value of raw materials exported	71	1,000,000
1	Capacity building to enable industries to adapt to climate change	Employment	71	4,000,000
1	Rehabilitation of industrial facilities	Value of industrial products exported	71	30,000,000
4	Conducting energy audits in order to increase industries' use of energy efficiency measures	Energy demand	70	5,500,000
5	Provision of suitable storage facilities for industrial products intended for export	Value of industrial products exported	65	18,000,000
5	Rehabilitation and maintenance of industrial equipment	Energy demand	65	9,000,000
7	Providing reliable electricity supply	Energy supply	41	10,000,000

Specific technical needs

There are no specific technical needs in the Gaza Strip regarding any of the adaptation options selected for this sector, as relevant technologies and techniques are readily accessible. However, dependent on the industry, capacity building to enable industries to adapt to climate change may require techniques that are available locally or may need to be sourced internationally.

Specific capacity needs

Although some level of knowledge and skills exists on which to build in relation to each of these options, a wide range of training needs have been identified:

- People involved in handling, fumigation, packaging and storage need training in best practices.
- The level of available knowledge and skills to provide capacity building to enable industries to adapt to climate change varies by industry and may need to be outsourced internationally.
- Training will be required to ensure that the rehabilitation of industrial facilities takes climate change into account.
- Knowledge and skills are available locally to conduct energy audits but training could be required to implement some energy efficiency measures, e.g. installation and use of new equipment.
- Knowledge and skills are available locally to rehabilitate and maintain industrial equipment. Some training courses are needed for the professional on maintenance
- Skills and knowledge in providing reliable sources of energy are readily available but some training could be needed with regard to sources that are used less commonly in the Gaza Strip, e.g. renewable energy.

3.5.8 Terrestrial ecosystems

3.5.8.1 West Bank

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	National network of protected areas, including 50 protected areas and 51 biodiversity hotspots	Habitat connectivity	66	12,000,000

Specific technical needs

National habitat maps were produced in 1995-96, were recently updated, and published in March 2016. This latest assessment includes identification of biodiversity hotspots and assessment of actions required to maintain and increase habitat connectivity. The resultant outputs are being input to development of the cross-sectoral National Spatial Plan. The work is being undertaken by consultants and Palestinians lack access to suitable software, e.g. for remote sensing, GIS, and landscape ecology. It is a Convention on Biological Diversity commitment in relation to the Cartagena Protocol to prepare a national framework on biosafety, e.g. in relation to genetically-modified organisms (GMOs). This has not yet been implemented. There are currently no measures in place for enabling rehabilitation of wildlife casualties, and there is a need to establish a wildlife rehabilitation centre.

Specific capacity needs

An assessment of national habitat maps is currently being undertaken by consultants and there is a need to train Palestinians in remote sensing, use of geographic information systems (GIS), and landscape ecology. There are few national taxonomic experts and very few with scientific training. There is a lack of research and scientific publications on the State of Palestine's biodiversity, although there are many publications for a general readership, particularly on birds. There is a need to build decision-makers understanding of the central importance of sustaining and restoring biodiversity and ecosystem services from a socioeconomic perspective in order to mainstream biodiversity conservation across sectors. There is a general lack of awareness about the importance of nature protection and a need to increase public appreciation of biodiversity.

3.5.8.2 Gaza Strip

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	National network of protected areas, including Wadi Gaza and 3 biodiversity hotspots	Habitat connectivity in Wadi Gaza	66	1,400,000

Specific technical needs

The description of technical needs for the West Bank also applies to the Gaza Strip.

Specific capacity needs

Specific capacity needs are also the same as those in the West Bank.

3.5.9 Tourism

3.5.9.1 West Bank

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Identify, design and implement flood management schemes for cultural heritage sites, where appropriate	Condition of cultural heritage	61	4,800,000
1	Identify, design and implement flood management schemes for eco-tourist attractions, where appropriate	Condition of cultural heritage	61	4,800,000

Specific technical needs

It is anticipated that any flood management scheme would make use of existing technologies already deployed in the State of Palestine.

Specific capacity needs

The necessary knowledge and skills are available in the State of Palestine. Consulting engineers could design the required infrastructure, while construction companies could build it. There would be no need for external experts.

3.5.10 Urban and infrastructure

3.5.10.1 West Bank

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Promoting green buildings	Urbanization	70	10,000,000
2	Rehabilitation of resilient road infrastructure	Urbanization	61	21,000,000

Specific technical needs

Green buildings are addressed by existing regulations. Both adaptation options can make use of available technologies, although it would be beneficial to introduce the latest green-building technologies to the State of Palestine.

Specific capacity needs

The necessary knowledge and skills for enhancing existing regulations for green buildings and for raising engineers' awareness of green buildings are available in the State of Palestine, but would be worth upgrading. Likewise, local consulting engineers and construction companies have the necessary knowledge and skills to undertake design and construction improvements to the road infrastructure. There would be no need to draw upon international experts.

3.5.10.2 Gaza Strip

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Rehabilitation of resilient road infrastructure	Urbanization	61	10,000,000
2	Promoting green buildings	Building conditions	60	12,600,000

Specific technical needs

See the West Bank above.

Specific capacity needs

See the West Bank above.

3.5.11 Waste and wastewater

3.5.11.1 West Bank

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Improving waste collection system	Waste management	61	34,250,000
2	Improve management of leachate from landfill sites	Waste management	57	5,000,000
3	Reduce, re-use, recycle	Waste management	56	8,000,000

Specific technical needs

Inadequate waste collection is already a serious issues and improving the current system is identified as a priority in the draft National Strategy for Solid Waste Management in Palestine 2016-2020. There would be a need to import new collection vehicles and equipment for transfer stations, e.g. loaders and transfer vehicles. Communal bins could be manufactured locally.

The current situation is that management of leachate from landfill sites relies on natural processes, governed by rainfall. As such, leachates are already concentrated and any worsening of the current situation will be unacceptable. The National Strategy for Solid Waste Management in Palestine 2010-2014has expired. A first draft of the strategy for 2016-2020 includes a need to improve waste management in sanitary landfill sites. Leachate management is specifically mentioned. There is a need to switch from a reliance on natural evaporation to a new process, reverse osmosis, which uses a sophisticated nano-filtration technology. This would need to be imported from the EU or other available sources.

Reduce, re-use, recycle would require import of equipment for sorting at source, on transfer, and on disposal, as well as for subsequent recycling

Specific capacity needs

There would be a need to provide a short training program on improving the waste collection system specifically with regard to design of the routing system, e.g. in use of GPS and management information systems

With regard to improving management of leachate from landfill sites, there is no existing experience of reverse osmosis in the State of Palestine. There would be a need to increase Palestinian's capacity to manage the process through conducting a short training program.

There would be a need for short training programs on use of recycling equipment for sorting.

3.5.11.2 Gaza Strip

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Improving waste collection system	Waste management	65	12,000,000
2	Improve management of leachate from landfill sites	Waste management	57	2,000,000
3	Reduce, re-use, recycle	Waste management	56	2,000,000

Specific technical needs

See West Bank above.

Specific capacity needs

See West Bank above.

3.5.12 Water

3.5.12.1 West Bank

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Rehabilitate water sources: wells, canals and springs	Condition of infrastructure	70	4,400,000
2	Control of leakage from distribution systems	Condition of infrastructure	65	16,500,000
3	Allocate transboundary water resources equitably and reasonably between Israel and the State of Palestine	Groundwater supply	62	117,600,000
4	Enhance the use of additional and alternative water resources for non-domestic purposes	Groundwater supply	51	152,000,000
5	Develop and improve storm-water systems and drainage infrastructure	Flood management	40	20,800,000

Specific technical needs

All of the adaptation options would make use of existing technologies and techniques available in the State of Palestine.

Specific capacity needs

Knowledge and skills would be available to implement all of the adaptation options (except for the construction of large dams), drawing up on local construction companies and construction engineers as necessary. There would be no need to seek input from international experts except in relation to large dams. Some capacity building might be beneficial in relation to rehabilitating wells, canals and springs.

3.5.12.2 Gaza Strip

Rank	Adaptation option	Highly vulnerable	Score	Total estimated cost (USD)
1	Increase share of imported water	Groundwater supply	81	1,000,000
2	Enhance the use of alternative water resources for non-domestic purposes	Groundwater supply	66	61,000,000
3	Build a large desalination plant for Gaza[137]	Groundwater quality and supply	56	510,000,000
4	Develop and improve storm-water systems and drainage infrastructure	Flood management	51	10,200,000

Specific technical needs

Like the West Bank, existing technologies and techniques are available in the Gaza Strip except with regard to building and operating the desalination plant, which could be achieved through reviewing available technologies in other countries and importing the best available suited to the Gaza Strip.

Specific capacity needs

Local knowledge and skills would be available to implement all options with the exception that water professionals would need to be trained to operate the large desalination plant.

3.6 Future developments to participate in climate-change modelling research

The main recommendation arising from the review of requirements for the State of Palestine to have the capability to generate its own climate modelling inputs to its future NAPs and NCs was to ensure that the fundamental requirements for undertaking climate change analyses are in place prior to developing local modelling capabilities. These fundamental requirements include:

- The development of observations systems to World Meteorological Organization (WMO) standards
- Digitisation and quality control of all observational data
- Creation of digitised databases for historical observations and for ingestion of future data, with quality control
- Consideration of staff training requirements
- Consideration of the use of existing global observations datasets, as input to research on Palestinian climate
- Consideration of the use of existing IPCC projections datasets, as the first stage towards research on climate change in the State of Palestine
- Development of links with international institutions to assist where appropriate in all studies.

At this time, it was recommended that any initial downscaling approach considered should be progressed through statistical means and not through use of numerical models. If numerical modelling is to be used then technical details need to be considered in consultation with the selected modelling house. However, it should be recognised that the use of a single model is not recommended, and that all work should be based on ensembles, ideally with combinations of global and regional models. The CORDEX dataset provides an extensive resource for research at this time, which might be considered

[137] Like all adaptation options listed here, this project is a high priority. It is viewed by the Palestinian Government as an urgent priority. It ranks lower than the options above it, in part, due to its substantial cost.

for initial work. The current state of knowledge suggests that numerical downscaling is most useful by coasts and over regions of marked topography; the former might apply to the Gaza Strip but the topography of the West Bank may be insufficient to benefit from the latter. Consideration should be given to Chapter 9 of the IPCC AR5 Working Group I report, in particular Section 9.6 onwards, prior to any final decision on implementing numerical downscaling. If work is to be progressed then it is recommended that it should be undertaken in cooperation with the CORDEX project.

Full details of the review can be found at Appendix 5 and resultant costings provided by the Palestinian Meteorological Office can be found at Appendix 6. Total cost is estimated as USD2,120,000.

3.7 Monitoring and evaluation

The development of a monitoring and evaluation process in relation to the NAP will consider possible options for monitoring, as relevant to each of the 'highly vulnerable' issues, in terms of changes in:

- Their climate sensitivity and/or
- Related adaptive capacity and/or
- Their vulnerability and/or
- Related direct and indirect impacts that may be attributed to climate change and/or
- Progress with implementation of related adaptation options.

While steps could be taken to address the current lack of quantitative national datasets in relation the 'highly vulnerable' issues (and their component climate sensitivities and adaptive capacities), the simplest monitoring solution would be to replicate the process used here to identify and prioritize vulnerabilities and adaptation options each time the NAP is reviewed and updated.

3.8 Alignment of donor programs and activities with the NAP's focal themes/sectors

Chapter 7 of the Initial National Communication Report (INCR) includes a section on "Establishing and enhancing climate finance readiness". It notes that now that the State of Palestine is a party to the UNFCCC, EQA has been selected as the Country's National Designated Authority (NDA) to the Green Climate Fund (GCF). In this context, an important next step is to identify how donor programs and activities align with the vulnerabilities and adaptation options prioritised by the NAP process. An initial review has identified the following donor programs:

- United Nations Development Assistance Framework for the State of Palestine and Program of Assistance to the Palestinian People (UNDP-PAPP)
- Palestinian Recovery and Development Plan Multi Donor Trust Fund Project (PRDP TF), involving the World Bank
- EU Palestine Single Support Framework (EU SSF)
- Palestinian Territory Belgium Partnership, Belgian Development Cooperation (BTC)
- German Development Cooperation (GIZ) programs on: Adapting to climate change (ACC); Adapting to climate change in the water sector in the MENA region (ACCW); and Open Regional Fund (ORF MENA)
- Swedish Development Cooperation (SIDA) with Palestine
- UK Department for International Development(DfID) Palestinian Program.

In addition, there are multilateral funds linked to UNFCCC, including the Global Environment Facility (GEF), GCF, Adaptation Fund, Special Climate Change Fund, and others. Additional bilateral funding mechanisms are also available for the State of Palestine to access.

Potential links between some of these donor programs and the vulnerable theme/sectors on which the NAP is focused are identified in Table 6. Although the links have been identified from what has been funded previously and from donor and program documentation, it should be noted that the latter may not be up-to-date and will be subject to change over time.

Table 6: Potential links between donors and programs and the NAP's vulnerable theme/sectors

Theme/Sector	Donor programs
Agriculture	UNDP-PAPP; PRDP TF; EU SSF; GIZ ACC;
Coastal and marine	UNDP-PAPP; EU SSF;
Energy	UNDP-PAPP; EU SSF;
Food	UNDP-PAPP; PRDP TF;
Gender	UNDP-PAPP; PRDP TF; EU SSF; BTC
Health	UNDP-PAPP; PRDP TF; EU SSF; BTC; GIZ ORF MENA; SIDA; DfID
Industry	EU SSF; SIDA
Terrestrial ecosystems	UNDP-PAPP; BTC
Tourism	UNDP-PAPP; EU SSF;
Urban and infrastructure	UNDP-PAPP; EU SSF; BTC
Waste and wastewater	UNDP-PAPP; EU SSF; BTC; DfID
Water	UNDP-PAPP; PRDP TF; EU SSF; GIZ ACC; GIZ ACCW; SIDA; DfID

3.9 Next steps

In relation to individual themes/sectors or adaptation options, follow on work (inclusive of stakeholder consultation) could usefully address:

- Development of detailed funding proposals for international donors, international financial institutions and international funds
- Review of the Palestinian Government's thematic/sectoral strategies and policies to ensure that they are aligned with the NAP and thereby integrate and mainstream climate change adaptation
- Planning implementation of adaptation options (including spatial plans where data allow)
- Establishing new data requirements for future enhancement of the NAP and monitoring and evaluation (including indicator development)
- Capacity building and training (including for all other activities in this list).

3.10 Conclusions

The Climate Change Adaptation Strategy and Program of Action for the Palestinian Government[138], previously identified water and food security as the most vulnerable issues in the State of Palestine with knock-on implications for all other themes/sectors. In keeping with those conclusions, the latest comprehensive assessment identified a wide range of 'highly vulnerable' issues in relation to water, agriculture and food that also affect the vulnerability of other themes/sectors. However, it also importantly revealed that many 'highly vulnerable' issues have inter-connections more generally across themes/sectors, most notably, in addition to water, agriculture and food, in relation to energy.

The assessment revealed that Israeli occupation substantially reduces the State of Palestine's adaptive capacities in relation to many issues across all themes/sectors thereby compounding climate vulnerabilities. For example, Israeli occupation of the State of Palestine restricts: availability of land and resources and degrades them; freedom of movement of goods and people; import and export of raw materials and products; development of domestic and industrial infrastructure; and abilities to respond to inter-related crises. These limitations on the State of Palestine's adaptive capacities are most prevalent in Area C, which covers 61% of the West Bank, and in the Gaza Strip but Israeli occupation

[138] UNDP, 2010. Climate Change Adaptation Strategy and Program of Action for the Palestinian Authority.

also increases vulnerabilities elsewhere. Hence, many issues rated as 'Vulnerable' without Israeli occupation have been rated as 'highly vulnerable' when Israeli occupation is taken into account.

Each of the adaptation options in the NAP is uniquely ascribed to a particular vulnerability within a theme/sector and will be the responsibility of the relevant Palestinian Government's Ministry for that theme/sector to deliver. However, many of the adaptation options provide co-benefits for multiple themes/sectors and their delivery will be of considerable interest to other Ministries and all related stakeholders. The Environment Quality Authority will maintain oversight and ensure coordination across all themes/sectors. The NAP has received approval from all relevant Ministers (Appendix 7) and the Palestinian Government's thematic/sectoral strategies and policies now need to be reviewed to ensure that they are aligned with the NAP and thereby integrate and mainstream climate change adaptation. This will help to secure funds for proposed national programs and projects.

The NAP will be maintained as a living document that may be reviewed on an ongoing basis by theme/sector in accordance with the systematic processes that have been used to identify and prioritise vulnerabilities and adaptation options. This is considered particularly important for some themes/sectors where thinking is less advanced and there is a need to build upon the scope and scale of adaptation options if they are to be commensurate with the challenges posed to the 'highly vulnerable' issues by the three climate scenarios.

All adaptation options identified in relation to 'highly vulnerable' issues have been included in the NAP, irrespective of their ranking. However, this remains a conservative approach as other 'vulnerable' issues have not been addressed. The adaptation options have each been prioritised in relation to the impact of them not being implemented, their efficacy in relation to all three climate scenarios, their timing and urgency for action, likely social acceptance, availability of suitable technologies and techniques, availability of relevant knowledge and skills, their costs, co-benefits for adaptation in other themes/sectors and co-benefits for mitigation. It is important not to compare the priority of adaptation options between the West Bank and the Gaza Strip or between themes/sectors, as relative scores have been used to rank options within each theme/sector.

It is self-evident that as Israeli occupation compounds climate vulnerabilities by reducing adaptive capacities, it also severely constrains the State of Palestine's abilities to adapt. Israeli restrictions are particularly challenging for options that require import of new technologies, import and export of raw materials and products, or the development of domestic and industrial infrastructure. Hence, unless lifting of these restrictions can be resolved with Israel, it may be much more difficult for the State of Palestine to adapt to projected climate change with potentially dire consequences.

Although adaptation options make use wherever possible of existing technologies and techniques available in Palestine, a considerable number do require their import. Many of the adaptation options also draw upon existing knowledge and skills available in Palestine but there are substantive needs for technology transfer, training and capacity building. It is these aspects and the scale of necessary implementation that drive financial needs, which are considerable, in total in excess of USD3.5 billion over the next ten years. Hence, the State of Palestine's ability to implement its NAP will be reliant on securing substantial financial support from international donors.

Appendices

Appendix 1 - Assessment of historic trends in climate

Executive summary

This report assesses historic trends in climate in relation to the State of Palestine. It thereby provides a context for considering the climate sensitivity of potential vulnerabilities across the State of Palestine's various sectors in preparing the National Adaptation Plan (NAP).

The objectives of climate-trend analysis are not only to identify multi-year trends in climate parameters but also to distinguish between natural variability, on any timescale resulting from natural causes, and long-term trends resulting from the influence of human beings.

It is not intended that this historic trend analysis should be used as the basis for establishing a baseline for future climate projections that can be used to inform assessment of exposure and prioritization of adaptation actions in preparing the State of Palestine's NAP. It should also be noted that historic trends need not necessarily continue in the future under climate change.

The report provides:

- A discussion of uncertainties in relation to estimating trends for the various parameters considered.
- Global analyses of observed trends in relation to the State of Palestine interpreted from the charts provided in the IPCC's Fifth Assessment Report, Working Group I, (IPCC AR5), published in 2013.
- A review of climate trends assessed at a national level in documents submitted to the UNFCCC for countries in the vicinity of the State of Palestine, namely Lebanon, Jordan, Israel and Egypt.
- A summary of a representative sample of numerous papers, identified from a literature search, that consider regional climate trends in and around the State of Palestine, assessing either trends in climate parameters themselves or trends in impacts of changes in these parameters. The geographical locations of the studies vary but, given the relative uniformity of the climate across the larger region, studies undertaken in climates similar to those in the West Bank and Gaza were reviewed. Thus, studies for Lebanon, Jordan, Syria, Israel, Saudi Arabia and Egypt have been included.

Temperature is the most straightforward of all climate parameters to submit to trend analysis. This is because temperature tends towards statistically normal distributions and uniformity over large areas, and adheres to basic laws of physics. Analyses of combined temperature parameters, such as the length of heat waves, however, suffer from the relatively few occurrences within the data record with which to determine any trends.

Trends in rainfall are more difficult to analyse than those for temperature. Rainfall is not only non-normally distributed but is also spatially variable, with trends perhaps dependent on the location of a specific rainfall gauge. In the case of the State of Palestine, rainfall is often convective (i.e. When the land warms up, it heats the air causing it to expand and rise. As the air rises it cools and condenses leading to rainfall) and is controlled to an extent by landform. Thus, geographically-close rainfall gauges may provide very different recordings of any particular event and it is plausible that a slight change in predominant wind direction might result in a rainfall trend at particular locations in the country.

Calculated trends may critically depend on the length or the selected period of the record. This is particularly the case for rainfall for which there may be inherent cycles of some form that may appear as trends over specific intervals of analysis. Even where cyclical behaviour is not apparent, trends in rainfall may appear for a number of years for reasons that may be difficult to ascertain and may then reverse, equally without obvious cause. The issue of possible cycles in rainfall in the Levant is certainly a complicating factor that might affect not only the identification of trends in the rainfall itself, but also trends in combined parameters, such as drought frequency and intensity.

The issues summarised above variously affect calculation of trends in additional parameters, such as in specific humidity, wind, sunshine, etc.

In order to embrace the difficulties and uncertainties related to identifying trends for the various parameters analysed, the report uses the terminology for likelihood and confidence from the IPCC AR5 and offers mirror images of confidence statements in order to provide a balanced presentation. The report's summary conclusions in relation to climate variables are as follows:

- **Average temperature:** There is *very high* confidence that temperatures have risen over the past 100 years or so but less confidence in assessed 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 but also *medium* confidence that the rate of increase was highest in the final 20 years of the century
- **Maximum and minimum temperatures and diurnal temperature stage:** 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, only *low* confidence for any changes in diurnal temperature ranges.
- **Temperature extremes[139]:**The different signs in the trends of the two global analyses of warmest day of the year illustrate the difficulties in providing stable assessments for the State of Palestine. Otherwise the available, but rather limited, evidence does provide partial support the contention of longer warm spells and shorter cold spells but *high* confidence that warm days/nights and cold days/nights have increased/decreased respectively in frequency.
- **Rainfall totals:** Some regional authors have argued that rainfall has decreased, however, not all authors agree. Taking all of the evidence into account, the interpretation of local rainfall trends, and perhaps even more so of rainfall extremes, should be treated with caution, despite the substantial number of analyses available. Thus, 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[1]**: 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. The IPCC AR5 notes that it is *very likely* that specific humidity has increased since the 1970s, a result reflected in the Jordanian and Egyptian National Communications. On a global scale, the IPCC AR5 states 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 presented for the Levant appear consistent with the statements of the IPCC, while others do not.
- **Oceanic parameters:** The only oceanic parameter for which any number of analyses has been obtained in the region of interest has been sea level. With the complexity of the Mediterranean system, sea level rises in the basin do not necessarily follow those of the global ocean and do appear to be variable in time. Equally, the limited evidence on sea-surface temperatures suggests variability in time.

[139] IPCC AR5: "An extreme weather event is an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., drought or heavy rainfall over a season)."In this document the word "extreme" is used with caution, not to imply any impact but only within the context of the IPCC definitions listed in Appendix 3.

1 Introduction

The objectives of this analysis are to:

- Provide an assessment of historic trends in the State of Palestine's climate and thereby contextualise consideration of the climate sensitivity of potential vulnerabilities across the State of Palestine's various sectors in preparing the National Adaptation Plan (NAP)
- Identify multi-year trends in climate parameters, such as temperature, rainfall, length and magnitude of heat waves, and extent of drought
- Distinguish between, and provide attribution of, natural variability, i.e. variability (including trends and cycles) on any timescale resulting from natural causes, and anthropogenically caused long-term trends, the latter representing the UNFCCC definition of climate change.

Difficulties encountered in the records themselves in achieving these objectives include:

- The limited length of records, gaps in records, errors in records, unrecorded changes of instruments and instrument locations, and non-availability of digitised records
- Incorrect exposure of recording instruments, either throughout the record or for part of the record, perhaps through subsequent modifications to the local environment (e.g., erection of new buildings or growth of vegetation).

It is not intended that this historic trend analysis should be used as the basis for establishing a baseline for future climate projections that can be used to inform assessment of exposure and prioritization of adaptation actions in preparing the State of Palestine's NAP. It should also be noted that historic trends need not necessarily continue in the future under climate change.

Trends are covered in Sections 2, 3 and 4, followed by an overall summary. Global analyses are reviewed from the perspective of the Levant, then consideration is given to official national analyses for countries surrounding the State of Palestine, as prepared for submission to the UNFCCC, and finally regional analyses printed variously in peer-reviewed and other publications are addressed.

1.1 Discussion of uncertainties

Calculated trends may critically depend on the length or the selected period of the record. This is particularly the case for rainfall for which there may be inherent cycles of some form that may appear as trends over specific intervals of analysis. Even where cyclical behaviour is not apparent, trends in rainfall may appear for a number of years for reasons that may be difficult to ascertain and may then reverse, equally without obvious cause.

Temperature is the most straightforward of all climate parameters to submit to trend analysis. This is because temperature tends towards statistically normal distributions and homogeneity over large areas, and adheres to basic laws of physics. This homogeneity and adherence permits ready completion of temperature records using proxies from surrounding stations. False positive trends may be found for locations where towns and cities have developed progressively, but can be addressed by available corrections. Analyses of amalgamated temperature parameters, such as the length of heat waves, however, suffer from the relatively few occurrences within the data record with which to determine any trends.

Trends in rainfall are more difficult to analyse than those for temperature. Rainfall is not only non-normally distributed but is also spatially variable, with trends perhaps dependent on the location of a specific gauge. In the case of the State of Palestine, rainfall is often convective and is controlled to an extent by orography. Thus, geographically-close gauges may provide disparate recordings of any particular event and it is plausible that a slight change in predominant wind direction might result in a rainfall trend at particular locations in the country. Other issues include errors and inconsistencies resulting from the design of each specific gauge, the effects of wind on gauges, and misinterpretation while preparing manual recordings. Difficulties in measuring rainfall trends reduce somewhat as the area of concern is expanded to include more gauges, although this may be counter to the desire to observe trends at specific locations. The issue of possible cycles in rainfall in the Levant is certainly a complicating factor that might affect not only the identification of trends in the rainfall itself, but also trends in amalgamated parameters, such as drought frequency and intensity.

The issues summarised above variously affect calculation of trends in additional parameters, such as in specific humidity, wind, sunshine, etc.

Separation of natural variability from anthropogenically-imposed change is a complex issue. It is normally approached through the use of global climate models in which simulations are compared that include anthropogenic emissions (and perhaps land-surface changes) on the one side but not on the other. The use of climate models introduces further uncertainties, and highest confidence in attributing climate trends to anthropogenic activities occurs for temperatures, most specifically on the largest scales. For the more complex parameters, such as rainfall, the technology provides less certainty in attribution, with that certainty reducing further as the spatial scale declines.

One issue rarely mentioned within the context of climate change is that while, as a general rule, temperature would be expected to increase with atmospheric greenhouse-gas concentrations, equivalent unidirectional linear trends are not necessarily certain with other parameters, such as rainfall. The physical dynamics of rainfall, on both the large and the small scales, is so complex that it is conceivable that any anthropogenically-forced changes in rainfall at a given location might not necessarily be consistently in one direction, perhaps reversing at certain times in the future.

1.2 Attribution according to the IPCC AR5

At this time, it is not possible to attribute directly to anthropogenic causes any observed trends in temperatures or rainfall, or any related measures, over areas the size of the State of Palestine, either in part or in full. However, a few broad statements may be made with regard to the results presented in the AR5. The IPCC (IPCC 2013) always attaches defined *confidence* terminology to statements made and these are summarised below. Details of the meaning of all terms used relating to *confidence* and *likelihood* are provided in Appendix 1.1, which should be considered as the terms used by the IPCC are open to misinterpretation.

Temperatures

For global temperature rises, the IPCC attributes *high* confidence that at least 50% of the warming from 1951 to 2010 is anthropogenically forced, and categorises it as either *very likely* or *extremely likely* dependent on the specific measure used. At the continental level, it is *likely* that there is an anthropogenic contribution to warming since the middle of the 20th Century, with *high* confidence.

Other temperature measures

According to the IPCC, it is *very likely* that changes in the frequency and intensity of daily temperature extremes at the global (but not necessarily the continental or below) level since the mid-20th Century are related to anthropogenic forcing, with *high* confidence. It is also *likely* that heat waves have increased in frequency for the same reason, but it is difficult to be specific regarding locations below the continental scale.

Rainfall

There is *medium* confidence by the IPCC that there have been anthropogenically-forced changes to global land-surface rainfall patterns since about 1950, in particular increases in mid-to-high latitudes of the Northern Hemisphere. Changes over this Northern Hemisphere area are relatively straightforward to attribute because of the quantity and quality of data available; for other areas with more sparse records no equivalent attribution is possible currently.

Other rainfall measures

For limited areas with sufficient high-quality data, there is *medium* confidence of an anthropogenically-related increase in heavy rainfall events since about 1950. There is only *low* confidence in attributing any changes in drought frequencies or intensities to anthropogenic causes.

Sea surface temperatures and sea level

It is *very likely*, with *high* confidence, that there are anthropogenic influences on raising sea-surface temperatures and sea level itself since the 1970s.

1.3 A word on the use of the word "extreme"

"Extreme weather", or "climate extremes", or similar phrases, are often heard in discussion. Working Groups I and II of the IPCC in the AR5 provide the following generic definition:
"An extreme weather event is an event that is rare at a particular place and time of year. Definitions of *rare* vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th*percentile*of a *probability density function* estimated from observations. By definition, the characteristics of what is called *extreme weather* may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an *extreme climate event*, especially if it yields an average or total that is itself extreme (e.g., *drought* or heavy rainfall over a season)."

It is a moot point whether an event within the 10th or 90th percentiles might be considered "rare", as statistically they would occur on average one day in ten. The word 'extreme' has been used rather loosely at times, frequently referring to any event that has negative impacts on society, and within that context statements of the type that "extreme events will become more frequent under climate change" become attractive from a political perspective but are difficult to interpret in quantitative terms.

The IPCC (2013) has defined a set of "extreme" events, reproduced in Appendix 1.3, that represent an attempt to identify individual events or sequences of events that could result in greater impacts in the future, notwithstanding any adaptation or other aspects that might reduce any such impacts. The advantage of IPCC's definitions of these events is that they can be recognized in quantitative form using any quality observational record or from outputs of climate models. A disadvantage is that there is no absolutely direct relationship between these events and harmful impacts, and harmful impacts may not necessarily occur only under such events. Furthermore, certain of the definitions, such as Consecutive Dry Days (CCD), may not be appropriate when applied to examine drought durations in areas with extended seasonal dry periods. It is not possible, of course, to attribute any specific impactful event directly to climate change.

In this document the word "extreme" is used with caution, not to imply any impact but only within the context of the definitions listed in Appendix 1.3.

2 Global analyses of observed trends

Global analyses, have the advantage of having a background of thorough data quality control, rigorous statistical procedures and, in some cases, use of model input to complete fragmented records. One disadvantage, which some may see, is that global analyses tend to provide information on a relatively large scale, thus failing to provide some of the smaller-scale detail that is often desired. In practice, as suggested earlier, working on the larger scales is generally preferable, although, as will be seen, it does not guarantee consistency in results. It should be noted that the regional quality of these datasets improves with the quality and quantity of information subsumed, thus, overall quality is reduced inevitably in areas with fewer and/or lower quality observations.

The results summarised in the tables in this section for Palestine are interpreted from the charts provided in the latest IPCC (2013) Assessment, AR5. Often the trends presented differ across the two regions of the charts that cover Palestine: Gaza is certainly included within the southern region but the West Bank is close to the border of the southern and northern regions and, hence, results for both are provided in the following tables when different for these two regions. The full titles of datasets referred to only by acronyms in the tables throughout Section 2 are summarised in Appendix 1.2

2.1 Temperature and related parameters

Table 7: Temperature trends interpreted from charts in IPCC's AR5

Dataset[140]	Period	Trend °C	Statistical significance
HadCRUT4	1901-2012	+1.0 to +1.25 (over period)	10% level
MLOST	1901-2012	+0.8 to +1.0 (over period)	10% level
GISS	1901-2012	+0.8 to +1.0 (over period)	10% level
MLOST	1911-1940	+0.2 to +0.3/decade	10% level
MLOST	1951-1980	-0.1 to -0.2/decade	Not significant[141]
MLOST	1981-2012	+0.5 to +0.6/decade	10% level

All analyses in Table 8are consistent in indicating that average temperatures have risen over the 112 years, 1901-2012, but there is some disagreement over the extent of the rise. According to the breakdown into shorter periods for the MLOST dataset, a period of (non-significant) cooling over Palestine in the later middle part of the 20th Century (observed also in global averages) was set between two periods of warming. The first period of warming over 1911 to 1940 is probably, only in limited terms, directly ascribable to anthropogenic influences, amongst others. For the second, relatively more rapid, period of warming some of the change can be attributed to anthropogenic causes.

Table 8: Trends in cold and warm days and nights interpreted from charts in IPCC's AR5

Parameter	Dataset[1]	Period	Trend in frequency	Statistical significance
Cold nights	HadEX2/ECA	1951-2010	-4 to -8/decade	10% level
Cold days	HadEX2/ECA	1951-2010	0 to -4/decade	10% level
Warm nights	HadEX2/ECA	1951-2010	+4 to +8/decade	10% level
Warm days	HadEX2/ECA	1951-2010	+4 to +8/decade	10% level
Warmest day of the year	HadEX2/ECA	1951-2010	0 to -0.25/decade in north; -0.5 to -0.75 in south	Not significant
	HadGHCND	1951-2010	0 to +0.25/decade	Not significant in north; 10% level in south

"Cold" and "warm" relate to temperatures in the lower 10th and the upper 90th percentiles respectively calibrated across the period 1961 to 1990 (see Appendix 1.3). It should be noted that all of the temperature-related analyses in Table 9incorporate the mid-century period of cooling, something that will affect the outcomes, and a factor that may account for the sign difference in the two "Warmest day of the year" analyses. It may further enhance the remaining positive figures in Table 9. Otherwise all analyses suggest that the recent warming has been observed accordingly in reduced frequencies of coldest and increased frequencies of warmest days and nights. It should be noted, however, that the IPCC (2013) AR5 accords a generic *medium* confidence to the trends in night-time temperatures and *low to medium* confidence to those in daytime temperatures (as discussed above, with definitions in Appendix 1.1).

[140] Full titles of datasets full titles of referred to only by acronyms here are summarised in Appendix 1.2.
[141]In these tables,"Not significant" indicates that trends do not reach statistical significance at the 10% level.

2.2 Rainfall and related parameters

Table 9: Rainfall trends interpreted from charts in IPCC's AR5

Dataset[142]	Period	Trend mm/year/decade	Statistical significance
GHCN	1901-2010	+5 to +10 in north; -5 to -10 in south	Not significant in north; 10% level in south
GPCC	1901-2010	0 to +2.5 in north; up to -25 to -50 in south	Not significant in north; 10% level in south
GHCN	1951-2010	+2.5 to +5	Not significant
GPCC	1951-2010	-2.5 to -5	Not significant

Values in Table 10illustrate the uncertainties involved in assessing rainfall trends. For the extended period 1901 to 2010, analysis of both datasets suggests that the climate has become drier in the south but wetter in the north, although there are substantial differences between the magnitudes of the calculated trends. By comparison, trends assessed for the more recent period of 1951 to 2010 are of opposing sign in the two datasets. Caution must be used in interpreting all of these analyses, as all represent multi-decadal periods that incorporate many shorter-term variations. It has been suggested that rainfall cycles over the region span either 5 to 6 years (Felis and Rimbu, 2010) or 8 to 10 years (Richard and Isaac, 2012) (see also the review of the existence, or non-existence, of rainfall cycles in Goldreich, 2012), and the selection of an analysis period may influence the results, dependent upon the cycles within the period.

Table 10: Trends in impactful rainfall events and other related parameters interpreted from charts in IPCC's AR5

Parameter	Dataset[3]	Period	Trend	Statistical significance
Rain from days with >95th Percentile (R95p[143])	HadEX2/ECA	1951-2010	0 to +5%/decade	Not significant
Daily precipitation intensity (SDII)	HadEX2/ECA	1951-2010	0 to -5%/decade in north; 0 to +5%/decade in south	10% level in north; Not significant in south
Frequency of annual maximum consecutive dry days (CCD)	HadEX2/ECA	1951-2010	0 to +5%/decade	Not significant
Hydrological intensity (HY-INT)	Various (see Giorgi *et al.* 2011)	1976-2000	+0.2 to +0.4	Significance not assessed
Specific humidity	HadISDH/NOCS	1973-2012	+0.1 to +0.15 g/kg/decade	10% level
Vertically-integrated water vapour over eastern Mediterranean	SSMI	1998-2012	+0.5 to +1.0 g/kg/decade	10% level

[142]Full titles of datasets full titles of referred to only by acronyms here are summarised in Appendix 1.2.
[143]Acronyms in this table, such as "R95p", are the standard abbreviations used by the IPCC (2013) for these statistics as listed in Appendix 1.3

Values in Table 10may require interpretation beyond that given in Appendix 1.3. The first three are all standard measures used by the IPCC to assess impactful rainfall events.

R95p is a measure of the total annual contribution to precipitation from the wettest 5% of days (based on 1961 to 1990) calculated across the record period. A positive trend in this measure indicates that there are more days of heavier rainfall later in the period. The trend is positive across Palestine, but not significantly so. The IPCC Working Group I (WGI) accords a generic *low* confidence to any changes because of insufficient evidence and spatially varying trends.

The daily precipitation intensity (SDII) is the average daily rainfall calculated across only those days with more than 1mm of rain. As with R95p, an increase in SDII with time suggests that rainfall is progressively becoming heavier on a daily basis. In the north, the SDII measure is indicative of reducing rainfall intensity over the 1951 to 2010 period, that reduction being significant at the 10% level. In the south, rainfall intensity is increasing according to SDII, although non-significantly so, and for this region the measure is consistent with R95p (but note that R95p and SDII measure rainfall intensity differently and it is conceivable that they may indicate opposing trends). As above, IPCC WGI accords *low* confidence to any changes.

Frequency of annual maximum consecutive dry days (CCD) is a measure of drought, being calculated on an annual basis from the number of days in the longest successive run of days each with less than 1mm of rainfall. A positive trend in CCD might be suggestive that drought periods are progressively extending in length, as could be the case here, although non-significantly so. However, in the type of climate existing for Palestine, CCD will normally pick up the length of the usual dry summer period, rather than any drought spell during the rainfall season. Hence, the positive trend is most likely suggesting that the summer dry spell is extending in length, or, inversely, that the rainfall season is shortening, which may, or may not, be an indicator of increasing drought. The IPCC WGI's generic assessment is for *medium* confidence in any increase.

Hydrological intensity (HY-INT) is a multi-valued measure based on the length of dry spells and on rainfall intensity, and its interpretation is ambiguous. According to Giorgi *et al.* (2011), the originators, HY-INT can be interpreted as "the average accumulated wet spell precipitation amount multiplied by the ratio between dry and wet spell mean duration. An increase in HY-INT would thus denote an increase in either or both of these quantities". Hence, an increase in HY-INT, as indicated over 1976 to 2000 for Palestine, can be interpreted as an increase in one or both of the length of drought or the intensity of impactful rainfall events. Assuming that both apply here then the HY-INT might be consistent with CCD in indicating an increase in the length of drought, although the same caveats as above apply, and an increase in heavier rainfall events, as suggested by R95p and SDII, but the latter only in the south. It should also be noted that HY-INT has been calculated across a substantially different period to the other measures, a fact that may affect inter-comparability of results.

The two measures of atmospheric water content, specific humidity and vertically-integrated water vapour, both suggest that the atmosphere over Palestine is progressively becoming moister. In part, this may be related to warming of the eastern Mediterranean and increased evaporation from it. An increase in atmospheric water content does not necessarily, however, translate to increased rainfall, as other factors determine the conversion of some of this moisture into rainfall. Thus, it is not possible at this stage to suggest that this trend is supportive of any trend in rainfall itself.

2.3 Sea level and hydrology

In a basin-wide assessment, IPCC Working Group II (WGII) in the AR5 indicates that sea-surface temperatures have been increasing but it is only that of the warmest month that is statistically significant at 0.11°C/decade over the period 1950-2009, 'large fluctuations' prior to 1980 eliminating significance in other measures. *High* confidence is ascribed to the increase. There is also evidence for increases in salinity, in acidity and in sea level in the basin, often at *medium* confidence, although none of these results are specific to the eastern coastline.

There do not appear to be any specific references to trends in hydrological parameters in the region in the AR5. Indeed, the impression has been developed that the extent of literature available for the region is rather less than that for the remainder of Asia.

3 Official national analyses

Climate trends, as assessed at a national level in documents submitted to the UNFCCC, are reviewed below for countries in the vicinity of Palestine, namely Lebanon, Jordan, Israel and Egypt. None of these countries have a National Adaptation Program of Action (NAPA) posted on the UNFCCC website (and, of course, given the stage of the process, none has posted a National Adaptation Plan, NAP), so the following is based solely on National Communications (NCs). All have posted at least two NCs. Syria has been excluded from this assessment, as it has only provided greenhouse gases (GHG) emissions inventories as part of an NC. In the tables in this section, NCs are numbered as NC1, NC2, etc. with year of publication, as on the UNFCCC site. The following NCs do not incorporate any specific analyses of trends and so are excluded from the tables:

- Lebanon NC1 1999, although it includes the statement: "However what is used here does support the picture emerging from precipitation curves, namely, that the current trend is towards more arid conditions".
- Jordan NC1 1997, although it includes the statement: "Consequently, the rise in global temperature that is predicted due to climate changes will result in less rainfalls, with a disastrous impact on Jordan."
- Jordan NC3 2014, which introduces no new trend analyses following the NC2 but in the Executive Summary (p20) does mention statistically significant increases in temperatures, rainfall decreasing at 1.2mm/year (with decreases throughout the year except during the dry season), significant increases in relative humidity and decreases in evaporation, and a significant decrease in the number of days with dust storms.
- Israel NC2 2010, which focuses mainly on the future apart from one indirect mention of historical temperature trends, as summarised in Table 11below.

3.1 Temperature and related parameters

Table 11: Temperature trends assessed at a national level in National Communications

Country	Report	Period	Parameter	Trend
Lebanon	NC2 2011	Beirut 1981-2000	Absolute annual highest temperature	Increasing
Jordan	NC2 2009	19 stations 1961-2005 (but not clear if all stations cover this period)	Mean	Increasing at all stations (significant[144] at 11)
			Maximum	Increasing at 16 stations (significant at 9), decreasing at 3 (none with significance)
			Minimum	Increasing at 18 stations (significant at 14), decreasing at 1 (not significant)
Israel	NC1 2000	Varies – not original analyses for the NC but summarised results from independent studies	Average	Warming, mainly in central and north, but cooling in south (Ben-Gai *et al*., 1998a, 1999). No warming according to Wigley (1992) and over 1964-1994 according to Ben-Gai *et al*.,1999)
			Maximum and Minimum	Decreasing in cool season but increasing in warm season (Ben-Gai

[144]"Significant" refers to statistical significance, although the level of significance is not always stated in the documents.

Country	Report	Period	Parameter	Trend
				et al., 1999 – analysis over 1964-1994); also increased extreme cold and warm temperatures (Ben-Gai *et al*., 1998, 1999)
Israel	NC2 2010	1948-2002	Mean	Statistically significant increase over period of 1°C in Jordan Valley
Egypt	NC1 1999	Not stated	Mean	Increased overall by about 40% of global value
			Maximum	Decreasing at 0.02°C to 0.06°C/year over north and part of south
			Minimum	Increasing at up to 0.1°C/year
Egypt	NC2 2010	1961-2000	Mean	Increasing at 0.017°C/decade
			Maximum	Increasing at 0.34°C/decade
			Minimum	Increasing at 0.31°C/decade

In general these analyses, as might be expected, suggest warming, although the rate of change is subject to uncertainty (the indication in the Egypt NC1 of a change that is 40% of the global average is not unreasonable, given that the major temperature changes have been over polar regions). That said, those analyses suggesting there has been no change, or a cooling, or differential changes in maxima and minima, should not be discounted; most may be consistent and some may be indicative of temporary trends.

Table 12: Trends in temperature-related parameters assessed at a national level in National Communications

Country	Report	Period	Parameter	Trend
Lebanon	NC2 2011	Beirut 1981-2000	Hot summer days (>30°C and >35°C)	Increasing
			Tropical nights (>20°C and >25°C)	Increasing faster than hot summer days
			Diurnal temperature range	Decreasing – attributed to faster increase in tropical nights than in hot summer days (see above)
Jordan	NC2 2009	19 stations 1961-2005 (but not clear if all stations cover this period)	Sunshine duration	Increasing at 1 station (not significant), decreasing at 15 (significant at 10)
Egypt	NC2 2010	1961-2000	Days with maxima >45°C	Increasing in the interior

These results, in general, are consistent with overall increasing temperatures. The suggested decrease in sunshine duration at a number of Jordanian stations, and by implication an increase in cloud, is not necessarily inconsistent with an increase in temperature.

3.2 Rainfall and related parameters

Table 13: Rainfall trends assessed at a national level in National Communications

Country	Report	Period	Trend
Lebanon	NC2 2011	Beirut 1981-2000	Decreasing
Jordan	NC2 2009	19 stations 1961-2005 (but not clear if all stations cover this period)	Decreasing at 13 stations (significant at 2), increasing at 6 (none with significance)
Israel	NC1 2000	Varies – not original analyses for the NC but summarised results from independent studies	Decreasing, mainly in centre and north (Steinberger and Gazit-Yaari, 1996, Ben-Gai *et al*., 1998b); countrywide decreases (Paz *et al*., 1998 – suggest caused by intra-seasonal changes; Alpert *et al*., 2000); decreases only along coastal zone (Sharon, 1993); increasing along southern coastline and northern Negev (Otterman *et al*., 1990; Ben-Gai *et al*., 1993; Sharon, 1993; Sharon and Angert, 1998). See also “Start of winter rains” under Israel in Table 14.
Egypt	NC1 1999	Not stated	Increasing over western coast by about 3mm/year
Egypt	NC2 2010	1961-2000	Increasing over coast by 0.76mm/year

The rainfall picture is not a consistent one of decreasing trends, with increases assessed especially over several coastal areas. For Israel, for which the greatest number of independent analyses is included in Table 13, there appears to be some inconsistency in the results, perhaps at least in part because of dependency upon the selected analysis periods.

Table 14: Trends in rainfall-related parameters assessed at a national level in National Communications

Country	Report	Period	Parameter	Trend
Lebanon	NC2 2011	Beirut 1981-2000	Maximum rainfall over a 5-day period	Decreasing
			Maximum length of consecutive dry days (<1mm)	Increasing
			Average rainfall per rain day (>1mm)	No trend
Jordan	NC2 2009	19 stations 1961-2005 (but not clear if all stations cover this period)	Relative humidity	Increasing at 15 stations (significant at 8), decreasing at 4 (none with significance)
			Evaporation	Decreasing at 13 stations (significant at 10), increasing at 2 (no significance)

Country	Report	Period	Parameter	Trend
Israel	NC1 2000	Varies – not original analyses for the NC but summarised results from independent studies	Start of winter rains	Became delayed over 1976-2000 (Kutiel, 2000), mainly through lower October/November rainfall; increased October rainfall (Steinberger and Gazit-Yaari, 1976).
			Rainfall intensity	Increasing frequency of high-intensity rains and decreasing frequency of moderate and weak intensity rains (Alpert *et al*., 2000)
			Evapotranspiration	Decreasing (Paz *et al*., 2000)
Egypt	NC1 1999	Not stated	Cloud cover	Decreasing (except over part of coast) at 0.02 octas/year
			Relative humidity	Increasing at up to 0.35%/year
			Surface pressure	Increasing at up to 0.05hPa/year
Egypt	NC2 2010	1961-2000	Relative humidity	Increasing at 0.18%/year
			Surface pressure	Increasing at 0.026hPa/year
			Sand storm frequency	Decreasing
			Hazy days frequency	Increasing

As a broad summarisation of these results, it might be suggested that drought conditions are becoming more prevalent, perhaps through delayed starts of the winter rains (and consistent with the increasing surface pressure over Egypt), and possibly also with an increasing frequency of higher-intensity rainfalls.

3.3 Oceanic parameters

Table 15: Sea-surface temperature trends assessed at a national level in National Communications

Country	Report	Period	Parameter	Trend
Israel	NC1 2000	Not stated	Surface temperature	Decreasing (Kutiel and Bar-Tuv, 1992; Paz *et al*., 1998, 2000)

In IPCC's AR5 (2013), it is noted that sea-surface temperatures in the eastern Mediterranean were somewhat variable prior to 1980 and, thus, a decrease in temperatures is plausible dependent upon the analysis period selected.

4 Regional and national analyses of observed trends

A literature search has identified numerous papers dealing with regional climate trends in and around Palestine. A representative selection of these papers is summarised below. Trends have been treated in these documents from a variety of perspectives, covering various parameters and assessing either trends in climate parameters themselves or trends in impacts of changes in these parameters. The geographical locations of the studies vary but, given the relative homogeneity of the climate across the larger region, it is reasonable to incorporate studies undertaken in climates akin to those in the West Bank and Gaza in the tables in this section. Thus studies for Lebanon, Jordan, Syria, Israel, Saudi Arabia and Egypt have been included. Techniques used also vary, from simple estimates of changes using tabulated data to sophisticated statistical analyses; all estimates have been summarised as presented in each paper without critiques of methodologies. Where statistical significance is tested but not found then "not significant" is used; not all authors have tested for statistical significance.

In the tables below, reviews are provided by parameter based on the literature search. Databases used are omitted. References are listed from the top in each table in order such that, approximately, the details cover geographical locations starting in the south and moving northwards.

4.1 Temperature and related parameters

Table 16: Temperature trends assessed in peer-reviewed and other publications

Reference	Location	Period	Trend
Almazroul *et al*., 2012	Saudi Arabia	1979-2009	+0.72°C/decade in dry season, +0.51°C/decade in wet season
Ajjur, 2012	Gaza	1976-2006	Decreasing trends in both of average daily maximum and minimum temperatures
Richard and Issac, 2012	Gaza	1997-2007	No trend as estimated from their Fig. 10 - annual
	Jerusalem	1964-2011	+0.1°C/decade estimated from their Fig 2 - annual
Asad, 2014	Jericho	1969-2008	+0.33°C/decade estimated from diagram
Kafle and Bruins, 2009	Israel – records of 39 stations assessed but results only for 12 presented	1970-2002 (one station only 1975-2002)	Increasing between +0.22°C/decade and +0.51°C/decade; all significant at 2.5% level or higher
Donat *et al*., 2014	Stations with high quality records in the Arab region: number of relevant stations – Egypt 2, Saudi Arabia 7, Syria 2, Jordan 2	1966-last record and 1981-last record (latest 2011)	For average daily maxima and minima trends, significant at 95% level, up to >0.9°C/decade; stronger trends in later period
Lionello *et al*., 2012	Entire Mediterranean region	1951-2005	Increasing in all seasons but not significant (90% level) except MAM Gaza (~+0.2°C/decade), JJA all of Palestine (~+0.15°C/decade)

Reference	Location	Period	Trend
			and SON Gaza (~+0.1°C/decade)
Khatib *et al.*, date unknown	Eastern Mediterranean [Note: original paper in colour but available copy in B/W – spectral analysis has been used to assist interpretation of figures]	1901-2003 based on 0.5°x0.5° latitude/longitude data set from Climatic Research Unit	In general decreases of -0.2°C to -0.6°C in the Levant region; increases over Turkey and east of Levant in Saudi Arabia and Iraq. In March and July temperatures have decreased.

As previously, the general picture is one of increasing temperatures but with a few analyses indicating decreasing or no trends. The decreasing trend for Gaza according to Ajjur (2012) is not readily explained, given the consistency of increases in other analyses for similar assessment periods, other than through possible low-quality data. The century-long temperature decrease, as identified by Khatib *et al.*, (unknown date), is also problematic in contrast to the trends listed for a similar period in Table 7(note that the data set used by Khatib and collaborators is not the same as those in Table 7, but does bear a close relationship with one of those data sets).

Table 17: Trends in temperature-related parameters assessed in peer-reviewed and other publications

Reference	Location	Parameter	Period	Trend
Donat *et al.*, 2014	Stations with high quality records in the Arab region: number of relevant stations – Egypt 2, Saudi Arabia 7, Syria 2, Jordan 2	Frequencies of cold days (TX10p) and cold nights (TN10p)	1966-last record and 1981-last record (latest 2011)	Decreasing at >4%/decade, significant at 95% level, stronger trends in later period
		Frequencies of warm days (TX90p) and warm nights (TN90p)		Increasing at >4%/decade, significant at 95% level, stronger trends in later period
		Warmest day of the year (TXx) and coldest night of the year (TNn)		For TXx warming at up to >0.6°C/decade, significant at the 95% level at some, not all, stations, stronger trends in later period; details for TNn not given but “warming at most stations”
		Durations of warm spells (WSDI) and cold spells (CSDI)		WSDI increasing by >5days/decade but mainly in later period; weak, non-significant, decreases in lengths of cold spells
Zhang *et al.*, 2005	Stations with high quality records in the Middle East; number of relevant stations – Israel 4, Syria 5, Jordan 2	Frequencies of cold days (TX10p) and cold nights (TN10p)	1950-2003 and 1970-2003	No trends in longer period; decreasing at 0.5-1.0%/decade in shorter period, significant (5% level) in Gaza area for TX10p and in West Bank for TN10p; seasonal trends for shorter period and all decreasing at 0.5-1.0%/decade

Reference	Location	Parameter	Period	Trend
				(slower in MAM), significant only in JJA
		Frequencies of warm days (TX90p) and warm nights (TN90p)		No trends in longer period; increasing at 0.5-1.0%/decade in shorter period, significant (5% level) (but perhaps not in Gaza area for TN10p)
		Annual daily maximum (TNx) and minimum (TNn) values		No trends in longer period; increasing trends in shorter period at up to +0.5°C/decade but generally not significant (5% level)
Lionello *et al*., 2012	Entire Mediterranean region (using E-OBS [Haylock *et al*., 2008] and ERA-40 [Efthymiadis *et al*., 2010])	Coldest 5% of nights (TN5n)	1958-2008	No trends in DJF or JJA according to E-OBS; significant (5% level) decrease only in JJA at 1 day/decade according to ERA-40
		Hottest 5% of days (TX95n)		No trends in DJF or JJA according to E-OBS; significant (5% level) increase only in JJA at >2 days/decade according to ERA-40

Decreasing numbers of cold days and nights, increasing numbers of warm days and nights and of warmest days and lengths of warm spells, etc., all point to a general pattern of increasing temperatures. It is of interest, therefore, that the high-quality observational database, E-OBS, suggests that no trends in temperature have occurred.

Table 18: Rainfall trends assessed in peer-reviewed and other publications

Reference	Location	Period	Trend
Almazroul *et al*., 2012	Saudi Arabia	1979-1993	Not significant increase
		1994-2009	Significant decrease, -35.1mm/yr/decade in wet season, -5.5mm/yr/decade in dry season
Ajjur, 2012	Gaza	1990-2010	Decreasing
Yatagai, 2011	Gaza and Israel coastal stations (amongst broader analysis)	1971-2004	Decreasing (not significant) at all stations but 1 in Israel in DJF; similar pattern in individual winter months other than January when for most stations rainfall is increasing (not significant)
Al-Rimmawi *et al*., 2010	8 stations around Ramallah	Varies; earliest 1953, latest 2007	Increase at one station, decrease at two stations, no trend at five stations
	Average of 8 stations around Ramallah	1968-1996	Decrease -1.4mm/yr/decade

Reference	Location	Period	Trend
	Average of 49 stations in West Bank	1968-1996	Increase +28.4mm/yr/decade
Richard and Issac, 2012	Jerusalem	1845-2011	Decrease -14mm/yr/decade
		1964-2011	Decrease -33mm/yr/decade
Asad, 2014	Jerusalem	about 1855-about 1995	No trend shown but diagram suggests increasing rainfall, in contradistinction to Richard and Issac above
	Hebron	1970-2015	Chart suggests negative trend
	Tulkarm	1975-2015	Chart suggests possible weak negative trend
Messerschmid, 2012	Jerusalem	1960-1998	Increasing trend
		1969-2002	No trend
		1967-1991	Decreasing trend
Kushnir and Stein, 2010	Jerusalem	~1845-~1997	20-year low pass filter based on 1961-1990 climate: extended wet period ~1875-~1920, extended dry period ~1920-~1970 (wetter period since); increasing rainfall ~1960-~1985, decreasing ~1985-~1997
	12 long-term stations across Egypt, Israel, Syria, Jordan and Lebanon	Varies by station, starting ~1840, ending ~2010, most cover ~1950-~2000	15-year running filter on individual stations illustrates some spatial variations in time, but general dry period at all stations centred on the 1950s, wet period at most stations across most of the 1960s into the early 1980s, and mixed since with drier conditions in general at Tel Aviv and Beirut but wetter in general at Hama (Syria)
Aliewi *et al.*, 2013	Nablus	1975-2005	Increasing trend
	Northern West Bank	1961-1990	Decreasing trend
	Southern West Bank	1961-1990	Decreasing trend
	Jerusalem	1961-1998	Increasing trend
	6 West Bank stations	1961-1989	Increase at 2 stations, decrease at 3 stations, no trend at 1 station
Ziv *et al.*, 2013	Israel (including West Bank but not Gaza)	1952/53-2009/10	Averaged over entire area decreasing at -0.1% to -0.5% per decade (varies according to measure) – not significant
		1974/75-2009/10	Averaged over entire area decreasing at −1.7% to −2.9% per decade (varies according to measure) – not significant; greatest in NE (>−5mm/yr) and generally over the hills and along the rift valley; lesser decreases over coastal regions; increases over a small area of central Israel (not

Reference	Location	Period	Trend
			significant) [but in general rainfall increases to ~1990 with decreases thereafter] No trends in SON and DJF seasonal rainfalls, but statistically significant decrease in MAM at >−15%/decade
Givati and Rosenfeld, 2013	Clusters of gauges in northern, coastal central and coastal southern Israel (north of Gaza), and in Golan Heights	1950-2009	Decreasing over all stations and in all clusters apart from increasing in the southern cluster; none reaching statistical significance
Rinat and Haaretz Correspondent (2008)	Israel	Not stated	No overall trends, perhaps slight decrease in north and increase in south; decreasing over Lake Kinneret basin
Steinberger and Gazit-Yaari, 1996	Israel (99 stations)	1960/61-1990/91	In the main decreasing at northern stations, increasing at southern stations, but in general no statistical significance (at 7 stations 95% level, at 12 stations 90% level)
Kafle and Bruins, 2009	Israel – records of 39 stations assessed but results only for 12 presented	1970-2002 (one station only 1975-2002)	Increasing at 3 out of 4 coastal stations, but none significant; decreasing at most inland stations, but only at one significant at 2.5% level (−9.6mm/decade); the trend at the single inland station with increases, not significant, is +1.24mm/decade. At most stations the correlation between temperature and rainfall is negative, significantly at least at the 5% level at 5
Dahamsheh, A.and Aksoy, H., 2007	13 stations across Jordan	1953-2002	No significant trends or jumps
Donat *et al.*, 2014	Stations with high quality records in the Arab region: number of relevant stations – Egypt 2, Saudi Arabia 7, Syria 2, Jordan 2	1966-last record and 1981-last record (latest 2011)	Decreases at up to >−20mm/year/decade for both periods but not significant; at one station, possibly in Jordan, increasing during the later period at >+20mm/year/decade but not significant
Zhang *et al.*, 2005	Stations with high quality records in the Middle East; number of relevant	1950-2003 and 1970-2003	No trend for longer period; slight, non-significant, increasing trend in shorter period

Reference	Location	Period	Trend
	stations – Israel 4, Syria 5, Jordan 2		
Lionello *et al*. 2012	Entire Mediterranean region	1951-2005	No statistically significant trends (90% level) in seasonal rainfall except JJA increasing in Gaza (~+5mm/season/decade) and SON increasing in north (including West Bank) (~+10mm/season/decade)
Khatib *et al*., date unknown	Eastern Mediterranean (Note: original paper in colour but available copy in black and white – spectral analysis has been used to assist interpretation of figures)	1901-2003 based on 0.5°x0.5° latitude/longitude data set from Climatic Research Unit	Authors state that changes are in range −60mm to +60mm over the century, but even with the use of spectral analysis it is not possible to assess the direction of change over Palestine. However in March rainfall has increased.

Perhaps there should be no surprise that more authors have focused on assessments of rainfall trends than on those for temperatures. Nevertheless, there is only limited consistency between the results, with both decreasing and increasing trends in rainfall detected; differences of analysis periods are likely to have been responsible, at least in part, for some of the differences. One possible pattern that does emerge from these analyses is that of a decreasing trend in rainfall in the north but an increasing one in coastal areas, including Gaza, in the south. Only one paper of those reviewed mentions an alternative to linear trends in rainfall; Richard and Isaac (2012) suggest that a step reduction took place in Jerusalem in the 1920s, but have not detected any others since.

Table 19: Trends in rainfall-related parameters assessed in peer-reviewed and other publications

Reference	Location	Parameter	Period	Trend
Asad, 2014	Nablus	No. of rain days	1975-2013	Chart suggests negative trend
	Palestine	Drought frequency	Past 20 years	Unsupported statement "is increasing"
Aliewi *et al*., 2013	Nablus	No. of rain days	1975-2005	Decreasing trend
		Rain per rain day	1975-2005	Increasing trend
Kutiel, 2000, reported by Salim and Wildi, 2005	Israel	Length of rainfall season	1976-2000	Decreasing trend

Reference	Location	Parameter	Period	Trend
Ziv *et al*., 2013	Israel (including West Bank but not Gaza)	Area with >200mm in a year	1974/75-2009/10	Decreasing at 2.5%/yr – not significant
		Number of rain days (undefined)		Decreasing at most stations in wet and semi-arid areas
		Average daily rainfall		Increasing at many stations – not significant
		Portions of days with >30mm and >50mm		No trends, except perhaps in coastal areas (not significant)
	Jerusalem and Haifa, and other representative stations	Duration of rainfall season – period between accumulation of 10% and of 90% of seasonal total		Shortening at ~3%/decade (Nnot significant) mainly through earlier cessation but also later onset (possible lengthening in Dead Sea but uncertain)
	Israel (including West Bank but not Gaza)	Length of wet spells within rainfall season		No consistent trend
		Length of dry spells within rainfall season at stations with >200mm		Lengthening at 6.1%/decade (95% significance level)
Kafle and Bruins, 2009	Israel – records of 39 stations assessed but results only for 12 presented	"Aridity" or "Humidity" index – annual rainfall divided by annual potential evaporation	1970-2002 (one station only 1975-2002)	Mixed trends along coast, all not significant; for most inland stations trend indicates increasing aridity, significant at least the 5% level at 2
Wittenberg *et al*., 2007	Around Mt. Carmel, near Haifa, Israel	Various flood-related parameters – see 4th column	1991-2003 contrasted with 1957-1969	• No trend in rainfall or number of rain days (1976/77-2003/4) but decrease in length of rainfall season (10%-90% accumulation) and in length of dry spells • No change in number of floods • Increase in frequency, magnitude and

Reference	Location	Parameter	Period	Trend
				volume of large floods • Increase in rainfall-runoff ratio • Decrease in rainfall threshold for flood generation
Donat *et al*., 2014	Stations with high quality records in the Arab region: number of relevant stations – Egypt 2, Saudi Arabia 7, Syria 2, Jordan 2	Frequency of days with >10mm (R10mm)	1966-last record and 1981-last record (latest 2011)	Decreasing at perhaps −10 days /year/decade, but not significantly so
		Consecutive dry days (CDD)		Increasing by around +5 days/decade but not significantly so
Zhang *et al*., 2005	Stations with high quality records in the Middle East; number of relevant stations – Israel 4, Syria 5, Jordan 2	Annual maximum daily precipitation (RX1day)	1950-2003 and 1970-2003	Possible statistically significant (5% level) increasing trend near Gaza in longer period; weak, non-significant, increasing trends in shorter period
Lionello *et al*. 2012	Entire Mediterranean region	Daily rainfall with 5-year and 50-year return periods	1950-2006	No significant trends (but not clear if these calculations include any Levantine stations)
Khatib *et al*., date unknown	Eastern Mediterranean (Note: original paper in colour but available copy in black and white – spectral analysis has been used to assist interpretation)	Clustered version of Köppen climate classification types (details not provided)	1901-2003 based on 0.5°x0.5° latitude/longitude data set from Climatic Research Unit	Difficult to assess diagram, even with assistance of spectral analysis, but, compared to areas of Turkey and further east in Saudi Arabia and Iraq, limited, if any, change in climate type over Levant
Sheffield and Wood, 2008	Mediterranean	Various drought characteristics	1950-2000	Not specific for the Levant but the general perspective for the larger area is for no trend

Analyses of the type in Table 19are frequently used to assess changes in drought and/or flood frequencies. The results are rather mixed, although some analyses support enhanced drought frequencies and at least one increasing flooding occurrences. In many cases the assessment of relatively uncommon events over restricted periods will have been based on limited information.

Table 20: Trends in oceanic parameters assessed in peer-reviewed and other publications

Reference	Location	Parameter	Period	Trend
Felis and Rimbu, 2010	Northern Red Sea	Winter sea-surface temperatures	1940-1995	Rapid warming ~1940-1945; no trend to ~1970, warming since to ~1985, rapid warming ~1985-~1990, rapid cooling ~1990-~1995
Lionello *et al*. 2012 quoting Calafat and Gomis (2009) (see also Martinez-Ascensio *et al*., 2014)	Mediterranean	Sea level	1945-~2003	Before 1960s increasing at +1-+2mm/yr; 1960-early 1990s no trend or possible decrease; 1993 on increase at several mm/yr; in latter half of 20th Century increasing at about half the rate (~+0.6mm/yr) of the global ocean
Šepić *et al*. 2012	Mediterranean	Sea-level variability	1958-2008	No specific information for the eastern Mediterranean but general result is one of no trend
Shirman and Melzer, 2009	Four stations along Israel coast	Sea level	1958-2008	Rising at ~+10mm/year/decade until about 2000; then stable or perhaps falling
Calafat and Gomis, 2009	Mediterranean	Sea level	1945-2000	Rising at ~+0.3mm/year along most of the east Mediterranean coast but about 0 off Israel
Gomis *et al*., date unstated	Mediterranean	Sea level	1993-2008	Rising off the east Mediterranean coast

Estimates of sea-level rise in the eastern Mediterranean are subject to similar difficulties to those for rainfall, i.e. a substantial background of inter-annual variability. The bulk of the information indicates that sea levels have risen but the rate of that rise, and its current state, are open to uncertainty, although it is evident that there are temporal variations in the rate of rise.

5 Summary and conclusions

5.1 A word on framing

It might seem that the information summarised in the previous sections is too variable for specific conclusions to be drawn. Indeed, that is the issue faced by the IPCC (2013, 2014) in drawing up its Assessment Reports, and based on which the IPCC takes a quantitative approach to likelihoods when appropriate and a qualitative approach to confidence levels otherwise and, in general, when used together with likelihood (Appendix 1.1). Normally, likelihoods and confidence levels are identified through expert decisions, i.e. an approach that includes an inevitable degree of subjectivity. A similar approach is taken here.

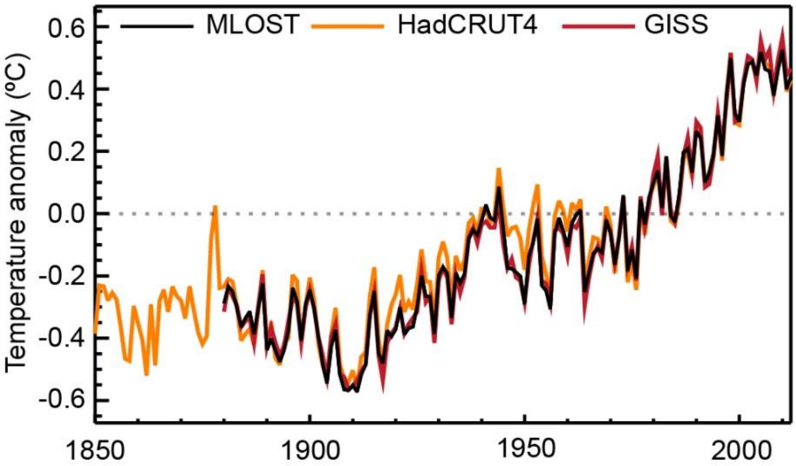
One (of several) potential presentational issues that arises with this approach is that of ‘framing’, i.e. the perceptions drawn from information are led to an extent by the manner in which it is framed, or presented. By and large the framing approach taken by the IPCC is from the perspective that change (whether or not linked to anthropogenic activities) is occurring. It is possible that different perceptions might be gained were the presented perspective that of change not occurring. For example, if the consensus is that change is *likely* (66-100% - Appendix 1.1) then there remains a 0% to 35% probability that no change is occurring. This can be misleading in relation to the more frequently used confidence approach. So a statement that there is *medium* confidence that change is occurring is also a statement that there is *medium* confidence that change is not occurring – a perceptual change might have occurred were the information framed in that latter manner.

Only the confidence approach is used below. Conclusions will be offered using mirror images of confidence statements in order to provide a balanced presentation. While likelihoods should always total 100% provided the complete range of possibilities is covered, the equivalent does not apply to statements of confidence, especially when these refer to specific outcomes in which there is *low* confidence; in these latter cases uncertainty in outcomes prevents any statement of *relatively high* confidence.

5.2 Average temperatures

The IPCC (2013) has concluded that it is *certain* that global average temperatures have risen over the last century or more, with *high* confidence that at least 50% of the rise is anthropogenically-linked (*low* confidence that it is not linked). Most, if not all, of the globe has shared in this rise. The global average temperature time series is illustrated in Figure 4based on three datasets (Appendix 1.2).

Figure 4: Global average temperature time series (IPCC AR5 WGI, Fig. 2.20)



In the 20th Century there was initially a period of decreasing temperatures to about 1910, followed by a period of increases to about 1940, then a period to about 1980 of little change. A period of relatively rapid increases followed until about 2000, since when again temperatures have been somewhat stable. On top of this large scale variability there is additional variability at a regional scale in the Levant associated in some way with circulation features, such as ENSO (El Niño/Southern Oscillation) and the Atlantic Oscillation. As a result of these complex variations at different spatial and temporal scales, the IPCC (2013) concludes: “Owing to natural variability, trends based on short records are very sensitive to the beginning and end dates and do not in general reflect long-term climate trends.” However, rising temperatures over the record since 1900 and over the two periods of increases within that record are significant at the 10% level.

By and large the official national analyses of temperature within the National Communications are consistent with Figure 4. Results suggest increasing temperatures when the analysis period covers at least a substantial part of the period 1980 to 2000. Where there is a period of no trend (e.g., according to Ben-Gai *et al*., 1999, covering the period 1964 to 1994) it includes a number of years in the mid-century time of temperature stability, and thus any positive trend might be expected to be dampened. It is plausible that the local variations identified in the various analyses, including some decreases in temperature, are no more than minor fluctuations, perhaps of local origin, but more likely dependent upon the analysis period.

A similar picture is presented by the local analyses, again with results dependent upon the period selected. Thus, most of the analyses of extended periods suggest rising temperatures whereas those of shorter periods (e.g. Richards and Isaacs, 2012, covering 1997 to 2007) present no trend, in agreement with Figure 4.

Based on this summary of the evidence in relation to average temperatures, it is not appropriate to be specific about rates of change, as these may vary between locations and assessed periods. However, it is reasonable to assert, in general, that average temperatures have risen over recent decades and over the last century.

5.2.1 Conclusions for average temperatures

Table 21: Confidence in trends in average temperatures

Parameter	From the perspective of change	From the perspective of no change
Average temperatures overall	*Very high* confidence that temperatures have risen over the past 100 years or so	*Very low* confidence that there has been no change in average temperatures
Seasonal average temperatures	*Low* confidence that there are detectable changes in trends between annual and seasonal temperatures because of limited evidence	*High* confidence that, as far as may be determined at present, annual and seasonal changes are similar
Location and time dependency of average temperatures	*Very high* confidence that the rate of change in temperatures is, to an extent, locally dependent, but also depends critically on the time period selected	*Very low* confidence that there is no dependency on rate of change on locality and on time period selected
Rate of change of average temperatures	*Low* confidence in assessed quantitative rates of change, because of spatial and temporal dependencies and issues of data quality	*High* confidence that assessed quantitative rates of change, at best, should include substantial error bars
	Medium confidence that the average temperature increased by 1°C over the 19th century but also *medium* confidence that the rate of increase was highest in the final 20 years of the century	

5.3 Maximum and minimum temperatures and diurnal temperature range

According to the IPCC (2013) it is *very likely* that, on a global basis, the number of cold days and nights has decreased and the number of warm days and nights has increased since 1950. It is also *virtually certain* that maximum and minimum temperatures have increased. Nevertheless, only *medium* confidence is ascribed by the IPCC to any reductions in diurnal temperature ranges.

In general, time series of maximum and minimum temperatures will follow those for average temperatures illustrated in Figure 4. Thus, the same issues of selection of analysis periods, and also of locations, holds. All results presented earlier are consistent in terms of increasing temperatures, maxima and minima, and of increased/reduced frequencies of warm/cold days and nights. It may be noted that the analyses of Zhang *et al*. (2005) and Donat *et al*. (2014) are consistent in noting stronger trends in periods that accord with the general average global temperature changes.

5.3.1 Conclusions for maximum and minimum temperatures, diurnal temperature range, and warm/cold days and nights

Table 22: **Confidence in trends in maximum and minimum temperatures, diurnal temperature range, and warm/cold days and nights**

Parameter	From the perspective of change	From the perspective of no change
Average maximum and minimum temperatures overall	*Very high* confidence that these temperatures have risen over the past 100 years or so	*Very low* confidence that there has been no change in these temperatures
Location and time dependency of average temperatures	*Very high* confidence that the rate of change in maximum and minimum temperatures is, to an extent, locally dependent, but also depends critically on the time period selected	*Very low* confidence that there is no dependency on rates of change on locality and on time period selected
Rate of change of average temperatures	*Low* confidence in assessed quantitative rates of change, because of spatial and temporal dependencies and issues of data quality	High confidence that assessed quantitative rates of change, at best, should include substantial error bars
	Medium confidence that maximum and minimum temperatures have increased at a similar rate to average temperatures	
Rates of change of the diurnal temperature range	*Very low* confidence that there is any change in the diurnal range, on the basis of minimal evidence	*Medium* confidence that there is no change in the diurnal temperature range
Changes in frequencies of cold/warm days and nights (TN10p etc.)	*High* confidence that there has been an increase in the numbers of warm days/nights and a decrease in the numbers of cold days/nights	*Low* confidence that there has been no change in the numbers of warm days/nights and no change in the numbers of cold days/nights
	High confidence that the changes in the number of cold/warm days/nights is to an extent spatially dependent, but is specifically dependent on analysis period	*Low* confidence that there is no spatial or temporal dependencies in changes in the frequencies of cold/warm days/nights

5.4 Temperature extremes

Extremes are, by definition, rare events. Thus, it becomes challenging to ascribe stable statistics to extremes. In many areas, including the Levant, the challenge is increased through the limited data available. The IPCC, on a global basis, ascribes only *medium* confidence to increases in the length and frequency of warm spells, including heat waves. This conclusion is somewhat biased through lack of information from Africa and South America but the IPCC (2013) feels it is *likely* that heat wave frequency has increased in large parts of Europe, Asia and Australia.

The different signs in the trends of the two global analyses of warmest day of the year (Table 23Table 17) illustrate the difficulties in providing stable assessments for Palestine. Otherwise the available, but rather limited, evidence does support the contention of longer warm spells and shorter cold spells, and possible increases in other temperature extremes assessed. However, more detailed analyses are required to improve confidence in the results.

5.5 Conclusions for temperature extremes

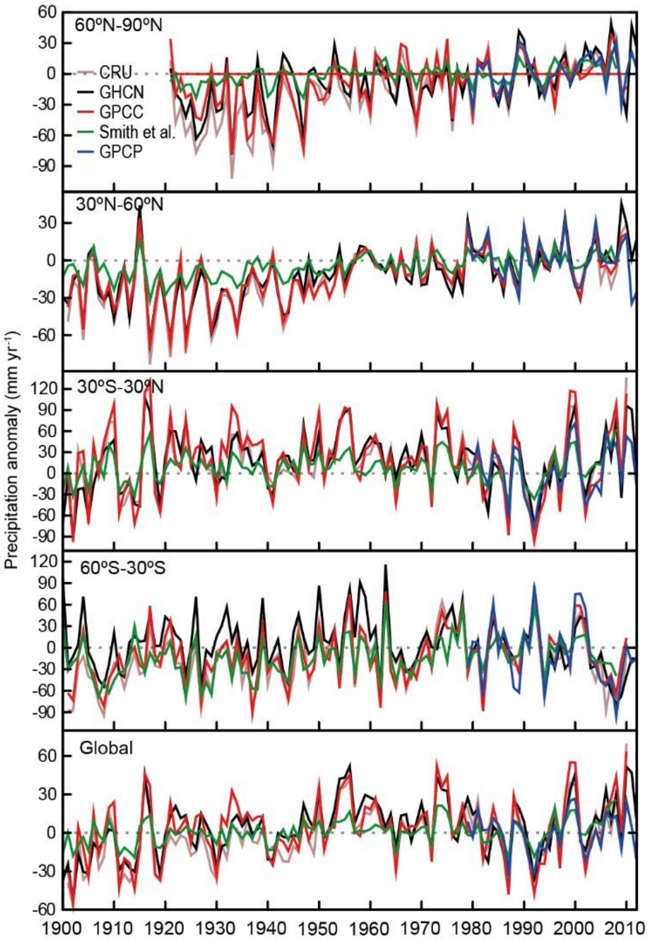
Table 23: Confidence in trends in temperature extremes

Parameter	From the perspective of change	From the perspective of no change
Changes in unusually high or unusually low daily temperatures	*Low* confidence that these temperatures have risen over the past 100 years or so, based on limited evidence	*Medium* confidence that there has been no change in these temperatures
Lengths of warm and cold spells and of frequencies of heat waves	*Low* to *medium* confidence that warm spells have extended in length; *low* confidence for any changes in lengths of cold spells and frequencies of heat waves through lack of information	*Medium* confidence that there is no change in these measures

5.6 Rainfall totals

Figure 5 provides time series of estimates of total rainfall over land in different latitudinal belts – Palestine resides in the 30°N-60°N belt.

Figure 5: Time series of estimates of total rainfall over land in different latitudinal belts (IPCC AR5 WGI, Figure 2-28)



Even at the large scale depicted in Figure 5the extent of the inter-annual variations in rainfall are apparent, variations that introduce difficulties for interpreting trends at more local scales. There are positive linear trends in rainfall in the 30°N-60°N belt over both periods 1901-2008 and 1951-2008, according to calculations presented in the AR5, although it does not follow that trends in specific land areas within the belt are necessarily similar. Nevertheless, treating this belt as a whole, the IPCC has concluded that it is *likely* that rainfall has increased since 1901, with *medium* confidence prior to 1951 and *high* confidence following 1951. The IPCC (2013) makes no specific statements regarding smaller areas, in part because of limited evidence.

Some regional authors have tended to be unequivocal regarding rainfall trends, in general, arguing that rainfall has decreased. For example, Tal and Ben-Gurion (2008) mention that "Israeli water resources face the … challenge of negative trends in precipitation …", and Gasith and Herschkovitch (2008) that "However, the alarming trend of declining average annual precipitation by ca. 12% during the past 16 years (possibly an effect of global warming)". Further, according to Deutsch (2012), "watersheds are receiving less precipitation than previous years. The lack of rainfall contributes to the thinning of lake sediment, and in turn, a more arid climate in Israel (Von Rad, Schaaf, Michels, Schulz, Berger, & Sirocko, 1999)". Lionello *et al*. (2012) quote Leliefeld *et al*. (2002) as identifying a 15-30% reduction in precipitation over the Mediterranean from aerosols reducing evaporation. At a conference in Spain in May 2014, the Palestinian team reported "Climate change facts from Palestine:

- Increase in the number of droughts
- Rainfall during 2003-2010 were less than the historical average
- Frequency of extreme events has increased
- Min. and max. summer temperatures have increased, while winter temperatures have declined
- Probability of very hot summer days has increased".

Nevertheless not all authors agree about decreases in rainfall. At the global scale, Sheffield *et al*. (2012) question evidence for increasing drought. For the Arab region, Donat *et al*. (2014) state that "On average … the 1960s were wetter than any of the more recent decades. So trends starting in the 1960s show drying, while trends starting in the 1970s show no change or perhaps even a slight wetting trend." Messerschmid (2012) illustrated the dependency trends in total rainfall on the period analyzed using Jerusalem data. This is arguably the longest high-quality record in the region (and Enzel *et al*., 2003, suggest that "…the Jerusalem rainfall data capture most of the temporal variability over a much larger area, probably all the way to Beirut, Lebanon"). Replicating the results presented in the regional and national analyses of rainfall (Table 24Table 18), Messerschmid (2012) demonstrated that: the trend for 1960-1998 was for an increase; move the years slightly to 1969-2002 and there was no trend; make a further adjustment to 1967-1991 and the trend becomes a decreasing one. Rinat and the Haaretz Correspondent (2008) account for the apparently widespread belief in decreasing rainfall by quoting a Haifa University researcher: "While models project gloom and doom for climate change, field observation of rainfall indicates a greyer stability"; "The common belief that weather events are becoming more extreme can therefore be attributed to greater press coverage of weather events, in particular extreme events, and not to an increase in these events"; "Frequent warnings of future extreme climatic phenomena like drought years and diminishing rainfall, have not been fulfilled in Israel. The deviation from multi-year rainfall averages has not increased in either direction in recent decades".

Taking all of the evidence into account, the interpretation of local rainfall trends, and perhaps even more so of rainfall extremes, should be treated with caution, despite the substantial number of analyses available.

Dealing with changes in annual and seasonal rainfall totals only, the following summaries of results from the earlier tables may be given:

- For 1951-2010 the two global datasets disagree on the sign of any trends; for 1901-2010 both agree on increases in the north (possibly including West Bank) and decreases in the south (certainly including Gaza), but differ on magnitudes
- In general, the National Contributions point to decreasing rainfall, with possible exceptions over the Gaza and adjacent Egyptian coasts
- For the regional analyses, a generic conclusion is difficult to draw because the analyses are made across such a wide selection of analysis periods. However, where there are consistencies in analyses, such as for Jerusalem for 1960-1998 (Messerschmid, 2012) and for 1961-1998 (Aliewi *et al*., 2013), the results are equivalent. There is no reason to doubt the veracity of any of the analyses reviewed, the issue is one of determining a generic outcome, not least as few reach statistical significance.

5.6.1 Conclusions for annual and seasonal rainfall totals

Table 24: Confidence in trends in annual and seasonal rainfall totals

Parameter	From the perspective of change	From the perspective of no change
Annual rainfall totals	*Very low* confidence that annual rainfall totals have changed in either direction over the past 50 years or so because of the high dependencies of results on analysis period and of limited quality data	*Very low* confidence that there has been no change in annual rainfall totals
Seasonal rainfall totals	*Very low* confidence that seasonal rainfall totals have changed in either direction over the past 50 years or so because of the high dependencies of results on	*Very low* confidence that there has been no change in seasonal rainfall totals

Parameter	From the perspective of change	From the perspective of no change
	analysis period and the few analyses available	
Location and time dependency of changes in annual rainfall totals	*Very high* confidence that any rate of change in rainfall is, to an extent, locally dependent, but also depends critically on the time period selected	*Very low* confidence that there is no dependency on rate of change on locality and on time period selected

5.7 Rainfall extremes and other related parameters

Only *very low* confidence can be ascribed to changes in rainfall extremes (Table 25), not least because of the limited evidence combined with the relative rarity of such events. The IPCC AR5 (2013) does note that it is *very likely* that specific humidity has increased since the 1970s, a result reflected in the Jordanian and Egyptian National Communications. The IPCC AR5 (2013) also notes that it is *likely* that the number of heavy rainfall events has increased in some regions since about 1950, but confidence in this is highest in North America and Europe where there are substantial networks of quality recording instruments. On a global scale, the IPCC AR5 (2013) states that confidence is *low* for any changes in drought intensities or frequencies, but also notes that these are *likely* to have increased in the Mediterranean.

Certain of the results presented above for the Levant appear consistent with the statements of the IPCC, while others do not.

5.7.1 Conclusions for rainfall extremes and other related parameters

Table 25:Confidence in trends in rainfall extremes and other related parameters

Parameter	From the perspective of change	From the perspective of no change
Specific (Relative) humidity	*High* confidence that specific humidity has increased in recent years	*Low* confidence that there has been no change in specific humidity in recent years
All other parameters, including rainfall extremes	*Very low* confidence that rainfall extremes have changed in either direction over the past 50 years or so because of the high dependencies of results on analysis period and the few analyses available	*Very low* confidence that there has been no change in rainfall extremes

5.8 Oceanic parameters

The only oceanic parameter for which any number of analyses has been obtained in the region of interest has been sea level. With the complexity of the Mediterranean system, sea level rises in the basin do not necessarily follow those of the global ocean, and do appear to be variable in time. Equally, the limited evidence on sea-surface temperatures suggests variability in time.

5.8.1 Conclusions for oceanic parameters

Table 26: Confidence in trends in oceanic parameters

Parameter	From the perspective of change	From the perspective of no change
Sea-surface temperatures	*High* confidence that it is variable in time but *low* confidence on the direction of any trend	*Low* confidence that sea surface temperatures have not changed.
Sea level	*High* confidence that it 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	*Low* confidence that there has been no change in sea level along the eastern Mediterranean coastline

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Appendices of Appendix 1

Appendix 1.1. IPCC AR5 confidence terminology

The following refers specifically only to the AR5; there are some differences between the terminology used in the AR3/4 and the AR5. In general, expert decisions are used, at least to some extent, in determining appropriate levels of confidence.

Likelihood

Likelihood provides a quantitative assessment of confidence:

- Virtually certain 99-100% probability
- Very likely 90-100% probability
- Likely 66-100% probability
- About as likely as not 33-66% probability
- Unlikely 0-33% probability
- Very unlikely 1-10% probability
- Exceptionally unlikely 0-1% probability

Confidence

Confidence is probably the more common terminology used in the AR5, and provides a qualitative assessment of the evidence. The definition is less robust than that of *likelihood*, and is based on a combination of two measures, the *amount* of evidence supporting a conclusion (in terms of type, amount, quality and consistency), and the extent of the *agreement* between the individual components of the evidence. Table 27provides an overview of the terminology and of its relationships to *amount* and *agreement*. It should be noted that some flexibility in interpretation is permitted.

Table 27: An overview of the IPCC AR5's definition of confidence

IPCC terminology	Amount of evidence	Agreement in evidence
Very high confidence	Robust evidence	High agreement
High confidence	Medium evidence	High agreement
	Robust evidence	Medium agreement
Medium confidence	Limited evidence	High agreement
	Medium evidence	Medium agreement
	Robust evidence	Low agreement
Low confidence	Limited evidence	Medium agreement
	Medium evidence	Low agreement
Very low confidence	Limited evidence	Low agreement

Appendix 1.2. Datasets used by the IPCC in global analyses of climate trends

Table 28: Full titles of acronyms for datasets referenced in this report

Acronym	Title	Authors
HadCRUT4	Hadley Centre – Climate Research Unit Temperature Data Base v4	Morice *et al*., 2012
MLOST	Merged Land-Ocean Surface Temperature Analysis (NOAA)	Vose *et al*., 2012
GISS	Goddard Institute of Space Studies	Hansen *et al*., 2010
HadEX2	Hadley Centre Climate Extremes Data Base v2	Donat *et al*., 2013
ECA	European Climate Assessment Data Base	Klok and Tank, 2009
HadGHCND	Hadley Centre Global Historical Climatology Network Daily Data Base	Caesar *et al.*, 2006
GHCN	Global Historical Climatology Network v3 Data Base	Lawrimore *et al*., 2011
GPCC	Global Precipitation Climatology Centre v6 Data Base	Becker *et al*., 2013
HadISDH	Hadley Centre Integrated Sub-Daily Humidity Data Base	Willett *et al*., 2013
NOCS	National Oceanography Centre Southampton Surface Flux and Meteorological v2 Data Base	Berry and Kent, 2009
SSMI	Special Sensor Microwave Imager Data Base	Wentz, 2013

Appendix 1.3. IPCC terminology for ‘extremes’

Table 29: Definitions of acronyms transcribed from IPCC (2013)

Index		Definition	Unit
	A. Temperature *Intensity*		
TXn*	Min Tmax	Coldest daily maximum temperature	˚C
TNn*	Min Tmin	Coldest daily minimum temperature	˚C
TXx*	Max Tmax	Warmest daily maximum temperature	˚C
TNx*	Max Tmin	Warmest daily minimum temperature	˚C
DTR*	Diurnal temperature range	Mean difference between daily maximum and daily minimum temperature	˚C
	Duration		
GSL	Growing season length	Annual number of days between the first occurrence of 6 consecutive days with Tmean > 5˚C and first occurrence of consecutive 6 days with Tmean < 5˚C. For the Northern Hemisphere this is calculated from 1 January to 31 December while for the southern hemisphere it is calculated from 1 July to 30 June.	days
CSDI	Cold Spell Duration Indicator	Annual number of days with at least 6 consecutive days when Tmin <10th percentile	days
WSDI	Warm Spell Duration Indicator	Annual number of days with at least 6 consecutive days with Tmax > 90th percentile	days
	Frequency		
TX10p*	Cool days	Share of days when Tmax <10th Percentile	% of days
TN10p*	Cool nights	Share of days when Tmin <10th Percentile	% of days
TX90p*	Warm days	Share of days when Tmax >90th percentile	% of days
TN90p*	Warm nights	Share of days when Tmin > 90th percentile	% of days
FD	Frost days	Annual number of days when Tmin < 0 ˚C	days
ID	Icing days	Annual number of days when Tmax < 0 ˚C	days
SU	Summer days	Annual number of days when Tmax > 25˚C	days
TR	Tropical nights	Annual number of days when Tmin > 20˚C	days
	B. Precipitation *Intensity*		
Rx1day*	Max 1-day precipitation	Maximum 1-day precipitation total	mm
Rx5day*	Max 5-day precipitation	Maximum 5-day precipitation total	mm

Index		Definition	Unit
SDII	Simple daily intensity index	Annual total precipitation divided by the number of wet days (i.e. when precipitation ≥1.0mm)	mm/day
R95p	Annual contribution from very wet days	Annual sum of daily precipitation > 95th percentile	mm
R99p	Annual contribution from extremely wet days	Annual sum of daily precipitation > 99th percentile	mm
PRCPTOT	Annual contribution from wet days	Annual sum of daily precipitation ≥ 1 mm	mm
	Duration		
CWD	Consecutive wet days	Maximum annual number of consecutive wet days (i.e. when precipitation ≥1.0mm)	days
CDD	Consecutive dry days	Maximum annual number of consecutive dry days (i.e. when precipitation <1.0mm)	days
	Frequency		
R10mm	Heavy precipitation days	Annual number of days when precipitation ≥ 10mm	days
R20mm	Very heavy precipitation days	Annual number of days when precipitation ≥ 20 mm	days
Rnnmm	Precipitation above a user-defined threshold	Annual number of days when precipitation ≥ nn mm (nn: user-defined threshold)	days

Appendix 2 –Stakeholders

Core stakeholders

West Bank

Organization	Representative
Environment Quality Authority	Ibrahim Alquqa
Ministry of Agriculture	Basem Hammad
Ministry of National Economy	Shifa Abu Saadehl
Palestinian Hydrology Group	Abdelrahman Tamimi
The Palestine Trade Center, (PALTRADE)	Osamah Abo Ali
Palestinian Water Authority	Omar Abo Zaid
Palestinian Meteorological Department	Issam Issa
Ministry of Planning and Administrative Development	Rehab Thaher
Applied Research Institute-Jerusalem	Fadi Dweek
Land Research Center	Mohamed Al Salimiaya

Gaza Strip

Organization	Representative
Environment Quality Authority	Mohammed Eila
Palestinian Water Authority	Jamal Al Dadah
Coastal Municipalities Water Utility	Ashraf Mushtaha
Ministry of Agriculture	Nabil Abu Shamala
Ministry of Local Government	Sofyan Abu Samra
Ministry of Health	Yousef Abu Alreesh

Wider stakeholders

West Bank

- Environment Quality Authority
- Ministry of Agriculture
- Palestinian Water Authority
- Palestinian Meteorological Department
- Palestinian Energy Authority
- Palestinian Central Bureau of Statistics
- Ministry of Planning and Administrative Development
- Ministry of Local Government
- Ministry of Health

- Ministry of National Economy
- Palestinian Hydrology Group
- Applied Research Institute-Jerusalem
- Land Research Centre
- Civil Defence
- Palestine Academy for Science and Technology
- Palestinian Red Crescent
- Palestinian Engineers Association

Gaza Strip

- Agricultural Relief Committee
- Environmental and Rural Research Center
- Port Authority
- Al Azhar University - Water Center
- UNRWA - Environment and Health Department
- Engineers Association

Appendix 3 – Future-climate scenarios for the State of Palestine

Executive summary

The aim of this report is to provide climate-change scenarios for use in the development of Palestine's National Adaptation Plan (NAP).

High-quality future-climate scenarios may be desired in order to ensure that adaptation planning is well-focused and to avoid maladaptation insofar as possible. However, developing such scenarios is not straightforward. The assessment of historic trends in climate demonstrates that it is not a simple process to determine changes in the climate from historical data, especially for parameters such as rainfall. When trying to establish future-climate scenarios such difficulties are compounded by the uncertainties inherent in climate models used for projections and uncertainties regarding future concentrations of greenhouse gases (GHGs) in the atmosphere, land-use change (particularly reduction in the area of tropical forests) and the future extent of mitigation actions taken by the international community.

In order to provide climate-change scenarios for Palestine based on the latest science, relevant scenarios presented in the literature have been reviewed to provide context for an analysis of projections from models used in the Intergovernmental Panel on Climate Change Fifth Assessment Report (AR5; IPCC 2013). The background review is presented in two parts: first, a review of available official perspectives on future climate change submitted in National Communications (NCs) to the UNFCCC from countries in the vicinity of Palestine (i.e. Lebanon, Jordan, Israel and Egypt), followed by a review of selected perspectives identified from a literature search of peer-reviewed journals and the grey literature.

The NCs perspectives of future climate change are consistent in expecting temperatures to increase. However, the range of temperature increase differs from less than 2°C to 4°C by the end of the century. These differences are to a major extent dependent upon the approaches taken. Most of the NCs anticipate reductions in rainfall; some by a few per cent, others by a substantial amount. Model results presented in the Egypt Second NC, albeit with relatively early generation climate models, illustrate the opposite possibility of substantial future increases in rainfall. There are some positions taken with respect to other aspects of rainfall, which would all lead to negative impacts, e.g. more droughts and floods, longer drought periods, and less daily rainfall but higher intensity falls leading to stronger floods.

The literature search of peer-reviewed journals and grey literature identified a range of perspectives on future climate change that are relevant to Palestine. There is unanimity that temperatures will increase, although there is some disagreement by how much. Most analyses suggest future decreases in rainfall, although the amount of the decreases is somewhat uncertain. Nevertheless, one or two analyses suggest the possibility that rainfall may increase. In general, the contention is that the overall water situation will deteriorate, with more potential for drought and floods, increased evaporation, reduced river flow, etc., in line with the majority of positions in the NCs. However where climate models are used, all analyses are based on limited numbers of projections, either one or just a few, rather than the much larger ensembles available to the IPCC.

This report reviews issues for climate projections of limited areas. The only viable approach available for assessing climate change is through the use of mathematical models, run on powerful computers, which simulate the climate over future decades. In order to run climate models, information is needed on future atmospheric GHG concentrations, which is provided through emissions scenarios or Relative Concentration Pathways (RCPs). However, no two models, or versions of a single model, will produce identical projections. Any differences in projections provided by the various climate models using a particular scenario or RCP can be traced predominantly to the way in which each model has been formulated. Relatively small changes to the structure of a model may have a disproportionately large impact on the projections produced. Thus, with numerous climate models, or their variants, being used to produce an ensemble of individual projections, none the same, there is an issue of how to interpret the broad spread of information produced. Several approaches have been used. At the simplest level a preferred model is used, however, there is no evidence to guide appropriate selection and predictability theory is clear in indicating the limitations of this approach. At the next level a small number of preferred models are used from the complete ensemble. However, there is no more justification in predictability theory for selecting a subset of models than there is for selecting a single model. Nevertheless, both approaches are used frequently in published papers, adaptation planning and NCs to the UNFCCC, including some reviewed here. The only approach that begins to satisfy predictability theory is to create and interpret as large an ensemble of models as possible. There are various ways of doing so. The main one used by the Intergovernmental Panel on Climate Change (IPCC) is to use all available models from the various climate modelling centres. Most of the NCs or documents reviewed in this report use much smaller ensembles than the IPCC.

The methodology used in this report to provide climate-change scenarios for Palestine incorporates two main steps:

- A background assessment of climate change projections for Palestine, calculating ensemble means for the atmosphere/ocean models used in the main IPCC AR4 and AR5 assessments, repeated for the AR5 using the projections from Regional Climate Models (CORDEX[145]) covering the Levant
- A detailed assessment of projections using the AR5 set based on the technique of self-organizing maps (SOMs).

The report notes that there are scientific issues still to be resolved with the regional models and, at this stage, it is considered appropriate only to use these as information rather than to exploit their enhanced temporal and spatial details.

Analyses have been prepared by year for 2016-2035 (summarised as 2025), 2046-2065 (2055) and 2081-2100 (2090) with changes calculated against simulations for each model for a historical period, 1986-2005. This report focuses presentation of results on two of the four scenarios considered by IPCC AR5: RCP2.6 and RCP6.0 (the larger the value at the end of each ‘RCP’ the higher are the emissions and atmospheric GHG concentrations). Results for the other two RCPs (RCP4.5 and RCP8.5) are included in an appendix supplied separately. Separate scenarios under all four of the (RCPs) for Palestine are presented in a further appendix for ease of comparison. The reasons for selecting RCP2.6 and RCP6.0 are that:

- RCP2.6 is the only AR5 scenario that provides a high probability of achieving the UNFCCC target of a maximum average global temperature rise of 2.0°C, and
- RCP6.0 is a realistic option should UNFCCC processes fail given reasonable expectations of international mitigation activities.

A standard approach to interpreting the projections is used here initially, i.e., an examination of ensemble means, their standard deviations, and ranges. However, the key additional step followed is to calculate SOMs. This is a technique to identify groupings within a dataset without assuming any statistical distributions (such as a normal distribution). Each grouping is then plotted on a scatter chart illustrating the complete temperature/rainfall projections, together with a companion chart showing the average temperature or changes associated at each time period with that particular group. Examination of the scatter charts typically suggests either a sequence of events in time, or, on occasions, individual groupings of models; the key aspect being that each model in each group is projecting similar future temperature and rainfall conditions. While this approach provides additional insight in comparison with the standard approach, both suffer from the same issues that lead to uncertainties:

- More outlying projections are taken into account only as components of the mean (or each group mean), and
- There is the possibility that the “answer” lies outside the entire range of the ensemble.

Thus, the interpretation of SOMs provided here is not necessarily the final solution but is consistent with a realistic perspective of the complete spread provided by each full ensemble.

The basic pattern of temperature rises is one of greater increases under the higher RCPs. For rainfall the differences between projections are more substantial. Based on the SOMs analysis, and in simplified form, under RCP2.6 rainfall increases 5% or reduces 10%, under RCP6.0 there is either indiscernible change or a reduction of 20% (which is similar for RCP4.5), while under RCP8.5 ultimate reductions might reach 30%. Note that these values are based on means across the SOMs, and so neglect the more outlying projections and the possibility that the “answer” might lie entirely outside the range of ensemble values.

[145]The results from the Mediterranean North Africa, MENA, CORDEX projections have been used.

In terms of the 'extremes', as defined by the IPCC, the number of warm days will increase and of cold days will decrease, more so as the average temperature increases. Extended warm spells will become more frequent. For rainfall 'extremes' there is limited evidence that there will be any substantial increase in the number of heavy rainfall events, although this is projected by some models and there is more of a consensus amongst models that these events will increase under RCP2.6. Of greater concern is the threat of increased drought frequency, although again the consensus is that this is least under RCP2.6.

Overall it is perhaps no surprise that the potential impacts of climate change on Palestine increase with the higher RCPs, i.e. impacts will be minimised if global emissions can be controlled. The extents of any negative rainfall changes are likely to be least under RCP2.6, although the country is, nevertheless, certain to be subject to increased temperatures.

These scenarios are not dissimilar to many already included within the NCs reviewed in Section 2.1, although some of the greater impacts outlined in some of those (e.g. increase in flooding) can be seen here as perhaps having low probability. The major difference between the scenarios suggested in this section and those reviewed in Section 2.1 is that three scenarios are suggested here that are representative of all projections considered by the IPCC AR5 and cover the full range of options, which might be beneficial for planning, as summarised below (changes by comparison with 1986-2005; 2025 represents 2016-2035, 2055 represents 2046-2065, and 2090 represents 2081-2100).

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 warmer periods, both becoming more prominent in 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.

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 warmer periods, both becoming more prominent in time; more so than under Scenario 1.
Rainfall	Decreases by ~10% by 2025, by ~15% by 2055, 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.

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 warmer periods, both becoming more prominent in time; perhaps moderated slightly in the Gaza Strip.
Rainfall	Decreases by ~20% throughout until 2055, and to ~30% by 2090.
Rainfall-related	In general, 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, especially in the West Bank, thus, raising a possibility of an increased flood risk.

1 Introduction

The aim of this report is to provide climate-change scenarios for use in the development of Palestine's National Adaptation Plan (NAP).

High quality future-climate scenarios may be desired in order to ensure that adaptation planning is well-focused and to avoid maladaptation insofar as possible. However, developing such scenarios is not straightforward. The assessment of historic trends in Palestine's climate demonstrates that it is not a simple process to determine changes in the climate from historical data, especially for parameters such as rainfall. When trying to establish future-climate scenarios such difficulties are compounded by the uncertainties inherent in climate models used for projections and uncertainties regarding future concentrations of greenhouse gases in the atmosphere, land use change (particularly reduction in tropical forest area) and the future extent of mitigation actions taken by the international community.
In order to provide climate-change scenarios for Palestine based on the latest science, climate projections for the region presented in the literature have been reviewed to provide context for:

- A background assessment of climate change projections for Palestine generated through all atmosphere/ocean models used in the main Intergovernmental Panel on Climate Change (IPCC) Fourth and Fifth Assessment Reports (IPCC AR4 ;AR5, IPCC 2013), plus those from a further set of projections (CORDEX) using Regional Climate Models
- A detailed assessment of projections using the AR5 set, which provides the scenarios recommended for use in the NAP.

The review of climate projections for the region in Section 2 is presented in two parts: first, a review of available official perspectives on future climate change submitted to the UNFCCC from countries in the vicinity of Palestine, followed by a review of selected perspectives identified from a literature search of peer-reviewed journals and the grey literature.

The datasets explored in the assessment of historic trends in Palestine's climate do not provide a suitable baseline against which assessment of AR4, AR5 or CORDEX projections, in Section 5 onwards, can be compared. Instead, the detailed assessment of the AR5 projections uses model simulations for Palestine's climate for the period 1986 to 2005 as a baseline. The scenarios presented are, therefore, projected changes from that period. In theory, changes calculated from varying baselines require adjustment in order to provide full consistency across analyses. However, in practice, adjustments have not been made as they would be small and well within the ranges of uncertainties.

2 A review of climate projections for the region, including Palestine

2.1 Official projections in documents submitted to the UNFCCC – National Communications

Projections, or at least perspectives, of future climate change have been submitted to the UNFCCC in National Communications by all countries in the vicinity of Palestine, namely Lebanon, Jordan, Israel and Egypt. None of these countries have a National Adaptation Program of Action (NAPA) posted on the UNFCCC website (and, of course, given the stage of the process, none has posted a NAP). As such, this section is based solely on National Communications. All have posted at least two National Communications. Syria has been excluded from this assessment, as it has only provided greenhouse-gas (GHG) emissions inventories as part of a National Communication. Table 30provides brief summaries of the future climate perspectives in these documents (National Communications are numbered as NC1, NC2, etc., with year of publication as on the UNFCCC site).

Table 30: Brief summaries of future climate change perspectives in relevant National Communications

National Communication	Future climate change perspective
Egypt NC1 1999. No specific climate scenarios calculated.	Quotes contemporary IPCC estimates of further temperature rises of 1°-3.5°C (no international GHG actions taken), and sea-level rise of 50cm. Recommends use of scenarios both from Global Climate Models and from arbitrary sensitivity tests, including +2°C/+4°C combined with ±10%/-20% rainfall, and 50cm-100cm sea-level rise
Egypt NC2 2010. No specific climate scenarios calculated.	Summarises independent research. For Nile river-flow uses arbitrary sensitivity tests, including ±50%, ±25%, ±10% rainfall, and ±20% rainfall combined with +2°/+4°C; also results from three Global Climate Models, as available in 1996 (projection date not stated): Model 1, +4.7°C/+22% rainfall; Model 2, +3.5°C/+31%; Model 3, +3.2°C/+5%. No details given of projections used for other sectors. For sea-level rise uses IPCC AR4 projections of 18-59cm by 2100.

National Communication	Future climate change perspective
Israel NC1 2000. No specific climate scenarios calculated	Assumes climate scenarios by implication in terms of impacts, but does not provide the basis of these assumptions. Temperature projections: • Increased temperatures • Longer and hotter summers Temperature-related projections: • Rising sea level temperatures • Higher concentrations of CO2 • Increased weather fluctuations, especially extreme cold and heat • More frequent extreme weather and climatic events • Greater annual and seasonal temperature variability • More frequent dust storms and sand storms Rainfall projections: • Increased rainfall intensity • Overall rainfall decrease • Lengthened intervals between rains Rainfall-related projections • Increased frequency and intensity of surface runoff • Exacerbated desertification • Rising sea level • Increased evaporation • Intensified drought In addition, using an estimate from a single global model (unspecified), suggests that the temperature will rise over Israel by 0.8°-0.9°C and rainfall will decrease by 2%-4% for every 1.0°C rise in the global average temperature. Sea-level rise figures are taken from the IPCC AR2 (1995): 18cm by 2030 and 50cm by 2100.
Israel NC2 2010. No specific climate scenarios calculated	Takes a similar approach to Israel's NC1, except that some projections are drawn from the IPCC's AR3 published in 2001, which uses scenarios named A1B, A2 and B2, explained in Appendix 3.1. Those projections not listed in the NC1 are detailed below. Temperature projections: • Maximum temperature to rise by 1.8°C by 2020 (against 1960-1990); average temperature by 1.5°C, both under A1B • Average temperatures to rise by 5.0°C and by 3.5°C by 2071-2100 under A2 and B2 respectively. Rainfall projections: • Decreased by 10% by 2020 and 20% by 2050 (scenario not stated) • Decrease in seasonal rains • Extreme rainy days mainly in autumn and early winter under B2, but in January and spring under A2 • Increased differences between very wet and very dry years Rainfall-related projections • Intervals between dry spells and wet spells to increase.
Jordan NC1 1997. No specific climate	The only comment regarding climate projections within the document is: "Since a rise in global temperatures, due to climate changes, is predicted, the resulting decrease in rainfalls will have a disastrous impact on Jordan."

National Communication	Future climate change perspective
scenarios calculated	
Jordan NC2 2009. Uses both 20 incremental scenarios and projections from three Global Climate Models.	For the 20 incremental scenarios uses all combinations of temperature rises of 1°, 2°, 3° and 4°C together with rainfall changes of 0%, ±10% and ±20%. Selects three Global Climate Models from 13 reviewed based on resolution and availability of grid points specifically within Jordan. Examines up to 2050: • Temperature increase of <2°C, with greater warming in summer, taken as 1°-1.3°C, consistent over the three models • Precipitation projections variable between models: o Changes to annual amounts 0%, -10% and -18% o Model A projects increases in wet season, decreases in dry season o Model B projects decreases in wet season o Model C projects increases in February to May plus December, deceases otherwise
Jordan NC3 2014. Used results from CORDEX AFRICA, with a Swedish RCM used with 8 global models and a Danish RCM with one global model.	Uses 1980-2010 as reference period for projections for 2020-2050, 2040-2070 and 2070-2100. “Reference” model selected for decision making after analysis of all projections. Additional statistical downscaling to 1km. Final summary after detailed review: A warmer climate – All models converge that the temperature will increase. AFRICA CORDEX results are consistent with the IPCC projections. For the 2070-2100 period the average temperature could reach according to RCP 4.5 up to +2.1 ºC (+1.7 ºC to +3.2 ºC) and +4 ºC (3.8-5.5) according to RCP8.5. A drier climate – Compared to the SNC that used CMP13 results, CMP15 results coupled with Regional Climate Models in CORDEX give a more consistent trends towards a drier climate. In 2070-2100 the cumulated precipitation could decrease by 15% (-6% to 25%) in RCP 4.5, by -21% (9% to -35%) in RCP 8.5. The decrease would be more marked in the western part of the country. Warmer summer, drier autumn and winter – The warming would be more important in summer. The reduction in precipitation would be more important in winter and autumn than in spring, as for instance median value for precipitation decrease reaching -35% in autumn of 2100. More heat waves – The analysis of summer temperatures monthly values and the inter-annual variability reveals that some thresholds could be exceeded. A pessimistic but possible projection for the summer months predicts that the average of maximum temperatures for the whole country could exceed 42-44ºC. More drought, a contrasted water balance – The maximum number of consecutive dry days would increase in the reference model to more than 30 days for the 2070-2100 period. In contrast annual values still show possible heavy rainy years at the end of the century. More intense droughts would be (partly) compensated by rainy years in a context of a general decrease in precipitation. Evapotranspiration would increase. The occurrence of snow would strongly decrease. This will complicate water management. No trend for intense precipitation or winds – The number of days with heavy rain (more than 10mm) does not evolve significantly nor does the maximum wind speed or the direction of winds.

National Communication	Future climate change perspective
Lebanon NC1 1999. Uses a single Global Climate Model (justification for selection not given) with 1%/year increase in CO_2 concentration.	**Table 30.1: Scenarios with projections for 2020, 2050 and 2080** (needs to be transcribed or sampled) (see below)
Lebanon NC2 2011. Uses a single Regional Climate Model within a single Global Climate Model (justifications for selections not given) under A1B scenario.	Projections for 2025-2044 and 2080-2098 against 1980-2000/10. Unfortunately, not all diagrams in the document transfer in readable form from the UNFCCC web site, but in summary: (see below)

Lebanon NC1 1999. Uses a single Global Climate Model (justification for selection not given) with 1%/year increase in CO_2 concentration.

Table 30.1: Scenarios with projections for 2020, 2050 and 2080 (needs to be transcribed or sampled)

Parameter	Minimum Temperature						Maximum Temperature					
Grid box	2123			2219			2123			2219		
Year / Month	2020	2050	2080	2020	2050	2080	2020	2050	2080	2020	2050	2080
JAN	1.16	1.61	2.51	1.22	1.86	2.77	1.37	2.1	3.57	1.57	2.28	3.77
FEB	1.6	2.06	3.05	1.31	2.24	3.28	1.75	2.69	4.23	1.94	2.84	4.25
MAR	1.63	2.43	3.54	1.88	2.62	3.66	1.99	2.92	4.45	2.08	2.89	3.99
APR	1.58	2.23	3.58	1.51	2.2	3.37	1.86	2.45	4.16	1.67	2.45	3.7
MAY	1.77	2.6	3.99	1.59	2.36	3.6	1.75	2.73	4.14	1.66	2.54	3.89
JUN	1.72	3.17	4.83	1.66	3.06	4.67	.156	3.31	5.3	1.54	3.37	5.24
JUL	1.89	3.11	4.7	1.81	3.19	4.97	1.92	3.54	5.83	1.88	3.57	5.95
AUG	1.99	3.11	4.48	1.71	2.69	4.12	1.7	2.66	4.27	1.55	2.42	4.11
SEP	2.04	3.67	5.46	1.92	3.47	5.23	1.99	3.66	5.68	2.01	3.74	5.82
OCT	2.12	3.72	5.2	2.03	3.78	5.44	2.1	3.34	4.34	2.14	3.37	4.58
NOV	1.57	2.37	3.17	1.64	2.48	3.46	1.61	2.12	3.15	1.73	2.25	3.19
DEC	0.8	1.47	2.39	0.97	1.76	2.59	1.44	2.17	3.57	1.52	2.22	3.62

Parameter	Average Temperature						Precipitation					
Grid box	2123			2219			2123			2219		
Year / Month	2020	2050	2080	2020	2050	2080	2020	2050	2080	2020	2050	2080
JAN	1.23	1.8	2.88	1.39	2.09	3.25	-3.1	-7.75	-17.98	-4	-4.34	-10.23
FEB	1.39	2.29	3.55	1.62	2.52	3.76	-8.12	-9.8	-13.72	-7.28	-5.88	-8.68
MAR	1.8	2.67	4.01	1.95	2.72	3.8	-3.72	-4.65	-10.85	-3.41	-3.72	-3.41
APR	1.73	2.34	3.89	1.59	2.31	3.53	-3	-1.8	-7.5	-2.7	-3.6	-6.6
MAY	1.74	2.65	4.02	1.62	2.43	3.7	-3.1	-4.03	-8.06	-0.93	-2.17	-4.96
JUN	1.62	3.23	5.06	1.58	3.22	4.97	-0.3	-0.6	-2.1	-0.3	-0.3	-0.9
JUL	1.88	3.34	5.32	1.86	3.41	5.52	0	0	-0.31	0	0	0
AUG	1.81	2.84	4.33	1.63	2.54	4.12	0.31	0	0	0	0	0
SEP	2.01	3.63	5.53	1.98	3.61	5.55	-0.3	-0.3	-0.9	0	0.3	-0.3
OCT	2.1	3.5	4.79	2.09	3.55	5	-2.48	-0.93	-2.48	-3.1	-1.55	-3.41
NOV	1.59	2.27	3.21	1.7	2.41	3.4	-4.5	-4.5	-12.3	-6.3	-0.75	-11.7
DEC	1.05	1.78	2.86	1.24	2	3.09	-10.85	-13.95	-22.94	-5.89	-6.2	-11.16

Lebanon NC2 2011. Uses a single Regional Climate Model within a single Global Climate Model (justifications for selections not given) under A1B scenario.

Projections for 2025-2044 and 2080-2098 against 1980-2000/10. Unfortunately, not all diagrams in the document transfer in readable form from the UNFCCC web site, but in summary:

- Temperature rises by c.4°C by end of century, more inland than on the coast and more in summer than winter
- Rainfall decreases by 10%-20% by 2040 and 25%-45% by 2090, with decreases in winter but increases in autumn
- Relative humidity decreases by up to 10% by 2080
- No change in wind and cloud fraction
- Longer summer dry season
- For IPCC 'extremes' indices, see Table 30.2.

Table 30.2: Projections for 2025-2044 or 2080-2098 against 1980-2000/10 for IPCC 'extreme' indices

Index	Beirut	Cedars	Daher-el-Baidar	Zahleh
SU30 (days)	+50	+62	+60	+53
TR20 (days)	+34	+53	+18	+62
P (mm)	-116	-205	-312	-191
RX_5day (%)	-14	-39	-26	-30
SDII (%)	-6	-14	-8	-15
CDD (days)	19	21	15	19
DTR (ºC)	-0.02	+0.61	+0.64	+0.27
Tn_x (ºC)	+5.21	+5.47	+6.18	+6.26

Certain of the earlier NCs have used incremental scenarios (i.e. based on assumptions that temperatures and rainfall will change in relation to pre-determined but arbitrary values), which is a valuable approach, given the lack of any other information. There has been a growing use of climate model projections, both global and regional, to provide scenarios but, in general, only a small number of models has been used with selection based on convenience rather than on scientific principles. Other NCs have relied simply on external bodies, such as the IPCC, to provide information.

The NCs perspectives of future climate change are consistent in expecting temperatures to increase. However, the range of temperature increase varies somewhat, some suggesting increases of less than 2°C and others double that, but these variations are to a major extent dependent upon the approaches taken. Most of the NCs anticipate reductions in rainfall; some by a few per cent, others by a substantial amount. Model results presented in the Egypt NC2, albeit with relatively early generation climate models, illustrate the opposite possibility of substantial future increases in rainfall. There are some positions taken with respect to other aspects of rainfall, which would all lead to negative impacts, e.g. more droughts and floods, longer drought periods, and less daily rainfall but higher intensity falls leading to stronger floods.

2.2 Projections in selected references

A literature search of peer-reviewed journals and grey literature identified a range of perspectives on future climate change that are relevant to Palestine. In each case, a brief review is provided in Table 31of the approach(es) taken and the final projection(s) produced.

Table 31: Brief summaries of future climate change perspectives in relevant peer-reviewed or grey publications

Reference	Approach(es)	Projection(s)
Feitelson, E., Tamimi, A. and Rosenthal, G. 2012. Climate change and security in the Israeli−Palestinian context. Journal of Peace Research 49: 241.	Based on IPCC AR4 (2007) and "wide-ranging" literature review, examined for consistency.	A warming trend, but trends in precipitation "ambiguous". Scenarios used tend to focus on decreased rainfall and an increase in "extreme" events. Significant reduction in rainfall under A2 scenario but changes unclear in B2 scenario. Effects on groundwater recharge could not be calculated at that time. Sea level will rise. It takes a scenario-based approach to considering future water resources. Extent of unanimity in impacts for Israel summarised below: • Water resources – increasing variability of precipitation may affect groundwater replenishment and surface run-off, loss of storage in coastal aquifer – no unanimity • Mediterranean coast – Loss of few sq km of beach area, accelerated cliff erosion – high unanimity • Public health – Heat effects – no unanimity • Agriculture – Less water for rain-fed crops – no unanimity • Biodiversity – Northward migration of ecological systems, loss of senstive ecosystems – no unanimity.
Freimuth, L., Bromberg, G., Mehyar, M., and Al Khateeb, N. 2007. Climate Change:A New Threat to Middle East Security. Prepared for the United Nations Climate Change Conference Bali, Indonesia by EcoPeace / Friends of the Earth Middle	Changes indicated in selected publications; basis of selection not indicated.	• Temperature +3°to +5°C by 2080 • Rainfall decrease by 20% by end of Century • Reduced stream flow and groundwater recharge • Evapotranspiration increase by 10% • Greater seasonal temperature variability • More severe weather events, such as droughts and flood • Significant sea-level rise (30-100cm) by end of the century.

Reference	Approach(es)	Projection(s)
East Amman, Bethlehem, and Tel-Aviv.		
Goubanova, K and Li, L. 2007. Extremes in temperature and precipitation around the Mediterranean basin in an ensemble of future climate scenario simulations. Global and Planetary Change, 57, 27–42.	Use of a high-resolution global atmosphere model using boundary conditions from three Global Climate Models under A2 scenario, with changes for 2030-2059 and 2070-2099 compared to 1970-1999.	• Three models used to check 'consistency' – 'good consistency' found so results are 'robust' • Average temperature increases by between 2°C and 4°C by end of century, with similar increases in maxima and minima • Rainfall changes are often in the range ±0.2mm/day, with the majority indicating reductions in all seasons, but with one suggesting marked increases • General characteristic of fewer rainfall events but more rainfall per event • Unlikely to have any abrupt climate changes during the century.
Hassan, M.A. and McIntyre, G. 2012. Palestinian Water: Resources, Use, Conservation, Climate Change, and Land Use. Digest of Middle East Studies, 21, 313–326.	Reviews other work prior to defining issues for water resources.	• Temperature to increase 3.5°-5.0°C by 2071-2100 (compared to 1961-1990), with increases in maximum and minimum temperatures • Higher rates of evapotranspiration • Rainfall to decrease 10%-30% by 2050 • Shorter, more intense rainfall season and longer dry summer period.
Hassouna, M. and Sinclair, Z. 2012. Environment and Security in the Occupied Palestinian Territory. Zoï Report 4/2012, Zoï Environment Network, 56pp.	Based on results from Mason M., Mimi Z., Zeitoun M. 2010. Climate Change Adaptation Strategy and Program of Action for the Palestinian Authority. United Nations Development Program, Program of Assistance to the Palestinian People.	• Temperature +2.2°-+4.8°C by end of Century, increase greatest in summer • Increased frequency of "extreme" temperatures (probably >30°C) and acute heat waves • Major sand storms • Rainfall reduced by 100-200mm annually in north (i.e. West Bank) • Greater rainfall variability • Rainy events shifted to both ends of season (Oct/Nov and Mar/Apr) • Rain events concentrated in short periods of heavy rainfall • Increased evapotranspiration • 50% decline in runoff by end of century • Sea level increases of 10mm annually.
Hertig, E. and Jacobeit, J. 2008. Assessments of Mediterranean precipitation changes for the 21st century using statistical downscaling techniques. Int. J. Climatol. 28: 1025–1045.	Uses statistical downscaling, as well as direct projections, from seven projections for 2071-2100 (compared to 1990-2019); four models are used to give seven projections (with three from an ensemble run) variously under	Too many projections to list here, but in general, whether from the statistical downscaling or from the model directly, projections are for decreases in rainfall of up to c.70% (but in general less); a few projections do suggest future increases, and with one set the 95% upper confidence limit is for an increase of about 50mm/year.

Reference	Approach(es)	Projection(s)
	scenarios IS92a, B2 and A2; all calculations made for running two-month periods through the year (Jan/Feb, Feb/Mar, etc.).	
Kitoh, A., Yatagai, A. and Alpert, P. 2008. First super-high-resolution model projection that the ancient "Fertile Crescent" will disappear in this century. Hydrological Research Letters 2, 1–4.	Projections with a high-resolution Global Climate Model for 2081-2100 (compared to 1979-1998), based on the A1B scenario but with two versions of the model with different climate sensitivities, 1.6°C and 3.2°C (climate sensitivity is the increase in temperature given a doubling of CO_2 concentration in the atmosphere).	• Rainfall decreases under the lower sensitivity case (1.6°C) by between 50mm and 200mm annually, but the decrease for Gaza might be <25mm • Rainfall decreases under the higher sensitivity case (3.2°C) by between 50mm and 200mm annually • Flow in the Jordan River to decrease by 82% in lower sensitivity case (1.6°C) • Flow in the Jordan River to decrease by 98% in higher sensitivity case (3.2°C).

Kloos, J., Gebert, N., Rosenfeld, T. And Renaud, F. 2013. Climate change, water conflicts and human security: regional assessment and policy guidelines for the Mediterranean, Middle East and Sahel. United Nations University Institute For Environment And Human Security (UNU-EHS), Report No. 10, 256pp.	Used 16 Global Climate Models under A2, A1B and B2 for projections for 2040-2069 (relative to 1961-1990) and 20 Global Climate Models under A1B for projections for 2031-2050 (relative to 1980-1999). Incorporates further details from the IPCC AR4 (2007) and the SREX, and other references. The area covered is broad and details below are extracted as possible with respect to the Palestinian area.	• In general, but not necessarily specifically for the Palestinian region:
		  ○ Overall climate to become warmer and drier
		  ○ Intensification of hydrological cycle, i.e. greater frequency and intensity of droughts and floods
		  ○ More severe droughts, with dry summers beginning earlier and lasting longer
		  ○ Increased variability during dry and warm season (not specific on what is becoming more variable)
		• 'Nearly consistent' projections of decreased rainfall in Jordan Valley under A2 and A1B scenarios, with a median decrease of 11%
		• Higher short-period rainfall intensities
		• High uncertainty over degree of sea-level rise, possibly over a range across the century of -2cm to +51cm under A2 and A1B scenarios.

Lonergan, S. and Kavanagh, B. 1991. Climate change, water resources and security in the Middle East. Global Environmental	Three Global Climate Models assessed under historic and doubled greenhouse gas concentrations, focusing on three river basins,	• Temperatures rises by over 6.5°C in one model, about 4°C in the other two • Annual rainfall decreases in two models, in one by c.0.1mm/day and in the other by c.0.2mm/day, and increases in the third by c.1.5mm/day; all models project increases in the first half of the rainfall seasons and decreases in the second

Reference	Approach(es)	Projection(s)
Change, September 1991, 272-290.	including those of the Jordan and Litani rivers.	• Evaporation to increase by 6% according to one model, with greater increases in the other two.
Mimi, Z.A. and Jamous, S.A. 2010. Climate change and agricultural water demand: Impacts and adaptations. African Journal of Environmental Science and Technology Vol. 4(4), 183-191.	Use of incremental changes following literature review.	All combinations of temperature changes of +1°C, +2°C and +3°C with rainfall changes of ±10% and ±20%.
Palestinian Team, Spain. May 2014. Impacts of Climate Change on Water Resources in Palestinian Territories, PowerPoint presentation – full reference details not available.	Based on the GLOWA River Jordan project; details of approach not provided.	• Temperature increase by 2050 1°-2°C • Rainfall decrease by up to 30% by 2050 • Drought lengths to increase 'slightly', more so in south • Frequencies of 'moderate' droughts to decrease and of 'extreme' droughts to increase.
Saadi, S., Todorovic, M., Tanasijevic, L., Pereira, L.S., Pizzigalli, C. and Lionello, P. 2015. Climate change and Mediterranean agriculture: Impacts on winter wheat and tomato crop evapotranspiration, irrigation requirements and yield. Agricultural Water Management, 147, 103–115.	Two sets of four Regional Climate Models, each set forced under a different Global Climate Model, used to assess conditions in 2000 and in 2050 under A1B scenario.	• Annual average temperature rise of 1.5°-1.8°C, possibly greater inland • Rainfall decrease in range -50 to -100mm/year in West Bank but <−25mm/year in Gaza (increase in summer rainfall) • Increase in evapotranspiration in range 60mm to 90mm/year.
Šepić, J., Vilibić, I., Jordà, G. and Marcos, M. 2012. Mediterranean Sea level forced by atmospheric pressure and wind: Variability of the present climate and future projections for several period bands. Global and Planetary Change, 86-87, 20–30.	Ocean model driven by single Global Climate Model under A2, A1B and B1 scenarios to assess changes in atmosphere-driven sea-level variability.	Atmosphere-driven sea-level variability will decrease, leading to possible over-estimation of coastal flooding potential with sea-level rise resulting from thermal expansion and possible ice melting.

Reference	Approach(es)	Projection(s)
Tolba, M.K. And Saab, N.W. 2009. Impact of climate change on Arab countries: Main findings and conclusions, in Arab environment. Climate change, 2009 report of the Arab Forum for Environment and Development (AFED).	Several of the papers within this document mention specific references with projections but the Tolba and Saab summary includes, without comment, results from a Regional Climate Model study by Hemming D, Betts R, & Ryall D. 2007 (full reference not provided) and these are summarised for Palestine as best as possible.	• Temperature changes: ○ By 2020's +1.2°C ○ By 2040's +2.0°C ○ By 2070's +3.0°C, but perhaps more • Rainfall changes: ○ By 2020's -10% to -20%, but perhaps <-10% in Gaza ○ By 2040's -20% to -30%, but perhaps <-20% in Gaza ○ By 2070's -20% to -30%, but perhaps <-20% in Gaza.

A varied set of approaches has been used by the authors in the documents cited in Table 31, from incremental approaches to the use of a cutting-edge (at the time) high-resolution global model. There is unanimity that temperatures will increase, although there is some disagreement by how much. Most analyses suggest future decreases in rainfall, although the amount of the decreases is somewhat uncertain. Nevertheless, one or two analyses suggest the possibility that rainfall may increase. In general, the contention is that the overall water situation will deteriorate, with more potential for drought and floods, increased evaporation, reduced river flow, etc., in line with the majority of positions in National Communications. It should be noted, however, that all analyses are based on limited numbers of projections where climate models are used, either one or just a few, rather than the much larger ensembles available under the IPCC. The issues related to this fact are discussed in Section 3.

3 A review of issues for climate projections of limited areas

The only viable approach available for assessing climate change is through the use of mathematical models, run on powerful computers, which simulate the climate over future decades[146]. This is the approach used by many research organizations with results summarised by the IPCC in its various Assessment Reports (AR). The latest, AR5 was produced in 2013/14.

Climate models have been developed continuously over recent years and progress has been reflected in each succeeding IPCC AR. The most advanced models (c. 20) used as the basis of AR4[147] in 2007 simulated both the atmosphere and the oceans in some detail. Although such models have progressed further for the AR5, and still provide the major information used (from over 30 models), they have been joined by more complex models that either incorporate additional details of the total environmental system, or cover reduced regions at higher spatial and temporal scales than the global models (Regional Climate Models – RCMs), or have systems of creating numerous projections from a single model by making changes directly to various settings in the model; one approach to making an ensemble[148].

In order to run climate models, information is needed on future atmospheric GHG concentrations, which is provided through an emissions scenario approach (see fuller details

[146]The incremental approach used in some of the NCs and other documents provides a basis for assessment of possible impacts but no guidance on the likelihoods of these.
[147]Note that, technically, the dataset used in the AR4 is known as CMIP3 and that used in the AR5 as CMIP5.
[148]An ensemble is a set of model predictions/projections, all for the same future period, produced either by variations of a single model, or by a group of different models, or by a combination of both methods.

in Appendix 3.1). In the AR4, the emissions scenarios used included: A2, a scenario with relatively high future emissions through rapid economic development based on carbon-based energy generation; and A1B, in which technological advances help reduce emissions. For the AR5 a different approach was used, referred to as Relative Concentration Pathways, RCPs, with emissions and atmospheric GHG concentrations increasing successively through RCP2.6, RCP4.5, and RCP6.0 to RCP8.5. Roughly speaking, A2 is equivalent to RCP8.5 and RCP6.0 is about halfway between A1B and B1 (a relatively low emissions scenario). RCP2.6 ultimately leads to zero emissions after about 2070 and is the only scenario that, if broadly followed, would offer a reasonable chance of reaching the UNFCCC target of restricting the average global temperature rise to below 2°C. Observed emissions to date have tended to follow approximately those of scenario A2 and RCP8.5.

Any differences in projections provided by the various climate models using a particular scenario or RCP can be traced predominantly to the way in which each model has been formulated. As noted above, climate models are mathematical representations of the climate system. All climate models handle the mathematics through somewhat different approaches, and not all models simulate all processes in the climate system. In addition, certain calculations within the models require the use of estimated values, and the projections produced by any model may change with even minor but reasonable changes to these values. It is changes to these estimated values that have been used produce an ensemble with a single model, as mentioned above.

In summary, the outcome of the issues précised above is that no two models, or versions of a single model, will produce identical projections. Relatively small changes to the structure of a model may have a disproportionately large impact on the projections produced. Predictability theory in fact requires such differences in projections to occur: if two independent models produced identical projections then there would be concern over the validity of these projections. Thus, with numerous climate models, or their variants, being used to produce an ensemble of individual projections, none the same, there is an issue of how to interpret the broad spread of information produced. Several approaches have been used:

- At the simplest level is the identification of a preferred model based on some approach. Unfortunately, there is no evidence to guide appropriate selection and predictability theory is clear in indicating the limitations of this approach. Published papers, including some reviewed above, frequently use this approach. It is quite valid as an examination of the performance of a model but caveats are needed if this approach is used to prepare scenarios. It is certainly not recommended as a basis for adaptation planning, although it has previously been used.
- At the next level is the identification of a small number of preferred models from the complete ensemble. However, there is no more justification in predictability theory for selecting a subset of models than there is for selecting a single model. Nevertheless, this approach is used frequently in adaptation planning and National Communications to the UNFCCC, including some reviewed above.
- The only approach that begins to satisfy predictability theory is to create and interpret as large an ensemble as possible. There are various ways of doing so. The main one used by the IPCC is to use all available models from the various climate modelling centres (although, as noted above, advances have been included within the IPCC AR5 that also produce large ensembles from a single base model by varying some of the estimated values). Most of the NCs or documents reviewed above do not use ensembles of the size taken by the IPCC.

With the AR4 and AR5 ensembles running to 20 or 30 or more projections respectively, various interpretive approaches have been used both by the IPCC and elsewhere:

- The simplest approach, and most popular technique, is to take the mean values (sometimes median values) across all individual projections within the ensemble, as it permits a straightforward deterministic interpretation to be provided. It is used commonly throughout IPCC reports. According to predictability theory taking an ensemble mean is an appropriate technique to use, as it averages out those aspects that are 'unpredictable' leaving behind a summary of the predictable elements. However, two caveats underlie this theory. The first is that values across all projections within the ensemble have a normal distribution. Experience indicates that often this is not so, particularly for rainfall. The second caveat is that the ensemble is formed 'properly'. In effect, this means that the ensemble needs to provide a complete distribution of all realistically possible future states with each given its correct probability of occurring. No tests have ever been made on the IPCC projections of this second caveat, for entirely pragmatic reasons, but experience with ensembles at shorter timescales indicate that the IPCC ensembles are unlikely to be proper. Considerable research was required before this caveat could be addressed at the shorter time scales. Use of the ensemble mean as the sole basis for planning, therefore, however straightforward, is not recommended. When it is used appropriate measures of uncertainty should be added. Despite these issues, some results using this approach are provided below.

- The next approach is to provide a range of possibilities based on the ensemble, with the range typically expressed around the ensemble mean. This approach is also used by the IPCC and certainly provides a degree of advice about the uncertainties involved. Nevertheless, the two caveats mentioned above remain an issue. In fact the caveats need to be broadened. Predictability theory indicates that a properly formed ensemble cannot and should not encompass the entire probability distribution of future states. Hence, for a properly formed ensemble there is always a possibility of the "answer" lying completely outside the range of the ensemble, that possibility decreasing as the ensemble size increases. Any range that lies fully within the ensemble is ignoring possible future states, even though sometimes these ranges are calculated in terms of a 95% or 99% coverage based of the ensemble itself. How large is large enough for an ensemble? If properly formed then the probability of the "answer" lying outside the complete ensemble range is roughly 10% for an ensemble of size 20 (about the AR4 size) and about 5% for an ensemble of 40 (slightly larger than the AR5 size). However, adding members eventually becomes a matter of decreasing returns in some regards, although when this applies with climate projections is unknown at present. With current technology it is probably best to assume that the larger the ensemble size the better. Nevertheless, inherent biases still remain in the IPCC ensembles, as not all models included are independent, i.e. different versions of the same base models are sometimes included.

- The only approach that provides all information inherent within an ensemble is to calculate probability distributions for each variable at each point and time of interest (with the assumption that the ensemble is properly formed). While the IPCC provides some information along these lines, it focuses principally on the average/range approach outlined above. Probability distributions are often not popular amongst users who may find them difficult to interpret. In addition not all published probability distributions consider the fact that the "answer" may lie outside the ensemble; none are able to consider that the ensemble may not be proper. One major disadvantage of this approach is that the vast amount of information produced can readily overwhelm the user.

4 Methodology used for the scenarios

The methodology used here incorporates two main steps:

- A background assessment of climate change projections for Palestine generated through all atmosphere/ocean models used in the main IPCC AR4 and AR5 assessments, plus those from a further set of projections (CORDEX) using Regional Climate Models

- A detailed assessment of projections using the AR5 set based on the technique of self-organizing maps (SOMs).

In the former, ensemble means have been calculated for the atmosphere/ocean models used in the main bodies of the two IPCC reports. In addition, this process has been repeated for the

AR5 using the projections from RCMs (CORDEX[149]) covering the Levant. According to IPCC Working Group I (WGI), RCMs provide most value near coastlines (e.g. Gaza) and in regions of marked topography (probably more topographically diverse than the West Bank).

There are scientific issues still to be resolved with RCMs, which are reviewed in the IPCC AR5 WGI report in Section 9.6 onwards. As such, it is recommended that they should only be used as a source of information rather than exploiting their enhanced temporal and spatial details. Combinations of RCMs should, ideally, be run in combination with a number of GCMs when downscaling in order to address uncertainties. Use of a single RCM for downscaling is, thus, inappropriate and has not been used here, although some results from RCMs have been included in the earlier reviews above. The SOMs approach has also not been used on the CORDEX data because the set is incomplete compared with that from the full IPCC AR5 set and may, therefore, include biases.

Analyses have been prepared by year for 2016-2035 (summarised as 2025), 2046-2065 (2055) and 2081-2100 (2090). Changes have been calculated against simulations for each model for a historical period, 1986-2005[150]. The reason for approaching the baseline in this manner is that it is unlikely that any of the models simulate the Palestinian climate in a manner fully consistent with reality, and thus calculating changes simulated by each model from a historical period helps to remove some of the biases inherent in that model' simulations. Care must be taken not to confuse specific values associated with this baseline extracted from model simulations with the idea of a baseline calculated from observations, or with any details discussed in the report on the assessment of historic trends in Palestine's climate. The objective is to estimate **changes** in climate from the baseline period, not absolute values.

A new approach to scenarios has been used in the AR5, namely Representative Concentration Pathways (RCPs), four of which, RCP2.6, RCP4.5, RCP6.0 and RCP8.5, have been assessed in detail by the IPCC. The larger the value at the end of each 'RCP' the higher are the emissions and atmospheric GHG concentrations. For comparison to the perhaps more familiar scenarios used in the IPCC AR4 (more details provided in Appendix 3.1):

- RCP8.5 matches closely to A2
- RCP6.0 lies roughly midway between A1B and B1
- RCP4.5 in general is a good match to B1
- RCP2.6 represents lower emissions than were considered in the AR4.

Of these the focus here will be on RCP2.6 and RCP6.0; results for the other two RCPs are included in Appendix 3.3*.* The reason for selecting these two RCPs, other than limiting the text length, is that RCP2.6 is the only one that provides a high probability of achieving the UNFCCC target of a maximum average global temperature rise of 2.0°C and RCP6.0 is a realistic option should UNFCCC processes fail, given reasonable expectations of international mitigation activities.

RCP2.6 envisages a full cessation of carbon emissions by about 2070, something that is considered by the IPCC to be technologically achievable. Other voices have called for more rapid or slower elimination of carbon emissions but without specific model projections the impacts on climate changes can only be estimated by interpolation. Thus, RCP2.6 offers the maximum information under the assumption that the UNFCCC process will be successful and the 2.0°C target will be not be breached.

Observed measured emissions have been following approximately the curve of RCP8.5 according to figures to the end of 2014. However, there are two reasons why RCP6.0 is a focus here rather than RCP8.5. Firstly, some preliminary figures have suggested a reduction in in the rate of growth of emissions in the early part of 2015 that, if continued, would lower the curve below that of RCP8.5. Secondly, even without full success under the UNFCCC there is growing momentum towards some reductions in emissions, including extensive installation of renewable energy sources. Thus, RCP8.5 may be too pessimistic with RCP6.0 perhaps more

[149]The results from the Mediterranean North Africa, MENA, CORDEX projections have been used.

[150]The baseline period used should always be noted as changes in the baseline will produce differences in calculated future changes. Baselines have changed between successive IPCC Assessments, and a variety of baselines has been used in the NCs and papers reviewed above – these have been recorded in the tables wherever possible.

representative of a plausible relatively high-emissions future. Should this assumption be unacceptable, then results for RCP8.5 (and RCP 4.5) are provided in Appendix 3.3. Unfortunately, there are results only for RCP4.5 and RCP8.5 for CORDEX.

One disadvantage of the approach based on RCP2.6 and RCP6.0 is that the modelling centres have tended to prioritize RCP 4.5 and RCP8.5. Thus, the number of models in each ensemble is: RCP2.6 – 20 models; RCP4.5 – 39; RCP6.0 – 15; RCP8.5 – 40. It is argued in Section 3 that there are advantages in larger ensemble sizes, not least, in a properly formed ensemble, of reducing the likelihood that the "answer" lies entirely outside the range of the ensemble. Full details of the RCP4.5 and RCP8.5 ensembles are provided in Appendix 3.3 and interpretations are included below in order to permit complete flexibility in the selection of those RCPs to be used. Notwithstanding the issue of ensemble size, we believe the reasons for prioritizing RCP2.6 and RCP6.0 are sound.

A standard approach to interpreting the projections is used here initially, i.e., an examination of ensemble means, their standard deviations, and ranges. However, the key additional step followed is to calculate SOMs. This is a technique to identify groupings within a dataset without assuming any statistical distributions (such as a normal distribution) within that dataset. The initial decision with SOMs is to determine the number of groups to calculate. Based on previous experience, all calculations have used four groups, although additional groups could be calculated, in principle, especially for those datasets with larger numbers of projections. The calculations have been run using the combined temperature (as a change in °C) and rainfall (as a change ratio expressed in %) projections for all three future time periods together (i.e., 2016-2035, 2046-2065 and 2081-2200). Each grouping is then plotted on a scatter chart illustrating the complete temperature/rainfall projections, together with a companion chart showing the average temperature or changes associated at each time period with that particular group.

Examination of the scatter charts typically suggests either a sequence of events in time, or, on occasions, individual groupings of models, the key aspect being that each model in each group is projecting similar future temperature and rainfall conditions. The straightforward approach to interpreting these groupings is to estimate or calculate group means (as opposed to the ensemble mean), an approach used here. While this approach provides additional insight in comparison with traditional approaches, it still suffers from issues identified above. These issues include that the more outlying projections are taken into account only as components of each group mean, and the possibility that the "answer" lies outside the entire range of the ensemble is ignored. Thus other interpretations of the SOMs results are possible, and can be facilitated by examination of the scatter charts, as presented below; indeed, the charts indicate maximum and minimum values across all projections. Therefore, the interpretation provided here is not necessarily the final solution, but it is one that is consistent with a realistic perspective of the complete spread provided by each full ensemble.

Recommended interpretations of the projections when assessed through the SOMs technique are provided in Section 7 and final recommended scenarios are provided in Section 11. In order to aid interpretation of these sections, separate scenarios under each RCP are provided in Appendix 3.4 together with brief discussion on the approach to collation of these scenarios into the final recommendations.

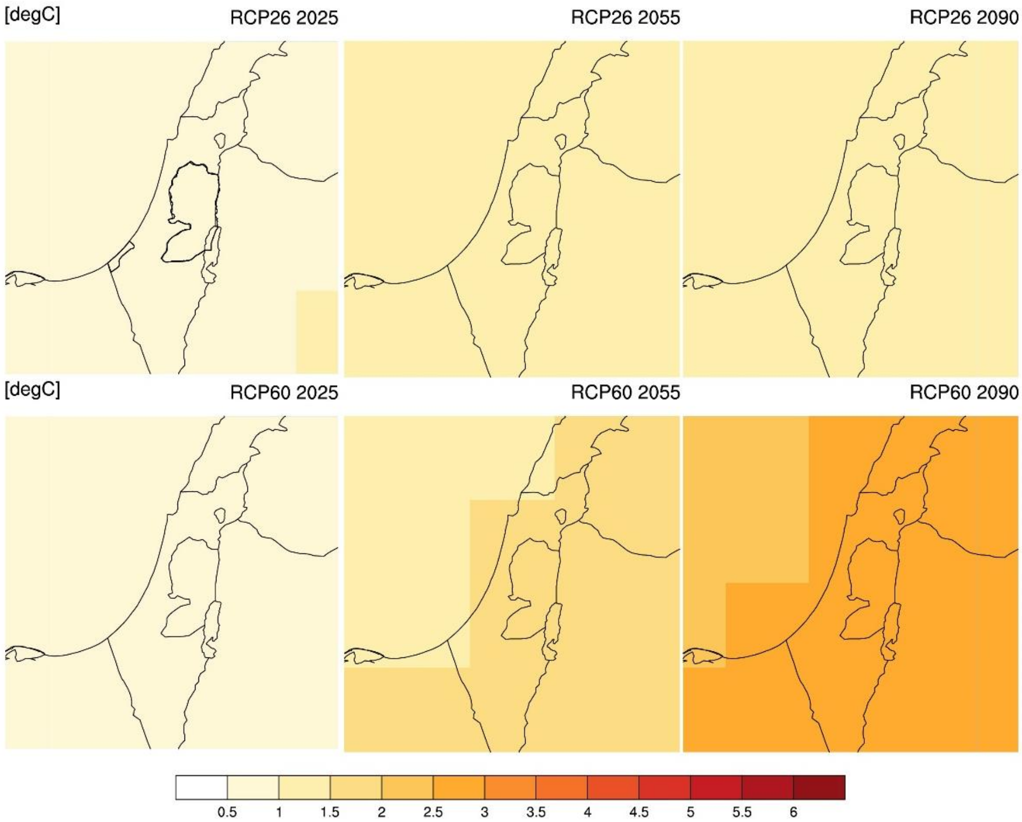
5 Temperature projections

Naturally, temperature projections for Palestine increase in time and with higher emissions, i.e., a higher RCP value or, under AR4, the A2 and A1B scenarios (see Appendix 3.3, Figure 21Figure 22Figure 23Figure 24, for results for CMIP3 [AR4] and for RCP 4.5 and RCP8.5[151]).

Figure 6shows projected changes in mean annual temperature for Palestine under RCP2.6 and RCP6.0. Even under RCP6.0 the temperature increase, according to the mean, is below 3°C, rather lower than many of the projections reviewed earlier (although the average increase exceeds 4°C for RCP8.5)

[151]Note that any changes between CMIP3 and CMIP5 may be assigned to several causes, the main one being the larger number of models in CMIP5

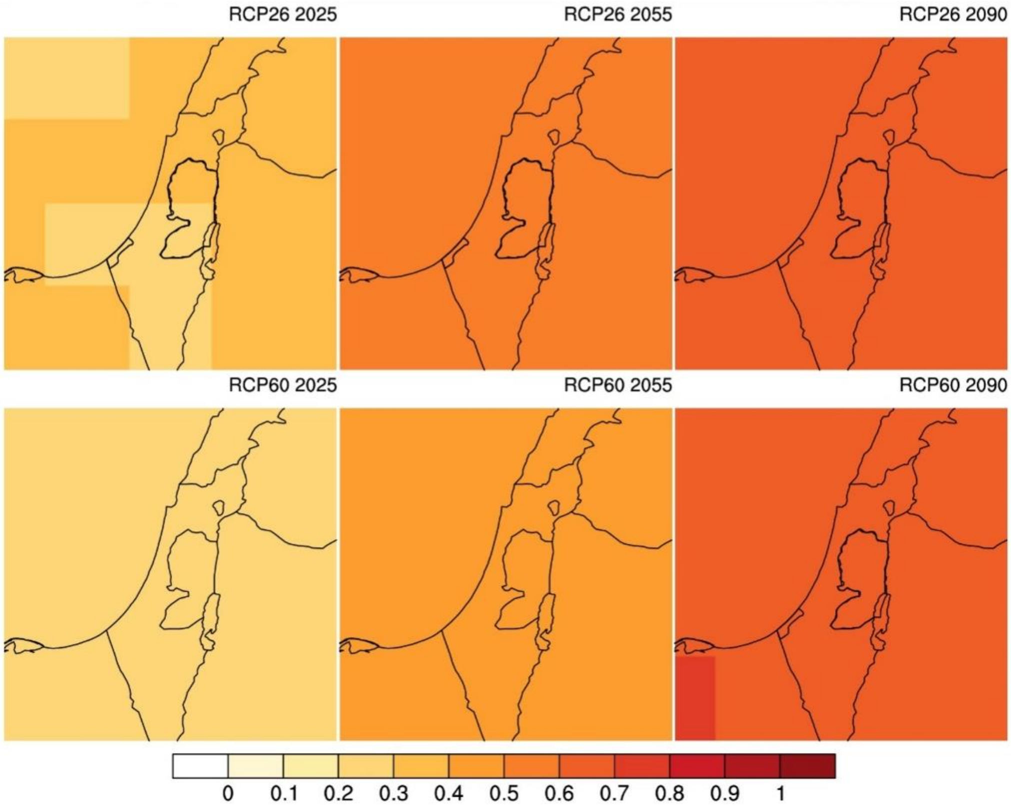
Figure 6: Projected changes in mean annual temperature (ºC) for Palestine under RCP2.6 and RCP6.0



The CORDEX projections are so similar to those for the AR5 that they need not be discussed here (see charts in Appendix 3.3,Figure 23). For all RCPs except 8.5, ensemble average projected increases for 2025 are of the order of 0.5°-1.0°C (for RCP8.5 they are closer to 1.0°C), rising by 2090 to 1.0°-1.5°C under RCP2.6 and 2.5°-3.0°C under RCP6.0.

Figure 7shows projected changes in standard deviation in mean annual temperature for Palestine under RCP2.6 and RCP6.0.For all RCPs, the standard deviation across the ensemble increases, as compared to that for the historic period, with the largest increases for RCP8.5 (for RCP4.5 and RCP8.5 from both CMIP5 and CORDEX see Appendix 3.3,Figure 24). Thus, by this measure, temperatures on an annual basis will become relatively more variable in the future.

Figure 7: Projected changes in standard deviation in mean annual temperature for Palestine under RCP2.6 and RCP6.0



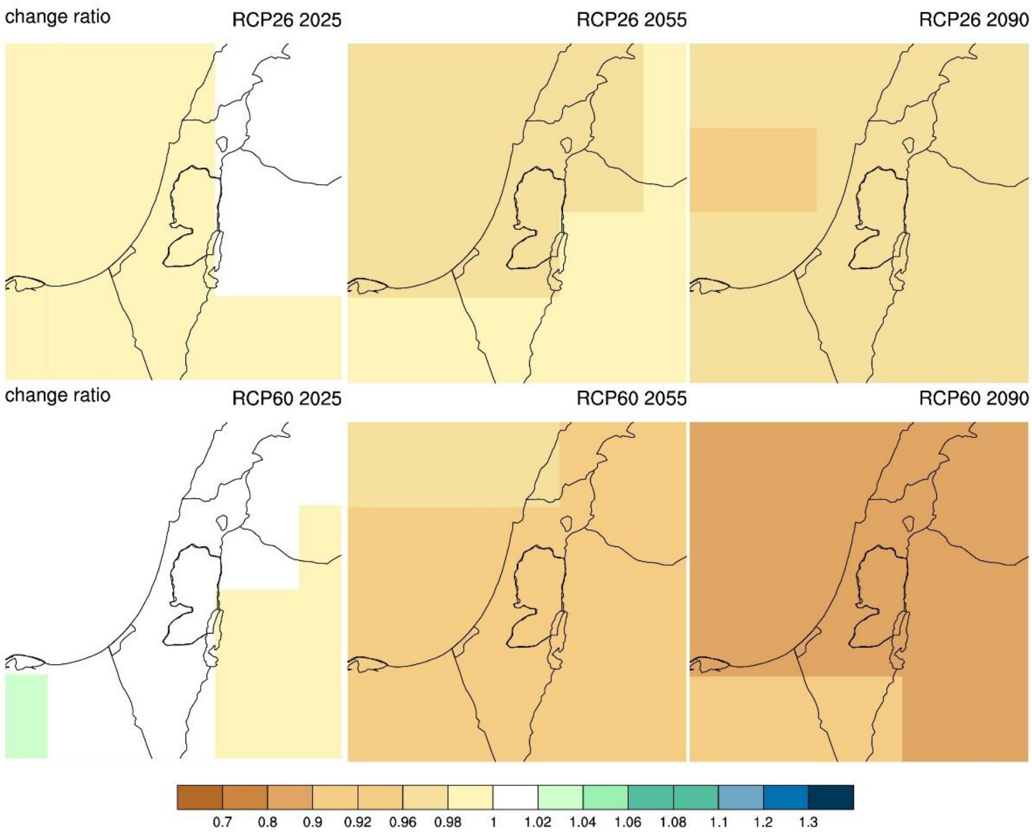
Changes in the temperature range, as assessed from the 10% and 90% levels across the CMIP5 ensembles are provided in the Appendix .3,Figure 22.

6 Rainfall projections

Rainfall changes are expressed in the Figures in this report and Appendix 3.3 as ratios with average annual rainfall over the period 1986-2005. Thus, a value of 0.9 represents a 10% decrease, as compared to the historic period, and one of 1.1 represents a 10% increase. One issue that should be stressed here is that, unlike the position with temperatures, there is no fundamental reason why rainfall changes should progress in a linear manner either through the higher emissions RCPs or through time.

In many cases the ensemble mean is indicating a reduction in rainfall across Palestine. However, under RCP2.6 and particularly under RCP6.0, there is perhaps a slight increase in rainfall by 2025 of no more than 2% but with an equally slight decrease in Gaza under RCP2.6 and perhaps also in the West Bank (Figure 8). The reduction in rainfall over both areas is between 2 and 4% under RCP4.5, (see Appendix 3.3,Figure 27), while it is between 4 and 6% under RCP8.5 (see Appendix 3.3, Figure 27). Decreases in rainfall grow larger with time under all RCPs, reaching 2-4% under RCP2.6 and over 10% under RCP6.0; see Figure 8(over 10% under RCP 4.5 and over 20% under RCP8.5; see Appendix 3.3, Figure 27). These reductions in rainfall are less than those suggested in a number of the earlier estimates made in the documents reviewed in Section 2. Any differences from the CMIP3 results are largely in terms of magnitudes, with means from the CMIP3 ensembles all indicating future decreases.

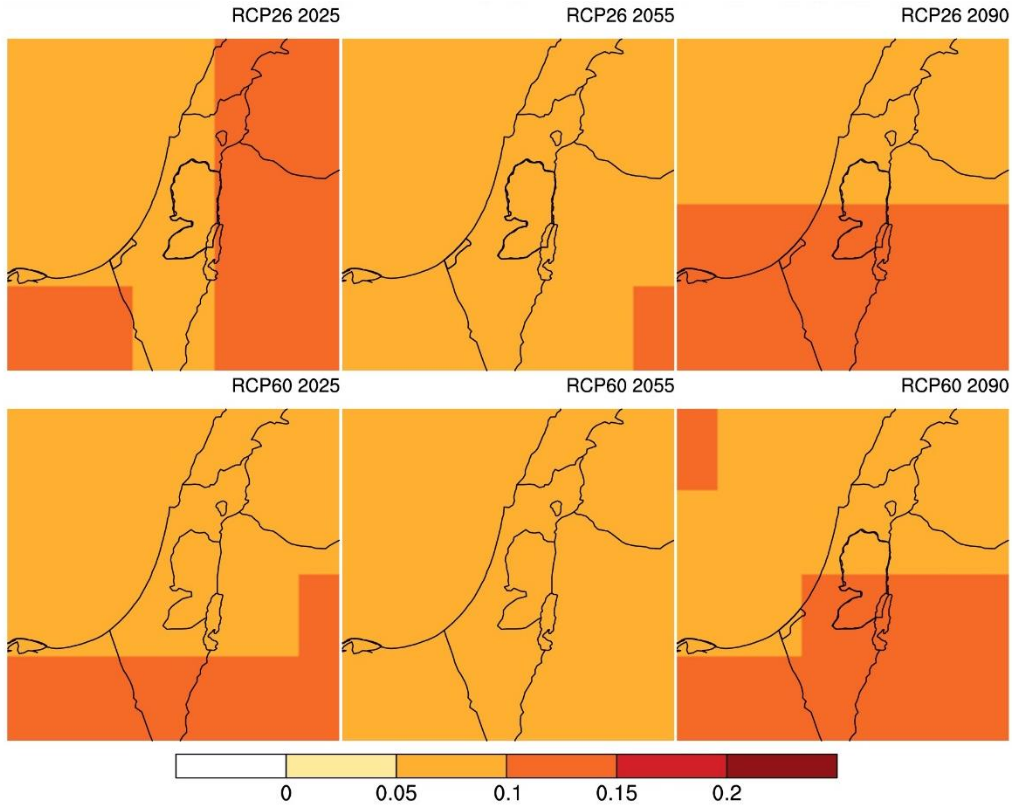
Figure 8: Projected changes in mean annual rainfall under RCP2.6 and RCP6.0 (expressed as ratios with average annual rainfall over the period 1986-2005 – 0.9 represents a 10% decrease, 1.1 represents a 10% increase)



The diagrams for CORDEX projections (for RCP4.5 and RCP8.5 only – see Appendix 3.3,Figure 30) show greater spatial detail than those for CMIP5, but caution is required in assuming that this extra detail is reliable. Often the CORDEX projections are for lesser decreases in rainfall over Palestine than the corresponding CMIP5 ones.

Adjustments in annual rainfall variability according to the CMIP5 standard deviations are in all cases towards greater variability (for RCP2.6 and RCP6.0, see Figure 9), with the greatest change in the south (i.e. Gaza) and under RCP8.5 (Appendix 3.3,Figure 28). Rather different patterns of change occur in the CORDEX ensemble (see Appendix 3.3, Figure 30), especially for RCP8.5 at 2090 when the greatest changes occur in the north. Range changes as provided by the 10% and 90% levels in CMIP5 under all RCPs are also provided in Appendix 3.3, Figure 12; in most cases the 90% value extends well into the regions of increased rainfalls.

Figure 9: Projected changes in standard deviation in mean annual rainfall under RCP2.6 and RCP6.0 (expressed as ratios with average annual rainfall over the period 1986-2005)



In summary, the approach through the use of standard ensemble statistics reveals a future of in which the likely scenario is one of steadily increasing temperatures and reducing rainfall, in both cases with increasing variability on an annual basis. By and large, these changes are greater with higher emissions, although under RCP6.0 the rainfall change is positive initially.

7 Self-organizing maps

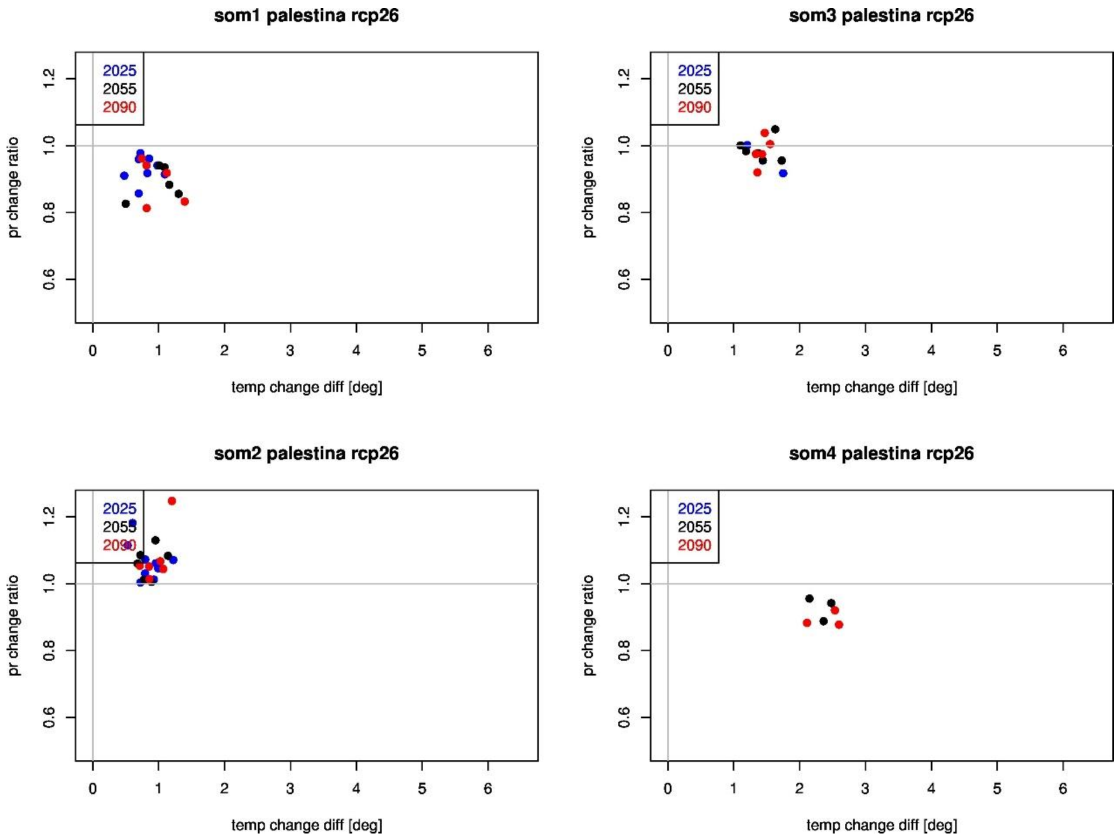
The SOMs analysis pairing mean annual temperature and rainfall totals changes is illustrated for RCP2.6 using CMIP5 in Figure 10. Rainfall as a ratio of change is on the y axis and temperature change in °C on the x axis; values above 1.0 for rainfall change indicate increased future rainfall, below 1.0 decreases. Dots show the combined temperature and rainfall changes from each model, in blue for 2025, in black for 2055 and in red for 2090. There is no specific order in which the SOMs methodology presents the groups, and so interpretation of each sequence is required; this interpretation is given numbering as in Figure 10(e.g., Chart 1 is top left, Chart 2 is bottom left, etc.). Interpretation may depend to an extent upon the observer but, in general, different assessors are likely to produce equivalent interpretations. SOMs are based on a neural network approach and changes in that approach may produce some, but normally limited, adjustments to the results. A consistent approach to the calculations has been used throughout. Note that in the discussions following, temperature and rainfall changes are often rounded – adding apparent precision to temperature and rainfall figures is not required given all of the uncertainties involved. Note also that maximum and minimum values indicated across all models, if required, can be deduced directly from the SOMs diagrams.

7.1 RCP2.6

Rather than suggesting that two or three of the SOMs charts are related in a time sequence, which is a typical result from this approach, in this case it appears that there are three independent groupings of the models, in each case with limited development of changes in time, plus one minor grouping that might be an extension of one of the main three. There are two groups with approximately similar likelihoods, as determined by the number of models incorporated (relative number of models is a valid indicator of likelihood if the ensemble is formed properly, but may not be otherwise). In the first, som1, temperatures rise by about 1°C at all future times and rainfall decreases by about 10%. It is likely that some of these models move into the possible extension, som4, with temperatures increases of 2.5°C and a 10% reduction in rainfall from 2055 onwards.

The second major group is that of som2, where the temperature increase is 1°C, equivalent to that in the group of som1, but in this case with a rainfall increase of around 5%. There is a final group in som3, with lower likelihood, in which temperatures rise by about 1.5°C but there is perhaps a small decrease in rainfall.

Figure 10: SOMs analysis pairing mean temperature and rainfall changes for RCP2.6 using CMIP5



Thus, in summary, the RCP2.6 sequences are:

- som1 (with a possible→som4): temperature increases 1°C, rainfall reduces 10%
- som2: temperature increases 1°C, rainfall increases 5%
- som3 (least likely): temperature increases 1.5°C, small decrease in rainfall.

Maps are provided below of averages for each of the model sets for each period in each SOM, and should be interpreted with reference to the scatter plots above (grey maps indicate that there are no points for that time slot within that SOM). The maps are provided in the order 2025, 2055 and 2090, with paired temperature and rainfall change charts in each case (Figures 6-8). There is little difference throughout in average temperature changes for the two most likely groups, those of som1 and som2, as noted above, although the map reveals that some areas warm slightly more in som1 by 2055 and in som2 by 2090. The main difference between the two SOMs is in the rainfall. As relatively few models are being averaged, and as rainfall is spatially variable, rather more variability is apparent in these rainfall maps than in the earlier charts for the full ensemble. Perhaps the major conclusion to be drawn from these maps is that, to an extent, rainfall changes increase in time in both groups, with, for som1, the largest rainfall reductions occurring immediately. som4, a possible extension of som1, does not appear, of course, at 2025, but then becomes warmer and generally drier than som1. The final main group, som3, is warmer than either som1 or som2 throughout, but with overall reductions in rainfall.

Figure 11: Paired maps of average changes in annual temperature and rainfall for each of the model sets for each period in each SOM under RCP2.6 for 2025

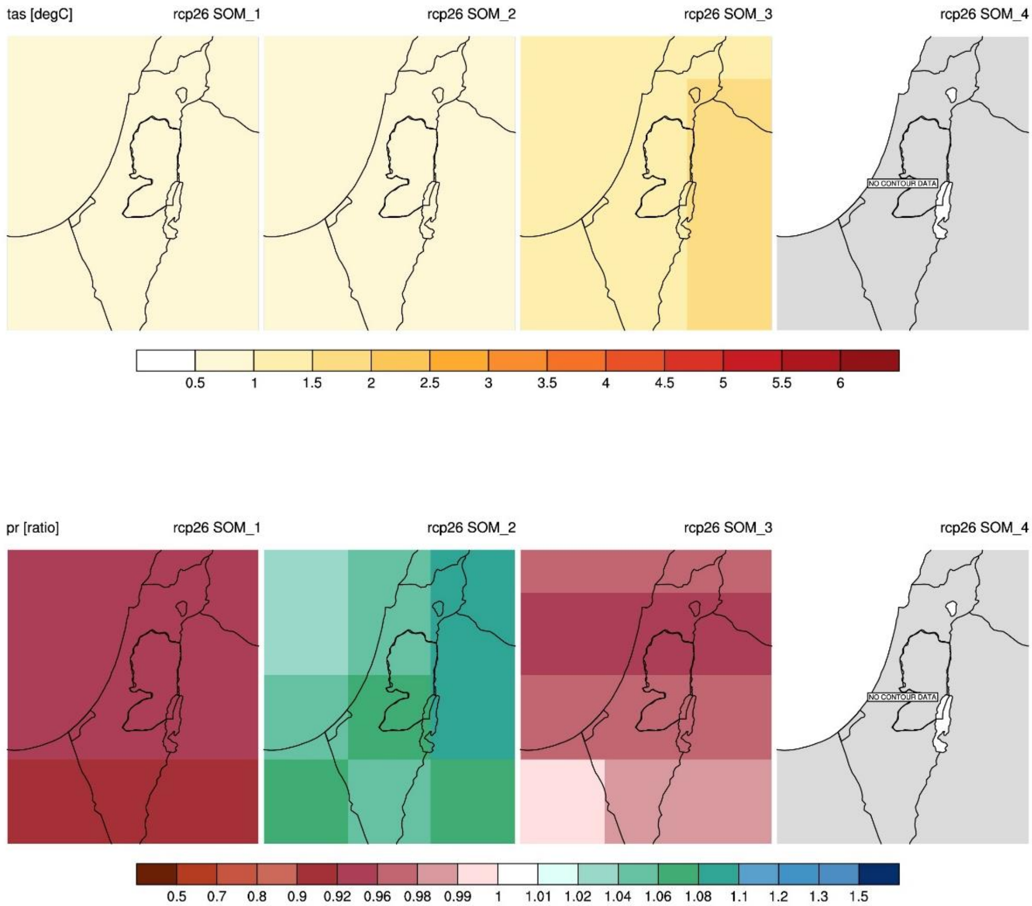


Figure 12: Paired maps of average changes in annual temperature and rainfall for each of the model sets for each period in each SOM under RCP 2.6 for 2055

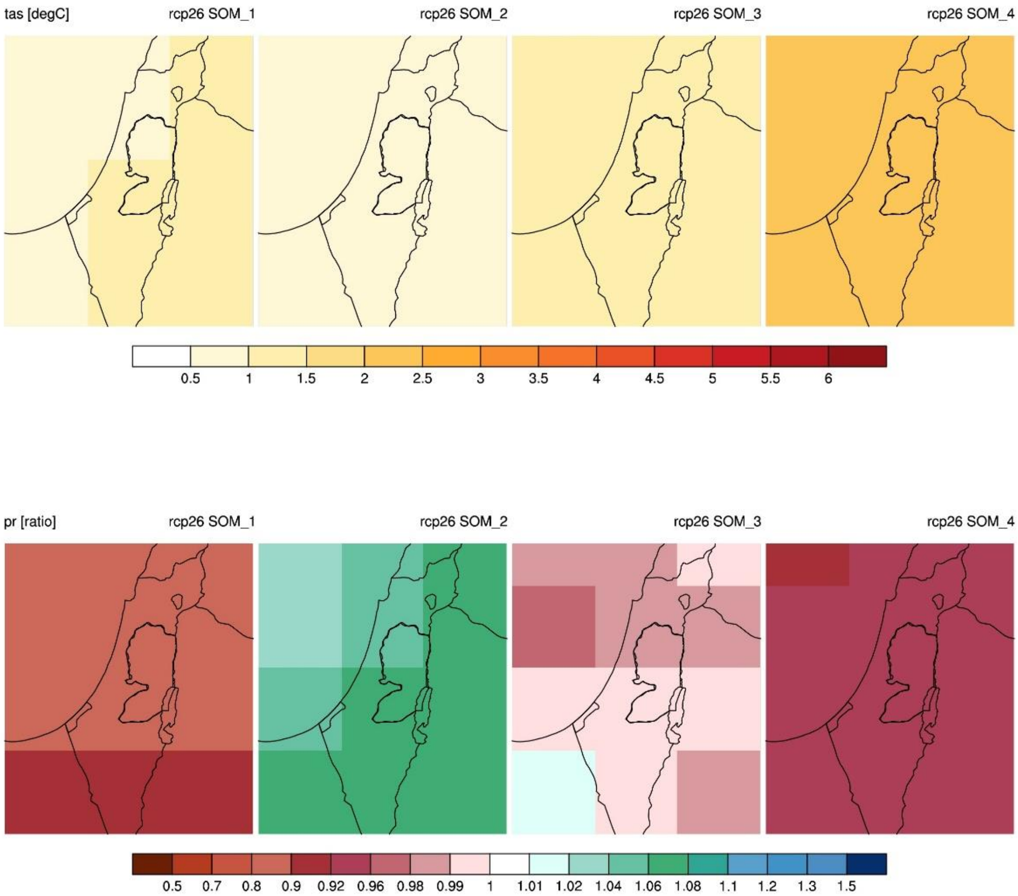
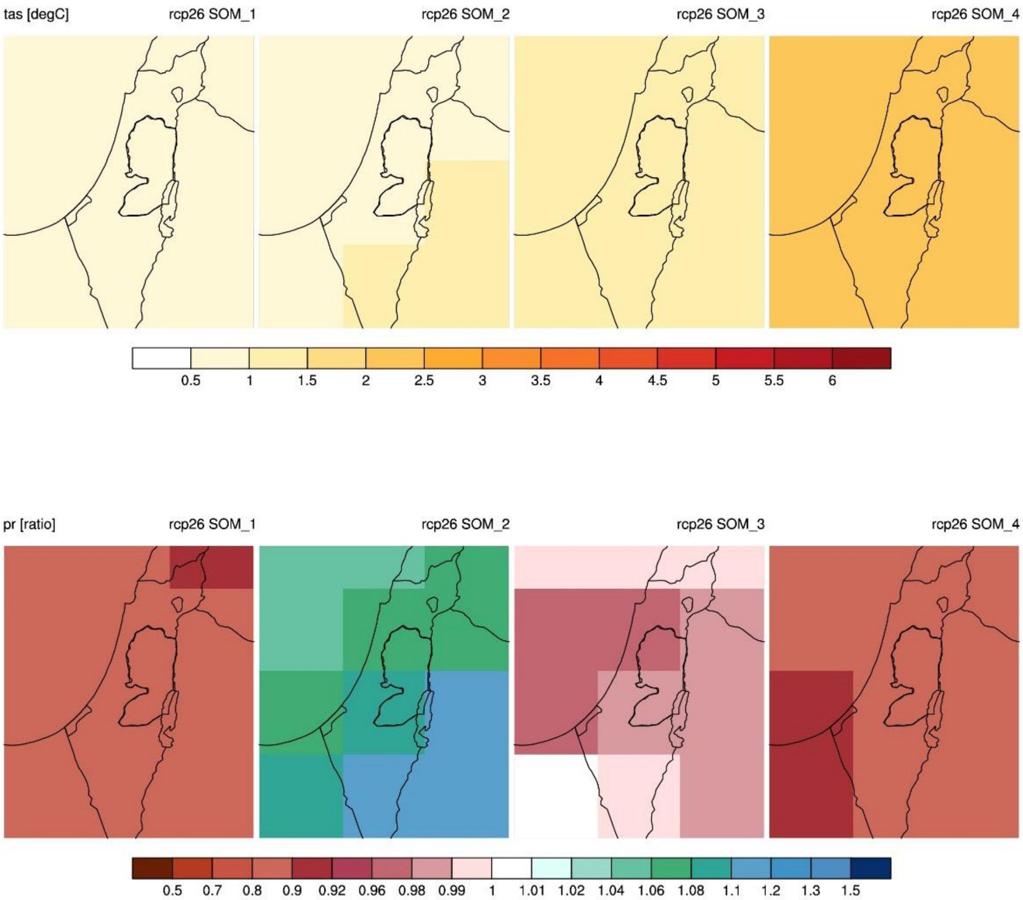


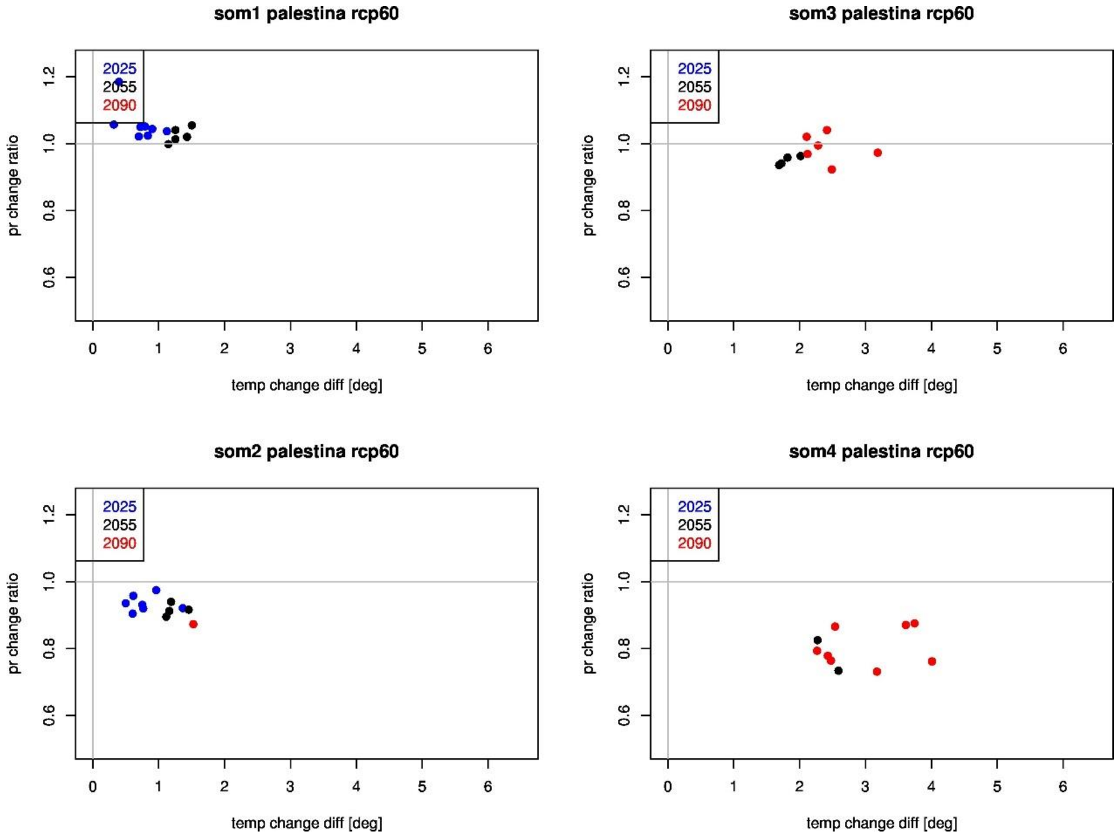
Figure 13: Paired maps of average changes in annual temperature and rainfall for each of the model sets for each period in each SOM under RCP2.6 for 2090



7.2 RCP6.0

There appear to be two sequences for RCP6.0, both of roughly equal probability. The first begins in som1, with temperature increases by 2025 below 1°C and rainfall increases of around 5%. This continues into som3, whereby the temperature increases by 2090 to over 2°C and rainfall returns roughly to recent values. The second sequence, som2→som4, produces a picture of ultimate temperature increases of around 3°C, with rainfall reducing steadily over time by 20%.

Figure 14: SOMs analysis pairing mean temperature and rainfall changes for RCP6.0 using CMIP5



In summary, the RCP6.0 sequences are:

- som1→som3: temperature up over 2°C by 2090, but rainfall, after initial increase of perhaps 5%, returns to close to current normal
- som2→som4: temperature increases steadily by 3°C and rainfall declines steadily eventually by 20%.

Maps for each of these two sequences are presented below (Figures 10-12). By 2025 there is little difference between the sequences in temperatures but a major difference in rainfall. However, for the first sequence, the initial increase in rainfall converts to indiscernible change in Gaza and a small decrease in the West Bank by 2090. For the intermediate 2055 period in this sequence, the models separate into two groups, one with increased rainfall the other with reduced rainfall, the overall average being approximately zero change. For the drier sequence, som2→som4, temperature rises tend to be higher than those in the first sequence already discussed, and again there is a suggestion that the worst of the rainfall decreases may happen prior to 2090.

Figure 15: Paired maps of average changes in annual temperature and rainfall for each of the model sets for each period in each SOM under RCP6.0 for 2025

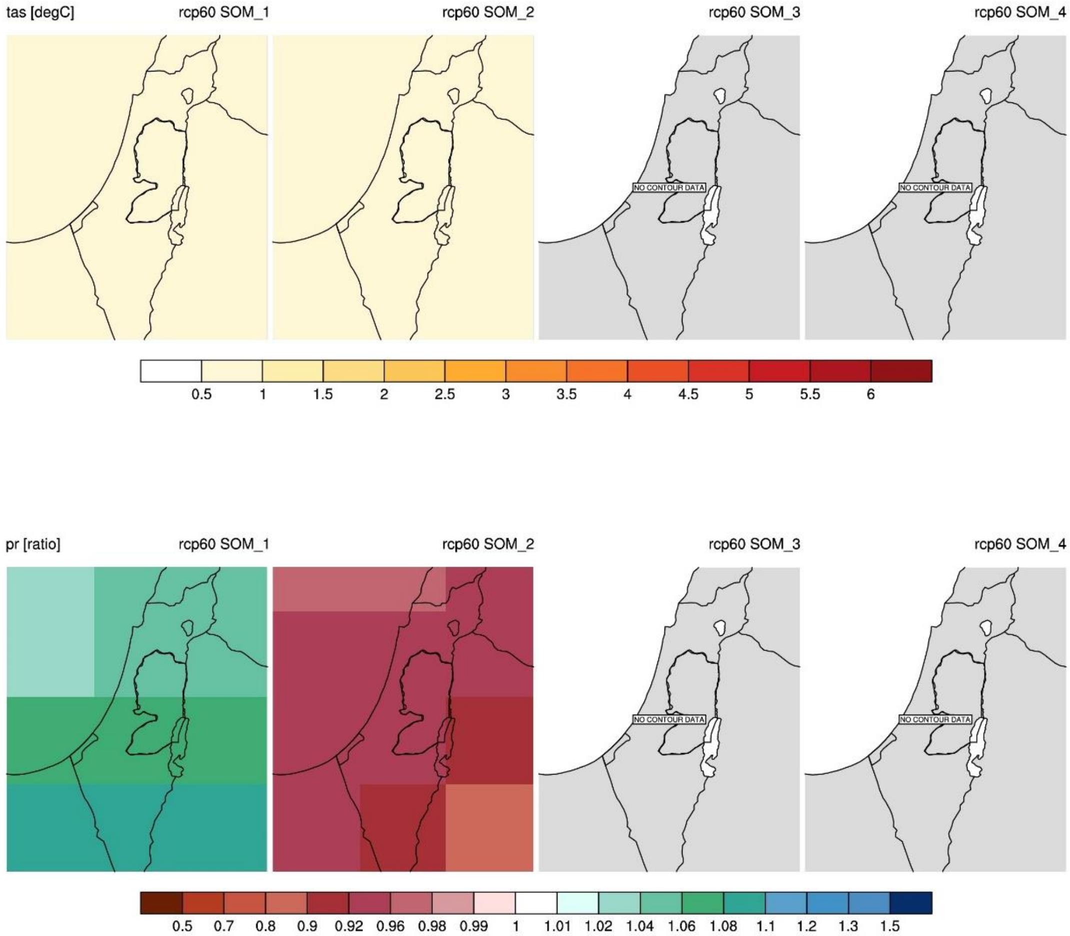
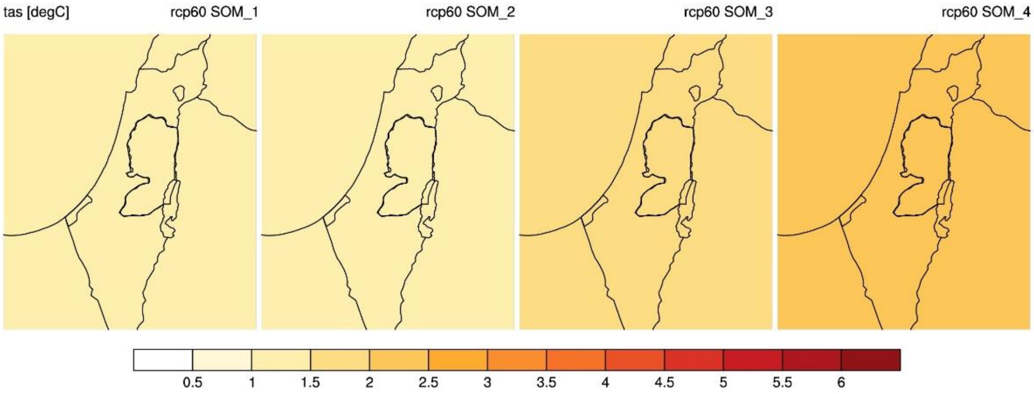


Figure 16: Paired maps of average changes in annual temperature and rainfall for each of the model sets for each period in each SOM under RCP6.0 for 2055



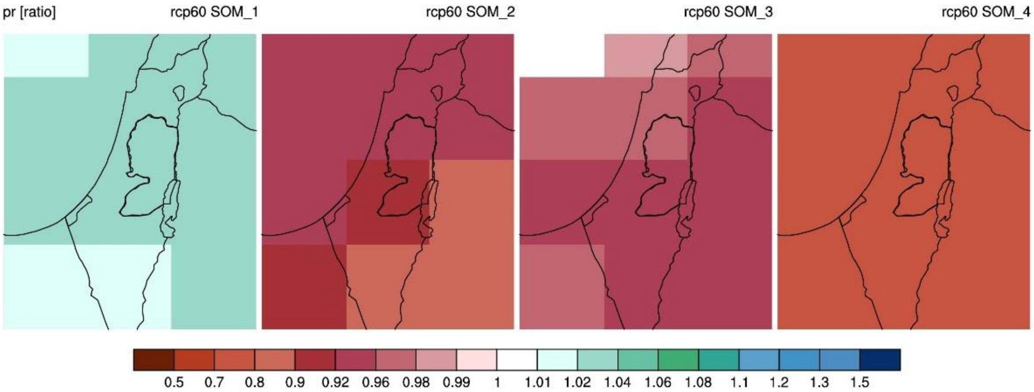
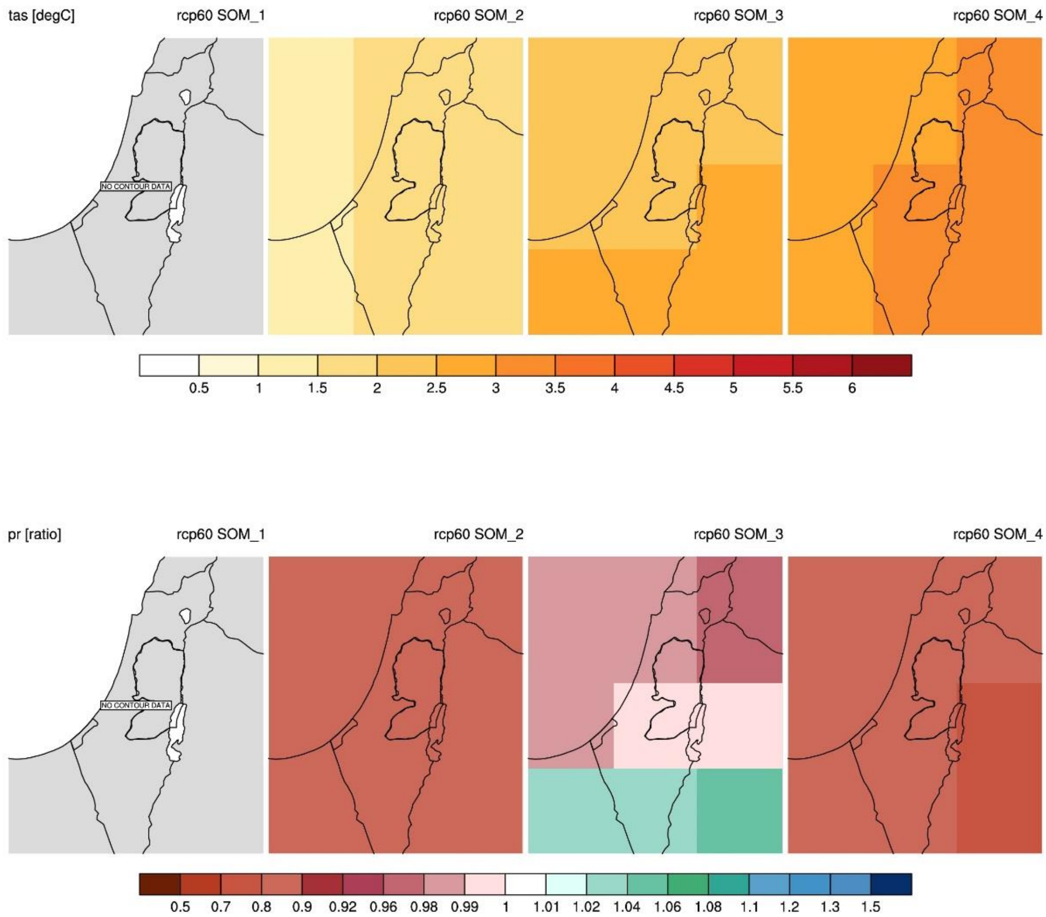


Figure 17: Paired maps of average changes in annual temperature and rainfall for each of the model sets for each period in each SOM under RCP6.0 for 2090



Under RCP4.5 (see Appendix 3.3,Figure 32) the patterns resemble those under RCP6.0 but are easier to interpret, perhaps on account of the larger number of models in the ensemble. There are two distinct sequences. In the first, marginally with higher probability given the number of projections included, rainfall remains similar to today but temperatures increase (1.0°C→1.5°C→2°C) – som1→som3. In the second, rainfall reductions are about 20% throughout (som2→som4), with temperatures increasing by 1.0°C→1.5°C→3.0°C, the larger temperature increase linked to reduced rainfall, as compared to the first sequence.

The only additional detail revealed by the maps is that, on the whole, the average rainfall changes in the first sequence are on occasion negative but, on overall average, marginally so. Hence in summary for RCP4.5, the sequences are:

- som1→som3: temperature increases of up to about 2.5°C by 2090, with rainfall probably remaining around current averages
- som2→som4: temperature increases similar to those in the first sequence, but rainfall decreases in excess of 10%.

For RCP8.5 (see Appendix 3.3,Figure 33) there are again two sequences, a relatively less dry one, som1→som4, and a drier one, som2→som3. In the first case, temperatures rise 1°C→3°C→4°C; rainfall changes are roughly -5%-->0%-->-20%. In the second case temperatures rise 1.5°C->2.5°C→4.5°C while rainfall reductions are 20%-->20%-->30%.

Results are presented, mainly for information, for SOMs calculations based on the CORDEX projections. Results for CORDEX are not immediately similar to those from CMIP5 for the same

RCPs. For example, under RCP4.5 CORDEX som1 (mainly 2020 and 2050), includes an increase of about 5% in rainfall, and the few models in som2 suggest decreases in excess of 20%.

There are several possible explanations for the differences between the CMIP5 and the CORDEX results, but more detailed analysis is required to determine the exact cause. However the possibilities include that the downscaling in CORDEX is producing results sufficiently different from those in CMIP5, an indication that more detail is being produced but not necessarily, until demonstrated otherwise, that more *valuable* detail is being produced. A second possibility, but unlikely, is that the downscaling is resulting in a significant change to the overall projections. However, the most likely reason is that the CORDEX ensemble uses only a subset of the global models present in the CMIP5 set and, thus, that the major differences in the SOMs analyses result from the corresponding relative biases introduced.

8 Extremes indices

The IPCC has defined a list of 27 'extremes indices' that can be extracted from both observations and from model simulations to provide indications of the manner in which certain aspects of some of the less common and impactful weather events might change in the future[152]. All such calculations, a selection of which are discussed below, come with warnings that:

- The ability of models to simulate such events is less than, for example, it is for global average temperature change
- These statistics are less stable than those for temperatures because of the relative rarity of the events.
- It is not known how well each individual model simulates the frequencies of each of these events over the Levant.

Results have been calculated only for a subset of the 27 indices, with all diagrams provided in Appendix 3.3, Figures 18-28.

9 Temperature indices

Tropical Nights (Tr)

A Tropical Night is defined as one with a minimum temperature greater than 20°C, a value selected as a global indicator, although it might not be ideal for all locations, including Palestine. Regardless of RCP used, the frequency of tropical nights increases throughout by about 40% for RCP2.6 to a doubling for RCP8.5.

Cold Spell Duration Index (csdi)

Basing calculations on averages for 1961 to 1990, a cold spell is defined as a period of at least six successive days during which the daily minimum temperature is within the lowest 10% of such temperatures calculated using a moving window through the year. The frequency of such spells is reduced by more than 20% by 2090 under RCP6.0 and RCP8.5, with lesser reductions under the remaining two RCPs.

Warm Spell Duration Index (wsdi)

The Warm Spell Duration Index is equivalent to that for cold spells, using events of at least six successive days with maximum temperatures in the highest 10%. Warm spells are projected to increase under all RCPs.

In all cases the above statistics are indicative of a warming climate, in general, more so under the higher RCPs.

[152]These indices have been listed in Appendix 2. Parameter names as listed in this Appendix have been added to the section titles.

10 Rainfall indices

Maximum One Day Precipitation (rx1day)

On an annual basis, this is the maximum precipitation on a single day; a statistic that may be unstable. The value increases by over 2% at all times in the future under RCP2.6 but results for other RCPs are somewhat variable, including in time. Reduced maximum daily rainfalls occur under all of these three RCPs in Gaza but both increases and decreases occur in West Bank. However, changes are small and are probably best assumed as being zero.

Maximum Five Day Precipitation (rx5day)

This is similar to rx1day but summed over five successive days to provide, probably, a more stable statistic. For Gaza, this amount always reduces under all RCPs at all time periods. For West Bank, there are increases of less than 2% throughout under RCP2.6 but mainly reductions otherwise, including of over 10% by 2090 under RCP8.5.

Annual 95p Total (r95p)

A further measure of high rainfall, this is based on 1961 to 1990 values of daily rainfall in the top 5% of totals when the daily rainfall is at least 1mm. It is calculated from the changes in the total rainfall on an annual basis from such heavier rainfall days. Again there is a mixed picture. The amount from such days increases under RCP2.6 by around 10% throughout. For other RCPs, there are periods of both increases and decreases, perhaps with increases earlier and decreases later as a broad generalisation.

Days with 10mm or more (r10mm)

This is a relatively straightforward measure of changes in heavy rainfall determined by the change in the number of days with rainfall exceeding 10mm. For both Gaza and West Bank under all RCPs the general tone is of a decrease in such events, the only exception being for the West Bank in 2025 under RCP6.0.

Days with 20mm or more (r20mm)

This index is identical to r10mm apart from the use of a 20mm daily threshold. Somewhat surprisingly, there is, in general, an increase in the number of these days. However this result has been checked and it is certain that it results from unstable statistics associated with a limited number of events. It has been included for the record, but should *not* be used in the derivation of scenarios.

Simple Precipitation Index (sdii)

For all days with rainfall of at least 1mm, the Simple Precipitation Index measures the change in the average daily rainfall across all such days on an annual basis. Changes are within ±2% in most periods under all RCPs, the only exception being for 2090 under RCP8.5.

Maximum Length of Dry Spell (cdd)

The Maximum Length of Dry Spell is calculated from the change in the longest annual period for which rainfall on consecutive days is less than 1mm. In general, this value increases, typically by about 2%, but by over 10% by 2090 under RCP8.5. It should be noted, however, that interpretation of this statistic requires care for Palestine. Instead of measuring dry spells within a period of rainfall, as is its intent, it most likely measures the length of the dry season. The most straightforward interpretation of an increase, therefore, is one of a possible extension to the dry summer period.

Maximum Length of Wet Spell (cwd)

This index is equivalent to cdd but may be more informative for Palestine, as it measures changes in the lengths of maximum wet spells in which each days' rainfall is at least 1mm. The results are uniformly for a reduced frequency of such events.

The statistics above are designed to provide some indication of rainfall changes with respect to heavy rainfalls, in particular, those that may lead to flooding and to dry spells, possibly periods of drought. For Palestine, the overall picture is one of limited, if any, increases in heavy rainfall events. Thus, increases in flooding frequency should be given low probability (although, of course, floods will continue to occur in the future). The greater concern is for a possible increase in the frequency of droughts.

11 Summary and recommended climate-change scenarios

Probably the outstanding issue in the determination of climate-change scenarios for Palestine is the decision as to which RCP(s) are to be used. Earlier it was argued that, given the target of the UNFCCC process of a global temperature rise not exceeding 2°C, RCP2.6 might be most representative for the future. For high emissions scenarios, it was argued that RCP8.5 might be too high, given actions being taken to reduce emissions, and that RCP6.0 is a more pragmatic selection. Unfortunately, modellers contributing to the IPCC AR5 have dedicated more computer time to, and therefore have produced more projections for, RCP4.5 and RCP8.5 than RCP2.6 and RCP6.0.

The basic pattern of temperature rises is one of greater increases under the higher RCPs. For rainfall the differences between projections are more substantial. Based on the SOMs analysis, and in simplified form, under RCP2.6 rainfall increases 5% or reduces 10%, under RCP6.0 there is either indiscernible change or a reduction of 20% (which is similar for RCP4.5), while under RCP8.5 ultimate reductions might reach 30%. Note that these values are based on means across the SOMs, and so neglect the more outlying projections and the possibility that the “answer” might lie entirely outside the range of ensemble values.

In terms of the ‘extremes’, as defined by the IPCC, the number of warm days will increase and of cold days will decrease, more so as the average temperature increases. Extended warm spells will become more frequent. For rainfall ‘extremes’ there is limited evidence that there will be any substantial increase in the number of heavy rainfall events, although this is projected by some models and there is more of a consensus amongst models that these events will increase under RCP2.6. Of greater concern is the threat of increased drought frequency, although again the consensus is that this is least under RCP2.6.

Overall it is perhaps no surprise that the potential impacts of climate change on Palestine increase with the higher RCPs, i.e. impacts will be minimised if global emissions can be controlled. The extents of any negative rainfall changes are likely to be least under RCP2.6, although the country is, nevertheless, certain to be subject to increased temperatures.

These scenarios are not dissimilar to many already included within the NCs reviewed in Section 2.1, although some of the greater impacts outlined in some of those (e.g. increase in flooding) can be seen here as perhaps having low probability. The major difference between the scenarios suggested in this section and those reviewed in Section 2.1 is that three scenarios are suggested here that are representative of all projections considered by the IPCC AR5 and cover the full range of options, which might be beneficial for planning, as summarised in Tables Table 32, Table 33and Table 34(changes by comparison with 1986-2005; 2025 represents 2016-2035, 2055 represents 2046-2065, and 2090 represents 2081-2100).

Table 32: 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 warmer periods, both becoming more prominent in 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 33: 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 warmer periods, both becoming more prominent in time; more so than under Scenario 1.
Rainfall	Decreases by ~10% by 2025, by ~15% by 2055, 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 34: 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 warmer periods, both becoming more prominent in time; perhaps moderated slightly in the Gaza Strip.
Rainfall	Decreases by ~20% throughout until 2055, and to ~30% by 2090.
Rainfall-related	In general, 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, especially in the West Bank, thus, raising a possibility of an increased flood risk.

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Appendices of Appendix 3

Appendix 3.1. Scenarios used by the IPCC

The IPCC has used a number of greenhouse gas (GHG) scenarios during the course of the five Assessment Reports to date, reflecting the state of the science at each stage. First projections, including before the IPCC commenced work, simply used two model runs, one with GHG set at historical values, the second with a doubling of that value. Models were then run over sufficiently long periods to achieve climatic steady state and differences between the two runs assessed. A slightly more sophisticated approach was to increase GHG concentrations by 1% per year. Both approaches were required in order that projections might be made in lieu of any information at that time on possible future GHG concentrations, but both are still in use as straightforward methods to inter-compare models and to assess the impacts of changes in model formulations.

The first attempts at a more realistic view of future GHG concentrations were prepared for the First Assessment Report of 1990 – SA90 (Scenario A 1990), SB90, SC90 and SD90, the latter three being modifications around the Business-As-Usual estimate of SA90 on which most modelling research was focused (for pragmatic reasons – limitations of computer time). An improved set was developed for the Second Assessment Report – IS92a, IS92b, …, IS92f (IPCC Scenario 1992a, etc.,), but it was in preparation for the Third Assessment Report that a major step forward was made through developing storylines quantified through the use of Integrated Assessment Models (complex computer models covering industry, commerce, population, etc., with relatively simple climate modules) published in 2000 in the Special Report on Emissions Scenarios (SRES). The main SRES Scenarios are shown in the second table below, which includes a brief summary of the related storylines. In principle highest emissions are to be expected under A2, in which the objective is economic growth in a competitive environment (regional decision making) as opposed to B1, lowest emissions, with globally-coordinated decision making focussed on environmental protection. In practice emissions were greater under A1FI than under A2 through most of the 21st Century. Again for reasons of limited computer time, most results reviewed in the Third Assessment focused on A1B, A2 and B1.

A new approach has been taken in the Fifth Assessment Report, in which Relative Concentration Pathways (RCPs) have been used; RCPs are based on future radiative properties of the atmosphere under various GHG concentrations but without an underlying storyline. Four RCPSs have been used, RCP2.6, RCP4.5, RCP6.0 and RCP8.5, progressively higher numbers indicating greater GHG concentrations. In straightforward terms:

- RCP8.5 is roughly equivalent to A1FI
- RCP6.0 is roughly midway between A2 and B1
- RCP4.5 is roughly equivalent to B1
- RCP2.6 introduces lower emissions than in any SRES Scenario, with all anthropogenic emissions ceasing by about 2070.

According to the IPCC all emissions must cease at some stage during the 21st Century if the 2°C target set by the UNFCCC as defining dangerous anthropogenic interference in the climate system is not to be breached. Some views indicate that cessation should be achieved by 2050, somewhat earlier than under RCP2.6. As of the end of 2014 observations indicated that emissions were following most closely the curves of A1FI and RCP8.5.

There is no objective manner in which the ‘optimal’ scenario might be selected, much depending on international agreements and national actions. The pessimistic view, based on currently observed emissions, is that the higher scenarios are likely to be followed. The optimistic view is that negotiations under the UNFCCC will succeed in meeting the 2°C target, and thus RCP2.6 is the most appropriate on which to base planning (all SRES Scenarios are too high from the perspective of the 2°C target). No selection is made in this document, but a balanced view has been presented based on all scenarios as represented by the RCPs.

Table 35. Approaches taken sequentially in generating climate scenarios using Global Climate Models

CO_2 Doubling (Steady State simulations)	Early work and used in all Assessments
1% increase in CO_2 per annum (Transient simulations)	Early work and used in all Assessments
SA90 – Scenario A of 1990 (Business as Usual) (there was also SB, SC and SD)	First Assessment Report and its Supplement
IS92 – IPCC Scenario (there was IS92a to IS92f)	Second and Third Assessment Reports
SRES – Special Report on Emissions Scenarios (to 2100) (see Table below)	Third, Fourth and Fifth Assessment Reports
RCPs – Representative Concentration Pathways (to 2100, but have been extended to 2300)	Fifth Assessment Report

Table 36. Summary of the storylines used in the SRES Scenarios

SRES Scenario	
A1FI (fossil fuel intensive)	Global; economic
A1T (technology-based generation)	
A1B (balanced between fossil fuels and technology)	
A2	Regional; economic
B1	Global; environmental
B2	Regional; environmental

Appendix 3.2. IPCC terminology for ‘extremes’

Table 37: Definitions of acronyms transcribed from IPCC (2013)

Index		Definition	Unit
	C. Temperature *Intensity*		
TXn*	Min Tmax	Coldest daily maximum temperature	˚C
TNn*	Min Tmin	Coldest daily minimum temperature	˚C
TXx*	Max Tmax	Warmest daily maximum temperature	˚C
TNx*	Max Tmin	Warmest daily minimum temperature	˚C
DTR*	Diurnal temperature range	Mean difference between daily maximum and daily minimum temperature	˚C
	Duration		
GSL	Growing season length	Annual number of days between the first occurrence of 6 consecutive days with Tmean > 5˚C and first occurrence of consecutive 6 days with Tmean < 5˚C. For the Northern Hemisphere this is calculated from 1 January to 31 December while for the southern hemisphere it is calculated from 1 July to 30 June.	days
CSDI	Cold Spell Duration Indicator	Annual number of days with at least 6 consecutive days when Tmin <10th percentile	days
WSDI	Warm Spell Duration Indicator	Annual number of days with at least 6 consecutive days with Tmax > 90th percentile	days
	Frequency		
TX10p*	Cool days	Share of days when Tmax <10th Percentile	% of days
TN10p*	Cool nights	Share of days when Tmin <10th Percentile	% of days
TX90p*	Warm days	Share of days when Tmax >90th percentile	% of days
TN90p*	Warm nights	Share of days when Tmin > 90th percentile	% of days
FD	Frost days	Annual number of days when Tmin < 0 ˚C	days
ID	Icing days	Annual number of days when Tmax < 0 ˚C	days
SU	Summer days	Annual number of days when Tmax > 25˚C	days
TR	Tropical nights	Annual number of days when Tmin > 20˚C	days
	D. Precipitation *Intensity*		
Rx1day*	Max 1-day precipitation	Maximum 1-day precipitation total	mm
Rx5day*	Max 5-day precipitation	Maximum 5-day precipitation total	mm

Index		Definition	Unit
SDII	Simple daily intensity index	Annual total precipitation divided by the number of wet days (i.e. when precipitation ≥1.0mm)	mm/day
R95p	Annual contribution from very wet days	Annual sum of daily precipitation > 95th percentile	mm
R99p	Annual contribution from extremely wet days	Annual sum of daily precipitation > 99th percentile	mm
PRCPTOT	Annual contribution from wet days	Annual sum of daily precipitation ≥ 1 mm	mm
	Duration		
CWD	Consecutive wet days	Maximum annual number of consecutive wet days (i.e. when precipitation ≥1.0mm)	days
CDD	Consecutive dry days	Maximum annual number of consecutive dry days (i.e. when precipitation <1.0mm)	days
	Frequency		
R10mm	Heavy precipitation days	Annual number of days when precipitation ≥ 10mm	days
R20mm	Very heavy precipitation days	Annual number of days when precipitation ≥ 20 mm	days
Rnnmm	Precipitation above a user-defined threshold	Annual number of days when precipitation ≥ nn mm (nn: user-defined threshold)	days

Appendix 3.3. Results for Representative Concentration Pathways 4.5 and 8.5

Figure 18: Projected changes in mean annual temperature (ºC) for Palestine calculated from the CMIP3 (AR4) ensemble under B1, A1B and A2 for periods centred on 2025, 2055 and 2090.

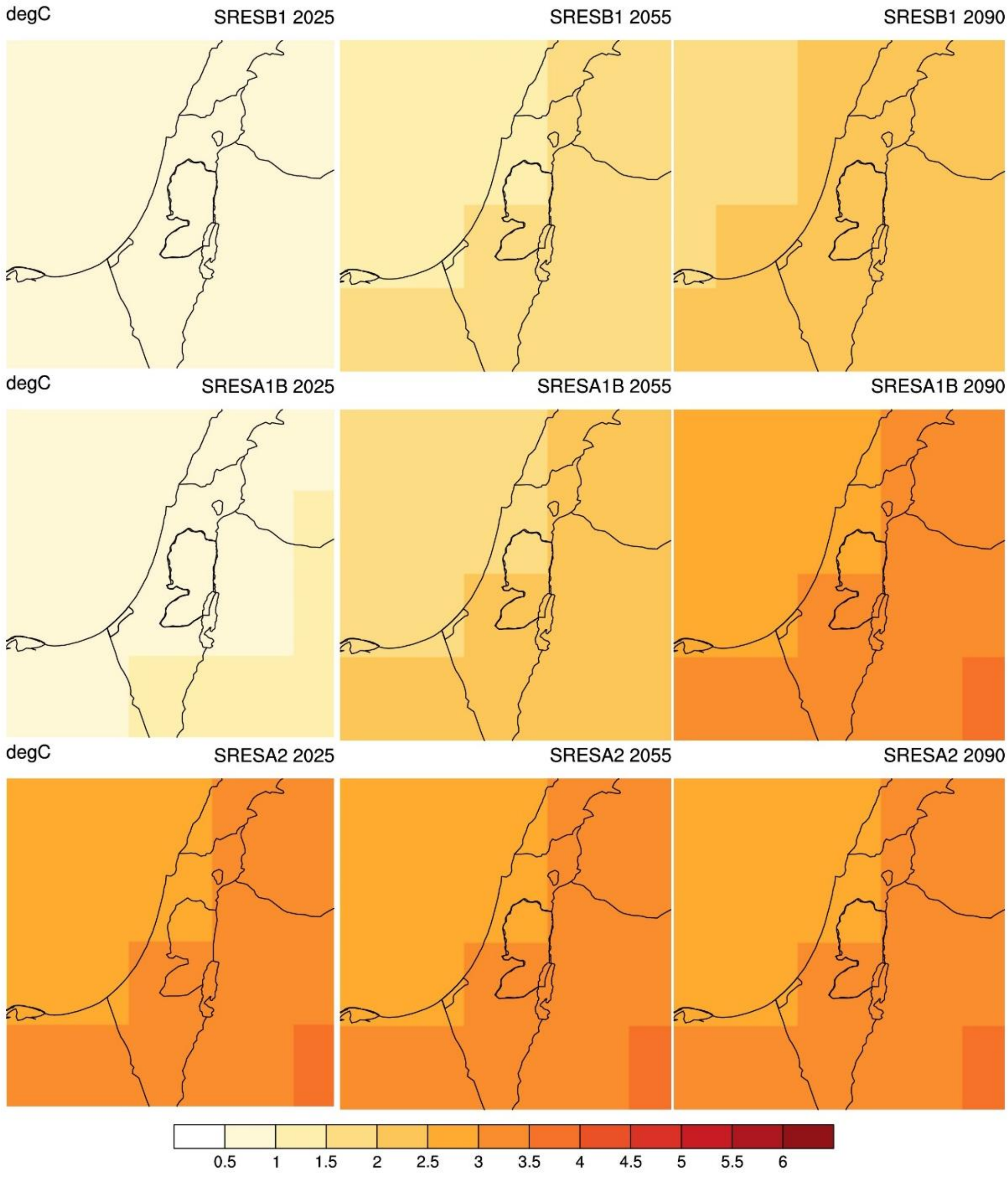


Figure 19: Projected changes in the standard deviation of annual temperatures (^oC) for Palestine calculated from the CMIP3 (AR4) ensemble under B1, A1B and A2 for periods centred on 2025, 2055 and 2090.

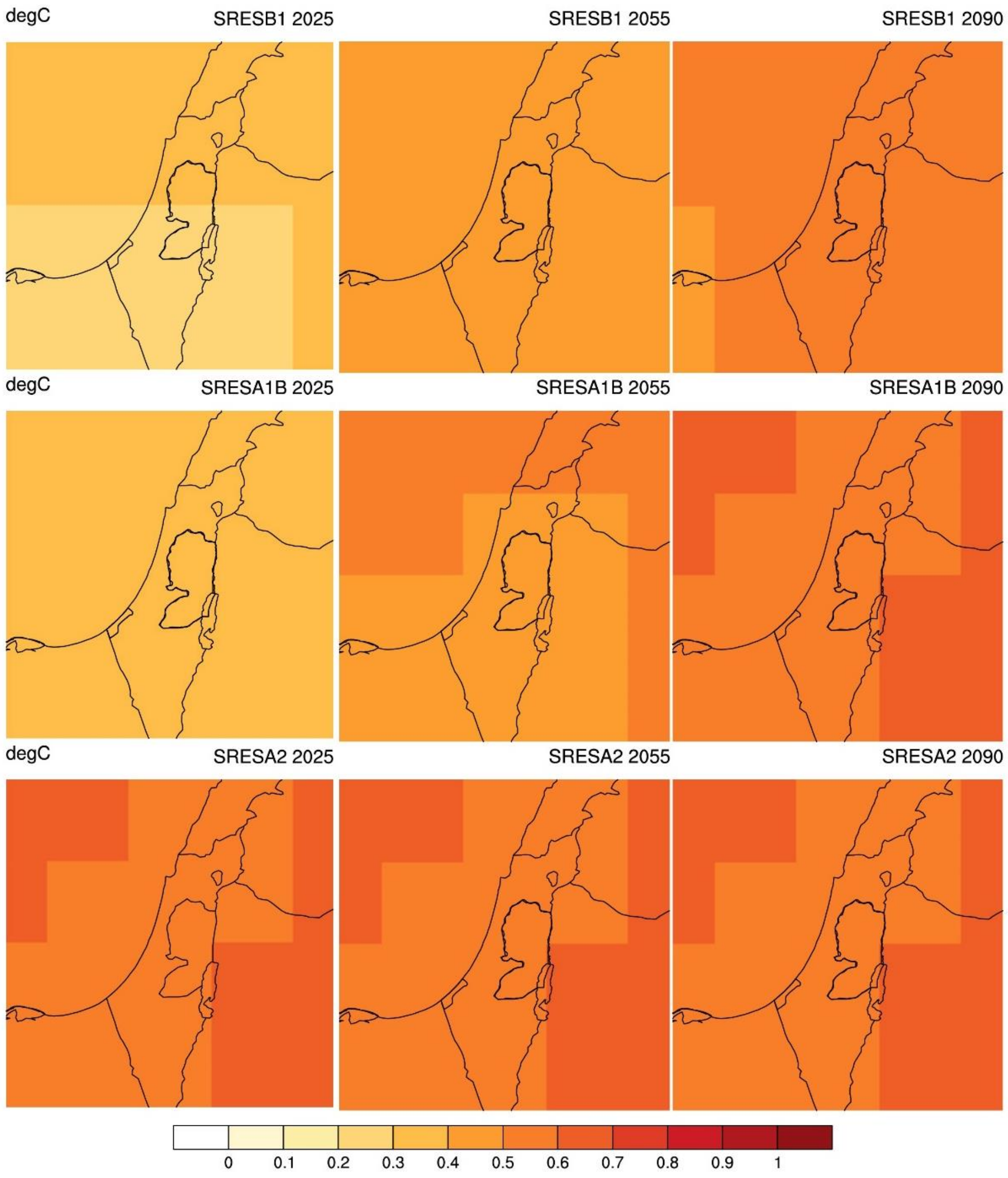
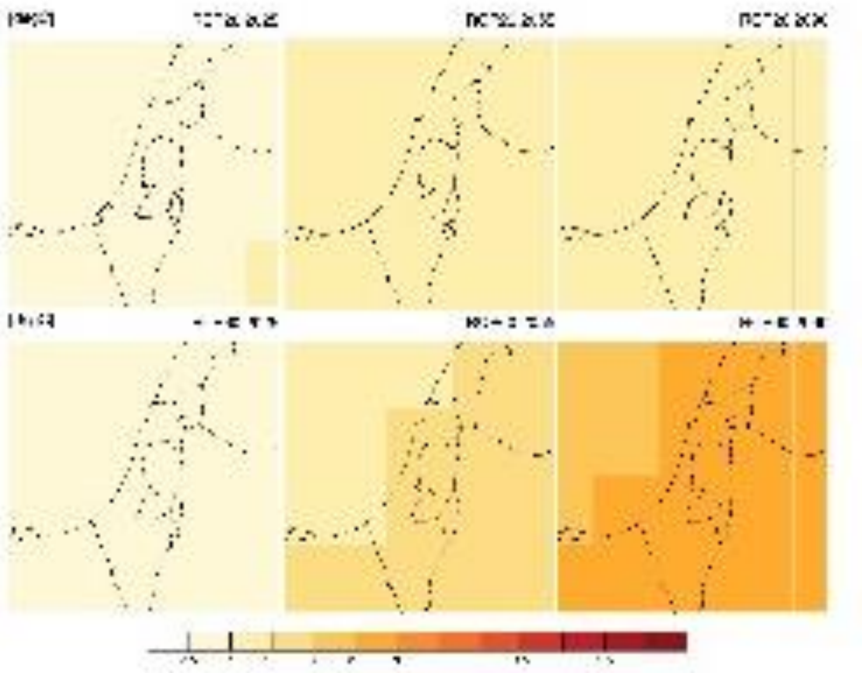


Figure 20: Projected changes in mean annual temperature (ºC) for Palestine calculated from the CMIP5 (AR5) ensemble under RCP2.6 and RCP6.0 (top group) and under RCP4.5 and RCP8.5 (bottom group) for periods centred on 2025, 2055 and 2090.



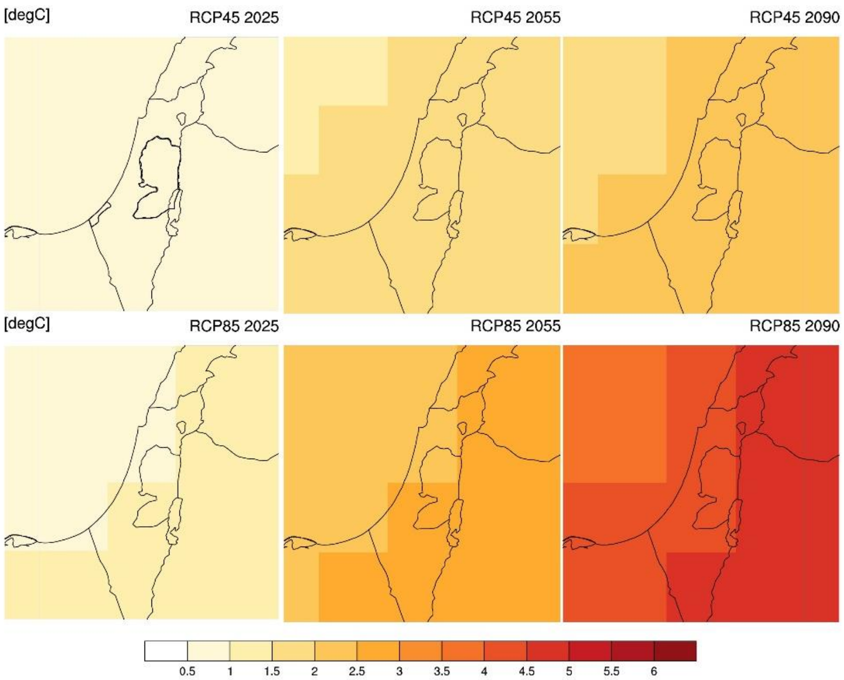


Figure 21: Projected changes in the standard deviation of annual temperatures (°C) for Palestine calculated from the CMIP5 (AR5) ensemble under RCP4.5, RCP8.5, RCP2.6 and RCP6.0 (top to bottom) for periods centred on 2025, 2055 and 2090.

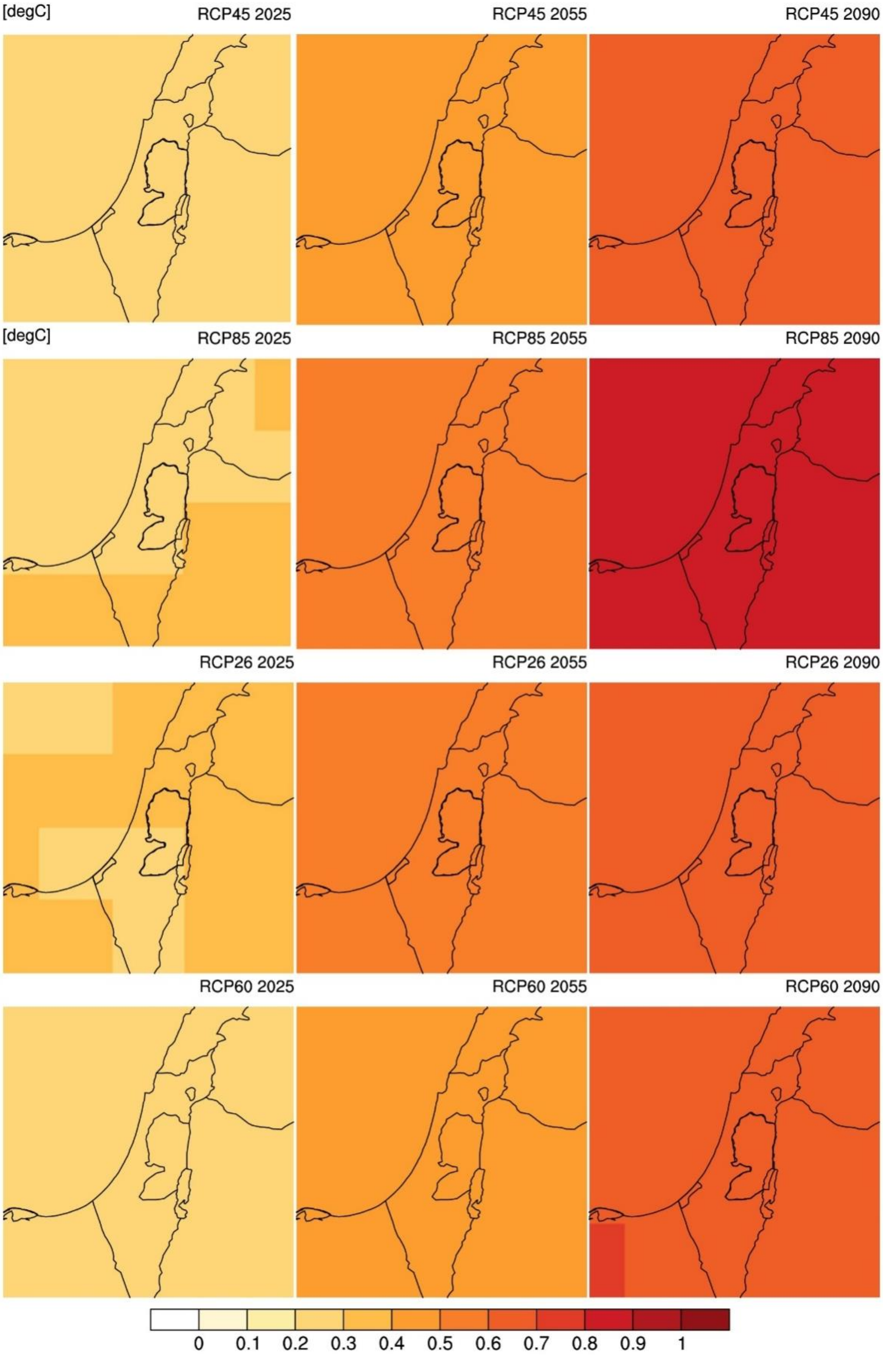
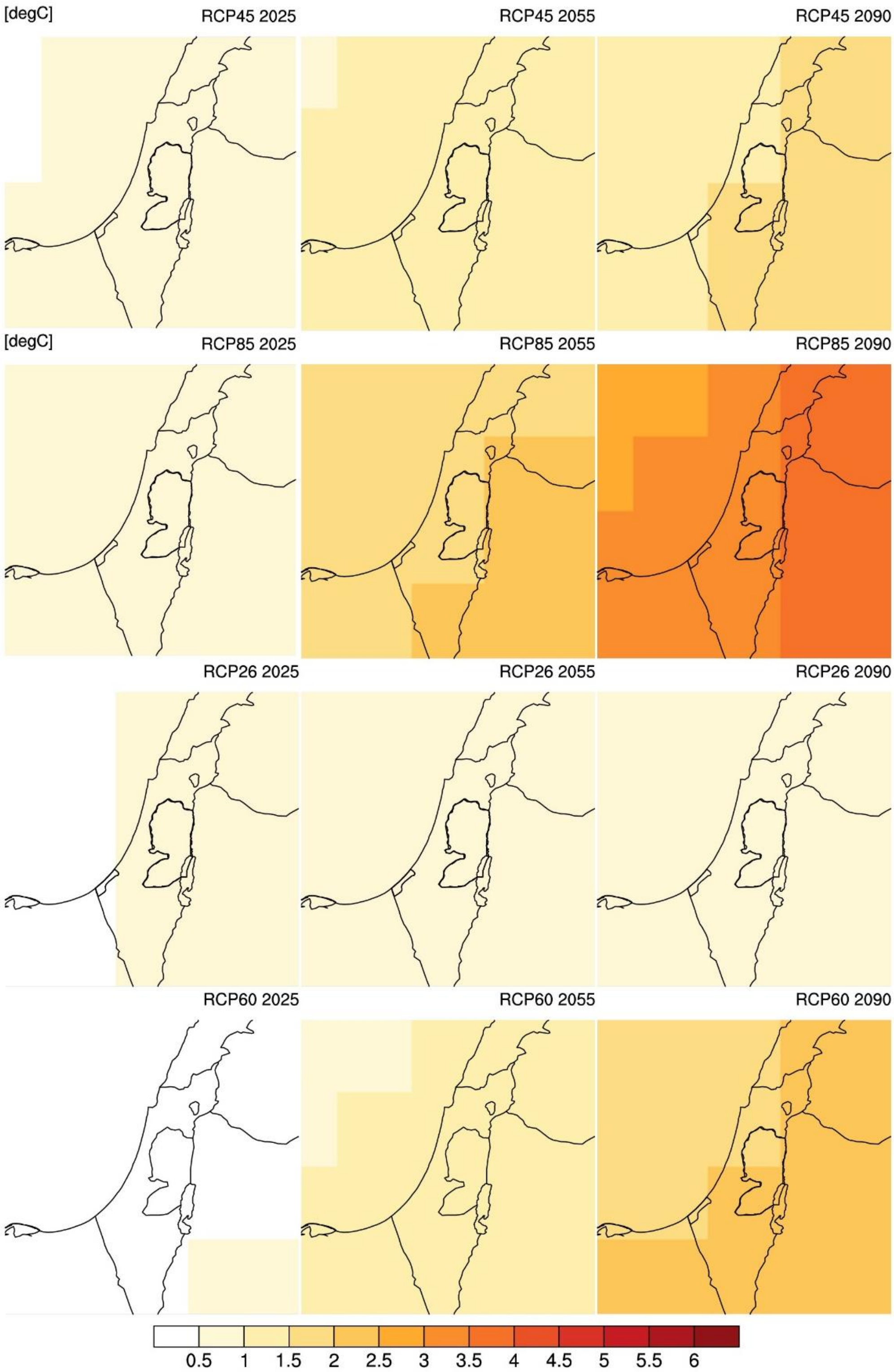
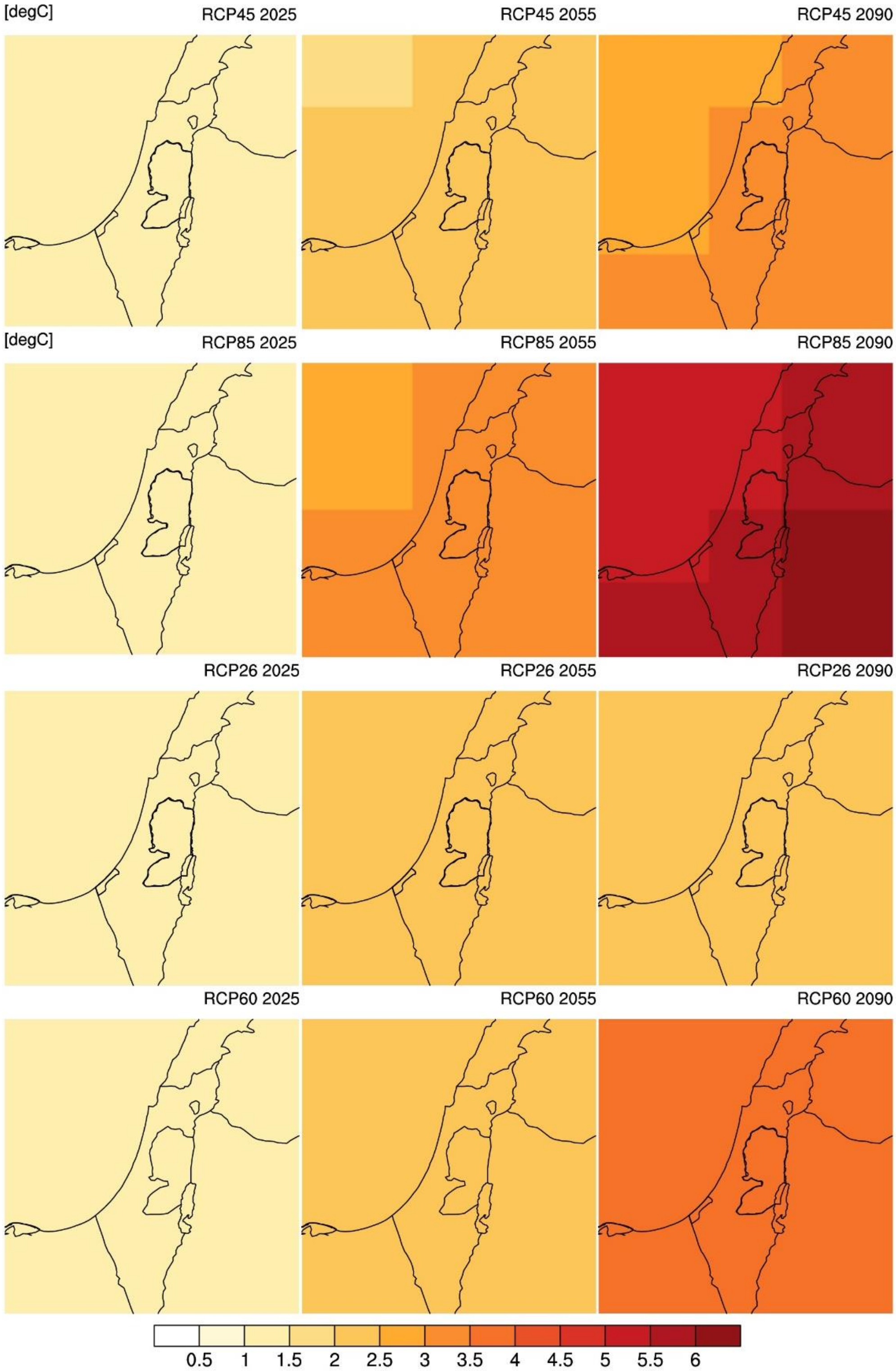


Figure 22: Projected ranges of changes in mean annual temperatures (°C) for Palestine calculated from the CMIP5 (AR5) ensemble under RCP4.5, RCP8.5, RCP2.6 and RCP6.0 (top to bottom) for periods centred on 2025, 2055 and 2090; first group 10% range, second group 90% range.

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RCP45 2025
RCP45 2055
RCP45 2090
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RCP85 2025
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RCP26 2090
RCP60 2025
RCP60 2055
RCP60 2090
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6

Figure 23: Projected changes in mean annual temperature (ºC) for Palestine calculated from the CORDEX (MENA) (AR5) ensemble under RCP4.5 and RCP8.5 (RCP2.6 and RCP6.0 have not been used for CORDEX) for periods centred on 2025, 2055 and 2090.

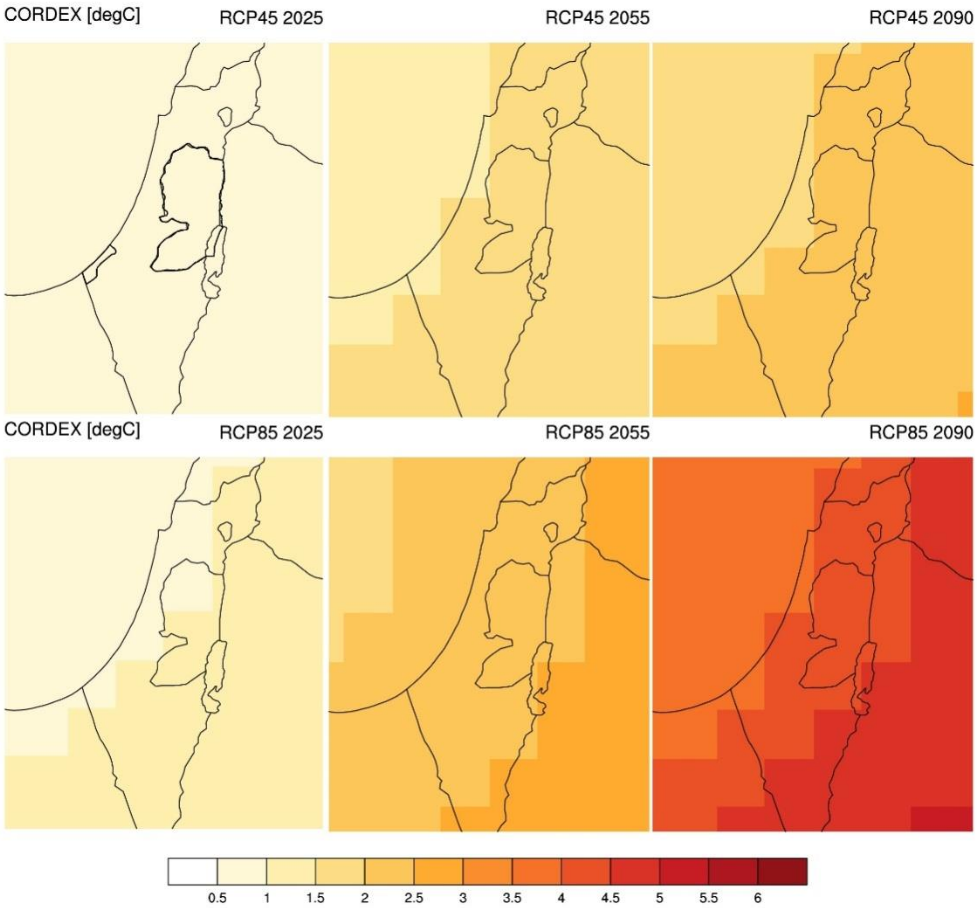


Figure 24: Projected changes in the standard deviation of annual temperatures (°C) for Palestine calculated from the CORDEX (MENA) (AR5) ensemble under RCP4.5 and RCP8.5 (RCP2.6 and RCP6.0 have not been used for CORDEX) for periods centred on 2025, 2055 and 2090.

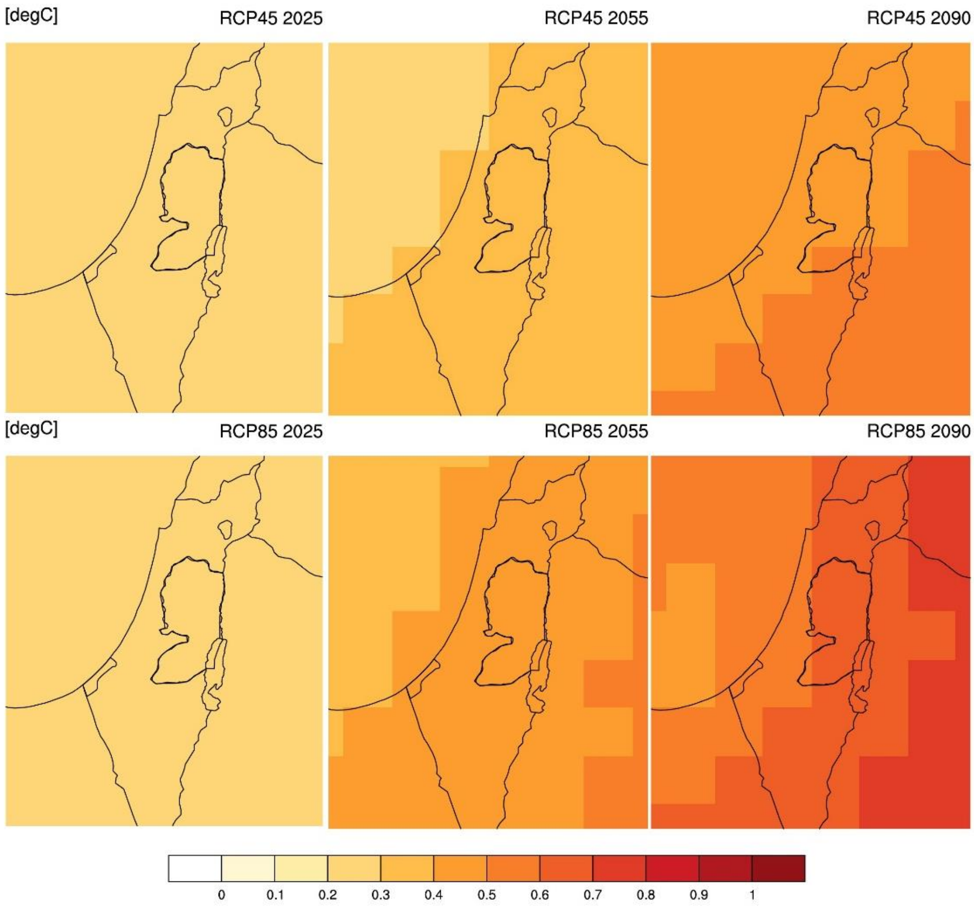


Figure 25: Projected changes in mean annual rainfall totals (expressed as a ratio in %) for Palestine calculated from the CMIP3 (AR4) ensemble under B1, A1B and A2 for periods centred on 2025, 2055 and 2090; values below 1.0 indicate reduced rainfall.

Figure 26: Projected changes in the standard deviation of annual rainfall totals (expressedas a ratio) for Palestine calculated from the CMIP3 (AR4) ensemble under B1, A1B and A2 for periods centred on 2025, 2055 and 2090; values above 0.0 indicate greater rainfall variability.

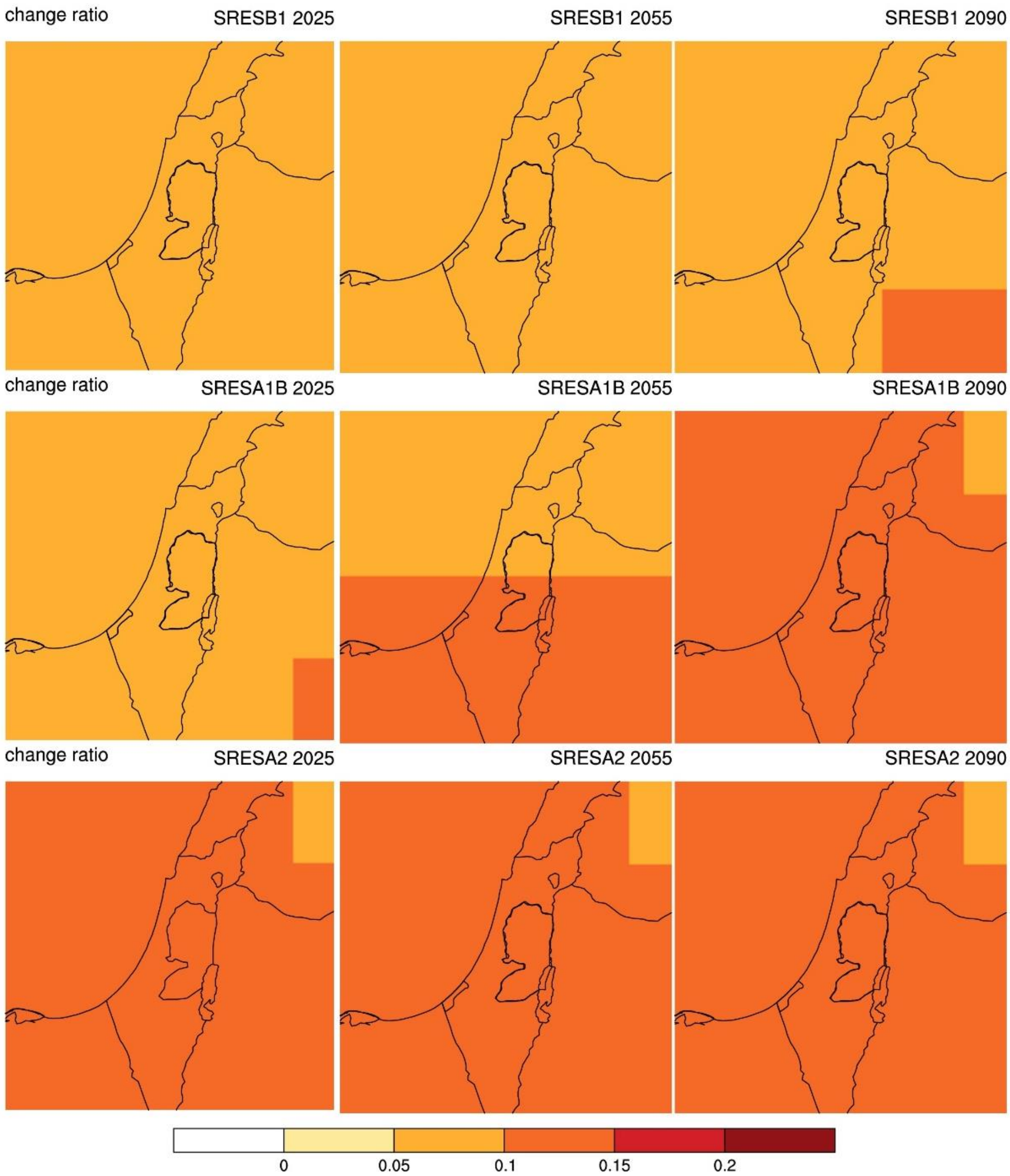
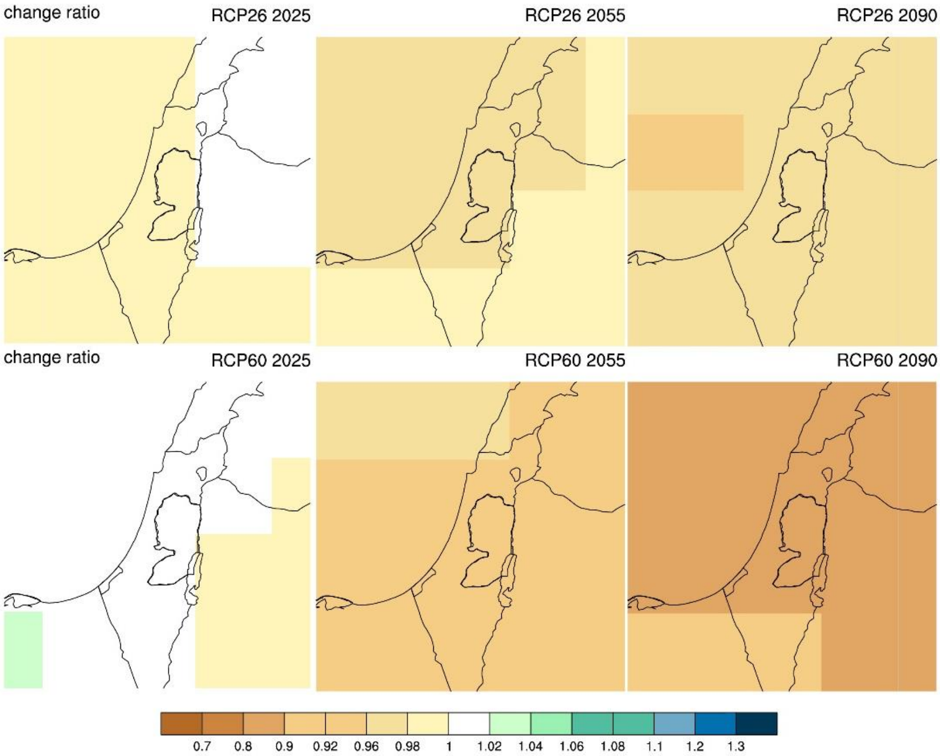
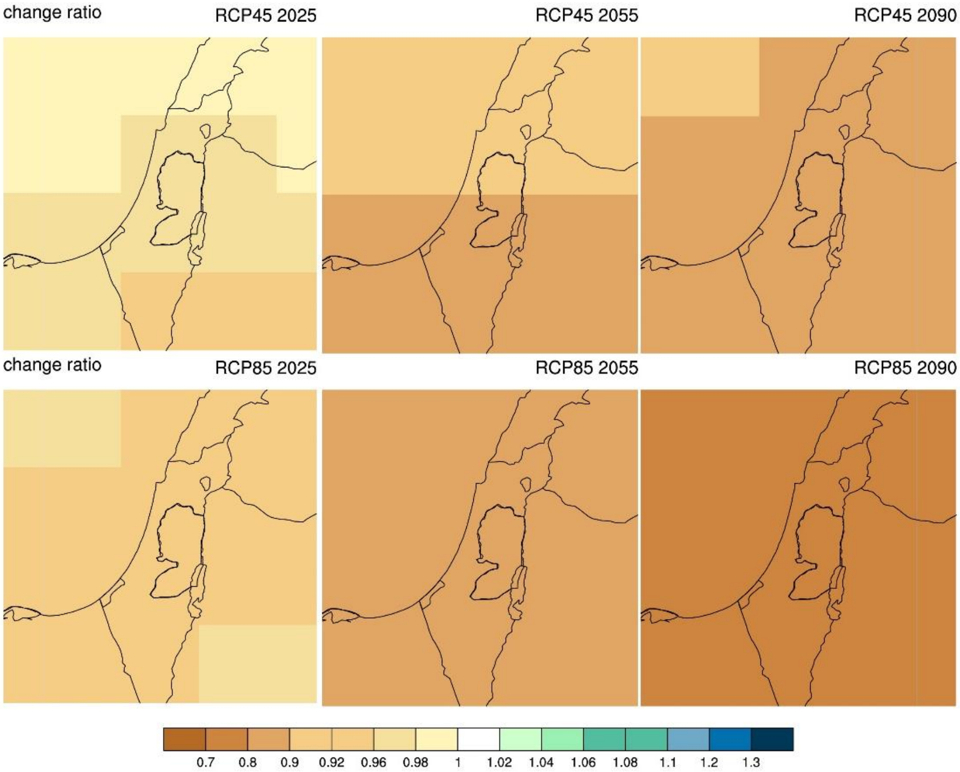


Figure 27: Projected changes in mean annual rainfall totals (expressed as a ratio in %) for Palestine calculated from the CMIP5 (AR5) ensemble under RCP2.6 and RCP6.0 (top group) and RCP4.5 and RCP8.5 (bottom group) for periods centred on 2025, 2055 and 2090; values below 1.0 indicate reduced rainfall.

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RCP85 2055
RCP85 2090
0.7 0.8 0.9 0.92 0.96 0.98 1 1.02 1.04 1.06 1.08 1.1 1.2 1.3

Figure 28: Projected changes in the standard deviation of annual rainfall totals (expressed as a ratio) for Palestine calculated from the CMIP5 (AR5) ensemble under RCP4.5, RCP8.5, RCP2.6 and RCP6.0 (top to bottom) for periods centred on 2025, 2055 and 2090; values above 0.0 indicate greater rainfall variability (note that the inclusion of deg C on the two upper rows is a coding error).

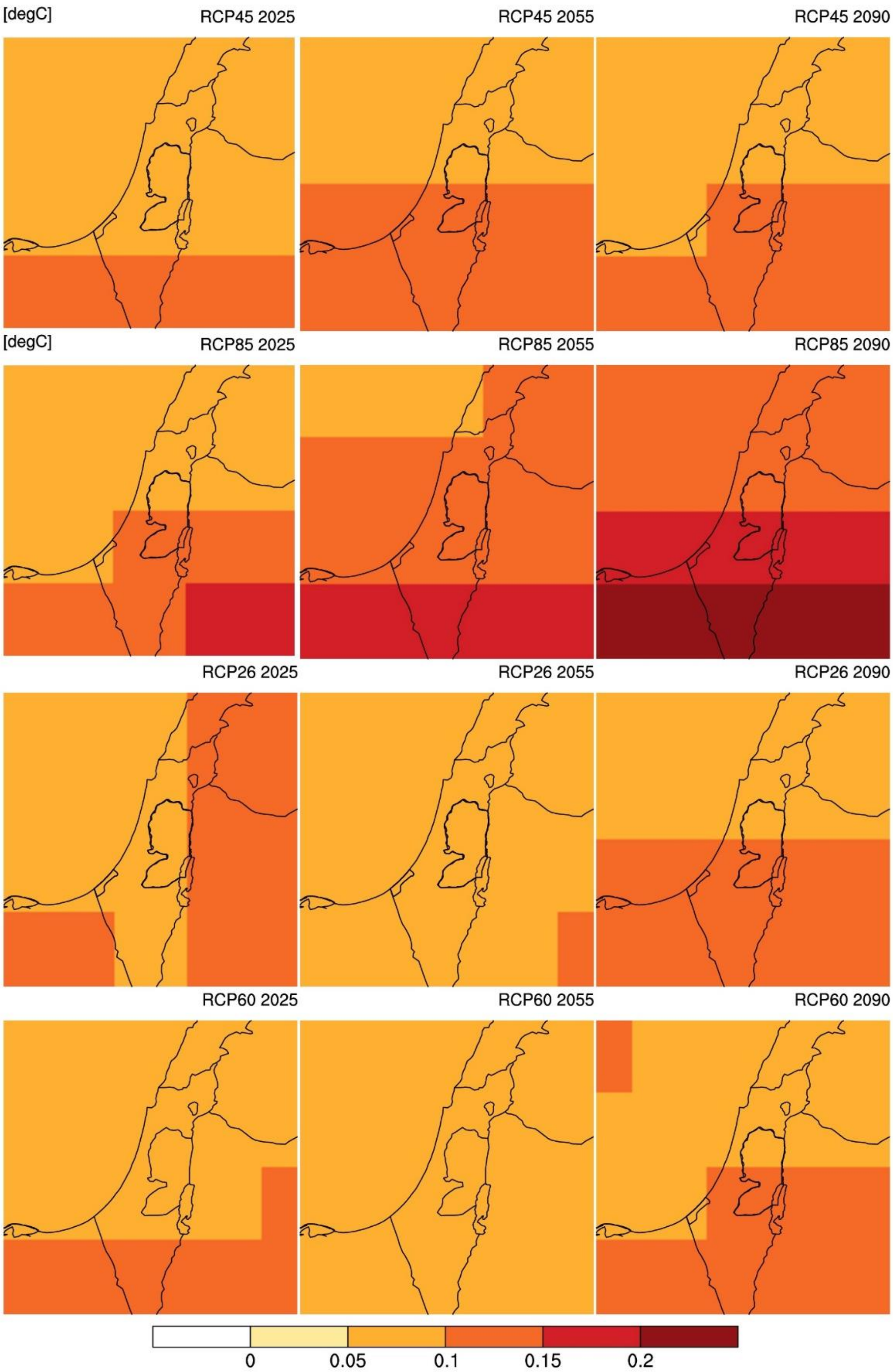
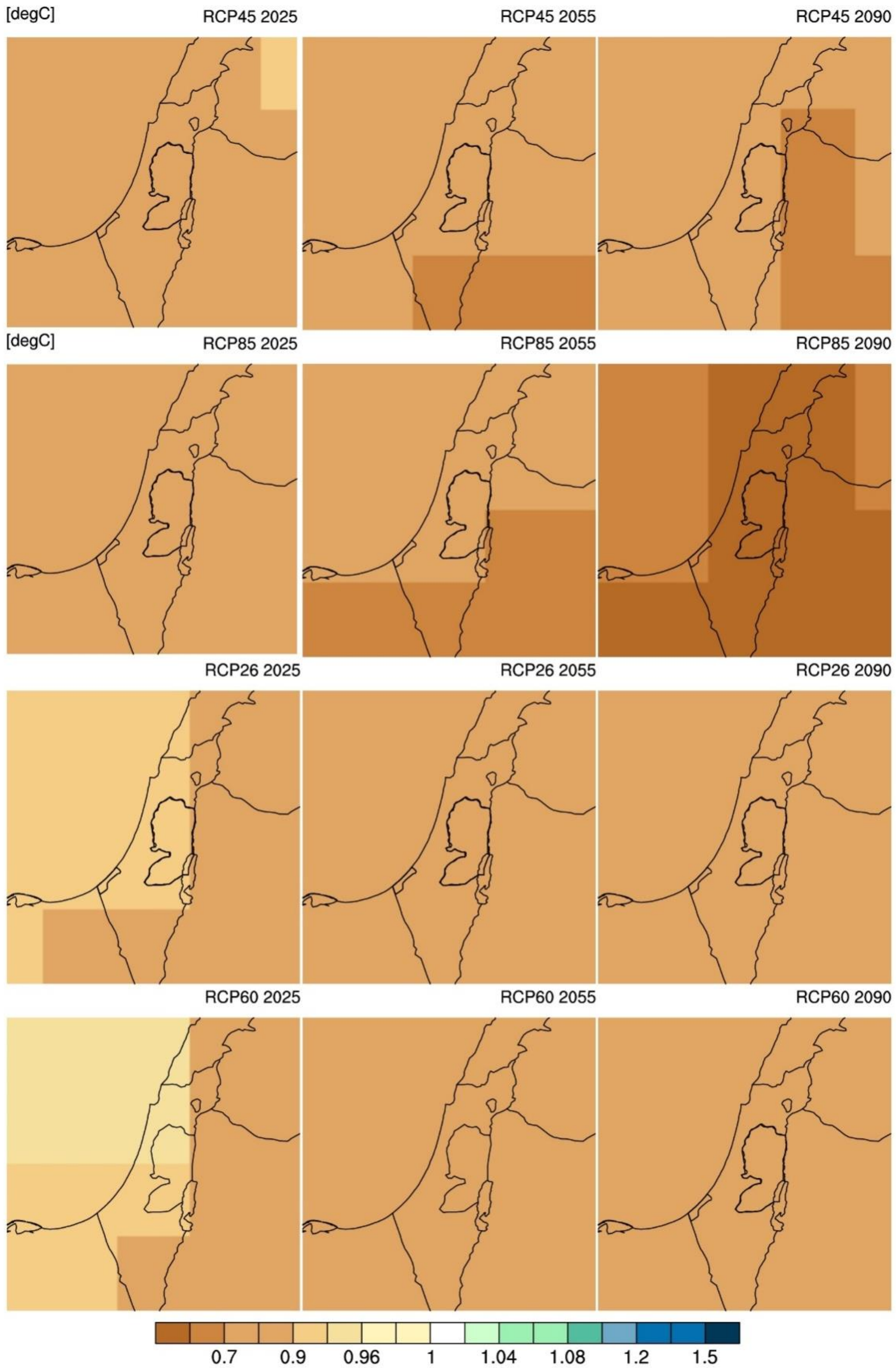
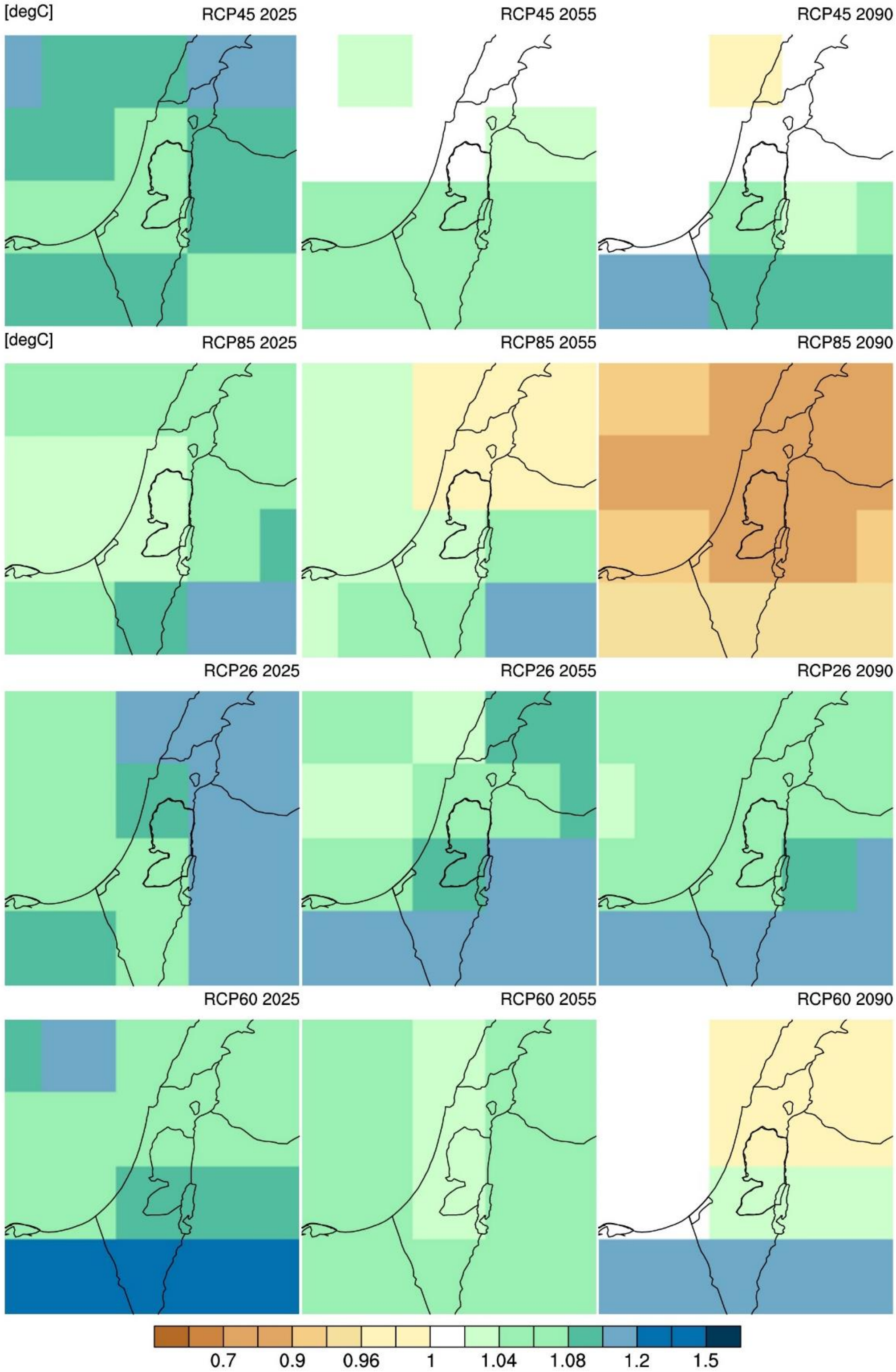


Figure 29: Projected ranges of changes in annual rainfall totals (expressed as a ratio) for Palestine calculated from the CMIP5 (AR5) ensemble under RCP4.5, RCP8.5, RCP2.6 and RCP6.0 (top to bottom) for

periods centred on 2025, 2055 and 2090; first group 10% range, second group 90% range; values above 1.0 indicate that the range has increased (note that the inclusion of deg C on the two upper rows in each case is a coding error)

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RCP60 2025
RCP60 2055
RCP60 2090
0.7
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1
1.04
1.08
1.2
1.5

Figure 30: Projected changes in mean annual rainfall totals (expressed as a ratio in %) for Palestine calculated from the CORDEX (MENA) (AR5) ensemble under RCP4.5 and RCP8.5 (RCP2.6 and RCP6.0 have not been used for CORDEX) for periods centred on 2025, 2055 and 2090; values below 1.0 indicate reduced rainfall.

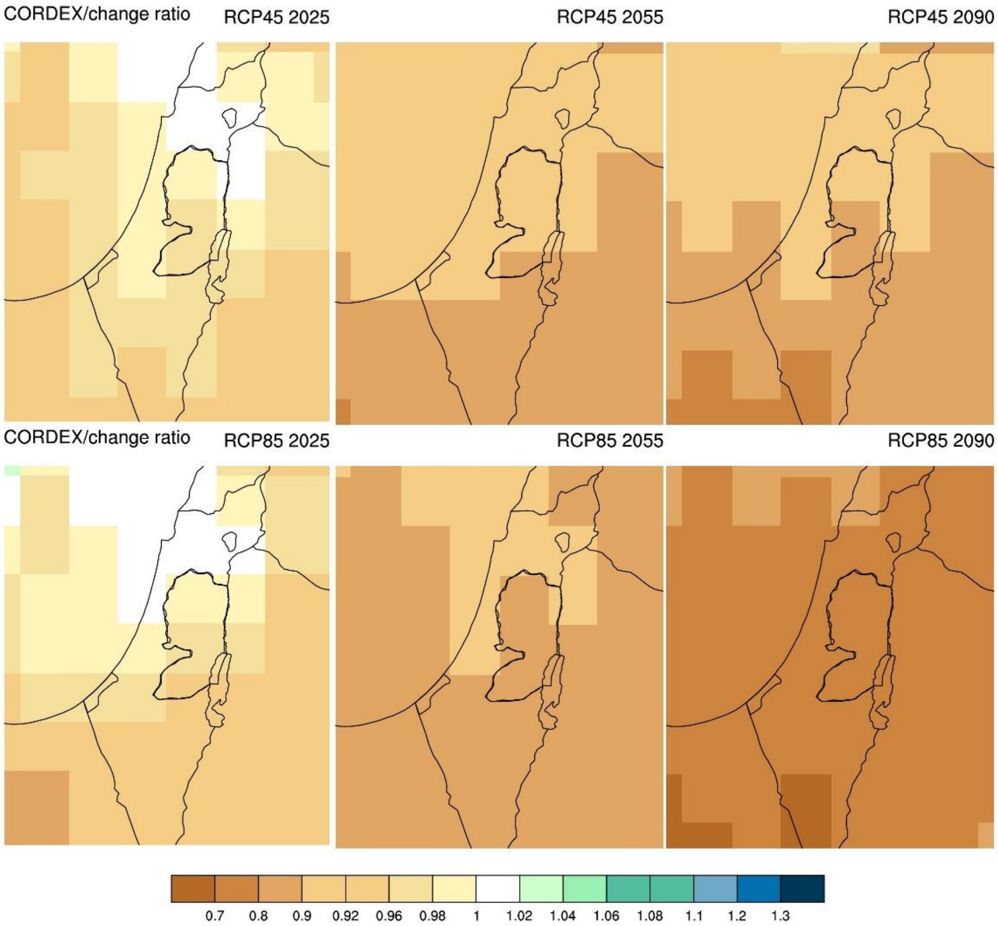


Figure 31: Projected changes in the standard deviation of annual rainfall totals (expressed as a ratio in %) for Palestine calculated from the CORDEX (MENA) (AR5) ensemble under RCP4.5 and RCP8.5 (RCP2.6 and RCP6.0 have not been used for CORDEX) for periods centred on 2025, 2055 and 2090; values above 0.0 indicate greater rainfall variability (note that the inclusion of deg C in each case is a coding error).

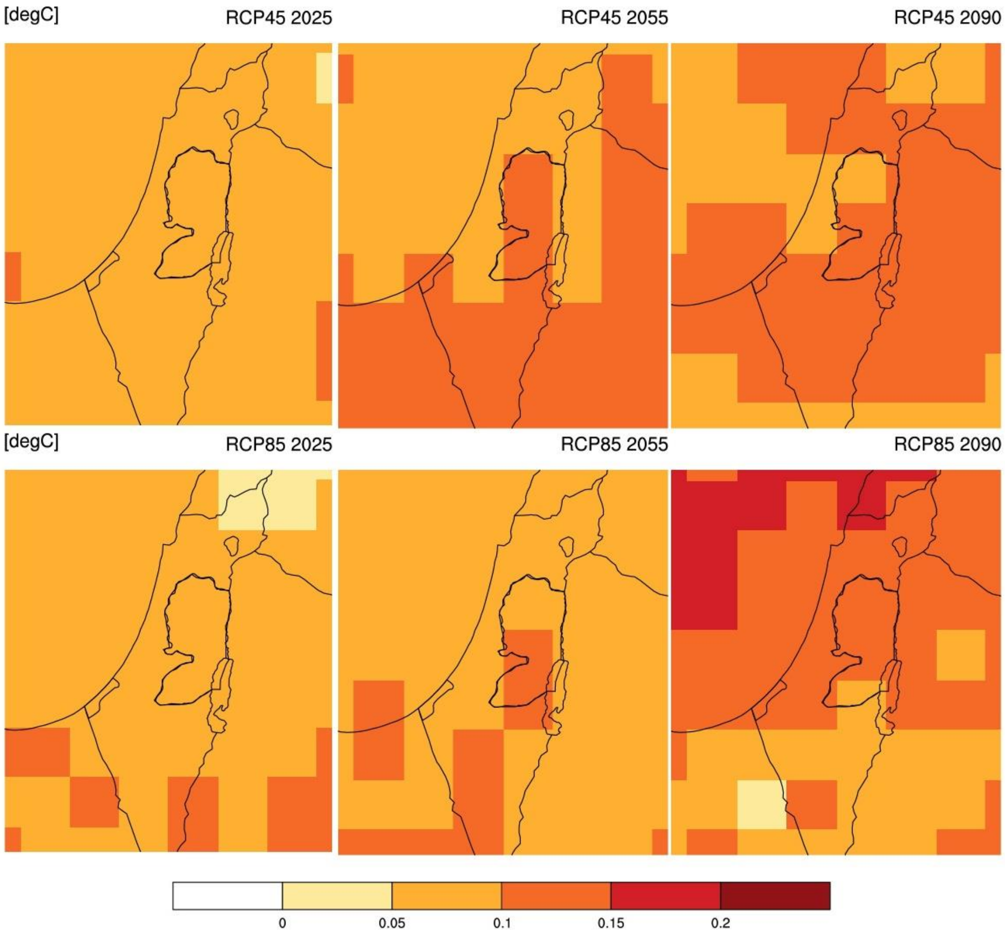
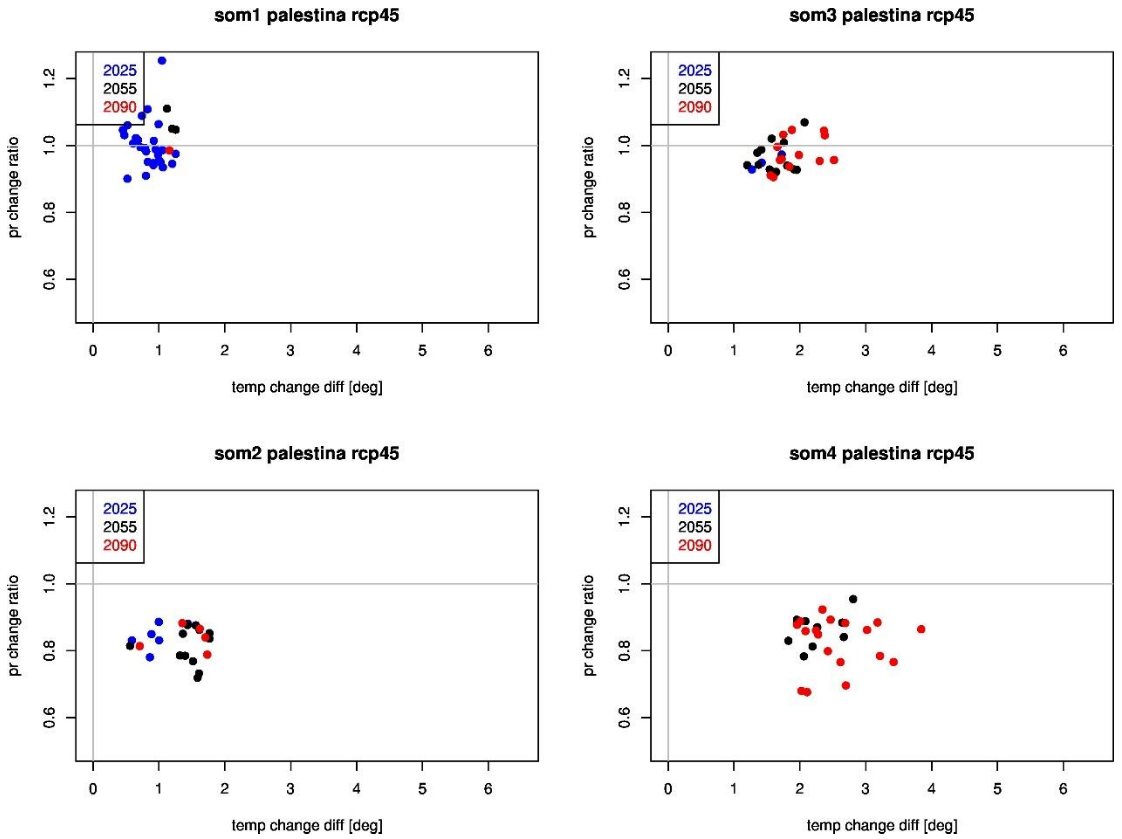
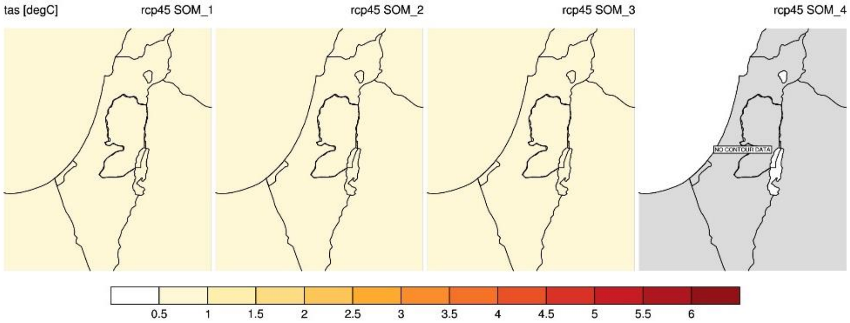


Figure 32: Self-organizing maps (SOMs) analysis of changes in annual mean temperatures (ºC) and annual rainfall totals (expressed as a ratio – values above 1.0 indicate increased rainfall) for Palestine (calculation area as in previous diagrams) calculated from the CMIP5 (AR5) ensemble under RCP4.5:

- First group: The four SOMs, with temperature changes along horizontal axis and rainfall changes along vertical axis (the ordering of the SOMs is arbitrary). Changes centred on 2025 are in blue, on 2055 in black and on 2080 in red with each dot indicating the projection from an individual model.
- Second group: Average temperature changes (top line) and rainfall changes (bottom line) for the period centred on 2025 for each SOM numbered as in the first group; greyed charts indicate that there are no projections for the period within that SOM.
- Third group: As second group but for period centred on 2055.
- Fourth group: As second group but for period centred on 2090.

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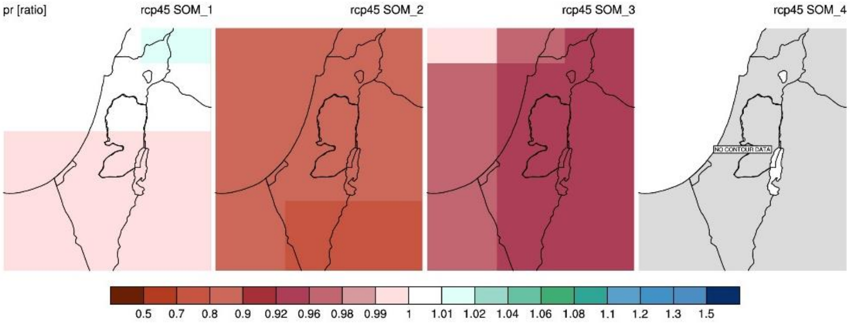
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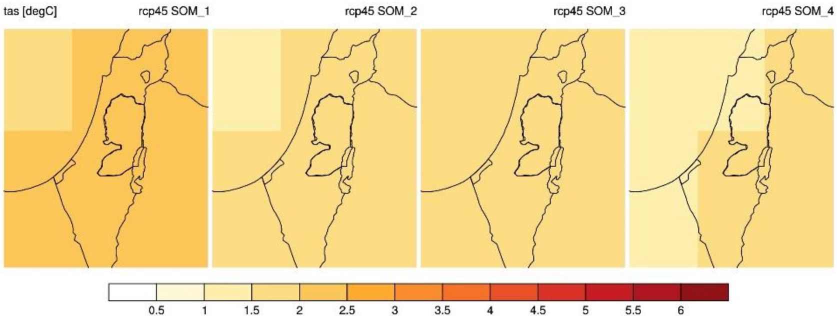
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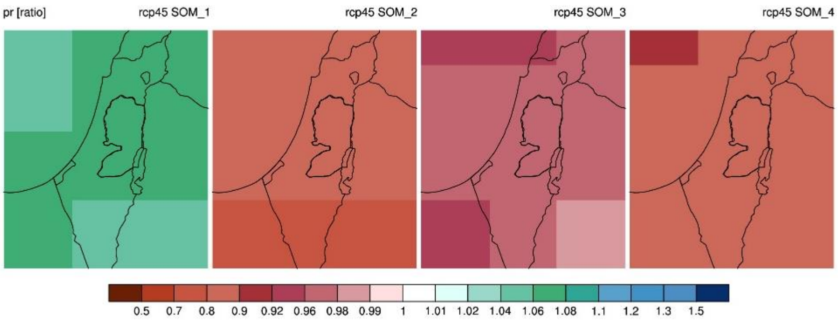
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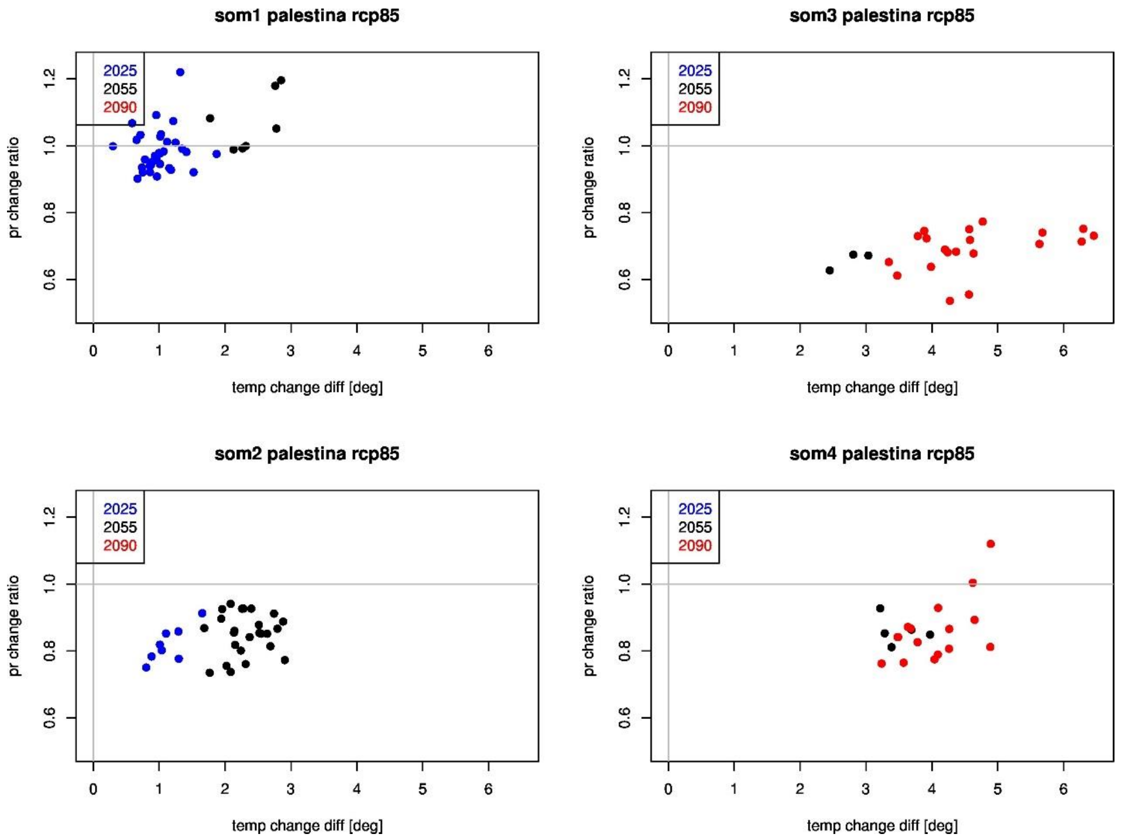
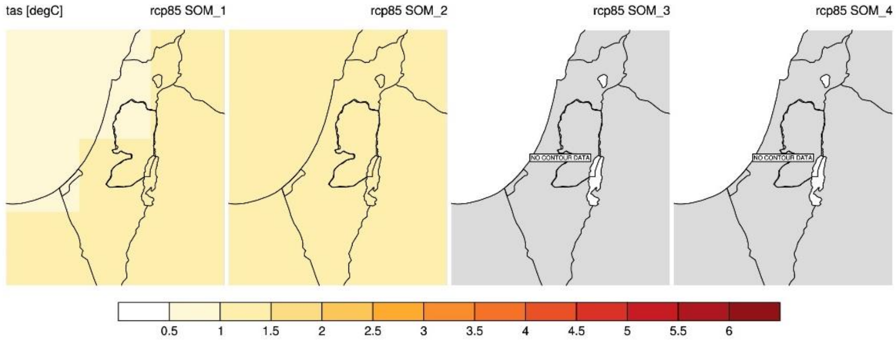
Figure 33: Self-organizing maps (SOMs) analysis of changes in annual mean temperatures (ºC) and annual rainfall totals (expressed as a ratio – values above 1.0 indicate increased rainfall) for Palestine (calculation area as in previous diagrams) calculated from the CMIP5 (AR5) ensemble under RCP8.5:

- First group: The four SOMs, with temperature changes along horizontal axis and rainfall changes along vertical axis (the ordering of the SOMs is arbitrary). Changes centred on 2025 are in blue, on 2055 in black and on 2080 in red with each dot indicating the projection from an individual model.
- Second group: Average temperature changes (top line) and rainfall changes (bottom line) for the period centred on 2025 for each SOM numbered as in the first group; greyed charts indicate that there are no projections for the period within that SOM.
- Third group: As second group but for period centred on 2055.
- Fourth group: As second group but for period centred on 2090.




tas [degC]
rcp85 SOM_1
rcp85 SOM_2
rcp85 SOM_3
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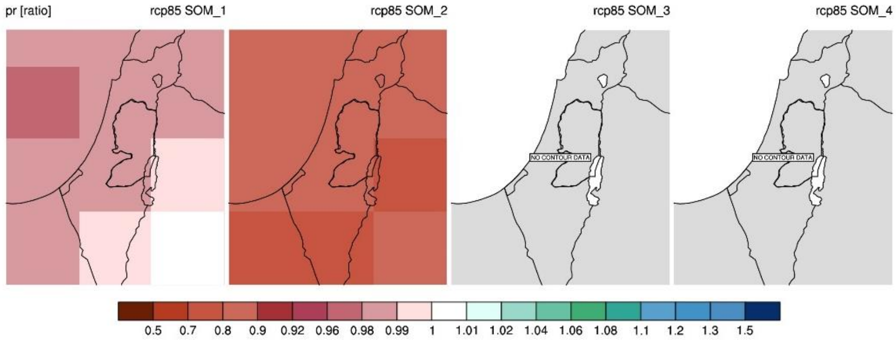
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6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rcp85 SOM_4
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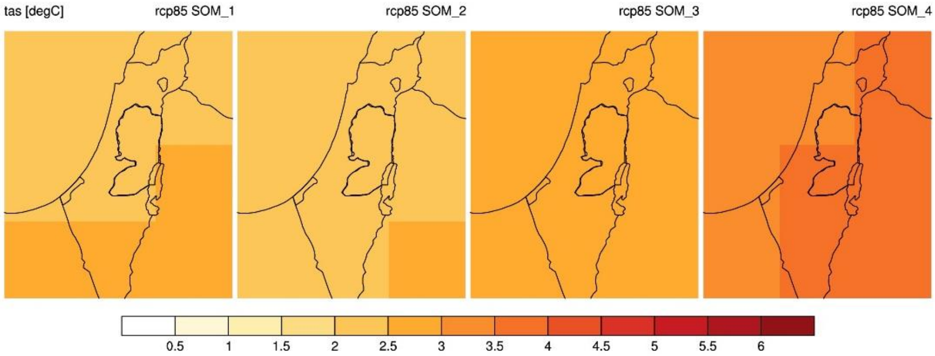
tas [degC]
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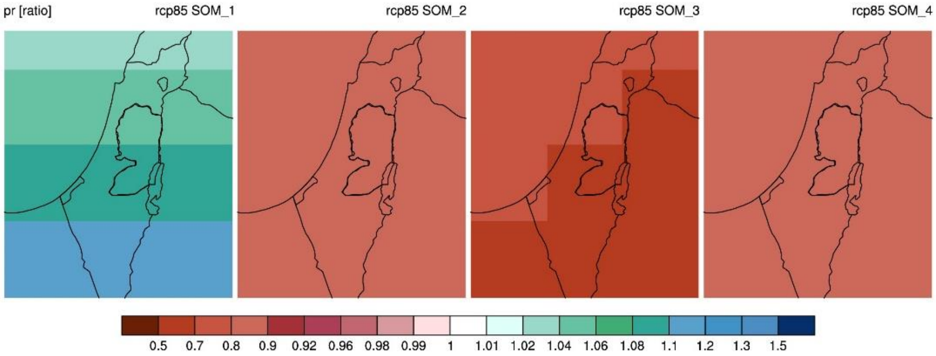
0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6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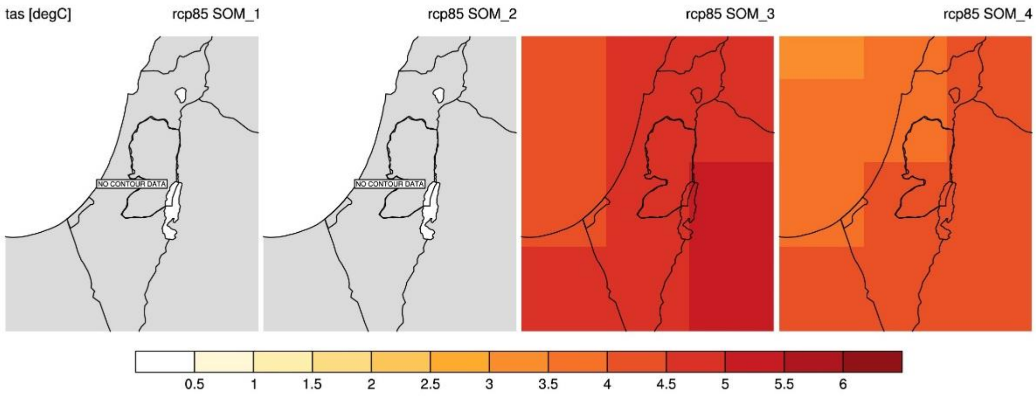
rcp85 SOM_4
0.5 0.7 0.8 0.9 0.92 0.96 0.98 0.99 1 1.01 1.02 1.04 1.06 1.08 1.1 1.2 1.3 1.5


tas [degC]
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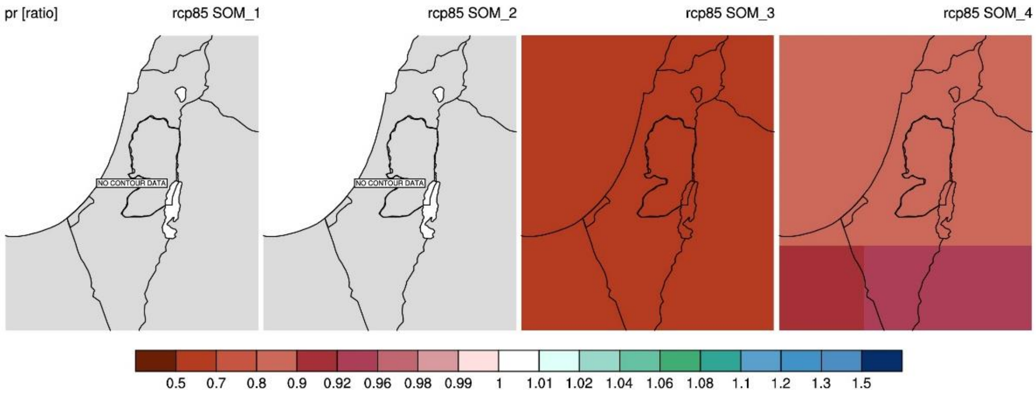
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rcp85 SOM_3
rcp85 SOM_4
NO CONTOUR DATA
NO CONTOUR DATA
0.5 0.7 0.8 0.9 0.92 0.96 0.98 0.99 1 1.01 1.02 1.04 1.06 1.08 1.1 1.2 1.3 1.5

Figure 34: Self-organizing maps (SOMs) analysis of changes in annual mean temperatures (°C) and annual rainfall totals (expressed as a ratio – values above 1.0 indicate increased rainfall) for Palestine (calculation area as in previous diagrams) calculated from the CORDEX (MENA) (AR5) ensemble under RCP4.5 (top group of four diagrams) and RCP8.5 (bottom group of four diagrams). Temperature changes along horizontal axis and rainfall changes along vertical axis (the ordering of the SOMs is arbitrary). Changes centred on 2025 are in blue, on 2055 in black and on 2080 in red with each dot indicating the projection from an individual model.

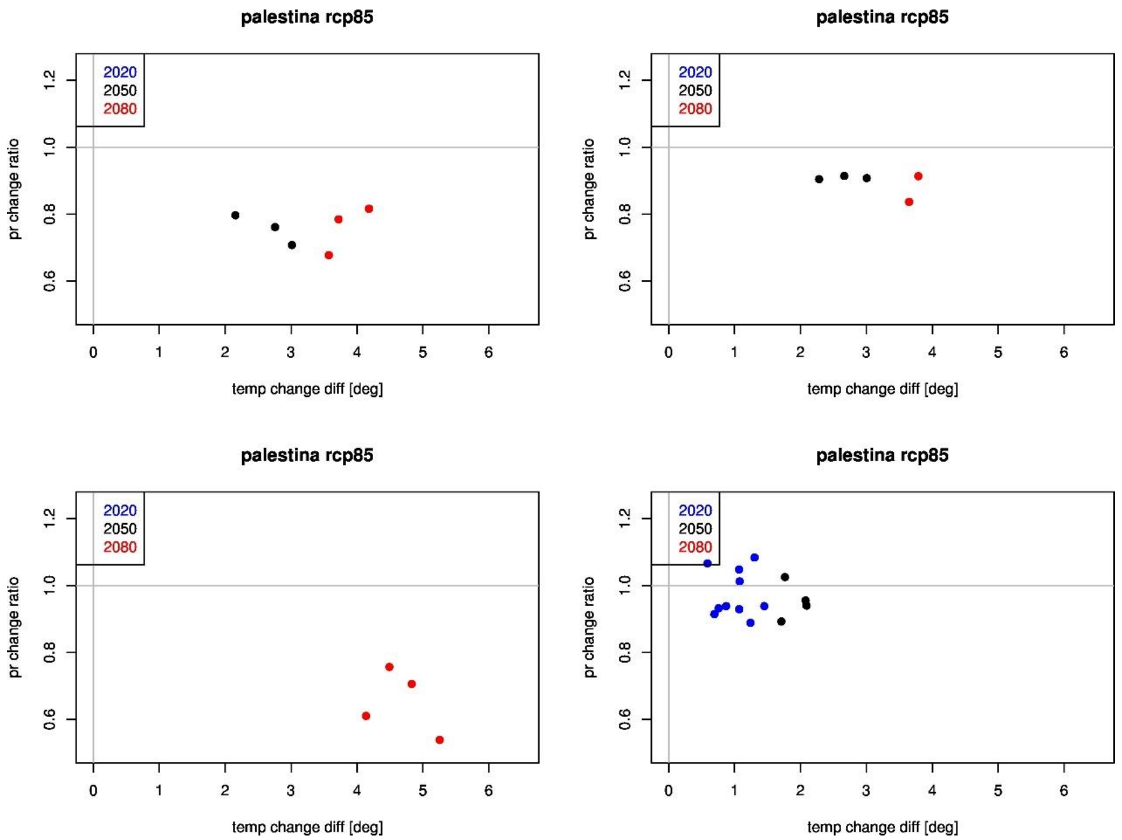


Figure 35: Projected changes in the frequency of tropical nights (expressed as a ratio) for Palestine calculated as a mean from the CMIP5 (AR5) ensemble under RCP4.5, RCP8.5, RCP6.0 and RCP2.6 (top to bottom) for periods centred on 2025, 2055 and 2090; values above 1.0 indicate an increase in the number of tropical nights. Tropical nights are defined by the IPCC as those in which the daily minimum temperature exceeds 20ºC.

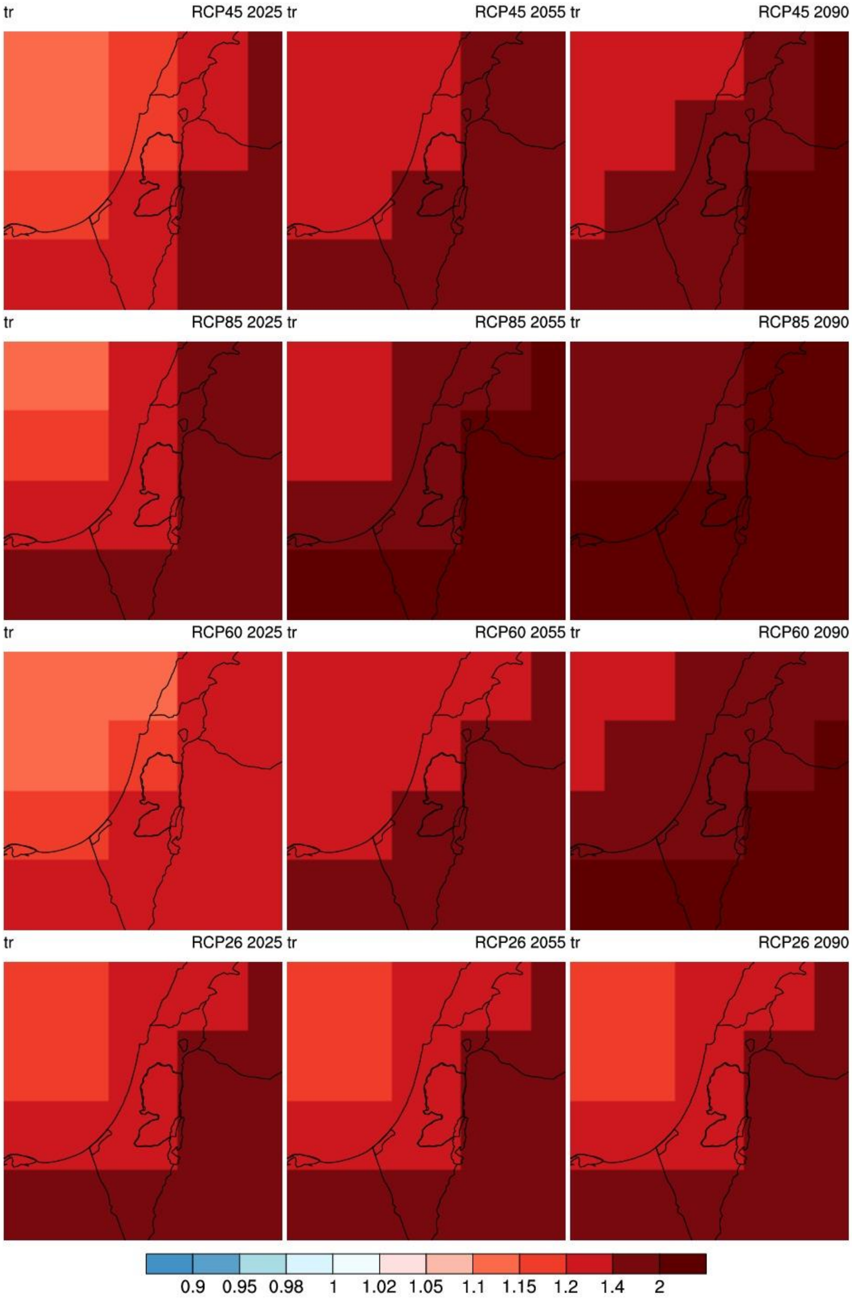


Figure 36: Projected changes in the cold spell duration index (expressed as a ratio) for Palestine calculated as a mean from the CMIP5 (AR5) ensemble under RCP4.5, RCP8.5, RCP6.0 and RCP2.6 (top to bottom) for periods centred on 2025, 2055 and 2090; values above 1.0 indicate an increase in the index and therefore more cold spell days. The cold spell duration index as defined by the IPCC is the annual count of days with at least 6 consecutive days on which the minimum temperature is in the lowest 10th percentile of such days calculated on a moving window through the year and based on 1961-1990.

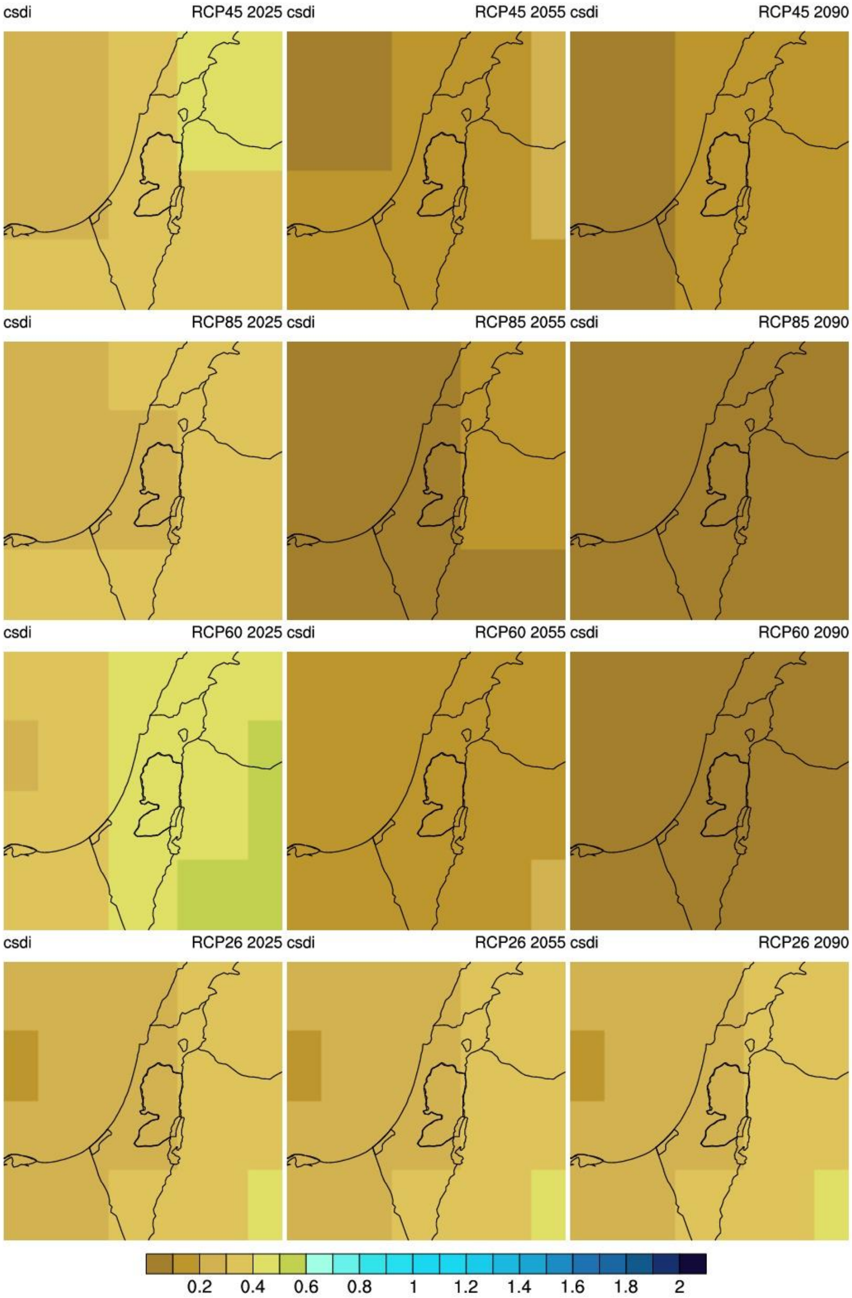


Figure 37: Projected changes in the warm spell duration index (expressed as a change in the value of the index) for Palestine calculated as a mean from the CMIP5 (AR5) ensemble under RCP4.5, RCP8.5, RCP6.0 and RCP2.6 (top to bottom) for periods centred on 2025, 2055 and 2090; values above 1.0 indicate an increase in the index and therefore more warm spell days. The warm spell duration index as defined by the IPCC is the annual count of days with at least 6 consecutive days on which the maximum temperature is in the highest 10th percentile of such days calculated on a moving window through the year and based on 1961-1990.

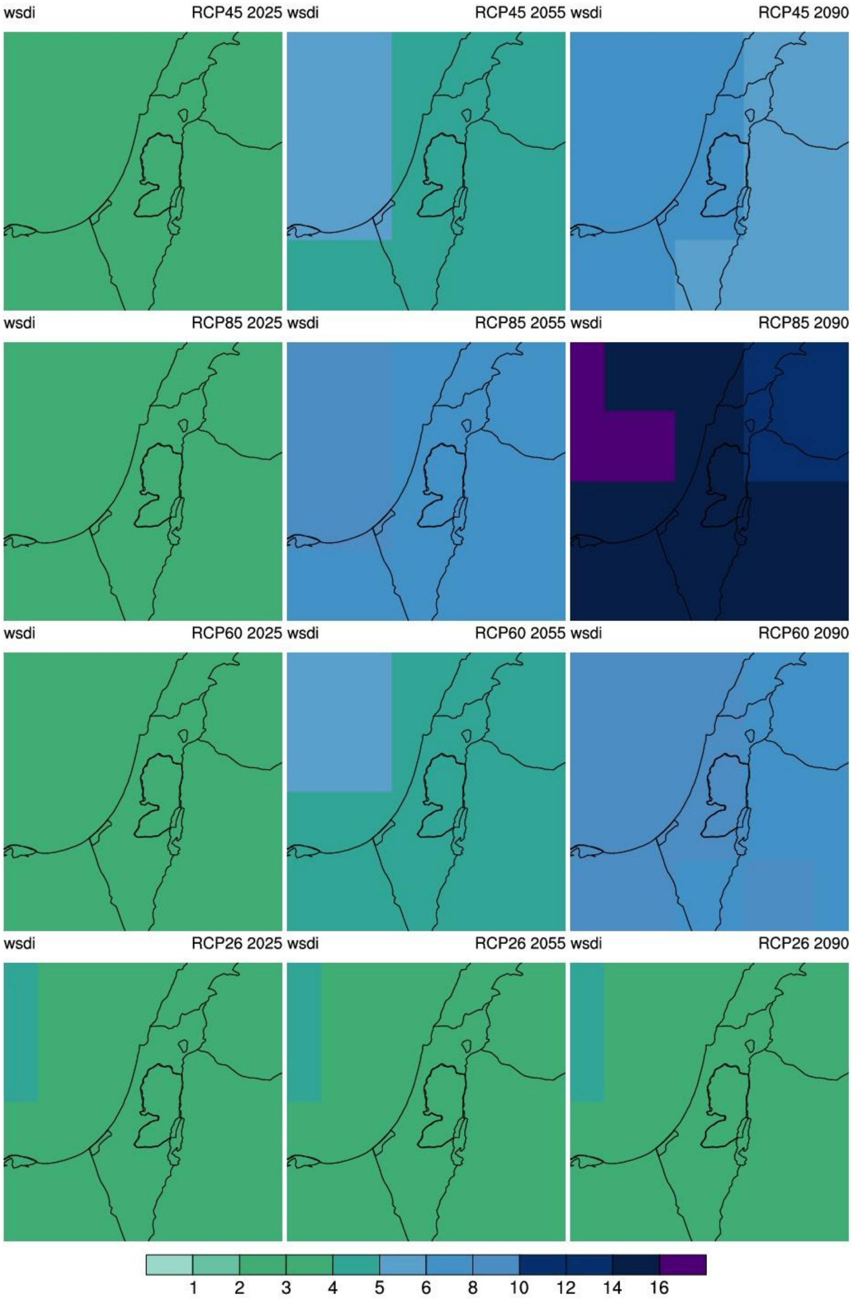


Figure 38: Projected changes in the maximum one-day precipitation (expressed as a ratio) for Palestine calculated as a mean from the CMIP5 (AR5) ensemble under RCP4.5, RCP8.5, RCP6.0 and RCP2.6 (top to bottom) for periods centred on 2025, 2055 and 2090; values above 1.0 indicate an increase in the maximum one-day precipitation. The maximum one-day precipitation as defined by the IPCC is that of the highest single-day total during the year; as such it is an unstable statistic and should be treated with caution.

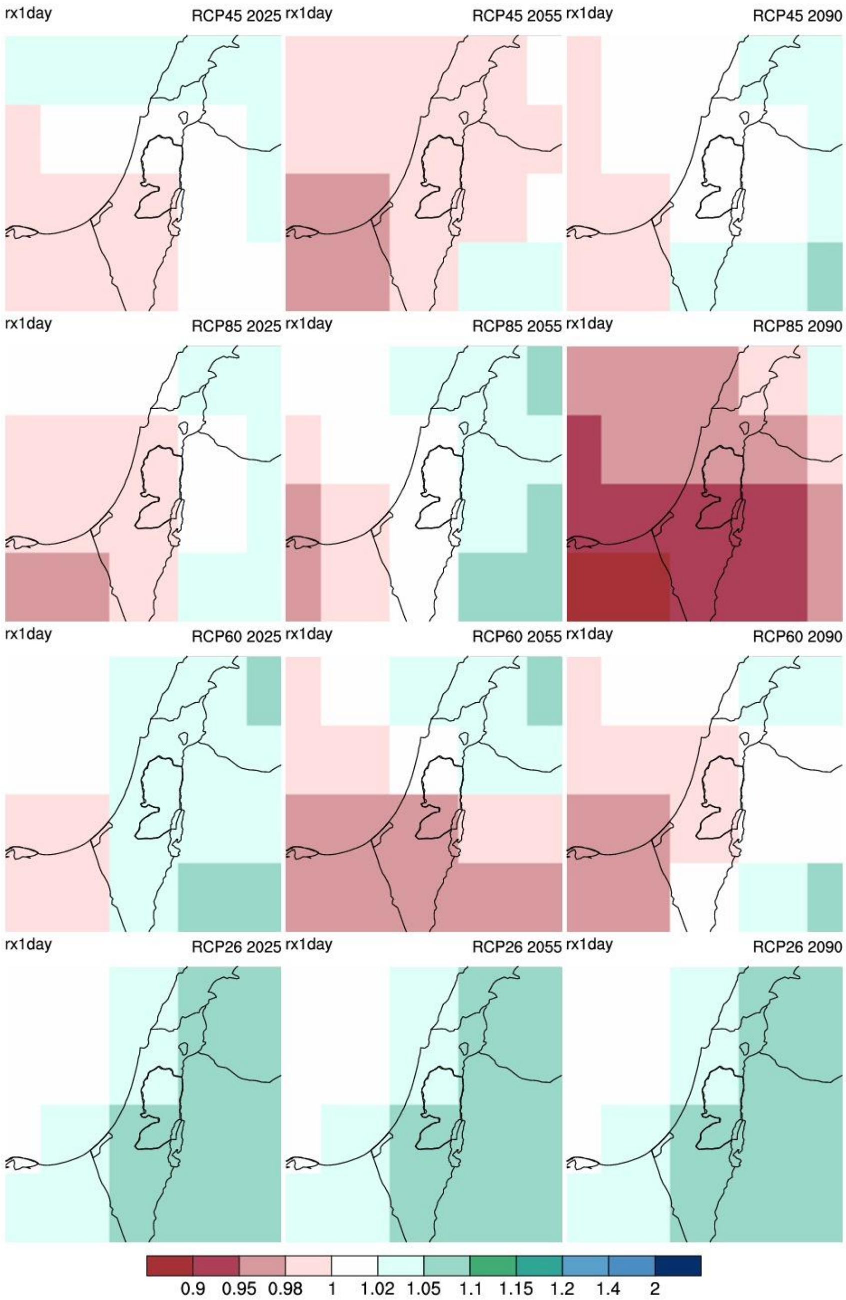


Figure 39: Projected changes in the maximum five-day precipitation (expressed as a ratio) for Palestine calculated as a mean from the CMIP5 (AR5) ensemble under RCP4.5, RCP8.5, RCP6.0 and RCP2.6 (top to bottom) for periods centred on 2025, 2055 and 2090; values above 1.0 indicate an increase in the maximum five-day precipitation. The maximum five-day precipitation as defined by the IPCC is that of the highest total when summed over five consecutive days during the year; as such it is a more stable statistic that the maximum one-day precipitation.

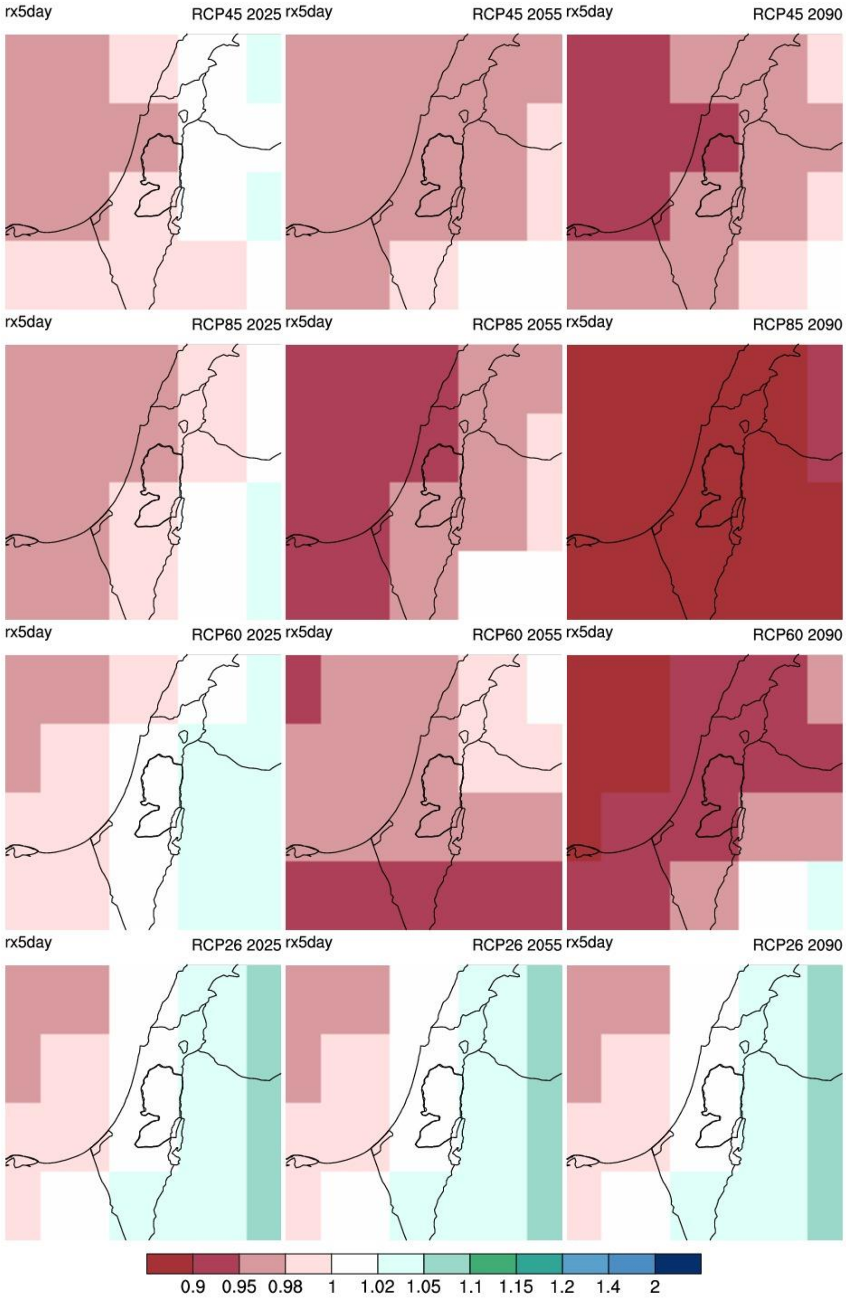


Figure 40: Projected changes in the annual total rainfall in the top 5% of rainfall days (expressed as a ratio) for Palestine calculated as a mean from the CMIP5 (AR5) ensemble under RCP4.5, RCP8.5, RCP6.0 and RCP2.6 (top to bottom) for periods centred on 2025, 2055 and 2090; values above 1.0 indicate an increase from the top 5% of rainfall days. The cut-off value for rainfall in the top 5% of days as defined by the IPCC is that as calculated from the 1961-1990 period.

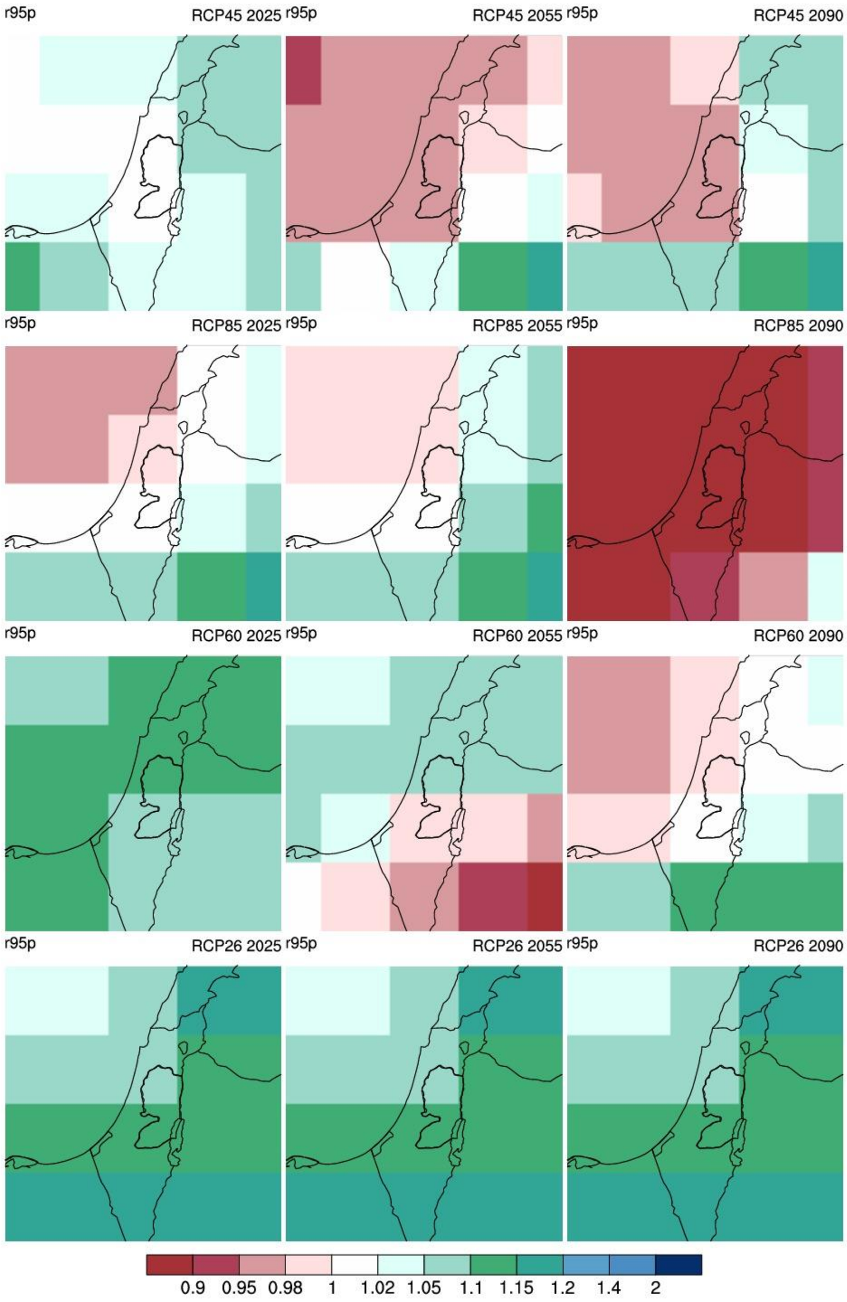


Figure 41: Projected changes in the annual number of days with more than 10mm of rainfall (expressed as a ratio) for Palestine calculated as a mean from the CMIP5 (AR5) ensemble under RCP4.5, RCP8.5, RCP6.0 and RCP2.6 (top to bottom) for periods centred on 2025, 2055 and 2090; values above 1.0 indicate an increase in the number of days with more than 10mm of rainfall. This is a more stable statistic than the change in the annual number of days with more than 20mm.

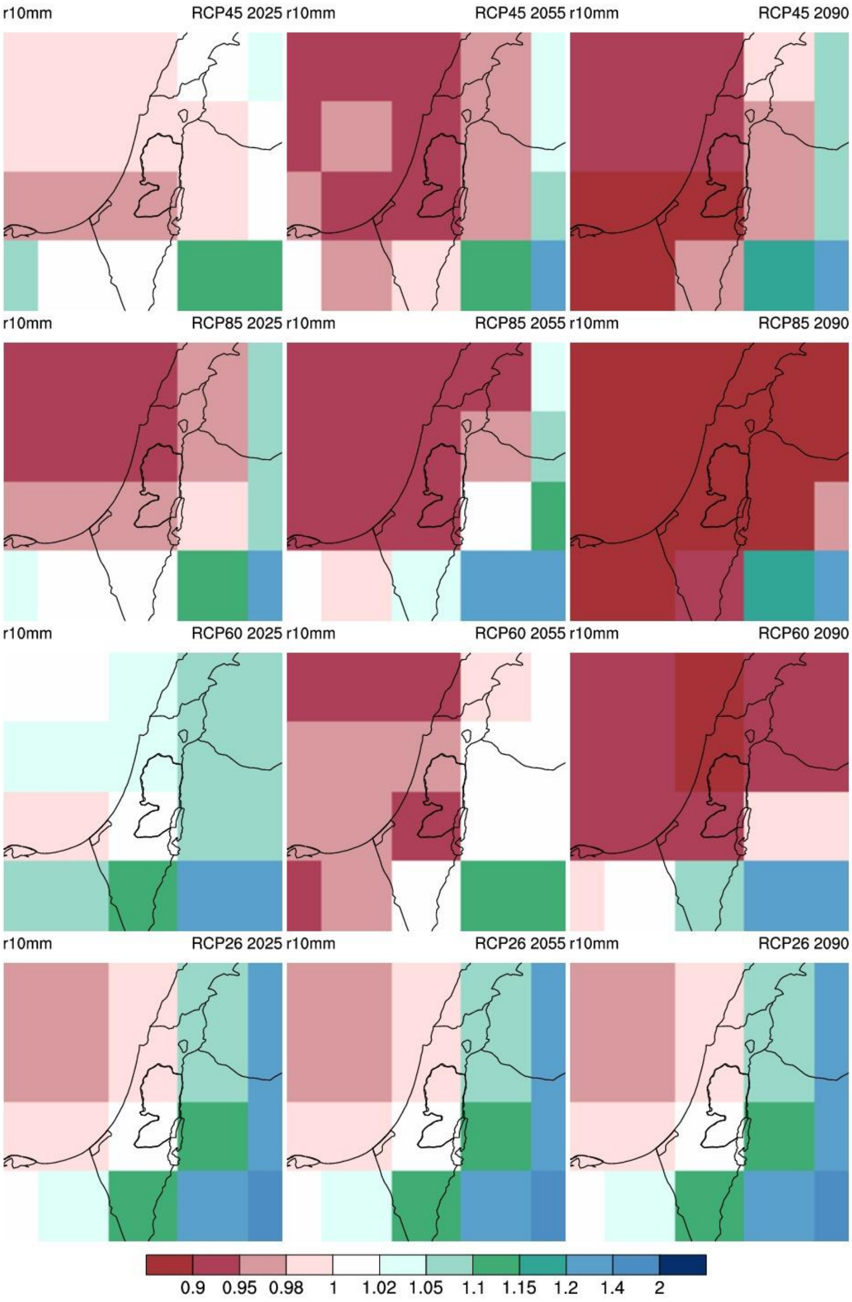


Figure 42: Projected changes in the annual number of days with more than 20mm of rainfall (expressed as a ratio) for Palestine calculated as a mean from the CMIP5 (AR5) ensemble under RCP4.5, RCP8.5, RCP6.0 and RCP2.6 (top to bottom) for periods centred on 2025, 2055 and 2090; values above 1.0 indicate an increase in the number of days with more than 20mm of rainfall. This is likely to be an unstable statistic and should be treated with caution.

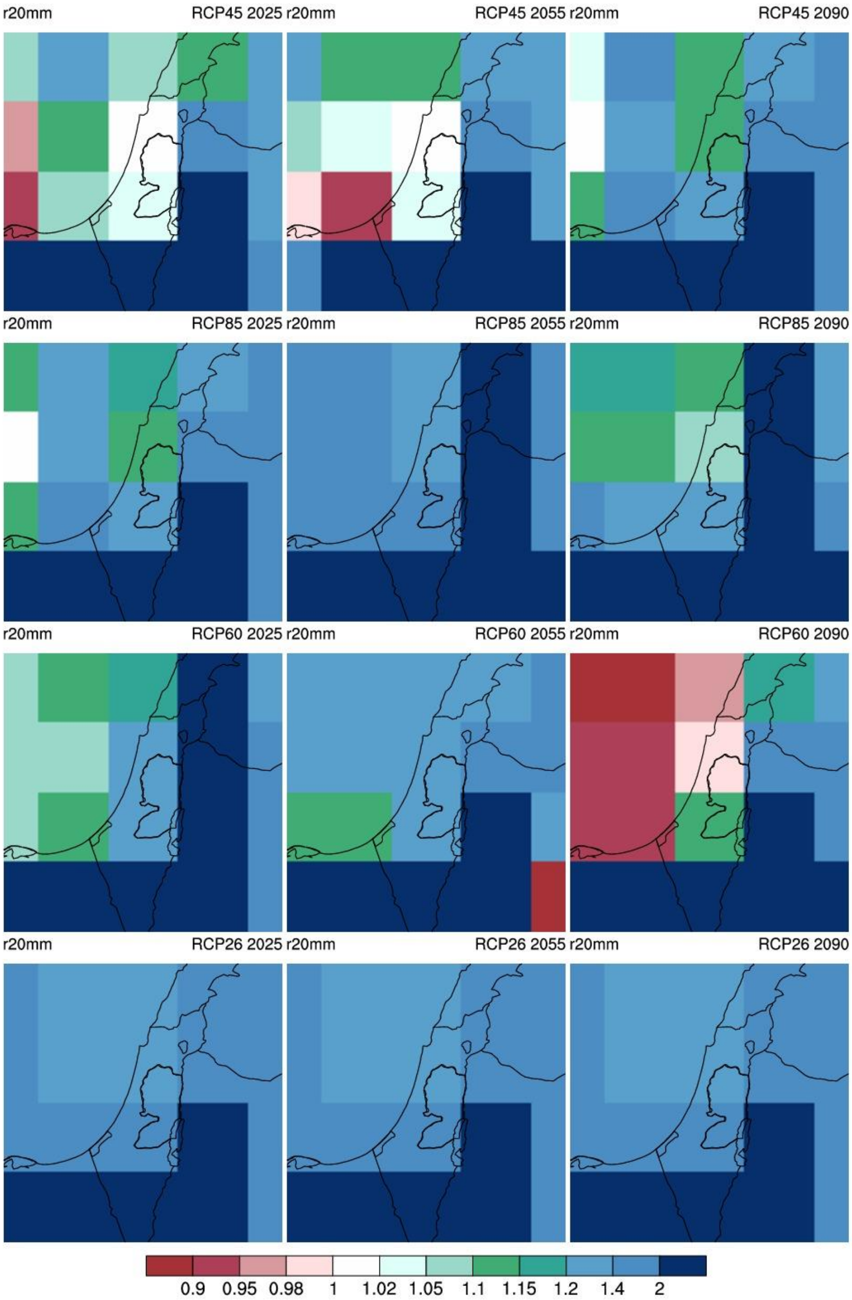


Figure 43: Projected changes in the simple precipitation intensity index (expressed as a ratio) for Palestine calculated as a mean from the CMIP5 (AR5) ensemble under RCP4.5, RCP8.5, RCP6.0 and RCP2.6 (top to bottom) for periods centred on 2025, 2055 and 2090; values above 1.0 indicate an increase in the index. The simple precipitation intensity index as defined by the IPCC is the average rainfall on days on which at least 1mm falls.

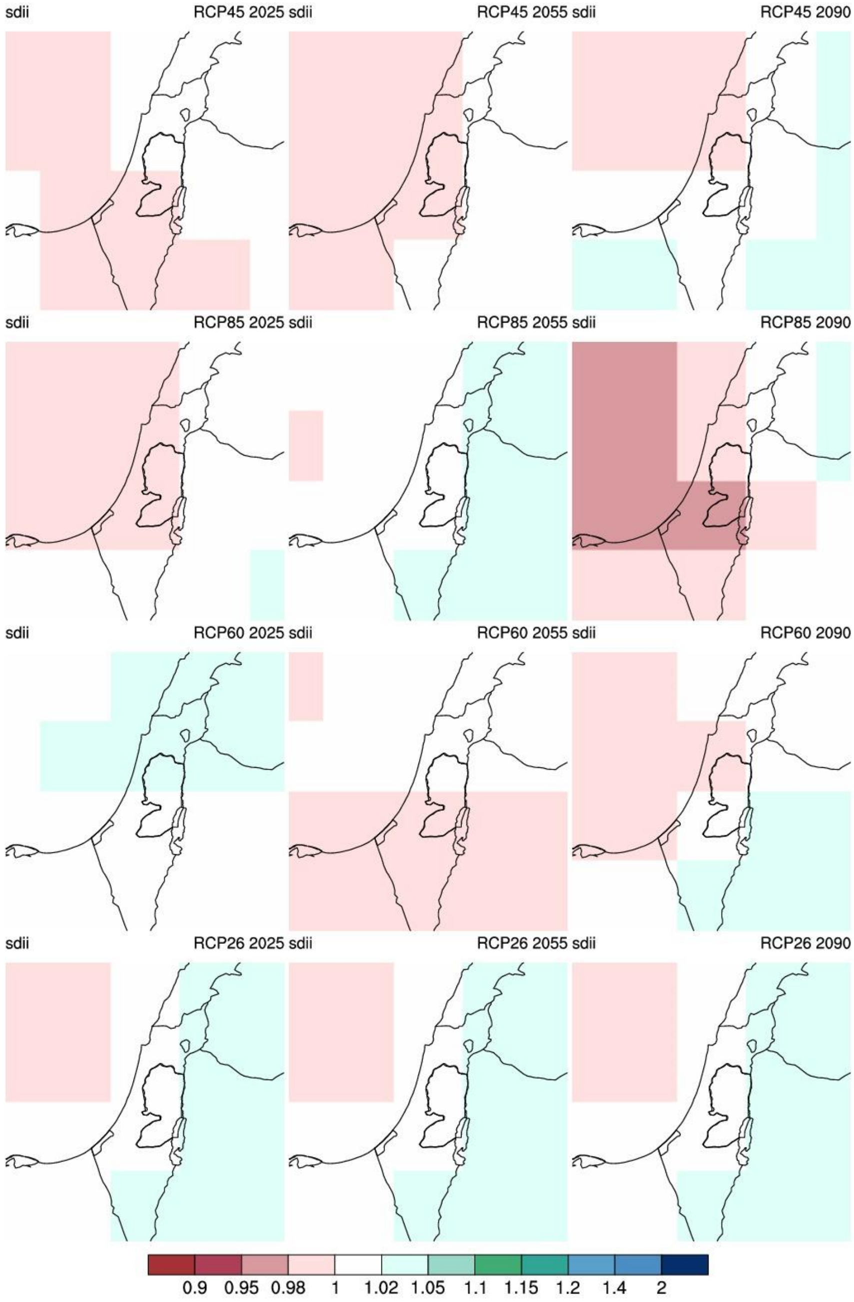


Figure 44: Projected changes in the maximum length of dry spells (expressed as a ratio) for Palestine calculated as a mean from the CMIP5 (AR5) ensemble under RCP4.5, RCP8.5, RCP6.0 and RCP2.6 (top to bottom) for periods centred on 2025, 2055 and 2090; values above 1.0 indicate an increase in the maximum length of dry spells. The maximum length of dry spells as defined by the IPCC is the maximum number of consecutive days in a year on each of which less that 1mm falls (note that in the Palestinian case this is likely to measure the length of the dry summer period).

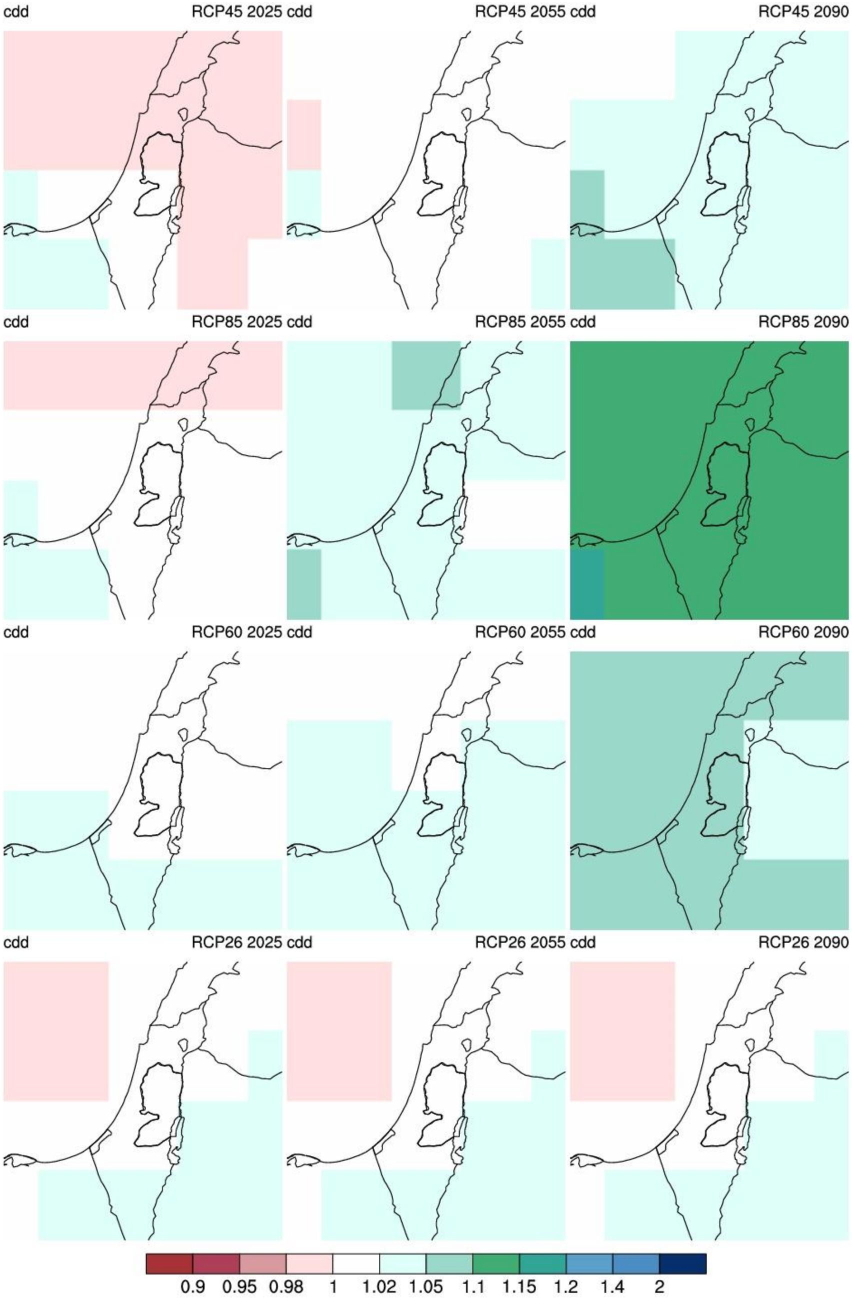


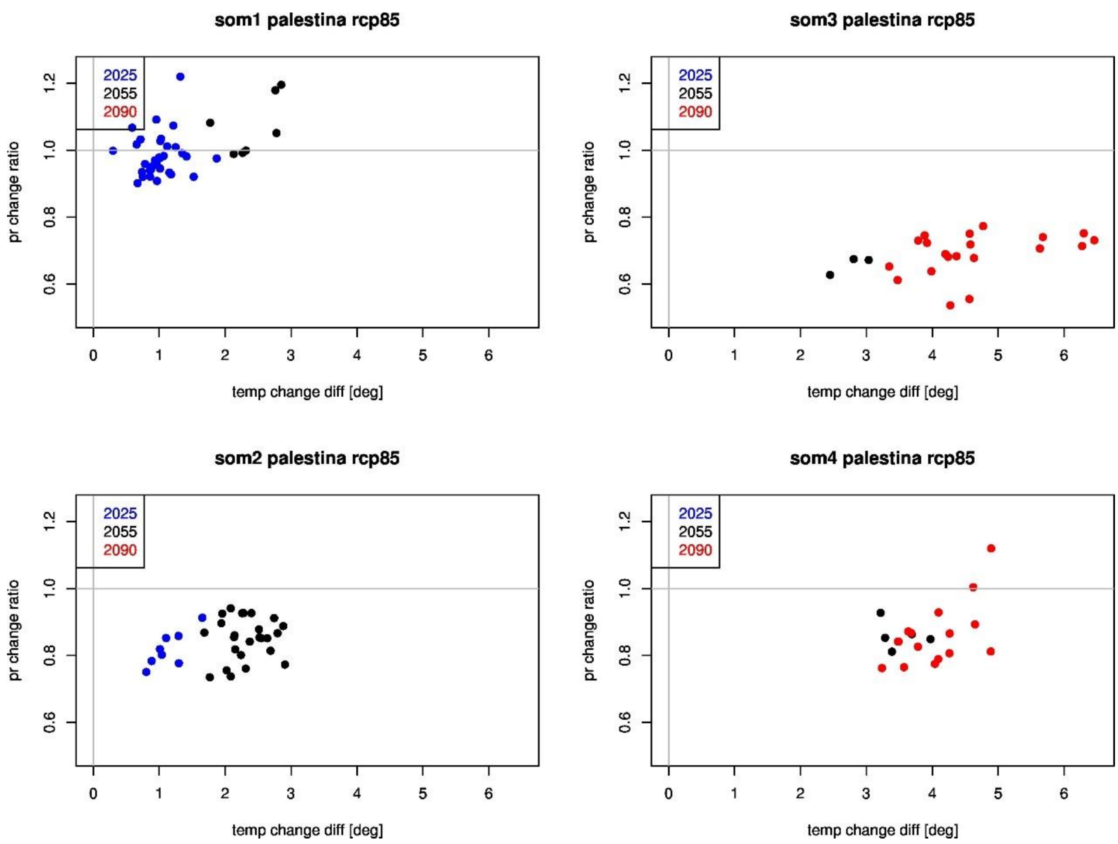
Figure 45: Projected changes in the maximum length of wet spells (expressed as a ratio) for Palestine calculated as a mean from the CMIP5 (AR5) ensemble under RCP4.5, RCP8.5, RCP6.0 and RCP2.6 (top to bottom) for periods centred on 2025, 2055 and 2090; values above 1.0 indicate an increase in the maximum length of wet spells. The maximum length of wet spells as defined by the IPCC is the maximum number of consecutive days in a year on each of which at least 1mm falls.

Appendix 3.4 Separate scenarios under each Relative Concentration Pathway and the approach to collating these scenarios in the final recommendations

Introduction

Separate scenarios under each of the Relative Concentration Pathways (RCPs) for Palestine are presented below for ease of comparison if required. All of the scenarios use the GCM projections prepared for the IPCC AR5. CORDEX scenarios are not reproduced. Some repetition with the main body of the report is unavoidable. Only the SOMs charts are reproduced here. For averages across each group identified by the SOMs refer to Appendix 3. Additional information is incorporated using the IPCC extremes calculations illustrated in Appendix 3. Finally, the recommended scenarios in Section 11 of the report are reiterated together with the arguments underpinning their selection.

RCP8.5



For RCP8.5 there are two sequences, a relatively less dry one, som1→som4, and a warmer, drier one, som2→som3. In the first case, temperatures rise 1°C→3°C→4°C; rainfall changes are roughly -5%-->0%-->-20%. In the second case, temperatures rise 1.5°C->2.5°C→4.5°C while rainfall reductions are 20%-->20%-->30%.

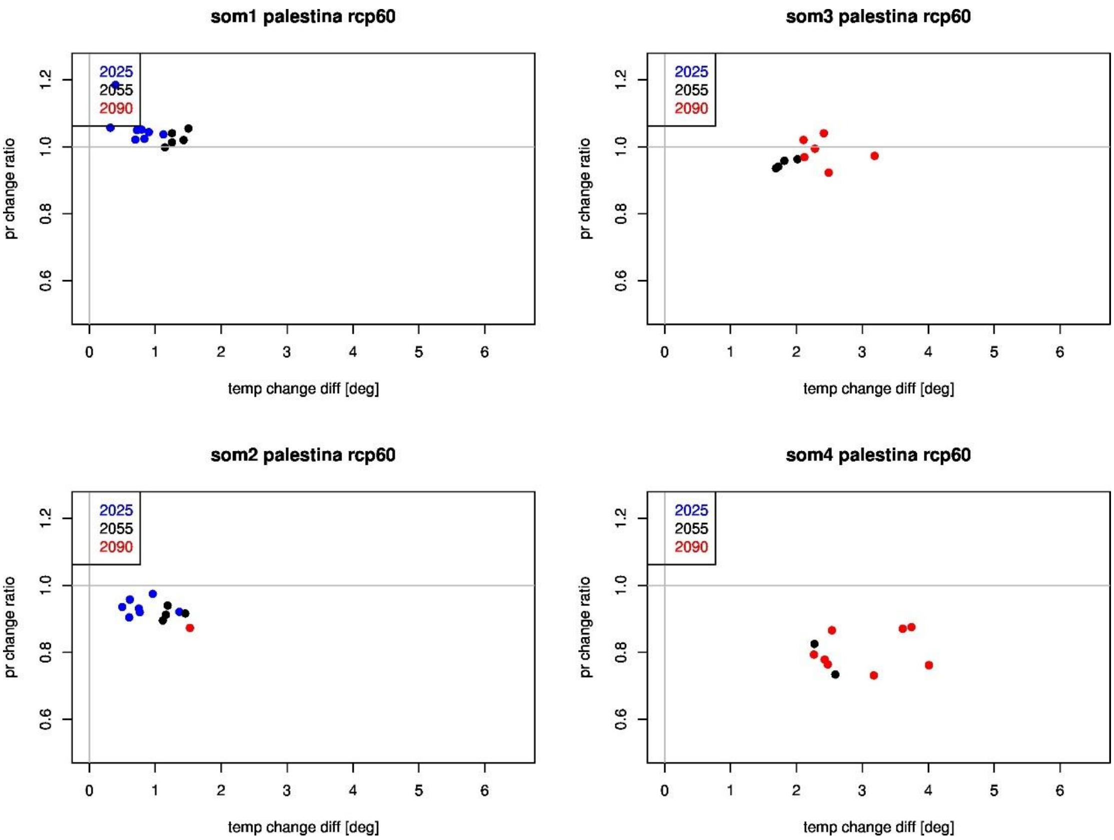
Scenario (RCP8.5)1 – a relatively less warm scenario with relatively lower rainfall reductions; roughly a 50% likelihood based on the numbers of models included

Temperature	Increases by ~1°C by 2025, by ~3°C by 2055, by ~4°C by 2090.
Temperature-related	Reduced cold periods and more warmer periods, both becoming more prominent in time and in general, more so than under any other RCP; perhaps slightly moderated in Gaza by proximity to the Mediterranean.
Rainfall	Indiscernible change initially, with any reduction in the early period perhaps recovered by 2055; main rainfall reductions occur by 2090, with reductions of around 20%.
Rainfall-related	In general, a pattern of reductions in average daily rainfall and in contributions to total rainfall by heavier rainfall days (but less so than under Scenario (RCP8.5)2), extended dry periods and reduced wet periods; thus an increase in drought risk, especially by 2090, with similar patterns for Gaza and the West Bank. However, an indication (stronger under Scenario (RCP8.5)2), that the rare wettest days might become more frequent, especially in the West Bank, thus, raising a possibility of an increased flood risk (but note that this might be a statistical anomaly arising through the rarity of the event).

Scenario (RCP8.5)2 – a relatively warmer scenario with relatively large rainfall reductions; roughly a 50% likelihood based on the numbers of models included

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 warmer periods, both becoming more prominent in time; more so than under Scenario (RCP8.5)1 but similarly greater than under any other RCP and perhaps moderated slightly in Gaza.
Rainfall	Decreases by ~20% throughout until 2055, and to ~30% by 2090.
Rainfall-related	In general, a pattern of reductions in average daily rainfall and in contributions to total rainfall by heavier rainfall days (stronger than under Scenario (RCP8.5)1), extended dry periods and reduced wet periods; thus an increase in drought risk throughout with similar patterns for Gaza and the West Bank. However, an indication (stronger than under Scenario (RCP8.5)1), that the rare wettest days might become more frequent, especially in the West Bank, thus, raising a possibility of an increased flood risk (but note that this might be a statistical anomaly arising through the rarity of the event).

RCP6.0



There appear to be two sequences for RCP6.0, both of roughly equal probability. The first begins in som1, with temperature increases by 2025 below 1°C and rainfall increases of around 5%. This continues into som3, whereby the temperature increases by 2090 to over 2°C and rainfall returns roughly to recent values. The second sequence, som2→som4, produces a picture of ultimate temperature increases of around 3°C, with rainfall reducing steadily over time by 20%. There are fewer projections under RCP6.0 than under RCP8.5 and RCP4.5, a fact that might introduce relative biases in the results.

Scenario (RCP6.0)1 – a relatively less warm scenario with possible initial increases in rainfall; roughly a 50% likelihood based on the numbers of models included

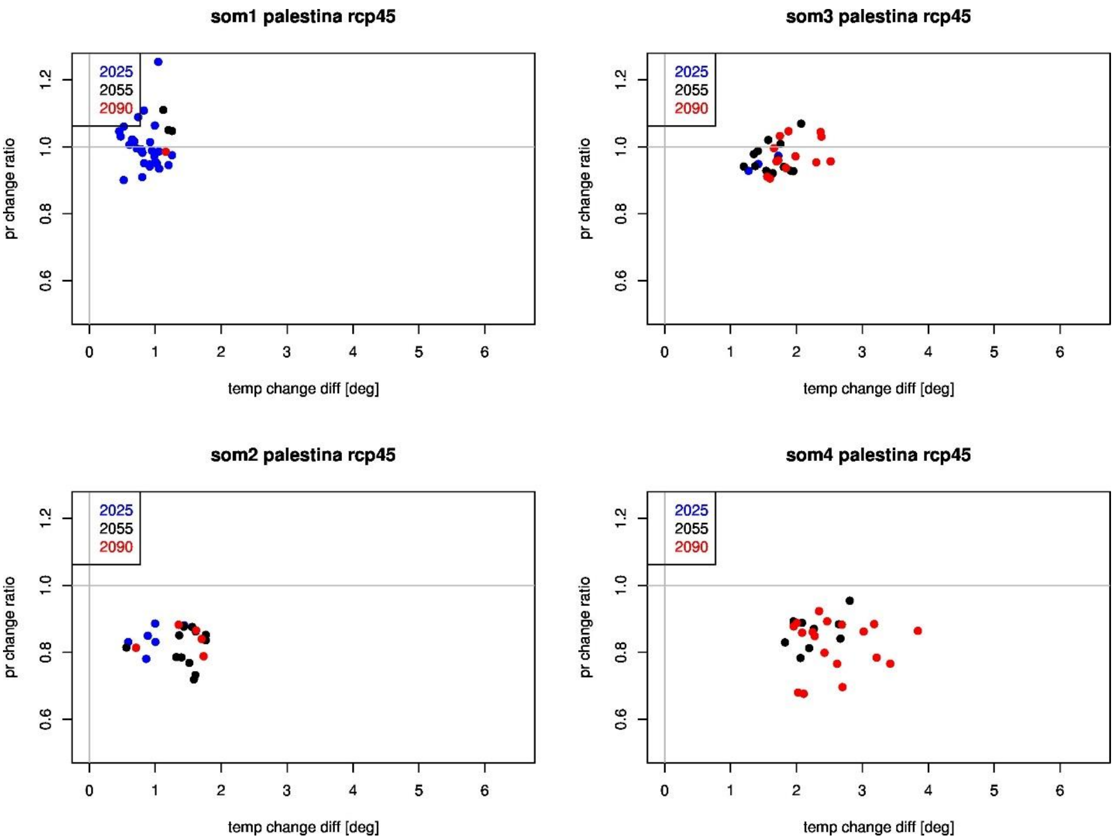
Temperature	Increases by ~0.75°C by 2025, by ~1.5°C by 2055, by ~2.5°C by 2090.
Temperature-related	Reduced cold periods and more warmer periods, both becoming more prominent in time but in general less, so than under Scenario (RCP8.5)1; perhaps slightly moderated in Gaza by proximity to the Mediterranean.
Rainfall	Indiscernible change throughout, with possible increases of 5% in the early period.
Rainfall-related	In general, a pattern of reductions in average daily rainfall and in contributions to total rainfall by heavier rainfall days (but less so than under Scenarios (RCP6.0)2 and (RCP8.5)1), in particular later in the century, extended dry periods and reduced wet periods; thus, an increase in drought risk, especially by 2090, with similar patterns for Gaza and the West Bank. However, an indication particularly for the earlier periods and more so in the West Bank, that the rare wettest days might become more frequent, especially in the West Bank (but note that this

Temperature	Increases by ~0.75°C by 2025, by ~1.5°C by 2055, by ~2.5°C by 2090.
	might be a statistical anomaly arising through the rarity of the event), and supported by an increase in the total contribution of wetter days up until 2055, thus, raising a possibility of an increased flood risk.

Scenario (RCP6.0)2 – a relatively warmer scenario with rainfall reductions increasing in time; roughly a 50% likelihood based on the numbers of models included

Temperature	Increases by ~0.75°C by 2025, by ~2°C by 2055, by ~3°C by 2090
Temperature-related	Reduced cold periods and more warmer periods, both becoming more prominent in time; more so than under Scenario (RCP6.0)1 but less than under Scenario (RCP8.5)2 and perhaps moderated slightly in Gaza.
Rainfall	Decreasing steadily throughout, reaching ~20% by 2090
Rainfall-related	In general, a pattern of reductions in average daily rainfall and in contributions to total rainfall by heavier rainfall days (stronger than under Scenario (RCP6.0)1), extended dry periods and reduced wet periods; thus, an increase in drought risk throughout with similar patterns for Gaza and the West Bank. However, an indication particularly for the earlier periods and more so in the West Bank (but probably less so than under Scenario (RCP6.0)1) that the rare wettest days might become more frequent, especially in the West Bank (but note that this might be a statistical anomaly arising through the rarity of the event), and supported by an increase in the total contribution of wetter days up until 2055, thus, raising a possibility of an increased flood risk; however, this flood risk is most likely restricted to Scenario (RCP6.0)1.

RCP4.5



Under RCP4.5 the patterns resemble those under RCP6.0. There are two distinct sequences. In the first, marginally with higher probability, given the number of projections included, rainfall remains similar to today but temperatures increase (1.0°C→1.5°C→2°C) – som1→som3. In the second rainfall reductions are about 20% throughout (som2→som4), with temperatures increasing by 1.0°C→1.5°C→3.0°C.

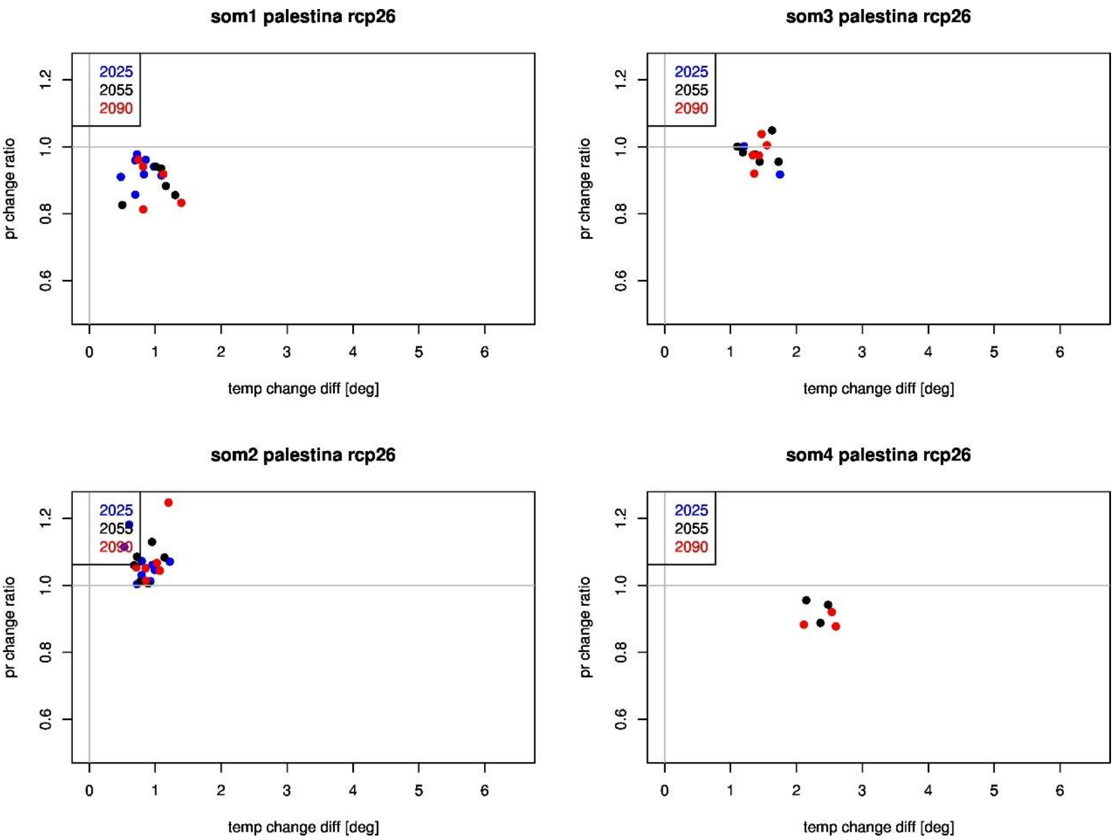
Scenario (RCP4.5)1 – a relatively less warm scenario with limited, if any, change in rainfall; marginally more probable than Scenario (RCP4.5)2 based on the numbers of models included

Temperature	Increases by ~1.0°C by 2025, by ~1.5°C by 2055, by ~2.0°C by 2090.
Temperature-related	Reduced cold periods and more warmer periods, both becoming more prominent in time and basically similar to Scenario (RCP6.0)1; perhaps slightly moderated in Gaza by proximity to the Mediterranean.
Rainfall	Indiscernible change throughout.
Rainfall-related	In general, a pattern of reductions in average daily rainfall and in contributions to total rainfall by heavier rainfall days (similar to under Scenario (RCP6.0)1), in particular later in the century, extended dry periods and reduced wet periods; thus, an increase in drought risk, especially by 2090, with similar patterns for Gaza and the West Bank. However, an indication particularly for the earlier periods and more so in the West Bank, that the rare wettest days might become more frequent, especially in the West Bank (but note that this might be a statistical anomaly arising through the rarity of the event), and supported by an increase in the total contribution of wetter days up until 2055, thus, raising a possibility of an increased flood risk.

Scenario (RCP4.5)2 – a relatively warmer scenario with rainfall reductions throughout; marginally less probable than Scenario (RCP4.5)1 based on the numbers of models included

Temperature	Increases by ~1.0°C by 2025, by ~1.5°C by 2055, by ~3°C by 2090.
Temperature-related	Reduced cold periods and more warmer periods, both becoming more prominent in time; more so than under Scenario (RCP4.5)1 but similar to under Scenario (RCP6.0)2 and perhaps moderated slightly in Gaza.
Rainfall	Decreases by ~20% throughout.
Rainfall-related	In general, a pattern of reductions in average daily rainfall and in contributions to total rainfall by heavier rainfall days (stronger than under Scenario (RCP4.5)1), extended dry periods and reduced wet periods; thus, an increase in drought risk throughout with similar patterns for Gaza and the West Bank. However, an indication particularly for the earlier periods and more so in the West Bank (but probably similar to under Scenario (RCP6.0)2), that the rare wettest days might become more frequent, especially in the West Bank (but note that this might be a statistical anomaly arising through the rarity of the event), and supported by an increase in the total contribution of wetter days up until 2055, thus, raising a possibility of an increased flood risk; however, this flood risk is most likely restricted to Scenario (RCP4.5)1.

RCP2.6



There are three independent groupings of the models, in each case with limited development of changes in time, plus one minor grouping that might be an extension of one of the main three:

- There are two groups with approximately similar likelihoods, as determined by the number of models incorporated:
  - In the first, som1, temperatures rise by about 1°C at all future times and rainfall decreases by about 10%
  - It is likely that some of these models move into the possible extension, som4, with temperature increases of 2.5°C and a 10% reduction in rainfall from 2055 onwards
- The second major group is that of som2, where the temperature increase is 1°C, equivalent to that in the group of som1, but in this case with a rainfall increase of around 5%
- The final group is som3, with lower likelihood, in which temperatures rise by about 1.5°C but there is perhaps a small decrease in rainfall.

Scenario (RCP2.6)1 – a relatively less warm scenario with reductions in rainfall of about 10%; similar probability to Scenario (RCP2.6)2 but more than that of Scenario (RCP2.6)3 based on the numbers of models included

Temperature	Increases by ~1.0°C throughout.
Temperature-related	Reduced cold periods and more warmer periods throughout; however, less so than under any other RCP Scenarios but similar to under Scenario (RCP2.6)2 and perhaps moderated slightly in Gaza by proximity to the Mediterranean.
Rainfall	Decreases by ~10% throughout.
Rainfall-related	Impacts on rainfall are less than under any other RCP, although probably with the strongest but limited, negative changes under this Scenario of all those for RCP2.6. Perhaps a marginally increased drought risk but limited increase in flood risk.

Scenario (RCP2.6)2 – a relatively less warm scenario with increases in rainfall of perhaps 5%; similar probability to Scenario (RCP2.6)1 but more than that of Scenario (RCP2.6)3 based on the numbers of models included

Temperature	Increases by ~1.0°C throughout.
Temperature-related	Reduced cold periods and more warmer periods throughout; however less so than under any other RCP Scenarios but similar to under Scenario (RCP2.6)1 and perhaps moderated slightly in Gaza by proximity to the Mediterranean.
Rainfall	Increases by ~5% throughout.
Rainfall-related	Limited impacts on rainfall, with a raised risk of flooding.

Scenario (RCP2.6)3 – a relatively warmer scenario with perhaps a small decrease in rainfall; less probable than either Scenario (RCP2.6)1 or Scenario (RCP2.6)2 based on the numbers of models included

Temperature	Increases by ~1.5°C throughout.
Temperature-related	Reduced cold periods and more warmer periods throughout; however, less so than under any other RCP Scenarios but more so than under Scenarios (RCP2.6)1 and (RCP2.6)2 and perhaps moderated slightly in Gaza.
Rainfall	Decreases by ~5% throughout.
Rainfall-related	Limited impacts on rainfall with, in general, indiscernible change in drought or flood risks.

Summary and recommendations

One anticipated conclusion emerges directly from the above scenarios: the lower the emissions the lesser the consequences to the climate of Palestine. The bulk of the evidence suggests that adjustments to rainfall will be minimal assuming that the UNFCCC target of a global average temperature increase of no more than 2°C is not breached (as represented by RCP2.6), although local temperature increases are to be expected. Progressively larger increases in temperatures will occur as emissions increase, with the risk of reduced rainfall increasing also.

Notwithstanding the above, the magnitude of the impacts on Palestinian climate does not increase simply as a consequence of increased emissions according to these calculations, especially in terms of rainfall. Much of this non-linearity in response (but perhaps not all) must be ascribed to the differing numbers of projections available (RCP2.6 – 20 models; RCP4.5 – 39; RCP6.0 – 15; RCP8.5 – 40). The omission of certain models in the RCP2.6 and RCP6.0 projections, as compared to those for RCP4.5

and RCP8.5, inevitably introduces biases and it appears that some of the models projecting drier conditions over Palestine have been among those omitted, leading to relatively wetter overall conclusions for the two less populated RCPs. This inherent bias must be considered in defining the final scenarios.

Nevertheless a pattern does emerge for all RCPs, other than RCP2.6, of one group of projections indicating limited adjustments to rainfall (with the main reductions restricted to the end of the century under RCP8.5), and a second group suggesting substantial decreases; naturally temperature rises less with the former group than with the latter. Thus, overall the projections are split between two courses for rainfall, with the course of limited change being consistent with the situation under RCP2.6.

Drawing upon all this evidence, without oversimplifying the final position, leads to the recommended scenarios:

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 warmer periods, both becoming more prominent in 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.

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 warmer periods, both becoming more prominent in time; more so than under Scenario 1.
Rainfall	Decreases by ~10% by 2025, by ~15% by 2055, 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.

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 warmer periods, both becoming more prominent in time; perhaps moderated slightly in the Gaza Strip.
Rainfall	Decreases by ~20% throughout until 2055, and to ~30% by 2090.
Rainfall-related	In general, 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, especially in the West Bank, thus, raising a possibility of an increased flood risk.

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Appendix 4– NAP summary costs

Highly vulnerable	Adaptation option	West Bank Years 1-5	West Bank Years 6-10	West Bank Total cost	Gaza Strip Years 1-5	Gaza Strip Years 6-10	Gaza Strip Total cost	Total Cost Years 1-5	Total cost Years 6-10	Total Cost
Agriculture										
Irrigation water	Improve water-use efficiency and using alternatives water resources	$70,000,000	$70,000,000	$140,000,000	$14,270,000	$14,270,000	$28,540,000	$84,270,000	$84,270,000	$168,540,000
Grazing area and soil erosion	Land-use planning and management - greening, afforestation, and rangeland development	$300,000,000	$300,000,000	$600,000,000	$0	$0	$0	$300,000,000	$300,000,000	$600,000,000
Irrigated vegetables	Enhance sustainable community-level irrigation schemes and infrastructure	$3,200,000	$16,200,000	$19,400,000	$0	$0	$0	$3,200,000	$16,200,000	$19,400,000
Livestock production	Increase the availability of animal feed (including plant and organic residues) at an affordable price	$8,000,000	$8,000,000	$16,000,000	$0	$0	$0	$8,000,000	$8,000,000	$16,000,000
Livestock production	Improve livestock-production pens	$15,000,000	$0	$15,000,000	$15,000,000	$0	$15,000,000	$30,000,000	$0	$30,000,000
West Bank - Production of olives, grapes, stone fruits, rain-fed vegetables and field crops Gaza Strip - citrus, olive	Climate-smart agriculture	$73,000,000	$73,000,000	$146,000,000	$20,200,000	$20,200,000	$40,400,000	$93,200,000	$93,200,000	$186,400,000

Highly vulnerable	Adaptation option	West Bank Years 1-5	West Bank Years 6-10	West Bank Total cost	Gaza Strip Years 1-5	Gaza Strip Years 6-10	Gaza Strip Total cost	Total Cost Years 1-5	Total cost Years 6-10	Total Cost
production, vegetable production, and employment										
West Bank - Production of olives, grapes, stone fruits, rain-fed vegetables, field crops and livestock Gaza Strip - Cost of Agricultural production	Agricultural disaster risk reduction and management (DRR/M)	$44,000,000	$44,000,000	$88,000,000	$22,000,000	$22,000,000	$44,000,000	$66,000,000	$66,000,000	$132,000,000
Cost of agricultural production	Establishment of farmers' support (subsidies, awareness training programs)	$0	$0	$0	$85,000,000	$0	$85,000,000	$85,000,000	$0	$85,000,000
TOTAL		$513,200,000	$511,200,000	$1,024,400,000	$156,470,000	$56,470,000	$212,940,000	$669,670,000	$567,670,000	$1,237,340,000
Coastal and marine										
Fishing/fisheries	Enlargement of the fishing area and improve fishing equipment	$0	$0	$0	$10,000,000	$80,000,000	$90,000,000	$10,000,000	$80,000,000	$90,000,000
Fish catch	Fish packaging/preservation industry	$0	$0	$0	$1,000,000	$0	$1,000,000	$1,000,000	$0	$1,000,000
Coastal agriculture	Introduction of new saline-tolerant crops	$0	$0	$0	$500,000	$0	$500,000	$500,000	$0	$500,000

Highly vulnerable	Adaptation option	West Bank Years 1-5	West Bank Years 6-10	West Bank Total cost	Gaza Strip Years 1-5	Gaza Strip Years 6-10	Gaza Strip Total cost	Total Cost Years 1-5	Total cost Years 6-10	Total Cost
Coastal agriculture	Rain-water harvesting	$0	$0	$0	$500,000	$0	$500,000	$500,000	$0	$500,000
Condition of beaches	Provision of beach nourishment, reclamation and beach drift rehabilitation	$0	$0	$0	$5,000,000	$5,000,000	$10,000,000	$5,000,000	$5,000,000	$10,000,000
Condition of beaches	Construction of detached breakwaters	$0	$0	$0	$5,000,000	$5,000,000	$10,000,000	$5,000,000	$5,000,000	$10,000,000
Condition of beaches	Provision of laboratories and equipment for data collection and analysis	$0	$0	$0	$2,000,000	$0	$2,000,000	$2,000,000	$0	$2,000,000
TOTAL		$0	$0	$0	$24,000,000	$90,000,000	$114,000,000	$24,000,000	$90,000,000	$114,000,000
Energy										
Domestic/local energy production	Enhancing the equipment and efficiency of the Gaza Power Plant (GPP)	$0	$0	$0	$10,000,000	$0	$10,000,000	$10,000,000	$0	$10,000,000
Domestic/local energy production	Generation of solar electricity for medium-large scale commercial and industrial application	$99,548,000	$0	$99,548,000	$0	$0	$0	$99,548,000	$0	$99,548,000
Domestic/local energy production	Implement energy efficiency measures to reduce consumption, mainly for commercial and industrial application	$10,500,000	$0	$10,500,000	$0	$0	$0	$10,500,000	$0	$10,500,000

Highly vulnerable	Adaptation option	West Bank Years 1-5	West Bank Years 6-10	West Bank Total cost	Gaza Strip Years 1-5	Gaza Strip Years 6-10	Gaza Strip Total cost	Total Cost Years 1-5	Total cost Years 6-10	Total Cost
Energy imports	Use of renewable energy such as solar to reduce imported energy.	$106,048,000	$0	$106,048,000	$50,000,000	$0	$50,000,000	$156,048,000	$0	$156,048,000
Energy imports	Implement energy efficiency measures to reduce consumption and hence imported energy	$13,500,000	$0	$13,500,000	$6,000,000	$0	$6,000,000	$19,500,000	$0	$19,500,000
Total energy imports	Additional supply of energy from neighbouring countries	$0	$0	$0	$10,000,000	$0	$10,000,000	$10,000,000	$0	$10,000,000
Condition of infrastructure	Electricity grid upgrading	$16,250,000	$0	$16,250,000	$100,000,000	$0	$100,000,000	$116,250,000	$0	$116,250,000
Condition of infrastructure	Building fossil-fuel storage facilities	$21,200,000	$0	$21,200,000	$0	$0	$0	$21,200,000	$0	$21,200,000
TOTAL		$267,046,000	$0	$267,046,000	$176,000,000	$0	$176,000,000	$443,046,000	$0	$443,046,000
Food										
Domestic food prices	Enhancing agricultural value chain by improving infrastructure for livestock-production	$150,000,000	$77,500,000	$227,500,000	$75,000,000	$46,250,000	$121,250,000	$225,000,000	$123,750,000	$348,750,000
Domestic food prices	Greenhouse management	$10,000,000	$15,000,000	$25,000,000	$5,000,000	$7,500,000	$12,500,000	$15,000,000	$22,500,000	$37,500,000
Domestic food prices	Construction large-scale cold storage	$21,000,000	$12,000,000	$33,000,000	$9,000,000	$6,000,000	$15,000,000	$30,000,000	$18,000,000	$48,000,000

Highly vulnerable	Adaptation option	West Bank Years 1-5	West Bank Years 6-10	West Bank Total cost	Gaza Strip Years 1-5	Gaza Strip Years 6-10	Gaza Strip Total cost	Total Cost Years 1-5	Total cost Years 6-10	Total Cost
Imported food prices	Construct large-scale steel silos for grain to enable import and storage during periods when prices on the international markets are low	$4,000,000	$0	$4,000,000	$5,000,000	$0	$5,000,000	$9,000,000	$0	$9,000,000
TOTAL		$185,000,000	$104,500,000	$289,500,000	$94,000,000	$59,750,000	$153,750,000	$279,000,000	$164,250,000	$443,250,000
Gender										
Major diseases related to water, sanitation, and food	Increasing the awareness of people, particularly women, in water-poor areas of measures they can take to help prevent major diseases related to water, sanitation, and food	$1,200,000	$1,000,000	$2,200,000	$1,700,000	$1,500,000	$3,200,000	$2,900,000	$2,500,000	$5,400,000
Employment and gender	Supporting improvements in efficient use of water in women's private small-scale agricultural projects	$0	$0	$0	$1,500,000	$1,500,000	$3,000,000	$1,500,000	$1,500,000	$3,000,000
Food security and gender	Encouraging women to use their house gardens to produce food	$0	$0	$0	$1,700,000	$1,500,000	$3,200,000	$1,700,000	$1,500,000	$3,200,000
TOTAL		$1,200,000	$1,000,000	$2,200,000	$4,900,000	$4,500,000	$9,400,000	$6,100,000	$5,500,000	$11,600,000
Health										

Highly vulnerable	Adaptation option	West Bank Years 1-5	West Bank Years 6-10	West Bank Total cost	Gaza Strip Years 1-5	Gaza Strip Years 6-10	Gaza Strip Total cost	Total Cost Years 1-5	Total cost Years 6-10	Total Cost
Major diseases related to water, sanitation, and food	Development of water, food and sanitation monitoring and safety systems using high technology	$3,850,000	$2,000,000	$5,850,000	$1,900,000	$1,000,000	$2,900,000	$5,750,000	$3,000,000	$8,750,000
Major diseases related to water, sanitation, and food	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	$1,680,000	$1,000,000	$2,680,000	$550,000	$300,000	$850,000	$2,230,000	$1,300,000	$3,530,000
TOTAL		$5,530,000	$3,000,000	$8,530,000	$2,450,000	$1,300,000	$3,750,000	$7,980,000	$4,300,000	$12,280,000
Industry										
Value of raw materials imported	Replace imported raw materials with local materials whenever possible	$14,000,000	$14,000,000	$28,000,000	$0	$0	$0	$14,000,000	$14,000,000	$28,000,000
Infrastructure	Improve water supply through wastewater collection and treatment systems	$29,000,000	$29,000,000	$58,000,000	$0	$0	$0	$29,000,000	$29,000,000	$58,000,000
Energy supply	Providing reliable electricity supply	$14,700,000	$14,700,000	$29,400,000	$0	$0	$0	$14,700,000	$14,700,000	$29,400,000

Highly vulnerable	Adaptation option	West Bank Years 1-5	West Bank Years 6-10	West Bank Total cost	Gaza Strip Years 1-5	Gaza Strip Years 6-10	Gaza Strip Total cost	Total Cost Years 1-5	Total cost Years 6-10	Total Cost
Energy supply	Building fossil-fuel storage facilities	$12,700,000	$12,700,000	$25,400,000	$0	$0	$0	$12,700,000	$12,700,000	$25,400,000
Energy demand	Reducing energy consumption through introduction of modern production technologies	$15,500,000	$15,500,000	$31,000,000	$0	$0	$0	$15,500,000	$15,500,000	$31,000,000
Value of industrial products exported	Provision of suitable storage facilities for industrial products intended for export	$0	$0	$0	$9,000,000	$9,000,000	$18,000,000	$9,000,000	$9,000,000	$18,000,000
Value of raw materials exported	Improve handling, fumigation, packaging, and storage techniques for raw materials intended for export	$0	$0	$0	$1,000,000	$0	$1,000,000	$1,000,000	$0	$1,000,000
Employment	Capacity building to enable industries to adapt to climate change	$0	$0	$0	$2,000,000	$2,000,000	$4,000,000	$2,000,000	$2,000,000	$4,000,000
Value of industrial products exported	Rehabilitation of industrial facilities	$0	$0	$0	$20,000,000	$10,000,000	$30,000,000	$20,000,000	$10,000,000	$30,000,000
Energy supply	Providing reliable electricity supply	$0	$0	$0	$10,000,000	$0	$10,000,000	$10,000,000	$0	$10,000,000

Highly vulnerable	Adaptation option	West Bank Years 1-5	West Bank Years 6-10	West Bank Total cost	Gaza Strip Years 1-5	Gaza Strip Years 6-10	Gaza Strip Total cost	Total Cost Years 1-5	Total cost Years 6-10	Total Cost
Energy demand	Conducting energy audits in order to increase industries' use of energy efficiency measures	$0	$0	$0	$3,000,000	$2,500,000	$5,500,000	$3,000,000	$2,500,000	$5,500,000
Energy demand	Rehabilitation and maintenance of industrial equipment	$0	$0	$0	$4,500,000	$4,500,000	$9,000,000	$4,500,000	$4,500,000	$9,000,000
TOTAL		$85,900,000	$85,900,000	$171,800,000	$49,500,000	$28,000,000	$77,500,000	$135,400,000	$113,900,000	$249,300,000
Terrestrial ecosystems										
Habitat connectivity	National network of protected areas, including 50 protected areas and 51 biodiversity hotspots	$8,500,000	$3,500,000	$12,000,000	$800,000	$600,000	$1,400,000	$9,300,000	$4,100,000	$13,400,000
TOTAL		$8,500,000	$3,500,000	$12,000,000	$800,000	$600,000	$1,400,000	$9,300,000	$4,100,000	$13,400,000
Tourism										
Condition of cultural heritage	Identify, design and implement flood management schemes for cultural heritage sites, where appropriate	$2,400,000	$2,400,000	$4,800,000	$0	$0	$0	$2,400,000	$2,400,000	$4,800,000
Condition of cultural heritage	Identify, design and implement flood management schemes for ecotourist attractions,	$2,400,000	$2,400,000	$4,800,000	$0	$0	$0	$2,400,000	$2,400,000	$4,800,000

Highly vulnerable	Adaptation option	West Bank Years 1-5	West Bank Years 6-10	West Bank Total cost	Gaza Strip Years 1-5	Gaza Strip Years 6-10	Gaza Strip Total cost	Total Cost Years 1-5	Total cost Years 6-10	Total Cost
	where appropriate									
TOTAL		$4,800,000	$4,800,000	$9,600,000	$0	$0	$0	$4,800,000	$4,800,000	$9,600,000
Urban										
Urbanization	Promoting green buildings	$5,000,000	$5,000,000	$10,000,000	$5,000,000	$5,000,000	$10,000,000	$10,000,000	$10,000,000	$20,000,000
Urbanization	Rehabilitation of resilient road infrastructure	$11,000,000	$10,000,000	$21,000,000	$6,600,000	$6,000,000	$12,600,000	$17,600,000	$16,000,000	$33,600,000
TOTAL		$16,000,000	$15,000,000	$31,000,000	$11,600,000	$11,000,000	$22,600,000	$27,600,000	$26,000,000	$53,600,000
Waste and Wastewater										
Waste management	Improve management of leachate from landfill sites	$5,000,000	$0	$5,000,000	$2,000,000	$0	$2,000,000	$7,000,000	$0	$7,000,000
Waste management	Improving waste collection system	$34,250,000	$0	$34,250,000	$12,000,000	$0	$12,000,000	$46,250,000	$0	$46,250,000
Waste management	Reduce, re-use, recycle	$8,000,000	$0	$8,000,000	$2,000,000	$0	$2,000,000	$10,000,000	$0	$10,000,000
TOTAL		$47,250,000	$0	$47,250,000	$16,000,000	$0	$16,000,000	$63,250,000	$0	$63,250,000
Water										
Ground water supply	Enhance the use of additional and alternative water resources for non-domestic purposes	$77,000,000	$75,000,000	$152,000,000	$28,000,000	$33,000,000	$61,000,000	$105,000,000	$108,000,000	$213,000,000
Ground water supply	Allocate transboundary water resources equitably and reasonably	$47,600,000	$70,000,000	$117,600,000	$0	$0	$0	$47,600,000	$70,000,000	$117,600,000

Highly vulnerable	Adaptation option	West Bank Years 1-5	West Bank Years 6-10	West Bank Total cost	Gaza Strip Years 1-5	Gaza Strip Years 6-10	Gaza Strip Total cost	Total Cost Years 1-5	Total cost Years 6-10	Total Cost
	between Israel and Palestine									
Condition of infrastructure	Rehabilitate water sources: wells, canals and springs	$2,200,000	$2,200,000	$4,400,000	$0	$0	$0	$2,200,000	$2,200,000	$4,400,000
Condition of infrastructure	Control of leakage from distribution systems	$8,250,000	$8,250,000	$16,500,000	$0	$0	$0	$8,250,000	$8,250,000	$16,500,000
Flood management	Develop and improve storm water systems and drainage infrastructure	$10,400,000	$10,400,000	$20,800,000	$5,000,000	$5,200,000	$10,200,000	$15,400,000	$15,600,000	$31,000,000
Groundwater quality and supply	Build a large desalination plant for Gaza	$0	$0	$0	$500,000,000	$10,000,000	$510,000,000	$500,000,000	$10,000,000	$510,000,000
Groundwater supply	Increase share of imported water	$0	$0	$0	$1,000,000	$0	$1,000,000	$1,000,000	$0	$1,000,000
TOTAL		$145,450,000	$165,850,000	$311,300,000	$534,000,000	$48,200,000	$582,200,000	$679,450,000	$214,050,000	$893,500,000
GRAND TOTAL		**$1,279,876,000**	**$894,750,000**	**$2,174,626,000**	**$1,069,720,000**	**$299,820,000**	**$1,369,540,000**	**$2,349,596,000**	**$1,194,570,000**	**$3,544,166,000**

Appendix 5 –Future developments within Palestinian institutions to participate in climate-change modelling research

1 Introduction

Climate-change scenarios for use in the development of Palestine's National Adaptation Plan (NAP) have been provided by CCRM (Climate Change Risk Management) working as part of an international team led by Ricardo-AEA. Relevant scenarios presented in the literature have been reviewed to provide context for an analysis of projections from models used in the Intergovernmental Panel on Climate Change Fifth Assessment Report (AR5; IPCC 2013). However, for Palestine to have the capability to generate its own climate modelling inputs to its future NAPs and National Communications (NCs) the following would be required:

- A comprehensive and readily accessible digitised database of ongoing weather and climate observations to World Meteorological Organization (WMO) standards[153]
- Similar databases to fulfil requirements for hydrological parameters
- Appropriately-qualified staff
- Computer resources.

In this note it is assumed, for simplicity, that no resources to meet these requirements exist currently in Palestine. Clearly that is not the case, however, a presentation in this form is intended to enable Palestine to select the appropriate entry level in relation to each of the areas noted above, which are further considered below.

2 Climate observations

A network of observations, fully quality controlled and digitised and all reaching at the minimum WMO standards is required. WMO standards for routine weather observations, but not necessarily SYNOP (surface synoptic) observations transmitted to aid weather prediction centres, require a higher density of observations than those for climate monitoring. However, the standards required for climate observations are higher than those for weather observations because of the need to identify adjustments in parameters over time that might be small compared to natural background variability. As part of the WMO standards, all sites require comprehensive, complete and accurate metadata.

Thirty years is frequently quoted as a desirable length of observations for making a standard statement of climate characteristics. For all other purposes the length of record required varies, but what is needed is the longest possible record of quality data from as many measuring stations as possible (WMO provides standards for density of observations). If starting a new data series then opportunities for careful analysis will arise well before 30 years of data have been gathered.

Climate observations are needed for:

- Assessing and describing present and past climate, in terms of mean values and variability over various timescales
- Monitoring climate
- Building a record suitable to determine any changes over time, e.g. trends, steps, or any type of possible cyclical phenomena
- Contributing to global observations and analyses of climate and climate change

[153] http://www.wmo.int/pages/prog/www/OSY/GOS.html

- Contributing to downscaling activities for shorter-range predictions, such as seasonal and inter-annual forecasts, and for climate projections, whether through statistical or dynamical approaches
- Providing input to assessments of associations between climate and other environmental, economic and social issues, such as water and food security, climate-sensitive production and export, and health
- Providing input to impacts studies, vulnerability assessments and adaptation planning for all timescales
- Providing data for validation of models and verification of forecasts on all timescales.

It is recommended that the following questions should be considered when examining observational information from an individual station:

- Is there a full and correct set of metadata?
- Does the metadata contain anything that would be of concern in a trend analysis, such as periods of non-calibrated equipment, changes to new equipment, site and exposure changes, etc., and if so are corrections available?
- Has the site been maintained to full WMO standards at all times?
- Is there any reason that errors may have occurred in the digitisation process?
- Have the data received any corrections for any reason, and if so with what justification?
- How complete is the data record, and is there sufficient data of high enough quality to undertake a trend analysis for the selected period (including if annual, seasonal, monthly, etc. trends are required)?
- Have any attempts been made to complete the record by using information from nearby ‘proxy’ stations and, if so, how?
- What approach will be used to account for missing data?
- Are there any clear issues from a charting of the time series that might suggest a non-homogeneous series for any reason, such as obvious changes in mean or variance?
- Based on the charting, does it appear that any trend is in one direction only, or are there periods of apparent trend reversals, or any evidence of possible cyclical phenomena?
- If non-homogeneities are detected can they be explained using the metadata or other sources, and can any statistical correction be incorporated?

Trend analysis should only be undertaken once answers to all these questions have been determined, and it is clear that the series is homogeneous and that there are no characteristics of the series that would invalidate a calculated trend (such as substantial evidence of cyclical phenomena).

In undertaking trend analyses, variability in time series from individual stations needs to be considered. In general, such variability can be reduced by considering averages over observations from a number of data series. Global observations’ datasets, whether based simply on available observations or processed though models (such as in the various re-analyses), tend to provide less variability in time series. However, the quality of the time series is reduced over areas with lower quantity and/or quality of observations. A number of global observations datasets are readily available that would provide a valuable source for research into Palestinian climate.

3 Appropriately-qualified staff

A good grounding in climate theory and a number of years of experience are the ideal requisites for climate scientists responsible for undertaking historic climate trend analysis and modelling future climate projections. As a rule of thumb, a minimum of 10 years is necessary. This should include achievement of an appropriate Masters or Doctorate degree, and other experiences that provide extensive opportunities to interact with climate experts. Continuing regular interaction with experts, including attendance at international meetings, is desirable; access to past and current journals is essential.

Training should include not only the interpretation of climate, but also a good grounding in predictability theory. The latter will be valuable in designing the studies, as well as in understanding the uncertainties involved. Without a grounding in predictability inappropriate conclusions may be drawn from analysis of historic trends in climate or climate projections.

4 Computer resources

In order to run climate models directly, suitable workstations, storage devices and printing facilities are required, supported by appropriate analysis software. Some models can be run on relatively inexpensive machines, although run times should be balanced against costs; the ideal is to use one or more dedicated workstations. A substantial amount of both temporary and permanent storage is required. Precise specifications are not provided here, as these vary with the model selected and the best approach is to work with the modelling house during discussions. The same applies to storage, communications between storage and computer, printing facilities, and software required[154].

In general, climate models run under UNIX or Linux operating systems, and appropriate skills are required. Nevertheless, models are generally provided as packages together with necessary training, and are relatively straightforward to run. The supporting modelling house can normally provide peripheral essential databases, such as atmospheric and oceanic analyses for initialisation, land surface conditions, greenhouse gas scenarios and concentrations, etc. If a Regional Climate Model (RCM) is used for downscaling then the model runs require boundary fields, which a modelling house can provide. Models tend to be written in a variety of languages, including FORTAN and C++. It is recommended that if there is a need to adjust modelling code then it should be done only in cooperation with the model's owners.

Often climate scientists themselves take responsibility for running a model on workstations. A more efficient approach, if feasible, is to use a computer expert for model runs, thus, freeing research time for work on analysis.

The IPCC projections are readily available and may be used for detailed assessments.

5 Critical note on uncertainties

An overview of uncertainties associated with climate projections is provided in the main projections report. However, in the context of this note, it is important to consider how uncertainties in climate modelling impact on the potential broad cost-benefit of Palestine investing in developing its capability to generate climate modelling inputs to its future NAPs and NCs. In summary, these uncertainties mean that work with a single model carries the risk of developing inadequate scenarios of the future; all scenarios should be developed using ensemble techniques.

Various organizations around the world have been undertaking independent climate modelling research using ported models (i.e. models moved from their original supercomputer environments to forms suitable for running on laptops, etc.), whether global or regional models. Modelling houses have been promoting the use of portable model versions within this context. The approach is a useful one for capacity building provided that the fundamentals have been addressed.

An issue, which has arisen in a number of countries where such work has been undertaken, is that ownership of results from in-house experiments leads to deterministic views of future climate change, its impacts and required adaptation measures. Such views have often been included in National Adaptation Programs of Action (NAPAs) and NCs. This is unfortunate. In brief, it is not possible to identify the "best" climate model, either globally or locally. Of course, it is possible that a particular model might provide perfect projections, but the chances of that are remote and, in any case, that capability will be known only in hindsight. More likely projections from any single model will include errors, perhaps small, perhaps large, that can only be assessed at some future date when final verification becomes possible. Planning based on a single model's projections carries substantial risks. While in-house work with a limited number of models, often just the one, may be useful for capacity building once all fundamentals have been addressed, it is recommended that all planning activities should be based on the largest ensemble possible. In practice, this is an ensemble developed with the maximum number of individual models.

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[154]Any computer is capable of undertaking the statistical analyses required to assess observational data, such as to perform a trend analysis; the main issue is to gather the necessary data into a data base.

Equivalent advice extends to the use of RCMs for downscaling. Often statistical downscaling[155] is as effective as, and perhaps more so, than numerical downscaling. However, it should be noted that results from any downscaling depends on the boundary fields provided. Thus, the ideal for statistical downscaling is to use boundary fields from all global models. The same applies to downscaling through RCMs with the added caveat that the ensemble should be built using all RCMs (not just one), as well as all global models. Currently, certain issues still arise with RCMs that prevent recommending their use as inputs to decision making in NAPs and NCs. If downscaled projections for Palestine are desired, the best solution at present would be either to use statistical downscaling or to be involved in the Coordinated Regional Climate Downscaling Experiment (CORDEX) project. CORDEX is seeking to advance and coordinate the science and application of regional climate downscaling through global partnerships.

6 Recommendations

In summary, the main recommendations are to ensure that the fundamental requirements for undertaking climate change analyses are in place prior to undertaking the development of local modelling capabilities. These fundamental requirements include:

- The development of observations systems to WMO standards
- Digitisation and quality control of all observational data
- Creation of digitised databases for historical observations and for ingestion of future data, with quality control
- Consideration of staff training requirements
- Consideration of the use of existing global observations datasets, as input to research on Palestinian climate
- Consideration of the use of existing IPCC projections datasets, as the first stage towards research on climate change in Palestine
- Development of links with international institutions to assist where appropriate in all studies.

At this time, it is recommended that any initial downscaling approach considered is progressed through statistical means and not through use of numerical models. If numerical modelling is to be used then technical details need to be considered in consultation with the selected modelling house. However, it should be recognised that the use of a single model is **not** recommended, and that all work should be based on ensembles, ideally with combinations of global and regional models. The CORDEX dataset provides an extensive resource for research at this time, which might be considered for initial work. The current state of knowledge suggests that numerical downscaling is most useful by coasts and over regions of marked topography; the former might apply to Gaza but the topography of the West Bank may be insufficient to benefit from the latter. Consideration should be given to Chapter 9 of the IPCC AR5 Working Group I report, in particular Section 9.6 onwards, prior to any final decision on implementing numerical downscaling. If work is to be progressed then it is recommended that it should be undertaken in cooperation with the CORDEX project.

[155]Statistical downscaling identifies statistical relationships between measures of atmospheric circulation and surface weather/climate from historical data. It then uses these relationships together with projections of the same measures of atmospheric circulation. Statistical downscaling can be run on any computer and often provides results as valid as, if not better at the present time, than downscaling through RCMs.

Appendix 6 – Palestinian Meteorological Office: costs

Fundamental requirements	Item	Cost
The development of observations systems to WMO standards	1. MESSIER forecasting system from CORBOR	$800,000
	2. 20 automatic weather stations from Campbell Scientific	$400,000
	3. Manual and mechanical meteorological equipment	$200,000
	4. Spare parts for existing automatic meteorological stations	$200,000
	5. 100 rain gauges	$40,000
	6. Upgrade the meteorological database, and web site, weather application	$100,000
Appropriately qualified staff	1. Capacity building in (seasonal forecast, numerical weather prediction climate modelling, weather forecasting, etc)	$150,000
	2. Establish training center facilities for new staff ,schools pupils ,and university students	$30,000
Computer resources	1. Computer resources (workstations, storage devices, printing facilities, software, etc)	$200,000
TOTAL		$2,120,000

Appendix 7 – Letters approving the NAP from Ministers

State of Palestine
Ministry of Agriculture
Minister's Bureau

دولـــــــــة فلسطيـــــن
وزارة الـــــــزراعـــة
ديـــوان الـــــوزير

Ref : الرقم: 2016/1472
Date: التاريخ: 2016/ /

عطوفة الأخت/ م. عدالة الاتيره حفظها الله،،،
رئيس سلطة جودة البيئة
تحية طيبة وبعد،،،

الموضوع: إعتماد الخطة الوطنية للتكيف مع تغير المناخ

تهـــديكم وزارة الزراعـــة أطيـــب تحياتهـــا ونـــثمن جهـــودكم فـــي تعزيـــز التعـــاون المشـــترك والمستمر مـا بـين وزارة الزراعـة وسـلطة جـودة البيئـة، وعطفـاً علـى كتـابكم رقـم 2016/588 بتـــاريخ 2016/3/20 والمتعلـــق بإعتمـــاد الخطـــة الوطنيـــة للتكيـــف المنـــاخي، وبعـــد دراســـة الخطـــة مـــن قبـــل جهـــات الإختصـــاص فـــي الـــوزارة، يســـرنا إعلامكـــم بالموافقـــة علـــى إعتمـــاد الخطـــة ونبـــارك اطلاقهـــا تحقيقـــاً للمصـــلحة العامـــة كمـــا ونؤكـــد بـــأن الـــوزارة ســـوف تشـــارك بكلمـــة خلال حفل الإفتتاح للورشة المذكورة.

وتفضلوا بقبول فائق الإحترام والتقدير،،،

أ.د.سفيان سلطان
وزير الزراعـــة

دولـــة فلسطين / ديوان الوزير / 28-03-2016 / صادر رقم 2016/782

دولـــة فلسطين / وزارة الزراعة / 28-03-2016 / البريد الصادر / الرقم 1472

نسخة/ الأخ وكيل الوزارة.
نسخة/ الأخ وكيل مساعد الموارد الطبيعية.
نسخة/الأخ مدير عام المياه الزراعية والري.

دولـــة فلسطين / سلطة جودة البيئة / وارد عام / 458 2016 / 29-3-2016

P.O. Box (197) * Ramallah * Telefax: +972 2403361-Tel:+972 2403360 * E-mail :www.moa.pna.ps

State of Palestine
Ministry of Health
Minister's Office

دولــة فـلسطين
وزارة الصحة
مكتب الوزير

دولة فلسطين
رام الله
مكتب وزير الصحة
صادر رقم 16/327/ ز/ 148
التاريخ 2016/4/4

معالي الأخت عدالة الأتيرة المحترمة
رئيـــس سلطـــة جـــودة البيئة

تحية طيبة وبعد،،،

الموضوع: اعتماد الخطة الوطنية للتكيف مع تغير المناخ

تهديكـم وزارة الصحــة أطيـب التحيـات، وبالإشـــارة إلــى الموضـــوع المذكور أعلاه، يرجى العلم أن وزارة الصحة متمثلة بدائرة صحة البيئة قد شاركت في ورشات العمل الخاصة بالمشروع، وعليـه فإننــا نوافــق علــى مــا ورد فـــي هذه الخطة بما يتعلق بقطاع الصحة.

متمنيـــن لكـــم التوفيــــق...

وتفضلوا بقبول فائق الاحترام والتقدير،،،

الدكتور جواد عواد
وزيـــــر الصحة

State of Palestine
Dr. Jawad Awwad
Minister of Health

نسخة:
/وكيـل الـــوزارة المحتـــرم
/ق.أ مدير عام الصحة العامة

Ministry of Health - Nablus- Tel.: 09/2384771/6 - Fax : 09/2384777
Ministry of Health -Ramallah- Behind Palestine Medical Complex
Tel.: 02/2964183 - Fax : 02-2964182
Ministry of Health - Gaza- Tel. : 08/2846949 - Fax : 08/2826295

وزارة الصحة - نابلس - تلفون : 09/2384771/6 - فاكس : 09/2384777
وزارة الصحة - رام الله - خلف مجمع فلسطين الطبي
تلفون : 02/2964183 فاكس : 02/2964182
وزارة الصحة - غزة - تلفون : 08/2846949 فاكس : 08/2826295

بسم الله الرحمن الرحيم

State of Palestine
Ministry of Local Government

دولـــة فلسطين
وزارة الحكم المحلي

Date 2016.4.4 التاريخ

No: 1388 - 29.4 الرقم

معالي الأخت م. عدالة الاتيرة حفظها الله

رئيس سلطة جودة البيئة

تحية طيبة وبعد،،،

الموضوع : الخطة الوطنية للتكيف مع تغير المناخ

يرجى التكرم بالعلم بأنه قد تم الاطلاع على الاجراءات التخفيفية الموصى بها و التي تم ادراجها على الخطة الوطنية للتكيف مع تغير المناخ فيما يتعلق في قطاع ادارة النفايات الصلبة و هي متوافقة مع ما تم مناقشته و الاتفاق عليه خلال ورشات العمل التحضيرية التي شاركت فيها وزارة الحكم المحلي.

مع فائق الإحترام والتقدير،

محمد حسن جبارين

وكيل الـــوزارة

State of Palestine
Ministry of Local Government

دولـــة فلسطين
سلطة جودة البيئة
وارد عام
الرقم 517-2016
التاريخ 4-4-2016

رام الله، فلسطين:
تلفون: 2401092-02، فاكس: 2401091-02
www.molg.pna.ps
P.O.BOX:731

STATE OF PALESTINE
Ministry of National Economy
Minister's Office

دولة فلسطين
وزارة الاقتصاد الوطني
مكتب الوزير

التاريخ: 2016/03/30
المرجع: MO45/04/2016

دولة فلسطين
وزارة الاقتصاد الوطني
مكتب الوزير
صادر 4866
التاريخ 2016.3.31
المرجع

عطوفة الأخت م. عدالة الأتيرة حفظها الله
رئيس سلطة جودة البيئة

الموضوع: اعتماد الخطة الوطنية للتكيف مع تغير المناخ
Palestinian National Adaptation Plan (NAP)

تحية طيبة وبعد،

تهديكم وزارة الاقتصاد الوطني أطيب تحياتها، وبالإشارة إلى الموضوع أعلاه، نود أن نعلمكم انه بعد الاطلاع على النسخة النهائية من خطة التكيف الوطنية فإننا نوافق على ما ورد فيها بخصوص قطاع الصناعة والقطاعات الأخرى ذات العلاقة.

وتفضلوا بقبول فائق الاحترام،

عبير عودة
وزيرة الاقتصاد الوطني

دولة فلسطين وزارة الاقتصاد الوطني مكتب الوزير
STATE OF PALESTINE MINISTRY OF NATIONAL ECONOMY

Tel: +970-2-2981213, Fax: +970-2-2987640 - P.O.Box: 1629, Palestine
Email: minister.office@met.gov.ps, www.met.gov.ps

STATE OF PALESTINE
Ministry Of Public Works and Housing
Minister's Office

دولــــة فلسطـــــين
وزارة الاشغال العامة والاسكان
مكتب الوزير

التاريخ: 2016/4/14
الرقم: و-م-و/274/ 2016

معالي الأخت/ م. عدالة الأثيرة حفظها الله،،
رئيس سلطة جودة البيئة

تحية طيبة وبعد،،

الموضوع: اعداد الخطة الوطنية للتكيف مع تغير المناخ.

تهديكم وزارة الاشغال العامة والإسكان أطيب التحيات، ونشكر جهودكم الكبيرة في اعداد الخطة الوطنية للتكيف مع تغير المناخ، وبالإشارة إلى الموضوع إعلاه، ارجو العلم بأنه لا مانع لدينا في اعتماد الخطة المذكورة اعلاه، ونوافق وندعم ما ورد فيها، كما ونسعى للتعاون معكم ومع جميع القطاعات للمضي قدماً لتنفيذ بنودها وتطويرها.

مع فائق الاحترام والتقدير،،

مفيد الحساينة
وزير الأشغال العامة والإسكان

دولــة فلسطين
وزارة الاشغال العامة والاسكان
14-04-2016

دولــة فلسطــين
سلطة جودة البيئة
وارد عام
الرقم 559-2016
التاريخ 18-4-2016

نسخة:
- الأخ/ الوكيل.
- الأخ/ نبيل ترزي.
- الملف.

Ramallah-almasyoun-M.darwish Rotary-Ministries Compound
P.O.Box : Al_Bireh (3961)
Ramallah _Tel : 2966006/7 _ Fax : 2987890
Gaza - Southern Rimal-Arab League St

رام الله- المصيون- دوار محمود درويش- مجمع الوزارات
صندوق بريد. البيرة (3961)
رام الله-تلفون: 2966006/7 – فاكس: 2987890
غزة - الرمال الجنوبي – شارع جامعة الدول العربية

بسم الله الرحمن الرحيم

State of Palestine
Ministry of Tourism & Antiquities
Minister's Office

دولـــة فلســطيـن
وزارة السيـاحـة والآثـار
مكتب الوزير

التاريخ:2016/4/4

دولـــة فلسطـين
وزارة السياحة والآثار
مكتب الوزير
التاريخ: ٤/٤/٢٠١٦
صادر رقم: س/٣/٣٣٩

معالي الأخت م. عدالة الأتيرة حفظها الله.
رئيس سلطة جودة البيئة
تحية طيبة وبعد،

الموضوع: اعتماد الخطة الوطنية للتكيف مع تغير المناخ.

Palestinian National Adaptation (NAP)

تهديكم وزارة السياحة والآثار اطيب التحيات، وبالإشارة الى الموضوع أعلاه نود ان نعلمكم انه بعد الاطلاع على النسخة النهائية من خطة التكيف الوطنية فإننا نوافق على ما ورد فيها بخصوص قطاع السياحة والتراث الثقافي، كما ونود إعلامكم بتكليف الأخ صبري حميدان للمشاركة في الورشة.

وتفضلوا بقبول الاحترام والتقدير

معايعة
وزير السياحة والآثار

دولة فلسطين
وزارة السياحة والآثار

دولـــة فلسطـين
سلطة جودة البيئة
وارد عام
الرقم: 458-2016
التاريخ: 4-4-2016

P.O.Box 534 - Bethlehem - Palestine. Tel.: 02-2741581-2-3 , Fax: 02-2743753
ص.ب ٥٣٤ – بيت لحم – فلسطين . هاتف: ٠٢-٢٧٤١٥٨١/٢/٣ , فاكس: ٠٢-٢٧٤٣٧٥٣

بسم الله الرحمن الرحيم

دولـــــة فلسطيــــن
وزارة النقل والمواصلات
مكـتـب الوزيــــر

State of Palestine
Ministry of Transport
Minister's office

الاخت / م . عدالة الاتيرة حفظها الله

رئيس سلطة جودة البيئة

اعتماد الخطة الوطنية للتكيف مع التغير المناخي

تهديكم وزارة النقل والمواصلات أطيب التحيات ، وبالاشارة الى الموضوع أعلاه ، وبناءا على كتابكم رقم ٥٨٨-٢٠١٦ بتاريخ ٢٠١٦/٣/٢٠ ، فاننا نبارك لكم جهودكم المبذولة وفريق العمل المشارك ، ضمن مشروع " رفع قدرات السلطة الوطنية الفلسطينية في ادماج البيئة والتغير المناخي في السياسات الوطنية " ، ويسرنا أن نؤكد لكم أن الخيارات المطروحة في الخطة تعكس أولوية وزارة النقل والمواصلات في التكيف مع التغير المناخي والمدرجة ضمن خطط وزارة النقل والمواصلات الاستراتيجية والقطاعية .

وتفضلوا بقبول فائق الاحترام والتقدير

م . سميح طبيلة

وزير النقل والمواصلات

السلطة الوطنية الفلسطينية
وزارة النقل والمواصلات
31-03-2016
البريد الصادر
الرقم 625 الملف سلطة البيئة

دولة فلسطين
وزارة النقل والمواصلات
31-03-2016
مكتب الوزير
صادر رقم 471

رام الله - الماصيون - شارع النهضة هاتف: 02-2951313 فاكس: 02-2951321 ص.ب: 399
الموقع الالكتروني: www.mot.gov.ps البريد الالكتروني: diwan@mot.gov.ps

State of Palestine
Ministry of Women's Affairs
Deputy Minister Office

دولة فلسطين
وزارة شؤون المرأة
مكتب الوكيل

التاريخ: 2016/3/29

معالي الأخت م. عدالة الأرتيري حفظها الله،،،
رئيس سلطة جودة البيئة .
تحية طيبة وبعد،،،

الموضوع :- إعتماد الخطة الوطنية للتكيف مع التغير المناخي
Palestinian National Adaptation Plan(NAP)

تهديكم وزارة شؤون المرأة أطيب تحياتها، وتتمنى لكم موفور الصحة والعافية، كما وتشكركم في سلطة جودة البيئة على جهودكم وإهتمامكم الدائم في رفع قدرات السلطة الوطنية الفلسطينية في إدماج البيئة والتغيير المناخي في السياسات الوطنية.

بالإشارة للموضوع أعلاه، وبعد الإطلاع على المحصلة النهائية لخطة التكيف الوطنية نود أن نعلمكم بأننا نوافق نحن وزارة المرأة على ما ورد فيها قطاع المرأة والقطاعات ذات العلاقة .

واقبلوا فائق الاحترام والتقدير،،،

بسام الخطيب
وكيل وزارة شؤون المرأة

Ministry Of Women's Affairs
وزارة شؤون المرأة

دولــــــة فلسطــــــين
سلطة جودة البيئة
وارد عام
الرقم ....458 - 2016....
التاريخ ....31 - 3 - 2016....

دولـــــة فلسطـــين
وزارة شـؤون المـرأة
31 -03- 2016
صادر رقم 299

Email: info@mowa.pna.ps (02) 2422175 فاكس 2423315،2429461،2429462 : تلفون

State of Palestine
Palestinian Energy & Natural Resources Authority

مكتب الوزير

دولة فلسطين
سلطة الطاقة والموارد الطبيعية

التاريخ: 2016/03/24

معالي الأخت/ م. عدالة الأتيرة حفظها الله
رئيس سلطة جودة البيئة
تحية طيبة وبعد،

الموضوع: اعتماد الخطة الوطنية للتكيف مع تغير المناخ
Palestinian National Adaptation Plan (NAP)

تهديكم سلطة الطاقة أطيب التحيات، وبالإشارة الى الموضوع أعلاه نود أن نعلمكم انه بعد الاطلاع على النسخة النهائية من خطة التكيف الوطنية فإننا نوافق على ما ورد فيها بخصوص قطاع الطاقة والقطاعات الأخرى ذات العلاقة.

وتفضلوا بقبول الاحترام والتقدير

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سلطة المياه
مكتب الوزير

04 نيسان، 2016

عطوفة الأخت / م. عدالة الأتيرة حفظها الله
رئيس سلطة جودة البيئة

<u>الموضوع: اعتماد الخطة الوطنية للتكيف مع تغير المناخ</u>

تهديكم سلطة المياه أطيب التحيات وبالاشارة الى الموضوع أعلاه، وبعد الاطلاع على النسخة النهائية من خطة التكيف الوطنية، فاننا نود إعلامكم اننا نوافق على ما ورد فيها بخصوص قطاع المياه والقطاعات الاخرى ذات العلاقة.

مع فائق الاحترام والتقدير،

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